In the Matter of:

PR Spring Tar Sands Project
February 15, 2011, Ground Water Discharge Permit-by-Rule

INDEX OF INITIAL RECORD

January 10, 2012

Abbreviations used:

- DEQ is the Department of Environmental Quality
- LR is Living Rivers
- WRA is Western Resource Advocates
- EER is Earth Energy Resources, Inc. [n/k/a U.S. Oil Sands, Inc. ("USOS")]
- HH is Holland & Hart
- ALJ is the Administrative Law Judge
- DWQ is the Division of Water Quality
- ExSec is the Executive Secretary
- ExDir is the Executive Director

Doc. List No.	Record Description	Date	Added to Record By	Record Page
1	Letter from Mark Novak of DWQ to Mr. Page Van Loben Sels of Earth Energy Resources, Inc. regarding Oil Extraction from Oil Sands - Spent Tar Sands	10/14/05	DWQ	IR-000001
2	Letter from Mark Novak of DWQ to Mr. Page Van Loben Sels of Earth Energy Resources, Inc. regarding Tar Sands Pilot Project Tailings December 5, 2005	12/15/05	DWQ	IR-000002
3	PR Spring Mine, Request for Permit-by-Rule Determination submitted by Bob Bayer of JBR Environmental	02/21/08	EER	IR-000003 - IR-000035
3a	Letter from Rob Herbert of DWQ to Barclay Cuthbert, EER re PR Spring Tar Sands Project, Uintah and Grand Counties, Utah, Ground Water Discharge Permit-by-Rule	03/04/08	DWQ	IR-000036 - IR-000037
4	Utah State Department of Health Division of Laboratory Services Environmental Chemistry Analysis Report of PR Spring water sample	07/03/08	DWQ	IR-000038 - IR-000042

Doc. List No.	Record Description	Date	Added to Record By	Record Page
5	Notice of Intention To Commence Large Mining Operations, Earth Energy Resources, Inc. PR Spring Mine, M0470090	05/2009	EER	IR-000043 - IR-000372
6	Letter from Barclay Cuthbert of Earth Energy Resources Inc. to Rob Herbert of DWQ informing DWQ of four operational changes to the PR Spring Tar Sands Project, Uintah and Grand Counties, Utah with attachments: March 4, 2008, Letter to EER from DWQ re PR Spring groundwater discharge permit-by-rule; Material Safety Data Sheets of the reagent used in the extraction process	02/08/11	EER	IR-000373 - IR-000385
6a	Email correspondence between EER and DWQ, various dates	01/30/07 to 02/09/11	DWQ	IR-000386 - IR-000403
6b	Letter from Rob Herbert of DWQ to Barclay Cuthbert, EER re PR Spring Tar Sands Project, Uintah/Grand Counties, Utah, Revised Ground Water Discharge Permit-by-Rule	02/15/11	DWQ	IR-000404 - IR-000405
	Other published reports and online references:			
7	Hydrologic Reconnaissance of the Southern Uinta Basin, Utah and Colorado, Technical Publication No. 49, State of Utah Department of Natural Resources, Don Price & Louise L. Miller, U.S. Geological Survey	1975	DWQ	IR-000406 - IR-000482
8	Characteristics of the PR Spring Tar Sand Deposit, Uinta Basin, Utah, USA, George F. Dana & Donna J. Sinks, Laramie Energy Technology Center, U.S. Department of Energy	1984	DWQ	IR-000483 - IR-000502
9	Tar-Sand Resources of the Uinta Basin, Utah, A Catalog of Deposits compiled by Robert E. Blackett, Utah Geological Survey, Open-File Report 335	05/1996	DWQ	IR-000503 - IR-000630

JON M. TSMAN, JR.
Governor

GARY HERBERT
Lieutenant Governor

State of Utah

Department of Environmental Quality

Dianne R. Nielson, Ph.D.
Executive Director

DIVISION OF WATER QUALITY
Walter L. Baker, P.E.
Director

FILE COPY

October 14, 2005

Mr. Page van Loben Sels
Earth Energy Resources, Inc.
8013-110 Street
Grande Prairie A.B. T8W 6T2
Canada

Subject: Oil Extraction from Oil Sands – Spent Tar Sands

Dear Mr. van Loben Sels:

I have reviewed information on Earth Energy Resources' plan for a pilot project to extract oil from tar sands. The information provided does not include the cumulative amount of tar sand to be processed, a proposal for tailings disposal or an estimate of the chemical quality of leachate that may result from precipitation that infiltrates oil sand tailings after disposal. Petroleum-related hydrocarbons would be the contaminants of concern in this case. There is also no information on hydrogeologic characteristics of the proposed disposal site

Lacking this information, we must treat this as a worst-case scenario, and the tailings should be managed in such a way that leachate does not form after final tailings disposal. You may temporarily store the tailings on an impermeable liner, but precipitation that comes in contact with the tailings must be managed to prevent contamination of ground or surface water.

Additional information on the composition of leachate from the tailings, disposal site conditions or proposed containment technology for tailings disposal could be used to justify disposal requirements that are less stringent.

Please contact me if you have any questions.

Sincerely,

MTN

Mark Novak, P.G.
Ground Water Protection Section

cc: Dave Ariotti. District Engineer
Tri-County Health Dept.
Susan White, DOGM
Kiran Bhayani

MNOVAK/WP/EARTHENRES.LTR

IR - 000001

State of Utah

Department of Environmental Quality

Dianne R. Nielson, Ph.D.
Executive Director

DIVISION OF WATER QUALITY
Walter L. Baker, P.E.
Director

JON M. ı ıTSMAN, JR.
Governor

GARY HERBERT
Lieutenant Governor

FILE COPY

December 15, 2005

Mr. Page Van Loben Sels
Earth Energy Resources, Inc.
8013-110 Street
Grande Prairie A.B. T8W 6T2
Canada

Dear Mr. Van Loben Sels:

Subject: Tar Sands Pilot Project tailings

Earth Energy Resources is currently conducting a pilot project on processing tar sands in Grand County, Utah. To evaluate potential environmental impacts of disposing tailings from this project, at our request Earth Energy Resources had American West Analytical Laboratories extract leachate from a sample of the tailings using the Synthetic Precipitation Leachate Procedure (SPLP) and analyze it for Total Recoverable Petroleum Hydrocarbons (TRPH) and TCLP metals. The results of this analysis indicate nondetectible levels of TRPH and all TCLP metals except barium in the leachate.

For a pilot project of this scale, disposal of the tailings according to procedures approved by the Division of Oil, Gas and Mining should not result in contamination of ground or surface water. However, if Earth Energy Resources decides to expand the pilot project or go into production, more extensive testing of leachate from the tailings would be necessary for the Division of Water Quality to determine an appropriate regulatory action for such a large-scale operation.

Please contact me if you have any questions.

Sincerely,

MTN

Mark Novak, P.G.
Ground Water Protection Section

cc: Dave Ariotti, District Engineer
Tri-County Health Dept.
Susan White, DOGM
Kiran Bhayani

MNOVAK/WP/EARTHENRESPILOT.LTR

IR - 000002

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February 21, 2008

RECEIVED
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DIVISION OF WATER QUALITY

MTN

Mr. Mark Novak
Utah Division of Water Quality
288 North 1460 West
P.O. Box 144870
Salt Lake City, Utah 84114-4870

RE: PR Spring Mine, Request for Permit-by-Rule Determination

Dear Mr. Novak:

On behalf of Earth Energy Resources, Inc. (Earth Energy), thank you for your involvement in the permitting process for the proposed PR Spring tar sands mining and processing operation. As you are aware, Earth Energy's PR Spring project is located primarily in southern Uintah County, and extends into northern Grand County. The project area lands and minerals are under lease from Utah State Institutional Trust Lands Administration.

This letter transmits a brief report with attachments, intended to provide information to support Earth Energy's request for a determination that the proposed means of ore processing and processed sand disposal be considered permitted by rule under Utah's Ground Water Protection Rules (UAC R317.6-6). In part, this information was compiled to address items discussed in the initial January 10, 2007 meeting at the Division of Water Quality (DWQ) office with you, Tom Rushing, and Jodi Gardberg, and additional comments in your e-mail dated March 30, 2007 (attached).

Please contact either the undersigned or Mr. Barclay Cuthbert with Earth Energy Resources, Inc. (403.233.9366) with any questions you may have. Thank you very much.

Sincerely,

Robert J. Bayer

Robert J. Bayer, PG
Managing Principal

Enclosure(s)
cc: Barclay Cuthbert/Earth Energy Resources, Inc.

Corporate Office • Sandy, Utah | Boise, Idaho | Eugene, Oregon | Elko, Nevada | Medford, Oregon | Reno, Nevada | St. George, Utah

Earth Energy Resources, Inc.
PR Spring Operation, Uintah and Grand Counties, Utah
Ground Water Discharge Permit-by-Rule Demonstration

Introduction

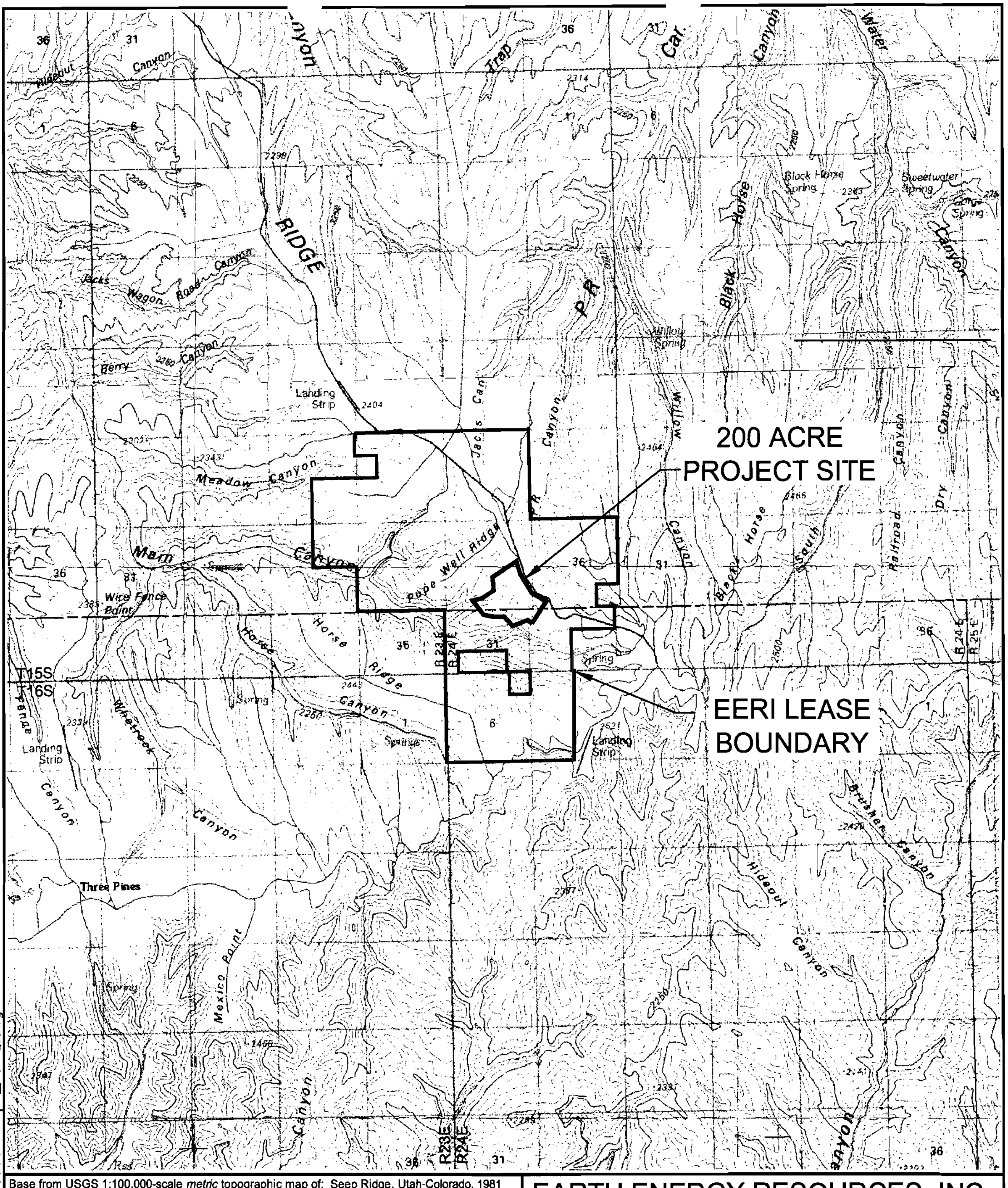
Earth Energy Resources, Inc. (Earth Energy) is in the process of acquiring all required state and federal permits prior to opening and operating a tar sands mine and process plant in northeastern Utah. Known as the PR Spring operation, the mine and plant would initially disturb approximately 200 acres of lands that Earth Energy has leased from Utah State Institutional Trust Lands Administration (SITLA). The project would be located in T15S, R23E, SLB&M, Uintah County, Sections 35 & 36, and T15½S, R24E, Grand County, Sections 31& 32 (**Figure 1**).

This report provides information to support Earth Energy's request to the Utah Division of Water Quality (DWQ) for a determination that the PR Spring operation be considered as a permitted-by-rule facility under Utah's Ground Water Protection Rules (UAC R317-6). UAC R317-6-6.2.A.1 states that "*facilities with effluent or leachate which has been demonstrated to the satisfaction of the Executive Secretary to conform and will not deviate from the applicable class TDS limits, ground water quality standards, protection levels or other permit limits and which does not contain any contaminant that may present a threat to human health, the environment or its potential beneficial uses of the ground water*" are considered to be permitted by rule. Also permitted by rule (at UAC R317-6-6.2.A.25) are "*facilities and modifications thereto which the Executive Secretary determines after a review of the application will have a de minimis actual or potential effect on ground water quality.*" Earth Energy believes that the proposed means of tar sands processing, processed sand disposal, and other aspects of the PR Spring operation meet these criteria, as described in detail below.

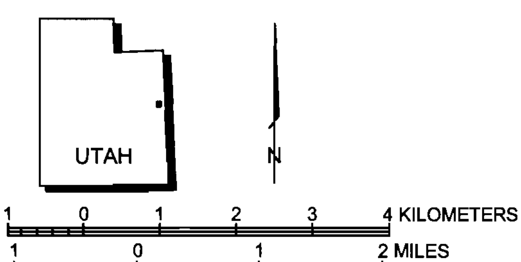
Environmental Setting

Earth Energy's PR Spring project would be located on the Tavaputs Plateau along the southeastern rim of the Uinta Basin. The site is within the Willow Creek sub-basin of the Green River watershed. The proposed disturbances would be located on a relatively flat interfluve between PR Canyon and Main Canyon, extending into the heads of two small ephemeral tributaries to Main Canyon. Average elevation at the project site is approximately 8,100 feet. The small headwater drainages contain very small active-channel cross-sections, and typically show no evidence of live water or riparian vegetation. Precipitation in this area is estimated at about 12 inches annually (Price and Miller 1975), which is generally not sufficient to sustain perennial flow in the smaller watersheds in this region. Instead, much of the area is dissected by numerous ephemeral drainages located in large canyons with steep side slopes.

Thick, cross-bedded sandstone, mapped by Gaultieri (1988) as the Renegade Member of the Wasatch Formation, crops out in the bottom of Main Canyon. These beds are overlain by the Green River Formation, which contains lenticular beds of lacustrine sandstone saturated with bitumen separated by intervals of barren sandstone, siltstone, shale, mudstone and calcareous



Base from USGS 1:100,000-scale *metric* topographic map of: Seep Ridge, Utah-Colorado, 1981 and Westwater, Utah-Colorado, 1980.



EARTH ENERGY RESOURCES, INC.

PR SPRING TAR SANDS DEVELOPMENT PROJECT

FIGURE 1
PROJECT LOCATION MAP

jbr environmental consultants, inc.

DESIGN BY	LM	DRAWN BY	CP	CH'D BY		SCALE	1:100,000	REVISION	DATE DRAWN 1/31/08

IR - 000005

drawings\EarthEnergy\Fig1 Location Map _ DWQ.dwg marl. The Parachute Member of the Green River Formation is the surface bedrock formation found throughout much of Earth Energy's lease, and the underlying Douglas Creek member of that formation contains the tar sands deposit that would be mined during this project. Five distinct asphalt impregnated sands, labeled "A", "B", "C", "D" and "E" with "E" the highest strata, occur in the upper portion of the Douglas Creek Member (Byrd, William D. 1970; Clem, K. 1984). The "E" bed is regionally known, but is not present locally. The remaining beds crop out in PR Canyon to the northeast and Main Canyon to the southwest of Earth Energy's proposed operations. All four beds occur in an interval 240 to 290 feet thick (Murphy, Leonard A., 2003 private report). Earth Energy's primary targets at this time are the "C" and "D" beds. The Douglas Creek Member forms the uppermost recognized aquifer in the project area.

BLM wrote the following about the geology and hydrogeology in the general vicinity of the project area (USDI BLM 2007):

> The Douglas Creek Aquifer receives recharge mainly by infiltration of precipitation and surface water in its outcrop area, with little leakage from underlying bedrock aquifers. It discharges locally to springs in the outcrop area and to alluvium along major drainageways such as the Green and White Rivers. In the study area, flow is generally to the north and northwest. The unit is roughly 500 ft thick, although in the center of the Uinta Basin it is as thick as 1,000 ft. Maximum well yields are less than 500 gpm. Water type is typically sodium sulfate to sodium bicarbonate. TDS levels range from 640 to 6,100 mg/L (Holmes and Kimball 1987).

Previous geologic exploration drilling at the site, at maximum depths of approximately 150 feet below ground surface, did not encounter ground water. However, there are several nearby springs and/or seeps that provide evidence of localized, shallow ground water. Most springs in the area, including the nearby PR Spring, are reported to discharge from the Parachute Creek Member of the Green River Formation (Price and Miller 1975), and represent isolated, perched aquifers. PR Spring is located slightly less than one mile east of Earth Energy's proposed operation, and is associated with several water rights for stock watering uses. It issues in the canyon bottom near the head of PR Canyon. Other springs mapped by the USGS and within a similar proximity to the site are located south of the proposed operation in the bottom of Main Canyon and its tributaries. PR Spring issues at an elevation of approximately 8,040 feet; other nearby springs issue at elevations ranging from about 7,700 to 8,160 feet.

While the Green River Formation includes various other water bearing zones (including the Birds Nest zone of the Parachute Creek Aquifer and the Douglas Creek Aquifer), the State Water Plan (Utah Division of Water Resources 1999) does not include any aquifers within this formation as significant enough to be targets for ground water development. Further, information from Green River Formation water wells and springs indicates generally low yields (Price and Miller 1975). Instead, the underlying Wasatch Formation and the Mesa Verde Formation (Group) are the nearest aquifers of a regional extent.

Price and Miller (1975) indicate that the potentiometric surface in the general area is 1,500 feet below ground level (BGL) or greater, with a gradient to the north. The Division of Oil, Gas and Mining's (DOGM) oil and gas well log records (DOGM 2007) were searched for relevant information on stratigraphy and ground water. Two of the well records (Webb (API #43-047-

30097, drilled in 1970-71), Lindisfarne (API #43-047-35567) drilled in 2006)) and other reports (Howells et al. 1987) describe the Mesa Verde as the nearest fresh water aquifer, under the low-permeability Green River and Wasatch formations. The average distance from ground level to the Mesa Verde was 2,011 feet, based on DOGM records of oil/gas wells within 3.3 miles of the project site and surrounding it in all directions. Table 1 shows the distance from ground level to the top of the Mesa Verde, taken from DOGM well files. Only recorded data is entered (e.g., if surface formation was not described it was left blank, if surface was described as the Green River Formation, zero (0) was entered in column 5).

Table 1. Distance BGL to Aquifer (from DOGM well files)

		Location Relative to Project Site		Distance BGL (in ft)			
Well Name	**T-R-S**	**Direction**	**Distance (mi)**	**Green River Formation**	**Wasatch Formation**	**Mesa Verde Formation**	**Noted Water Occurrence**
Lindisfarne	15-23-26	NNW	1.35	0	1,282	1,966	
Black Horse Canyon	15-24-31	ENE	1.2			1,905	
Webb	15-24-31	E	1.3			1,266	1,266
Divide 32-32	15.5-24-32	ESE	0.7	0		2,148	
UTFEE	15.5-24-32	SE	1.1	0	710	1,768	
UTON	16-24-5	SSE	1.8	0	600	1,800	
Horse Point	16-24-6	SSW	1.2			2,123	
Little Berry	16-23-2	SW	3.3			2,108	
Duncan 3	15-23-28	W	2.8	0	900	2,100	
Duncan 14	15-23-28	WNW	3.1	0		2,465	
Main 1	15-23-28	NW	2.35	0	1,365	2,475	

The nearest water well in the State water rights database (DWR 2007) is a BLM well (water right #49-1597) approximately three miles east in T15S, R24E, SESE Section 32; BLM initially drilled and abandoned a dry well (822 feet deep), then drilled a second well six feet away from the first and finished the well at 98 feet (static water level 60.9 ft; pumping at two gallons per minute (gpm) for one hour caused a 15-foot drop) (DWR 2007). According to the database, no proof of beneficial use was ever submitted for the water right associated with this well, and the right lapsed in 2002. The current physical status of the well is not known; there is no record in the database of the well having been plugged and abandoned.

A water rights application (No. 49-1567) has been filed with the State Engineers Office by a private party on a small spring located within Earth Energy's proposed disturbance area, as well as several other nearby springs; in general, these springs are ones that are not shown on USGS mapping. To date, the State Engineer has not granted this water right, in part because there were official protests filed and in part because the applicant has not submitted requested information to the State Engineer. A May 16, 2007 reconnaissance trip to locate the on-site spring and determine a flow rate found no evidence of ground water discharge at this site. It is not known whether such a spring previously discharged at this location or whether the site location associated with the water right application was reported incorrectly. A very minor seep, with flow too small to be measured, was found approximately 100 vertical feet down from, and ¼ mile west of, the spring identified with the water right. No other water was found in the immediate vicinity during this survey. Further, as noted above, exploration drilling in the vicinity, to depths of 150 feet, did not encounter ground water.

The baseline water quality of ground water underlying the project area is not known. However, the BLM (1984) notes that known springs within the combined Hill Creek and PR Springs Special Tar Sands Area (STSA) typically range from fresh to moderately saline, with total dissolved solids (TDS) ranging from about 300 mg/L to 6,100 mg/L (BLM 1984). Generally, the springs are freshest near the southern extent of the STSA, in the vicinity of the Project Area, with TDS concentrations of less than 500 mg/L (Price and Miller 1975). In 1964, PR Spring was discharging at 5.6 gpm and had a dissolved solids concentration of 380 mg/L (Price and Miller 1975).

More recently BLM has written the following (USDI BLM 2007):

> Dissolved salt in the rivers is a major concern in the Uinta Basin. The salts originate from marine and lacustrine sedimentary rocks and their derived soils that have high salt content. Surface runoff, irrigation return flow, saline groundwater discharges, and evapotranspiration are the major causes of the elevated TDS concentrations in the surface water (Price and Miller 1975). The concentrations of dissolved salt in streams generally are low near headwater areas, but increase dramatically near the lower reaches of the streams. This is magnified during low-flow periods.

In spring 2008, Earth Energy plans to drill a test water well approximately 1¼ mile east of the proposed PR Spring operation, in order to develop a source for its process water requirements. Geologic logging will include observations on specific locations where ground water is encountered, an aquifer pump test will be conducted, and water quality samples of the target aquifer will be collected. These will help to further define the location and the baseline chemistry of the area's ground water.

Surface water quality data for nearby streams is lacking. However, Willow Creek, to which Main Canyon is tributary, is listed as an impaired stream on Utah's 303(d) list. The listed pollutant is total dissolved solids (DWQ 2006).

PR Spring Operation Description

Earth Energy plans to mine tar sands from a 62-acre open pit (**Figure 2**), from which it will also remove overburden and interburden. Under the terms of the SITLA lease, mining may occur up to a maximum depth of 500 feet below ground surface; the current pit design, which will mine the D and C beds, extends to a maximum depth of about 150 feet. Based upon exploration boreholes and a five-acre test pit, overburden varies from 0 to 50-feet thick, and interburden thickness averages 15 feet. The "D" bed averages 21 feet thick, and the "C" bed averages 24 feet thick.

The mined tar sands would be stockpiled adjacent to the processing facility; up to about 40,000 yd^3 of tar sands (a two-week supply) could be stockpiled at any one time. Overburden and interburden would initially be placed in overburden/interburden disposal sites, which will be constructed as small valley fills. As the tar sands are processed and mining progresses, sand and fines remaining after extraction of the bitumen will be used to backfill the open pit. The waste sand and fines will be alternately placed with the available over/interburden rock to provide stability. At the end of this phase of mining, two external overburden/interburden disposal sites (approximately 25 acres each) will remain, and the open pit will have been backfilled to about 50-percent of capacity.

The processing facility (**Figure 3**) will be adjacent to the open pit, covering approximately 15 acres, and will include a mine office and associated parking area; a maintenance shop, warehouse, power plant, equipment parking and service area; process equipment, sand de-watering equipment, a tank farm, tank truck loading area, and a lined water storage pond that will serve as a reserve process water pond and plant-site runoff collection pond; and stockpiles for processed sand, reject materials (ore loads that contain too much interburden or overburden to be viable for processing), and ore. The mine office will be a modular building placed on a gravel pad. The process equipment will be skid-mounted. The warehouse and maintenance shop will be "Sprung-type" semi-permanent structures placed on concrete pads. The tank farm will be designed, constructed, and operated as required by the Spill Prevention, Control, and Countermeasures (SPCC) regulations at 40 CFR 112. Among other requirements, these regulations set forth requirements for secondary containment of stored oil products (i.e. 110 percent of the capacity of the largest tank). Because the tank truck loading area will involve the transfer of large quantities of hydrocarbons, Earth Energy's SPCC Plan will also address best management practices (BMPs) to prevent or manage releases from this area as well as from the tank farm.

Earth Energy has patented a chemical method for extracting hydrocarbons from tar sands. Known as the Ophus Process, this production method produces clean (chemically inert), "damp-dry" sand tailings that can be backfilled into the quarry. The method relies upon a proprietary cleaning emulsion, whose specifications and Material Safety Data Sheet (MSDS) have been provided to DWQ as confidential information. As indicated in the MSDS, while the cleaning emulsion's biodegradability has not been determined, related chemicals are known to be biodegradable. Further, the emulsion evaporates rapidly when exposed to air and is insoluble in water.

Figure 4 shows the process flow diagram (confidential). The extraction process begins when the mined tar sand is sent through a crusher or de-lumper and reduced to a two-inch-minus aggregate size. From there, the crushed ore is augered to a heated slurry mixer where the cleaning emulsion is introduced along with water and the ore slurried to the consistency of a thick, gritty milkshake. The oil sand slurry is then moved by screw conveyor to the slurry tank where primary separation of the bitumen from the sand occurs. The produced sand with residual bitumen is then pumped through a series of separation towers where the last traces of bitumen are removed. All of the liberated bitumen is captured, polished with cyclones and/or centrifuges and then pumped to a storage tank for heated storage prior to transport. The cleaning chemical is then removed from the bitumen by distillation and recycled to the front of the process.

Although this is a closed system, Earth Energy is coordinating with EPA and the Utah Division of Air Quality in regard to possible air emissions due to fugitive or other losses. The chemical is not changed as a result of processing – it acts as a diluting and a cleaning agent, but is not itself altered by bitumen extraction operations.

Approximately 85 percent of the total water used during the extraction of bitumen from oil sand will be recycled. The chemically cleaned produced sand is de-watered on a shale shaker (or similar device) and the recovered water is pumped to a holding tank for recycle to the front of the process. Additional cleaning agent is added to the re-cycled water to bring it back to full strength. De-watered sand and fines represent the two solid streams of residual waste material that will then be conveyed to a stockpile for loading and backhaul to the mine pit. The first stream, coarse solids, is primarily quartz sand which has particle sizes large enough to separate from the hydrocarbon phase and gravimetrically separate from the liquids. This phase is collected at the bottom of the separation towers and dewatered. The second stream is the fines (including clays), which typically remain entrained in the hydrocarbon phase during the initial bitumen separation. After the bitumen is extracted from the oil sands, a combination of hydrocarbon phase, water, and clays and fines are routed to the separation/polishing components of the Ophus Process where they are separated. The dewatered sands and fines are placed in a temporary storage pile, from which they are back-hauled to the pit backfill every 24 hours. The dewatered residual solids in the storage pile will contain approximately 15 to 20 percent moisture and when mixed will have a plastic consistency that will not release free water while in the stockpile. This material will be near optimum moisture for compaction when it is returned to the pit.

The final grading plan for the plant site will ensure that all plant site run off, including any free water from the residual solids storage pile (after a precipitation event, for example) will flow to the reserve water pond. The water in the reserve pond will be used during outages of the main water supply system, and may also be used for dust suppression on haul roads and in the open pit.

Water is expected to be consumed at a rate of approximately 1.5-2 barrels for each barrel of produced bitumen. The 2,000 barrel/day operation would use approximately 4,000 barrels of water, or 116 gpm based upon 24-hour processing. All of the water that is not recycled would either evaporate or be returned to the open pit as moisture within the processed sand, which would be mixed with returned overburden and interburden as pit backfill. The backfill would be unsaturated and non-free-draining.

In Utah, discharge of process waters, wastewaters, and storm water runoff from industrial facilities to surface water is typically regulated by DWQ through the Utah Pollutant Discharge Elimination System (UPDES) program, except where Tribal Land is involved, in which case EPA has regulatory authority over such discharges. Earth Energy's PR Spring operation will be located partially on Tribal Land and partially on non-tribal land, thus both EPA and DWQ have jurisdiction over any such discharges to surface water. As there will be no discharge of process water or wastewater to surface waters, a permit for these types of discharges will not be required from either agency. The need to obtain a permit for storm water discharges is currently being investigated with both EPA and DWQ. However, regardless of whether a permit is required by either or both agencies, storm water generated on-site will be managed so as to prevent its release to surface water (through BMPs such as grading, impoundment, and re-use).

Demonstration of Permit-by-Rule Conformance

Earth Energy believes that all aspects of the PR Spring operation will conform to the requirements stated at UAC R317-6-6.2.A.1 and A.25 (quoted above), thus allowing it to be considered as permitted by rule. First, the facility design and the nature of the operation minimize the potential for contaminant release. Second, the characteristics of residual water associated with the tar sands process do not suggest an environmental threat. Last, the hydrogeologic setting of the area in combination with various aspects of the project design limits the vulnerability of the aquifer to direct or leached contamination. In sum, Earth Energy's PR Spring operation is expected to have no more than a *de minimis* effect on ground water or surface water. These subjects are discussed in detail below.

Potential for Contaminant Release

As described above, the 15-acre process facility would include a fuel farm with full secondary containment capacity, a lined water pond, and self-contained process equipment. All of these facilities are designed to prevent release of fuels, process water, or process chemical. Any inadvertent release due to an accident or upset condition would be properly contained and mitigated. Temporary stockpiles of raw or processed tar sands would be protected from storm water run-on: the site is located atop a flat ridge with little or no up-gradient watershed, and berms would be used to control what runoff is produced from local precipitation. Further, as noted above, the process chemical itself is not water soluble and does not pose a threat other than that due to its flammability. There would be no effluent released during the operations; water would be used and recycled in a closed-loop fashion, with only a small portion exposed and lost to the environment as unrecoverable entrained moisture in the pore spaces of the produced sand and fines.

The overburden/interburden disposal sites would contain excavated non-oil-bearing sedimentary rock that would be chemically inert. The western-most of these disposal sites would be located on the area for which a water right (discussed above) has been filed on a small spring. Although there is no sign that such a spring exists at this location, the disposal site has been designed with a drain system to accommodate any flow from such a spring, should one be located within its footprint. Any such outflow would be routed down-slope along the eastern limit of the fill to a discharge point below the toe of the disposal site.

In sum, all of the above-described aspects of the PR Spring operation represent a negligible potential for contaminant release.

The processed tar sands that would be disposed back into the open pit represent the material with the characteristics most likely to contaminate water that contacts the material. Petroleum compounds associated with bitumen residual, entrained process water, or remaining process chemical represent, in theory, potential sources of contamination. To further investigate this potential, lab analyses -- using Toxicity Characteristic Leaching Procedure (TCLP Method 1311) and Synthetic Precipitate Leachate Procedure (SPLP Method 8270C/3510C and GC/MS 8260B), as well as leaching procedures using other solvents (EPA Method 8015B/3545), were run on unprocessed tar sands, processed sands and processed fines. Results of those tests are described below.

Characteristics of Residual

After processing, the tar sands will be nearly dry (10 to 20-percent moisture remaining from entrained process water); they will also contain some residual hydrocarbon due to a less-than-100-percent processing efficiency, and some residual process chemical. Processing produces two streams of residual material: 1) eighty percent in the sand size-class (d_{50} = 117 μm), and 2) twenty percent fines (d_{50} = 18 μm)[1]. This material would be placed back into the open pit and layered with removed overburden and interburden as a disposal/reclamation practice. Once the backfill is complete, the area would be topsoiled and revegetated. Any residual extraction fluid would be expected to evaporate quickly, due to its high volatility.

To investigate the chemical characteristics and leaching potential of the processed tar sands, two sets of samples were collected and analyzed. In 2005, samples of unprocessed tar sand were obtained from the Leonard Murphy #1 pit at the PR Spring site. The Leonard Murphy #1 pit is a small (approximately five acres) test pit located within the footprint of the proposed 62-acre quarry. One of the tar sands samples was analyzed in its raw state, and one was processed through a shop-scale demonstration plant prior to laboratory analysis. In 2007, additional tar sands samples were obtained from Asphalt Ridge, located approximately 40 miles north of the PR Spring site. One of the tar sands samples was analyzed in its raw state, and one was processed at Earth Energy's pilot-scale plant in Grande Prairie, Alberta prior to analysis; the produced sands and fines were analyzed separately because they are generated as two separate waste streams, as described above. For both the 2005 and the 2007 sampling events, the tar sands were processed using the same Ophus Process that was described above and proposed for the upcoming PR Spring operation. The Asphalt Ridge samples are assumed to be a valid stand-in for the PR Spring operation because of their similarity geologically and analytically. Results from both sets of analyses are provided in Tables 2 and 3 and the discussion that follows. The full laboratory analysis reports for the 2007 samples are attached.

Table 2 Leonard Murphy #1 Tar Sands Analytical Summary

ANALYTICAL PARAMETER (UNITS)	UNPROCESSED TAR SAND	PROCESSED SAND
Total Petroleum Hydrocarbon – Diesel Range Organics		
TPH-DRO (mg/kg)	19,000	2,700
TCLP Volatiles [1]		
Benzene (mg/L)	NA	<0.042
Ethylbenzene (mg/L)	NA	<0.042
Toluene (mg/L)	NA	<0.042
Xylenes, total (mg/L)	NA	<0.042

[1] Note that the unmilled PR Spring ore has a d_{50} of 173 μm.

ANALYTICAL PARAMETER (UNITS)	UNPROCESSED TAR SAND	PROCESSED SAND
TCLP Metals		
Arsenic (mg/L)	<0.10	<0.10
Barium (mg/L)	0.47	1.6
Cadmium (mg/L)	<0.030	<0.030
Chromium (mg/L)	<0.050	<0.050
Lead (mg/L)	<0.10	<0.10
Mercury (mg/L)	<0.0010	<0.0060
Selenium (mg/L)	<0.10	<0.10
Silver (mg/L)	<0.10	<0.10
TRPH		
TRPH (mg/L)	3.3	<3.0

(Source: American West Analytical Laboratories)
[1]Sample was received with headspace, which could compromise results

Table 3 Asphalt Ridge Tar Sands Analytical Summary

ANALYTICAL PARAMETER (UNITS)	UNPROCESSED TAR SAND	PROCESSED SAND	PROCESSED FINES
Total Petroleum Hydrocarbon – Diesel Range Organics			
TPH-DRO (mg/kg)	12,000	930	3,400
SPLP Semi-volatiles[1]			
3&4-Methyphenol (mg/L)	<0.025	<0.025	<0.025
2-Methylphenol (mg/L)	<0.025	<0.025	<0.025
2,4-Dinitrotoluene (mg/L)	<0.025	<0.025	<0.025
Hexachlorobenzene (mg/L)	<0.025	<0.025	<0.025
Hexachlorobutadiene (mg/L)	<0.025	<0.025	<0.025
Hexachloroethane (mg/L)	<0.025	<0.025	<0.025
Nitrobenzene (mg/L)	<0.025	<0.025	<0.025
Pentachlorophenol (mg/L)	<0.025	<0.025	<0.025
Pyridine (mg/L)	<0.025	<0.025	<0.025
2,4,5-Trichlorophenol (mg/L)	<0.025	<0.025	<0.025
2,4,6-Trichlorophenol (mg/L)	<0.025	<0.025	<0.025
SPLP Volatiles[1]			
Benzene (mg/L)	<0.040	<0.040	<0.040
Carbon tetrachloride (mg/L)	<0.040	<0.040	<0.040
Chlorobenzene (mg/L)	<0.040	<0.040	<0.040
Chloroform (mg/L)	<0.040	<0.040	<0.040
1,4-Dichlorobenzene (mg/L)	<0.040	<0.040	<0.040
1,2-Dichloroethane (mg/L)	<0.040	<0.040	<0.040
1,1-Dichloroethane (mg/L)	<0.040	<0.040	<0.040
2-Butanone (mg/L)	<0.020	<0.020	<0.020
Tetrachloroethene (mg/L)	<0.040	<0.040	<0.040
Trichloroethene (mg/L)	<0.040	<0.040	<0.040
Vinyl chloride (mg/L)	<0.020	<0.020	<0.020
TCLP Metals			
Calcium (mg/L)	2.1	0.71	3.1
Magnesium (mg/L)	<0.50	<0.50	0.77
Potassium (mg/L)	<0.50	<0.50	1.2
Sodium (mg/L)	3.8	9.9	29
Inorganic Analysis			
Alkalinity (as $CaCO_3$) (mg/kg)	<20	63	75
Bicarbonate (as $CaCO_3$)	<20	63	66

ANALYTICAL PARAMETER (UNITS)	UNPROCESSED TAR SAND	PROCESSED SAND	PROCESSED FINES
(mg/kg)			
Carbonate (as $CaCO_3$) (mg/kg)	<10	<14	<12
Chloride (mg/kg)	<5.0	19	21
Sulfate (mg/kg)	<5.0	60	61
Total Dissolved Solids (mg/kg)	24	300	6,100
Other Hydrocarbons			
Oil & Grease (mg/kg)	140,000	3,000	30,000
TRPH (mg/kg)	64,000	1,100	9,500

(Source: American West Analytical Laboratories)
[1] Holding times were exceeded

Volatile and Semi-Volatile Organics
All sample results – before and after processing – show that both volatile and semi-volatile organics were below detection in the leachate, confirming that the organics present are among the least mobile. However, it may be relevant to note that the analyses for these parameters were compromised to an unknown extent: the 2005 samples were received with headspace in the vials, which does not meet sampling protocol, and the 2007 samples were not analyzed by the lab within the allowable holding times. In addition to these sampling and lab errors, reporting limits for volatiles and semi-volatiles were generally above the applicable ground water standard for these analytes. Thus, it is possible that greater concentrations than those measured by the lab were actually present in the samples. Tar sands are comprised of bitumen, which is the non-volatile end member of the petroleum maturation process. By definition, then, bitumen contains little or no volatile or semi-volatile constituents. Therefore, it is believed that the results still indicate a *de minimis* effect on ground water from volatile or semi-volatile components, particularly given the hydrogeologic setting as described below.

Non-volatile Hydrocarbons
As expected, all sample results show that TRPH, TPH-DRO, and oil and grease were very high in the unprocessed ore and significantly reduced by processing. In spite of these reductions, some levels remain relatively high, particularly in the processed fines. In fact, the lab analytical reports note that the results for oil and grease are outside the method limits for the unprocessed ore and the processed fines, as well as for TRPH for the processed fines. Note that both of these analyses used EPA Method 1664a, which uses n-Hexane as the solvent; while this may be useful in characterizing the processed tar sand material, it does not characterize the likely leachate from precipitation. The absence of volatile or semi-volatile constituents in the processed material indicates that the organic compounds in the residual material are likely to be no more mobile than the *in situ* tar sands themselves.

One way of considering the environmental effects of the residual material is to compare it with the Utah's Department of Environmental Quality, Division of Environmental Response and Remediation's clean-up standards for petroleum-contaminated soils at underground storage tank sites. The initial screening and Tier 1 risk-based screening levels for oil and grease or TRPH are 1,000 mg/kg and 10,000 mg/kg, respectively. Of the total petroleum analyses preformed on the Asphalt Ridge samples, only the oil and grease analysis for the processed fines sample exceeded the Tier 1 screening level. However, when the processed fines are mixed with the processed sands in their produced ratio of 1:4, the combined result would be 8,400 mg/kg, which complies with the applicable Tier 1 screening level. Table 4 shows the effect of recombining the processed sands and fines for the three types of total petroleum analyses performed on the Asphalt Ridge samples.

Table 4 Comparison of Total Petroleum Analyses with Tier 1 Screening Levels

Analysis	Processed Sand	Processed Fines	((b*.708)+(c*.177))/(.708+.177)	Tier 1 Screening Criteria
TPH-DRO	930	3,400	1,424	5,000
Oil & Grease	3,000	30,000	8,400	10,000
TRPH	1,100	9,500	2,780	10,000
All analyses are in mg/kg				

Metals and Other Inorganics
The 2005 samples were analyzed for TCLP trace metals, and non-detects were reported for all of the analyzed metal constituents except barium. At DWQ's request, the 2007 samples were analyzed for TCLP calcium, magnesium, potassium, and sodium as a means of determining the potential of the leachate to cause salinity in any ground water it might enter. The results were detectable, but levels of the constituents were unremarkable. In regard to ground water quality standards, for those parameters for which TCLP metals were analyzed in 2005, the following is noted: barium, chromium, lead, and silver concentrations met ground water quality standards. The detection limits for the TCLP extract from analysis of arsenic, cadmium, mercury, and selenium were greater than the ground water quality standards for these parameters; therefore, comparison of these analyses with ground water quality standards is not possible.

It is believed that the results indicate a *de minimis* effect on ground water from the analyzed metals, particularly given the hydrogeologic setting as described below.

Total Dissolved Solids
Because the project is located within the Colorado River Basin, salinity (as measured by total dissolved solids) is a concern for any potential discharges to surface waters or ground water. Further, ground water in the State is classified according to its TDS, which, in-turn, drives protection levels established in a ground water permit. The TDS concentration of ground water in the general project vicinity varies by an order of magnitude (from 300 to 6,000 mg/L as described above), but site-specific TDS data for ground water underlying the project area are not available. The TDS analyses in Table 3 are reported in mg/kg and result from a non-standard analytical method; therefore these results are not considered relevant for estimation of the TDS of leachate from the process residuals. The expected TDS of leachate that might develop from the processed oil sands is not known, however, the Orphus process affects organic compounds and does not possess the acid or caustic qualities necessary to dissolve inorganic compounds. In addition containment of the residual material in the open pit will generally prevent the release of any fluids from the waste material.

Extraction Fluid Residual

In addition to the residual product characterized in the above tables, there would likely be some residual extraction fluid in the processed residual. The previously provided MSDS for the proprietary extraction fluid supports the contention that, in the unlikely event that leaching by rain water mobilizes residual extraction fluid, the fluid poses virtually no ecological or human health risk. Given the nature of this emulsion and the concentration in which it will occur in the produced sands and fines, no impact to water quality would be expected as a result of its use and the subsequent placement of dried produced sands and fines at the proposed disposal site.

Hydrogeologic Setting

Another factor in assessing risk to ground water is the vulnerability of the aquifer to direct or leached contamination from the storage site. The lack of water wells in the area complicates this task, but also suggests that no productive aquifer has been located close enough to the ground surface to provide an economical water source. As discussed above, the relevant major, regional aquifer in this area is likely to be associated with the Mesa Verde Formation (Group). The vertical distance between the placed processed sands and this aquifer is documented in oil and gas well logs to be in the range of 1,500 to 2,000 feet, which would provide a sufficient interval of protection from any leachate.

At the same time, there is evidence of shallower, localized ground water in the area (see the Environmental Setting section, above). While the presence of such ground water directly underlying the storage site is thought to be unlikely (no springs have been noted and exploration drilling did not encounter ground water between the surface and 150 feet), it is not possible to preclude its presence.

To analyze the potential for precipitation falling on the disposed processed residual material to migrate through the depository to native materials at the bottom of the pit excavation, the following factors need to be considered. The processed sand will be dry (10-20 percent moisture content), and because of the low rainfall in the area, breakthrough of infiltrating precipitation to the base of the pit waste deposits is not anticipated to occur. In order for breakthrough to occur, the dried sand and clay fines would have to exceed their field capacity. The addition of the intervening layers of waste rock, which is comprised primarily of shale, will help to further reduce infiltration as time goes on.

State and federal publications (Price and Miller 1975; Howells, Longson & Hunt 1987) describe the Green River, Mesa Verde and Wasatch formations as intermixed strata of sandstone, shale, siltstone, and mudstone, with permeabilities ranging from very low to high. This profile is in keeping with the documented springs in the area, localized/perched aquifers, fresh to briny ground water quality, and lack of ground water developments. While none of this precludes the possibility of shallower localized ground water in the area, it reduces the likelihood that leachate from the processed sands could reach and contaminate an aquifer of economic significance. It should also be noted that the maximum surface area of exposed residual material at any one time will be approximately 25 acres, since areas would be reclaimed (topsoil and vegetation) as soon as they are "filled."

Nevertheless, to err on the side of caution, Earth Energy will implement several measures during the initial operations. First, the additional exploration drilling scheduled for the spring of 2008, within a wider area of the proposed pit (and storage site for processed sands), will provide more information on subsurface conditions and encountered water, if any. Should evidence of shallow ground water be discovered, Earth Energy will coordinate with DWQ to further investigate this issue. When pit excavations begin, visual monitoring for the presence of intercepted ground water will be performed routinely. While precipitation will also be contributing water to the pit, careful observation, along with sampling, should allow the two sources to be distinguished from each other. Again, if it appears that ground water has been intercepted, Earth Energy will coordinate with DWQ to further investigate this issue.

Summary

The above information supports Earth Energy's request that DWQ find the PR Spring operation to be permitted by rule as allowed by the Ground Water Protection rules. The operation is not expected to generate contaminants in quantities that would present a threat to human health or the environment, and the hydrogeologic setting of the operation greatly reduces the potential for any water associated with the operation to commingle with ground water. Chemical analyses of leachate from processed materials revealed no problematic results, except where leaching was performed using solvents that would not accurately characterize leachate from precipitation. Further, the operation will manage process water and storm water so as to avoid discharge of either to surface waters. We believe this demonstrates a *de minimis* impact from the proposed operation.

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Kyle F. Gross
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Peggy McNicol
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August 24, 2007

Barclay Cuthbert
Earth Energy Resouces, Inc.
Suite 704, 404 - 6th Avenue SW
Calgary, Alberta T2P 0R9

TEL: (403) 233-9366
FAX: (403) 668-5097

RE: RJN #028-Asphalt Ridge

Lab Set ID: L79307

Dear Barclay Cuthbert:

American West Analytical Labs received 3 samples on 8/10/2007 for the analyses presented in the following report.

All analyses were performed in accordance to National Environmental Laboratory Accreditation Program (NELAP) protocols unless noted otherwise. If you have any questions or concerns regarding this report please feel free to call. The abbreviation "Surr" found in organic reports indicates a surrogate compound that is intentionally added by the laboratory to determine sample injection, extraction and/or purging efficiency.

Thank you.

Approved by: ____________________
Laboratory Director or designee

INORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN
WEST
ANALYTICAL
LABORATORIES

Lab Sample ID: L79307-01C
Field Sample ID: **Unprocessed Oil Sand**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

TCLP METALS Method 1311

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result
Calcium	mg/L	8/20/2007 1:36:00 PM	6010B	0.50	**2.1**
Magnesium	mg/L	8/20/2007 1:36:00 PM	6010B	0.50	< 0.50
Potassium	mg/L	8/20/2007 1:36:00 PM	6010B	0.50	< 0.50
Sodium	mg/L	8/20/2007 1:36:00 PM	6010B	0.50	**3.8**

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Laboratory Director

Peggy McNicol
QA Officer

INORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert

Project ID: RJN #028-Asphalt Ridge

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L79307-02C

Field Sample ID: **Processed Sand**

Collected: 7/31/2007 3:55:00 PM

Received: 8/10/2007

TCLP METALS Method 1311 Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result
Calcium	mg/L	8/20/2007 1:52:00 PM	6010B	0.50	**0.71**
Magnesium	mg/L	8/20/2007 1:52:00 PM	6010B	0.50	< 0.50
Potassium	mg/L	8/20/2007 1:52:00 PM	6010B	0.50	< 0.50
Sodium	mg/L	8/20/2007 1:52:00 PM	6010B	0.50	**9.9**

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Laboratory Director

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INORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L79307-03C
Field Sample ID: **Processed Fines**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

TCLP METALS Method 1311

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result
Calcium	mg/L	8/20/2007 1:56:00 PM	6010B	0.50	**3.1**
Magnesium	mg/L	8/20/2007 1:56:00 PM	6010B	0.50	**0.77**
Potassium	mg/L	8/20/2007 1:56:00 PM	6010B	0.50	**1.2**
Sodium	mg/L	8/20/2007 1:56:00 PM	6010B	0.50	**29**

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INORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L79307-01
Field Sample ID: **Unprocessed Oil Sand**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result	
Alkalinity,(As CaCO3)	mg/kg-dry	8/13/2007 8:40:00 AM	310.1	20	< 20	*
Bicarbonate (As CaCO3)	mg/kg-dry	8/13/2007 8:40:00 AM	310.1	20	< 20	*
Carbonate (As CaCO3)	mg/kg-dry	8/13/2007 8:40:00 AM	310.1	10	< 10	
Chloride	mg/kg-dry	8/17/2007 1:33:00 PM	9251	5.0	< 5.0	1
Oil & Grease	mg/kg-dry	8/15/2007 11:10:00 AM	1664 MOD.	150	**140000**	#
Sulfate	mg/kg-dry	8/13/2007 8:00:00 AM	9038	5.0	< 5.0	*
TDS	mg/kg-dry	8/17/2007 1:45:00 PM	160.1	10	**24**	**H**
Total Recoverable Petroleum Hydrocarbons	mg/kg-dry	8/15/2007 3:15:00 PM	1664-SGT	150	**64000**	

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**Analysis is performed on a 1:1 DI water extract for soils.*
 # Analyte concentration is above the method range of 1000 mg/sample indicating a potential for low recovery.
[1] Spike recovery indicates matrix interference. The method is in control as indicated by the laboratory control sample (LCS).
H - Sample was received outside of holding time.

Kyle F. Gross
Laboratory Director

Peggy McNicol
QA Officer

INORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L79307-02
Field Sample ID: **Processed Sand**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result	
Alkalinity,(As CaCO3)	mg/kg-dry	8/13/2007 8:40:00 AM	310.1	27	**63**	*
Bicarbonate (As CaCO3)	mg/kg-dry	8/13/2007 8:40:00 AM	310.1	27	**63**	*
Carbonate (As CaCO3)	mg/kg-dry	8/13/2007 8:40:00 AM	310.1	14	< 14	
Chloride	mg/kg-dry	8/17/2007 1:33:00 PM	9251	6.8	**19**	
Oil & Grease	mg/kg-dry	8/15/2007 11:10:00 AM	1664 MOD.	200	**3000**	
Sulfate	mg/kg-dry	8/13/2007 8:00:00 AM	9038	18	**60**	*
TDS	mg/kg-dry	8/17/2007 1:45:00 PM	160.1	14	**300**	H
Total Recoverable Petroleum Hydrocarbons	mg/kg-dry	8/15/2007 3:15:00 PM	1664-SGT	200	**1100**	

**Analysis is performed on a 1:1 DI water extract for soils.*
H - Sample was received outside of holding time.

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INORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L79307-03
Field Sample ID: **Processed Fines**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

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QA Officer

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result	
Alkalinity,(As CaCO3)	mg/kg-dry	8/13/2007 8:40:00 AM	310.1	25	**75**	*
Bicarbonate (As CaCO3)	mg/kg-dry	8/13/2007 8:40:00 AM	310.1	25	**66**	*
Carbonate (As CaCO3)	mg/kg-dry	8/13/2007 8:40:00 AM	310.1	12	< 12	
Chloride	mg/kg-dry	8/17/2007 1:33:00 PM	9251	6.2	**21**	
Oil & Grease	mg/kg-dry	8/15/2007 11:10:00 AM	1664 MOD.	190	**30000**	2
Sulfate	mg/kg-dry	8/13/2007 8:00:00 AM	9038	16	**61**	*
TDS	mg/kg-dry	8/17/2007 1:45:00 PM	160.1	12	**6100**	H
Total Recoverable Petroleum Hydrocarbons	mg/kg-dry	8/15/2007 3:15:00 PM	1664-SGT	190	**9500**	2

**Analysis is performed on a 1:1 DI water extract for soils.*
[2] Analyte concentration is too high for accurate spike recovery.
H - Sample was received outside of holding time.

ORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc.
Project ID: RJN #028-Asphalt Ridge

Contact: Barclay Cuthbert

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L79307-01A
Field Sample ID: **Unprocessed Oil Sand**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

Extracted: 8/10/2007
Analyzed: 8/13/2007 4:57:42 PM

Analysis Requested: TPH by SW8015B

Analytical Results **TPH-DRO by 8015B/3545**

Units = mg/kg-dry **% Moisture: 0.6**
Dilution Factor = 10

Compound	Reporting Limit	Analytical Result
Total Petroleum Hydrocarbon (DRO - C10-28)	800	**12000**
Surr: 4-Bromofluorobenzene	10-169	**52.0**

The reporting limits were raised 4x due to sample matrix interference.

463 West 3600 South
Salt Lake City, Utah
84115

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Fax (801) 263-8687
e-mail: awal@awal-Labs.com

Kyle F. Gross
Laboratory Director

Peggy McNicol
QA Officer

ORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc.
Project ID: RJN #028-Asphalt Ridge

Contact: Barclay Cuthbert

AMERICAN
WEST
ANALYTICAL
LABORATORIES

Lab Sample ID: L79307-02A
Field Sample ID: **Processed Sand**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

Extracted: 8/10/2007
Analyzed: 8/13/2007 5:18:25 PM

Analysis Requested: TPH by SW8015B

Analytical Results **TPH-DRO by 8015B/3545**

Units = mg/kg-dry **% Moisture: 26**
Dilution Factor = 10

Compound	Reporting Limit	Analytical Result
Total Petroleum Hydrocarbon (DRO - C10-28)	270	**930**
Surr: 4-Bromofluorobenzene	10-169	**76.3**

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ORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. | Contact: Barclay Cuthbert

Project ID: RJN #028-Asphalt Ridge

AMERICAN
WEST
ANALYTICAL
LABORATORIES

Lab Sample ID: L79307-03A

Field Sample ID: **Processed Fines**

Collected: 7/31/2007 3:55:00 PM | Extracted: 8/10/2007

Received: 8/10/2007 | Analyzed: 8/13/2007 5:39:07 PM

Analysis Requested: TPH by SW8015B

Analytical Results | **TPH-DRO by 8015B/3545**

Units = mg/kg-dry | **% Moisture: 20**

Dilution Factor = 10

Compound	Reporting Limit	Analytical Result	
Total Petroleum Hydrocarbon (DRO - C10-28)	250	3400	
Surr: 4-Bromofluorobenzene	10-169	214	S

S - High surrogate recovery attributed to TPH interference. The method is in control as indicated by the MB & LCS.

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ORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN
WEST
ANALYTICAL
LABORATORIES

Lab Sample ID: L79307-01C
Field Sample ID: **Unprocessed Oil Sand**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

Extracted: 8/15/2007 11:06:24 PM
Analyzed: 8/21/2007 11:51:00 A

Analysis Requested: Semi Volatiles by SW 8270C

Analytical Results for SPLP **SPLP Semivolatile Organics by 8270C/3510C**

Units = mg/L **% Moisture: 0.6**
Dilution Factor: 1

Compound	Reporting Limit	Analytical Result
3 & 4-Methylphenol	0.025	< 0.025
2-Methylphenol	0.025	< 0.025
2,4-Dinitrotoluene	0.025	< 0.025
Hexachlorobenzene	0.025	< 0.025
Hexachlorobutadiene	0.025	< 0.025
Hexachloroethane	0.025	< 0.025
Nitrobenzene	0.025	< 0.025
Pentachlorophenol	0.025	< 0.025
Pyridine	0.025	< 0.025
2,4,5-Trichlorophenol	0.025	< 0.025
2,4,6-Trichlorophenol	0.025	< 0.025
Surr: 2,4,6-Tribromophenol	14-159	**65.0**
Surr: 2-Fluorobiphenyl	10-124	**68.2**
Surr: 2-Fluorophenol	10-106	**39.7**
Surr: 4-Terphenyl-d14	10-199	**49.0**
Surr: Nitrobenzene-d5	10-180	**65.2**
Surr: Phenol-d6	10-122	**31.0**

H - Sample was tumbled outside of holding time.

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Laboratory Director

Peggy McNicol
QA Officer

ORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L79307-02C
Field Sample ID: **Processed Sand**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

Extracted: 8/15/2007 11:06:24 PM
Analyzed: 8/21/2007 3:40:00 PM

Analysis Requested: Semi Volatiles by SW 8270C

Analytical Results for SPLP **SPLP Semivolatile Organics by 8270C/3510C**

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Peggy McNicol
QA Officer

Units = mg/L **% Moisture: 26**
Dilution Factor: 1

Compound	Reporting Limit	Analytical Result
3 & 4-Methylphenol	0.025	< 0.025
2-Methylphenol	0.025	< 0.025
2,4-Dinitrotoluene	0.025	< 0.025
Hexachlorobenzene	0.025	< 0.025
Hexachlorobutadiene	0.025	< 0.025
Hexachloroethane	0.025	< 0.025
Nitrobenzene	0.025	< 0.025
Pentachlorophenol	0.025	< 0.025
Pyridine	0.025	< 0.025
2,4,5-Trichlorophenol	0.025	< 0.025
2,4,6-Trichlorophenol	0.025	< 0.025
Surr: 2,4,6-Tribromophenol	14-159	**63.5**
Surr: 2-Fluorobiphenyl	10-124	**49.2**
Surr: 2-Fluorophenol	10-106	**28.6**
Surr: 4-Terphenyl-d14	10-199	**43.1**
Surr: Nitrobenzene-d5	10-180	**42.7**
Surr: Phenol-d6	10-122	**21.1**

H - Sample was tumbled outside of holding time.

ORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L79307-03C
Field Sample ID: **Processed Fines**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

Extracted: 8/15/2007 11:06:24 PM
Analyzed: 8/21/2007 4:13:00 PM

Analysis Requested: Semi Volatiles by SW 8270C

Analytical Results for SPLP **SPLP Semivolatile Organics by 8270C/3510C**

Units = mg/L **% Moisture: 20**
Dilution Factor: 1

Compound	Reporting Limit	Analytical Result
3 & 4-Methylphenol	0.025	< 0.025
2-Methylphenol	0.025	< 0.025
2,4-Dinitrotoluene	0.025	< 0.025
Hexachlorobenzene	0.025	< 0.025
Hexachlorobutadiene	0.025	< 0.025
Hexachloroethane	0.025	< 0.025
Nitrobenzene	0.025	< 0.025
Pentachlorophenol	0.025	< 0.025
Pyridine	0.025	< 0.025
2,4,5-Trichlorophenol	0.025	< 0.025
2,4,6-Trichlorophenol	0.025	< 0.025
Surr: 2,4,6-Tribromophenol	14-159	**69.7**
Surr: 2-Fluorobiphenyl	10-124	**49.0**
Surr: 2-Fluorophenol	10-106	**30.9**
Surr: 4-Terphenyl-d14	10-199	**50.1**
Surr: Nitrobenzene-d5	10-180	**45.9**
Surr: Phenol-d6	10-122	**22.0**

H - Sample was tumbled outside of holding time.

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ORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN WEST ANALYTICAL LABORATORIES

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Peggy McNicol
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Lab Sample ID: L79307-01C
Field Sample ID: **Unprocessed Oil Sand**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

Extracted: 8/15/2007 11:08:40 PM
Analyzed: 8/17/2007 8:06:00 AM

Analysis Requested: 8260B/5030B
Analytical Results for SPLP

SPLP VOLATILES by GC/MS 8260B

Units = mg/L
Dilution Factor: 20

Compound	Reporting Limit	Analytical Result	
Benzene	0.040	< 0.040	H
Carbon tetrachloride	0.040	< 0.040	H
Chlorobenzene	0.040	< 0.040	H
Chloroform	0.040	< 0.040	H
1,4-Dichlorobenzene	0.040	< 0.040	H
1,2-Dichloroethane	0.040	< 0.040	H
1,1-Dichloroethene	0.040	< 0.040	H
2-Butanone	0.20	< 0.20	H
Tetrachloroethene	0.040	< 0.040	H
Trichloroethene	0.040	< 0.040	H
Vinyl chloride	0.020	< 0.020	H
Surr: 1,2-Dichloroethane-d4	81-143	**112**	H
Surr: 4-Bromofluorobenzene	85-115	**106**	H
Surr: Dibromofluoromethane	80-124	**106**	H
Surr: Toluene-d8	88-120	**105**	H

H - Sample was received outside of holding time.

ORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc. Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L79307-02C
Field Sample ID: **Processed Sand**
Collected: 7/31/2007 3:55:00 PM
Received: 8/10/2007

Extracted: 8/15/2007 11:08:40 PM
Analyzed: 8/17/2007 8:27:00 AM

Analysis Requested: 8260B/5030B
Analytical Results for SPLP

SPLP VOLATILES by GC/MS 8260B

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Units = mg/L
Dilution Factor: 20

Compound	Reporting Limit	Analytical Result	
Benzene	0.040	< 0.040	H
Carbon tetrachloride	0.040	< 0.040	H
Chlorobenzene	0.040	< 0.040	H
Chloroform	0.040	< 0.040	H
1,4-Dichlorobenzene	0.040	< 0.040	H
1,2-Dichloroethane	0.040	< 0.040	H
1,1-Dichloroethene	0.040	< 0.040	H
2-Butanone	0.20	< 0.20	H
Tetrachloroethene	0.040	< 0.040	H
Trichloroethene	0.040	< 0.040	H
Vinyl chloride	0.020	< 0.020	H
Surr: 1,2-Dichloroethane-d4	81-143	**111**	H
Surr: 4-Bromofluorobenzene	85-115	**104**	H
Surr: Dibromofluoromethane	80-124	**104**	H
Surr: Toluene-d8	88-120	**105**	H

H - Sample was received outside of holding time.

AMERICAN
WEST
ANALYTICAL
LABORATORIES

ORGANIC ANALYSIS REPORT

Client: Earth Energy Resouces, Inc.   Contact: Barclay Cuthbert
Project ID: RJN #028-Asphalt Ridge

Lab Sample ID: L79307-03C
Field Sample ID: **Processed Fines**
Collected: 7/31/2007 3:55:00 PM   Extracted: 8/15/2007 11:08:40 PM
Received: 8/10/2007   Analyzed: 8/17/2007 8:48:00 AM

Analysis Requested: 8260B/5030B

Analytical Results for SPLP   **SPLP VOLATILES by GC/MS 8260B**

Units = mg/L
Dilution Factor: 20

Compound	Reporting Limit	Analytical Result	
Benzene	0.040	< 0.040	H
Carbon tetrachloride	0.040	< 0.040	H
Chlorobenzene	0.040	< 0.040	H
Chloroform	0.040	< 0.040	H
1,4-Dichlorobenzene	0.040	< 0.040	H
1,2-Dichloroethane	0.040	< 0.040	H
1,1-Dichloroethene	0.040	< 0.040	H
2-Butanone	0.20	< 0.20	H
Tetrachloroethene	0.040	< 0.040	H
Trichloroethene	0.040	< 0.040	H
Vinyl chloride	0.020	< 0.020	H
Surr: 1,2-Dichloroethane-d4	81-143	111	H
Surr: 4-Bromofluorobenzene	85-115	104	H
Surr: Dibromofluoromethane	80-124	104	H
Surr: Toluene-d8	88-120	105	H

H - Sample was received outside of holding time.

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Peggy McNicol
QA Officer

State of Utah

Department of Environmental Quality

Richard W. Sprott
Executive Director

DIVISION OF WATER QUALITY
Walter L. Baker, P.E.
Director

JON M. HUNTSMAN, JR.
Governor

GARY HERBERT
Lieutenant Governor

March 4, 2008

Mr. Barclay Cuthbert
Earth Energy Resources, Inc.
Suite 740, 404 – 6th Avenue SW
Calgary, Alberta, Canada T2P 0R9

Subject: PR Spring Tar Sands Project, Uintah and Grand Counties, Utah
Ground Water Discharge Permit-By-Rule

Dear Mr. Cuthbert:

The Division of Water Quality (DWQ) has reviewed the information submitted by JBR Environmental Consultants, Inc. on February 22, 2008 requesting ground water discharge permit-by-rule for the proposed Earth Energy Resources, Inc. PR Spring tar sands project. The proposed operation consists of open-pit mining of tar sands, extraction of bitumen, and disposal of tailings and waste rock.

Below are several relevant factors for determining whether the proposed operation will have a *de minimis* effect on ground water quality or beneficial uses of ground water resources.

1. Based on Material Safety Data Sheets and other information that you sent to DWQ in January 2007, the reagent to be used for bitumen extraction is generally non-toxic and volatile, and most of it will be recovered and recycled in the extraction process. (Because the extraction process is proprietary at this time, this reagent will not be identified in public documents.)

2. Bitumen extraction will be done using tanks and equipment at the processing facility located at the mine site, and no impoundments or process water ponds are planned. Most of the water used in the process will be recovered and recycled.

3. Processed tailings will not be free-draining and will have moisture content in the 10 to 20 percent range. The tailings will not contain any added constituents that are not present naturally in the rock, other than trace amounts of the reagent used for bitumen extraction. Analysis of processed tailings using the Synthetic Precipitation Leachate Procedure indicates that leachate derived from the tailings by natural precipitation would have non-detectable levels of volatile and semi-volatile organic compounds. Unprocessed tar sands and processed tailings were analyzed using the Toxicity Characteristic Leaching Procedure (TCLP) with an extraction process that uses a much lower pH than is likely to occur at the mine site. Analytical results indicate that TCLP metals would not be leached from the tailings at detectable levels except for barium, which was detected at levels below the Utah ground water quality standard of 2.0 milligrams per liter (Table 1 of UAC 317-6). Based on these data, the tailings will be disposed by backfilling into the mine pit.

288 North 1460 West • PO Box 144870 • Salt Lake City, UT 84114-4870 • phone (801) 538-6146 • fax (801) 538-6016
T.D.D. (801) 536-4414 • *www.deq.utah.gov*

4. The uppermost geologic formations at the site are the Parachute Creek and Douglas Creek Members of the Green River Formation, which consist of fluvial-deltaic and lacustrine-deltaic deposits of claystone, siltstone, fine-grained sandstone, and limestone. The Parachute Creek Member outcrops over most of the Earth Energy lease and is the 0 to 50-foot thick overburden above the tar sand deposits of the Douglas Creek Member. Shallow ground water at the site is not part of a regional aquifer but occurs in localized laterally discontinuous perched sandstone lenses of the Douglas Creek Member. Exploration drilling did not encounter ground water within 150 feet of the land surface. Based on records from the Division of Oil, Gas, and Mining, the closest major aquifer is the Mesa Verde Formation, which occurs approximately 2000 feet below ground surface in the area of the proposed mine. The topography of the project area is characterized by mesas incised by deep, narrow canyons, and limited shallow ground water discharges as springs in the canyon bottoms. There are no springs in the Earth Energy leased area and the nearest spring is PR Spring located slightly less than a mile east of the project site.

Considering the factors described above, the proposed mining and bitumen extraction operation should have a *de minimis* potential effect on ground water quality and qualifies for permit-by-rule status under UAC R317-6-6.2.A(25). If any of these factors change because of changes in your operation or from additional knowledge of site conditions, this permit-by-rule determination may not apply and you should inform the DWQ of the changes. If future project knowledge or experience indicates that ground water quality is threatened by this operation, the Executive Secretary may require that you apply for a ground water discharge permit in accordance with UAC R317-6-6.2.C.

This operation may require a storm water permit under the Utah Pollutant Discharge Elimination System (UPDES). Please contact Mike George of this office at (801) 538-9325 to determine if a storm water permit is required.

Disposal of domestic wastewater from the operation should be done in a manner approved by the appropriate local health department; Tri-County Health Department for Uintah County or Southeastern Utah Health Department for Grand County.

If you have any questions about this letter, please contact Mark Novak at (801) 538-6518.

Sincerely,

Robert L. Herbert

Rob Herbert, P.G., Manager
Ground Water Protection Section

cc: Robert Bayer, JBR
Paul Baker, DOGM
Carl Adams, DWQ-TMDL
Mike George, DWQ-UPDES Storm Water
Dave Ariotti, Southeastern Utah District Engineer
Scott Hacking, Tri-County District Engineer
Southeastern Utah Health Department
Tri-County Health Department

F:/MNovak/WP/EarthEnResPBR.Ltr

UTAH STATE WATER QUALITY SYSTEM 08 JUN 27 15 32 000 4258
MONITORING RUN PROGRAM

MONITORING RUN:
TRIP ID: SEIW062408 RUN SEQUENCE NUMBER.
STORET: LAB ID: [65] TYPE. [4] PROJECT: 352
DESCRIPTION: PR Spring
COLLECTOR: [Bird] [Shaw] [ ] [ ] [ ] [ ] AGENCY: [0] [1]
DATE: [0] [8] [0] [6] [2] [4] (Y Y M M D D) TIME: [1] [4] [0] [0]

WEATHER CONDITIONS: [ ] [ ] / [ ] [ ] / [ ] [ ]
FIELD CONDITIONS. [ ] [ ] / [ ] [ ] / [ ] [ ]

FIELD TESTS

AIR TEMP. (CELCIUS): [ ] [ ] . [ ] TRANSPARENCY (METERS): [ ] [ ] . [ ]
TEMPERATURE (CELCIUS): [ ] [ ] . [ ] Cl. RESID: [ ] . [ ] [ ]
pH: [ ] [ ] . [ ] TURBIDITY (NTU): [ ] [ ] [ ]
SP COND UMHOS/CM [ ] [ ] [ ] [ ] [ ] FLOW (MGD): [ ] [ ] [ ] [ ]
SALINITY PPM: [ ] [ ] [ ] [ ] . [ ] [ ] FLOW (GPM): [ ] . [ ] [ ]
% D.O. SATURATION: [ ] [ ] [ ] . [ ] FLOW (CFS): [ ] [ ] [ ] [ ] [ ] [ ] [ ] . [ ]
D.O.: [ ] [ ] . [ ] FLOW ESTIMATED: [ ] MEASURED: [ ]
DEPTH: (METERS) [ ] [ ] [ ] . [ ]

~~B.O.D.: ( )~~ TEMP: ___ pH: ___ COMMENTS: ___

~~BACTERIAL: ( )~~ TEMP: ___ pH: ___ COMMENTS: ___

CHEMISTRY: (1) TDS x 1 TEMP: 8.7 pH: ___ COMMENTS: ___

~~CYANIDE: ( )~~ TEMP: ___ pH: ___ COMMENTS: ___

~~FILTERED METALS: ( )~~ TEMP: ___ pH ___ COMMENTS: ___

~~NON-FILTERED NUTRIENT: ( )~~ TEMP: ___ pH: ___ COMMENTS: ___

METHOD: 624: (X) x 4 TEMP: 10.3 pH: ___ COMMENTS: ___

METHOD: 625: (X) x 1 TEMP: 8.5 pH: ___ COMMENTS: ___

~~METHOD: OIL & GREASE: (X)~~ TEMP: ___ pH: ___ COMMENTS: ___

~~METHOD: SULFIDE: ( )~~ TEMP: ___ pH: ___ COMMENTS: ___

TPH (X) x 2 134

rcvd one 624 empty

IR - 000038

Cost Code: 352

METHOD 8015 B TPH
Total Petroleum Hydrocarbon

Lab# 200804258

Send Report To:
UDEQ - DWQ / WATER QUALITY
ARNE HULTQUIST
PO BOX 144870
SALT LAKE CITY UT 84114-4870

Utah Division of Laboratory Services
46 North Medical Drive
Salt Lake City, UT 84113

Date/Time Collected: 06/24/08 14:00
Sample Matrix: Water
Collected By: BIRD SHAW
Sampling Site:
Description of Sampling Point: PR SPRING

Analyst: [signature]
Date Received: 06/27/2008
Date Extracted: 6/30/08
Dilution Factor:
Date Analyzed: 6/30/08

Compound	MRL/Results	water mg/l	~~soil mg/kg~~
GRO (C6-C10)	1.0	U	
DRO (C10-C28)	1.0	U	
Total TPH	1.0	U	

U- Analyzed for but not detected.

Analysis Certified By: [signature]
Date: 7/3/08

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ / WATER QUALITY
ARNE HULTQUIST
PO BOX 144870
SALT LAKE CITY UT 84114-4870 801-538-6146

Lab Number: 200804258 Sample Type: 04 Cost Code: 352
Description: PR SPRING
Collector: BIRD SHAW

Site ID:	Source No: 00	Organic Review: 08/05/2008
Sample Date: 06/24/2008	Time: 14:00	Inorganic Review: 07/07/2008
		Radiochemistry Review:
		Microbiology Review:

TEST RESULTS:

TDS @ 180C 384 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

9, 01214

FAXED

Cost Code: 352

EPA METHOD 524.2/8260B GC/MS
Purgeables

Lab #: 200804258

Send Report To:
UDEQ - DWQ / WATER QUALITY
ARNE HULTQUIST
PO BOX 144870
SALT LAKE CITY UT 84114-4870

APR 29 2009

Utah Division of Laboratory Services
46 North Medical Drive
Salt Lake City, UT 84113

Date/Time Collected: 06/24/200814:00 Sample Matrix: Water
Collected By: BIRD SHAW Sampling Site:
Description of Sampling Point: PR SPRING

Analyst: ______ Date Received: 06/27/2008 Date Analyzed: ______

Regulated	MRL	Results ug/L	List 1	MRL	Results ug/L
Benzene	1.0	U	Chloroform	1.0	U
Carbon Tetrachloride	1.0	U	Bromodichloromethane	1.0	U
1,2-Dichloroethane	1.0	U	Chlorodibromomethane	1.0	U
1,1-Dichloroethylene	1.0	U	Bromoform	1.0	U
Para-Dichlorobenzene	1.0	U	m-Dichlorobenzene	1.0	U
1,1,1-Trichloroethane	1.0	U	1,1-Dichloropropene	1.0	U
Trichloroethylene	1.0	U	1,1-Dichloroethane	1.0	U
Vinyl Chloride	1.0	U	1,1,2,2-Tetrachloroethane	1.0	U
o-Dichlorobenzene	1.0	U	1,3-Dichloropropane	1.0	U
cis 1,2-Dichloroethylene	1.0	U	Chloromethane	1.0	U
trans 1,2-Dichloroethylene	1.0	U	Bromomethane	1.0	B1.4
1,2-Dichloropropane	1.0	U	1,2,3-Trichloropropane	1.0	U
Ethylbenzene	1.0	U	1,1,1,2-Tetrachloroethane	1.0	U
Monochlorobenzene	1.0	U	Chloroethane	1.0	U
Styrene	1.0	U	2,2-Dichloropropane	1.0	U
Tetrachloroethylene	1.0	U	o-Chlorotoluene	1.0	U
Toluene	1.0	U	p-Chlorotoluene	1.0	U
Xylenes (total)	1.0	U	Bromobenzene	1.0	U
Dichloromethane	1.0	U	cis-1,3-Dichloropropene	1.0	U
1,2,4-Trichlorobenzene	1.0	U	trans-1,3-Dichloropropene	1.0	U
1,1,2-Trichloroethane	1.0	U	Dibromomethane	1.0	U
Ethylene Dibromide	1.0	U			
1,2-dibromo-3-chloropropane	1.0	U			

List 3	MRL	Results ug/L		MRL	Results ug/L
1,2,4-Trimethylbenzene	1.0	U	p-Isopropyltoluene	1.0	U
1,2,3-Trichlorobenzene	1.0	U	Isopropylbenzene	1.0	U
n-Propylbenzene	1.0	U	Tert-butylbenzene	1.0	U
n-Butylbenzene	1.0	U	Sec-bytylbenzene	1.0	U
Napthalene	1.0	U	Fluorotrichloromethane	1.0	U
Hexachlorobutadiene	1.0	U	Dichlorodifluoromethane	1.0	U
1,3,5-Trimethylbenzene	1.0	U	Bromochloromethane	1.0	U
Methyl T-Butyl Ether	1.0	U			

U- Analyzed for but not detected

Analysis Certified By: ______ Date: ______

Cost Code: 352

EPA METHOD 625/8270A (GC/MS)
Base Neutral/Acid Extractables

Lab # 200804258

Send Report To:
UDEQ - DWQ / WATER QUALITY
ARNE HULTQUIST
PO BOX 144870
SALT LAKE CITY UT 84114-4870

Utah Division of Laboratory Services
46 North Medical Drive
Salt Lake City, UT 84113

Date/Time Collected: 06/24/200814:00 Sample Matrix: Water
Collected By: BIRD SHAW Sampling Site:
Description of Sampling Point: PR SPRING

Analyst: ______ Date Received: 06/27/2008 Date Analyzed: ______
Aliquot Sample Extracted: ______ Final Extract Volume: ______
(MDL based on 1 L. extracted, 1 ml final volume)

Name	MRL/Results	ug/l		MRL/Results	ug/l
Acenaphthene	2.0	U	Hexachlorobenzene	6.0	U
Acenaphthylene	2.0	U	Hexachlorobutadiene	4.0	U
Anthracene	2.0	U	Hexachloroethane	2.0	U
Aniline	8.0	U	Hexachlorocyclopentadiene	20.0	U
Benzidine	40.0	U	Ideno(1,2,3-c,d)pyrene	2.0	U
Benzo(a)anthracene	2.0	U	Isophorone	2.0	U
Benzo(b)fluoranthene	2.0	U	2-Methyl-4,6-dinitrophenol	10.0	U
Benzo(k)fluoranthene	2.0	U	2-Methyl naphthalene	2.0	U
Benzo(a)pyrene	2.0	U	2-Methyl phenol (o-cresol)	2.0	U
Benzo(ghi)perylene	2.0	U	3-Methyl phenol (m-cresol)	2.0	U
Benzylbutylphthalate	2.0	U	4-Methyl phenol (p-cresol)	4.0	U
Benzyl alcohol	10.0	U	Naphthalene	2.0	U
Benzoic acid	60.0	U	2-Nitroaniline	2.0	U
Bis(2-chloroethyl)ether	2.0	U	3-Nitroaniline	4.0	U
Bis(2-chloroethoxy)methane	2.0	U	4-Nitroaniline	4.0	U
Bis(2-chloroisopropyl)ether	2.0	U	Nitrobenzene	4.0	U
Bis(2-ethylhexyl)phthalate	2.0	U	2-Nitrophenol	10.0	U
4-Bromophenyl phenyl ether	2.0	U	4-Nitrophenol	20.0	U
4-Chloraniline	2.0	U	n-Nitrosodimethylamine	8.0	U
2-Chloronaphthalene	2.0	U	n-Nitrosodiphenylamine	4.0	U
4-Chloro-3-methyl phenol	2.0	U	n-Nitrosodinpropylamine	6.0	U
2-Chlorophenol	2.0	U	Pentachlorophenol	20.0	U
4-Chlorophenyl phenyl ether	4.0	U	Phenanthrene	2.0	U
Chyrsene	2.0	U	Phenol	4.0	U
Dibenzo(a,h)anthracene	2.0	U	Pyrene	2.0	U
Dibenzofuran	4.0	U	1,2,4-Trichlorobenzene	2.0	U
Di-n-butyl phthalate	2.0	U	2,4,6-Trichlorophenol	4.0	U
1,3-Dichlorobenzene (meta)	2.0	U			
1,2-Dichlorobenzene (ortho)	2.0	U			
1,4-Dichlorobenzene (para)	2.0	U			
3,3-Dichlorobenzidine	4.0	U			
2,4-Dichlorophenol	4.0	U			
2,4-Dimethylphenol	2.0	U			
Diethyl phthalate	2.0	B2.5			
2,4-Dinitrophenol	20.0	U			
Dimethyl phthalate	2.0	U			
2,4-Dinitrotoluene	2.0	U			
2,6-Dinitrotoluene	2.0	U			
Di-n-octyl phthalate	2.0	U			
Fluoranthene	2.0	U			
Fluorene	2.0	U			

Tentatively Identified Compounds

Name	Scan #	Results

U - Analyzed for but not detected.
J - An estimated value for a tentatively identified compound OR a value less than the detection limit but greater than zero.
B - Found in the blank.

Analysis Certified By: ______ Date: ______

Task: 4278

Notice of Intention
To Commence Large Mining Operations

US Oil Sands (Utah) Inc.
PR Spring Mine
M0470090

U.S. OIL SANDS

May 2009

Submitted by:

US Oil Sands (Utah) Inc.
Suite #950 633 – 6th Avenue SW
Calgary, Alberta T2P 2Y5

to:

Utah Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
Salt Lake City, Utah 84114-5801

Prepared in part by:

JBR Environmental Consultants, Inc.
8160 S. Highland Drive
Sandy, Utah 84093
(801) 943-4144

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Introduction

US Oil Sands (Utah) Inc. (Earth Energy) is a publicly held Canadian firm engaged in the development of process technology for extraction of bitumen from naturally occurring tar sand deposits in the United States and Canada. Earth Energy holds State Institutional Trust Lands Administration (SITLA) oil sands leases on 5,930 acres in Utah's Uinta Basin, near PR Spring. The PR Spring deposits are the largest of the Uinta Basin special Tar Sand Areas defined by the U.S. Geological Survey. Within the SITLA lease areas, Earth Energy has defined a 2,255-acre Study Area for the PR Spring Mine. The initial mine development under this NOI will take place in the southeastern part of this Study Area on approximately 213 acres (referred to throughout this NOI as the Affected Area) (See **Figures 1** and **2**). The Affected Area is equivalent to the area that will be disturbed and the area that will be bonded for and reclaimed. The remaining 2,042 acres within the Study Area were the subject of environmental data collection efforts, but will not be subject to disturbance under this NOI. Should additional mine development be planned in the future, beyond that described herein as occurring on the 213-acre Affected Area, permit amendments or revisions would be required. These amendments or revisions would address any expansion that would occur, including details on any needed re-handling of materials, alterations to the processing plant, etc. Conditional Use Permits (CUP) for the mine from Uintah and Grand Counties are included in Appendix B.

Earth Energy has patented a chemical method for extraction of hydrocarbons from oil sands. Known as the Ophus Process, this production method produces clean (inert), "damp-dry" sand tailings that can be backfilled into the quarry. The planned sequence of exploration and pilot processing and production tests underway are intended to refine and adapt the process to fit the unique characteristics of the Utah PR Spring deposits. Oil (tar) sands in Utah vary significantly from the oil sand deposits and extraction methods commonly used in the Athabasca oil sands of Alberta.

Earth Energy conducted exploration drilling in spring of 2005 under Exploration Permit (E/019/052), Earth Energy PR Spring 1 Project (less than ½-acre disturbance). Additional drilling was conducted under Exploration Permit (E/019/053) within a 100-acre area along Seep Ridge Road. These programs included twenty-five 4-inch diameter holes drilled to depth of 50 to150 feet on 30-foot by 30-foot drill pads located on drill roads or adjacent to the main Seep Ridge Road. The drilling programs were used to select the 5-acre mine site for the fall 2005 production test conducted under a Small Mine Permit, Leonard Murphy #1 (S/019/059).

Other geophysical activities have been ongoing in a small portion of Earth Energy's lease area. These existing rights and activities ongoing in the area are described below in Section 104.2.

Drilling and geophysical work planned for 2009 will provide grade-thickness data of the tar sand beds necessary for detailed planning, permitting, site development and mining to go forward.

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R647-4. Large Mining Operations

R647-4-101. Filing Requirements and Review Procedures

101. As is required of the party that is planning to conduct large mining operations, this NOI is submitted by Earth Energy Resources, Inc. for review and Division approval.

2. The Division has 30 days from the last action on the NOI to approve/deny the NOI, and then to publish a Notice of tentative decision in accordance with R647-4-16.

3. As stated at R647-4-101.3, upon Division approval of the NOI and execution of the Reclamation Contract by Earth Energy, both the Division and Earth Energy will be bound by the NOI and implementing regulations, and Earth Energy will be able to begin mining. Earth Energy understands that execution of the Reclamation Contract is not complete until the contract and the surety receives Division approval; only then can mining commence. Further, Earth Energy explicitly commits to conform to all of the operation and reclamation practices that are described in this NOI and that are required by all applicable regulations at R647-4.

4. Earth Energy will provide notification to the Division within 30 days of starting mining operations.

5. Earth Energy's LMO is greater than 50 acres, for purposes of calculating permit fees. Fees are due annually by the last Friday in July unless the NOI is closed out under R647-4-101.5.13.

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R647-4-102. Duration of the Notice of Intention

It is understood that, when approved, Earth Energy's NOI, including any subsequently approved amendments or revisions, remains in effect for the life of the mine.

R647-4-103. Notice of Intention to Commence Large Mining Operations

Earth Energy's NOI addresses the requirements of the rules listed in this section as follows:

104. Operator(s), Surface and Mineral Owner(s)
105. Maps, Drawing, and Photographs
106. Operation Plan
108. Hole Plugging Requirements
109. Impact Assessment
110. Reclamation Plan
112. Variance

Under this section, rules at 107 and 111 are not required to be addressed; however those subjects are covered within the NOI in other sections.

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R647-4-104. Operator(s), Surface and Mineral Owner(s)

104.1. Operator Responsible for Mining Operations/Reclamation of the Site

MINE NAME: PR Spring

NAME OF PERMITTEE/ OPERATOR/ APPLICANT: US Oil Sands (Utah) Inc., a Corporation registered to do business in the State of Utah.

Business License #:	5834125-0142	
Registered Agent:	Daniel A. Jensen	
Address:	185 South State Street, Suite 800 Salt Lake City, UT 84111	
Phone:	801-532-7840	Fax: 801-532-7750
E-mail address:	djensen@parrbrown.com	

PERMANENT ADDRESS: US Oil Sands (Utah) Inc.
Suite #950, 633 – 6 Avenue SW
Calgary, Alberta T2P 2Y5
Phone: 403-233-9366 Fax: 403-290-0045

COMPANY REPRESENTATIVE: Barclay Cuthbert, Vice President, Operations

Address:	Suite #950, 633 – 6 Avenue SW Calgary, Alberta T2P 2Y5	
Phone:	403-233-9366	Fax: 403-290-0045
E-mail address:	barclay.cuthbert@usoilsandsinc.com	

LOCATION OF OPERATION: Uintah and Grand Counties, Utah (the CUP's are attached in Appendix B)

Universal Transverse Mercator (UTM) Coordinate System: UTM Datum NAD27 4369592 km Northing, 645187 km Easting, Zone 12

Sections: T. 15 S., R. 23 E., SLB&M, Uintah County, Sections 35 & 36.
T. 15.5 S., R. 24 E., SLB&M, Grand County, Sections 31& 32.

The Uintah County portion of the operations will be on lands under Indian Jurisdiction (tribal land but not part of an Indian Reservation). As such, certain aspects of environmental permitting for the PR Spring Operation will be handled by the Environmental Protection Agency (EPA) rather than Utah's Department of Environmental Quality.

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104.2. Surface and Mineral Owners of All Lands to be Affected

OWNERSHIP OF THE LAND SURFACE: Utah State Institutional Trust Lands Administration.

OWNERS OF RECORD OF THE MINERALS TO BE MINED: SITLA (Earth Energy has lease rights to mine up to a 500-foot depth below ground surface)

BLM LEASE OR PROJECT FILE NUMBER(S): None for the mine operation. A BLM right-of-way (No. UTU-86004) has been approved and offered to allow construction of the appurtenant water well and pipeline. Correspondence with the BLM on this issue is included in Appendix B. (This pipeline also crosses SITLA land and the well/pipeline process is permitted by DOGM under Exploration Notice #E0190053)

ADJACENT LAND OWNERS:

Canyon Gas Resources, LLC – Natural Gas Pipeline Right of Way
7400 East Orchard Rd., Suite 30025, Englewood, CO 80111

Uintah County - Road 2810 Right of Way
147 East Main St.
Vernal, UT 84078

Bureau of Land Management, Vernal Field Office
170 South 500 East
Vernal, UT 84078

<u>Township 15 South, Range 23 East, SLB&M</u>

Section 26:	
Grazing Permit 20905:	Alameda Corporation PO Box 22608 Houston, TX 77227-2608
Mineral Lease 49944:	EOG Resources, Inc. PO Box 4362 Houston, TX 77210-4362
Section 27:	
Grazing Permit 20905:	Alameda Corporation PO Box 22608 Houston, TX 77227-2608
Mineral Lease 49280:	Robert L. Bayless Producer LLC 621 17th Street Ste. 1640 Denver, CO 80293

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Section 28:	
Grazing Permit 20905:	Alameda Corporation PO Box 22608 Houston, TX 77227-2608
Mineral Lease 49280:	Robert L. Bayless Producer LLC 621 17th Street Ste. 1640 Denver, CO 80293
Section 33:	
Grazing Permit 20905:	Alameda Corporation PO Box 22608 Houston, TX 77227-2608
Grazing Permit 21202:	Burt De Lambert PO Box 607 Vernal, UT 84078-0607
Mineral Lease 49281:	Robert L. Bayless Producer LLC 621 17th Street Ste. 1640 Denver, CO 80293
Section 34:	
Grazing Permit 20905:	Alameda Corporation PO Box 22608 Houston, TX 77227-2608
Grazing Permit 21202:	Burt De Lambert PO Box 607 Vernal, UT 84078-0607
Mineral Lease 49281:	Robert L. Bayless Producer LLC 621 17th Street Ste. 1640 Denver, CO 80293
Section 35:	
Grazing Permit 20905:	Alameda Corporation PO Box 22608 Houston, TX 77227-2608
Mineral Lease 49944:	EOG Resources, Inc. PO Box 4362 Houston, TX 77210-4362
Section 36:	
Grazing Permit 20995:	Alameda Corporation PO Box 22608 Houston, TX 77227-2608
Mineral Lease 49944:	EOG Resources, Inc. PO Box 4362 Houston, TX 77210-4362

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Township 15.5 South, Range 24 East, SLB&M

Section 31:	
Grazing Permit 20905:	Alameda Corporation PO Box 22608 Houston, TX 77227-2608
Grazing Permit 21202:	Burt De Lambert PO Box 607 Vernal, UT 84078-0607
Mineral Lease 49572:	Moose Mountain Land Company 935 E South Union Avenue Suite D-202 Midvale, UT 84047
Section 32:	
Grazing Permit 20905:	Alameda Corporation PO Box 22608 Houston, TX 77227-2608
Mineral Lease 49572:	Moose Mountain Land Company 935 E South Union Avenue Suite D-202 Midvale, UT 84047

HAVE THE LAND, MINERAL, AND ADJACENT LANDOWNERS BEEN NOTIFIED IN WRITING? The adjacent owners (BLM and SITLA) will be notified in writing once this NOI is tentatively approved (those agencies are both currently aware that the project is pending), and those agencies will notify other land users or right-of-way holders as they deem appropriate.

DOES THE PERMITTEE/ OPERATOR HAVE LEGAL RIGHT TO ENTER AND CONDUCT MINING OPERATIONS ON THE LAND COVERED BY THIS NOTICE? Yes.

104.3. Federal Mining Claims or Lease Numbers

There are no Federal mining claims or permits.

A summary of lands under lease to Earth Energy is provided in Appendix A.

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R647-4-105. Maps, Drawings and Photographs

105.1. USGS topographic base maps, as well as other select figures in the NOI) provide the following information:

1.11 Property boundaries of surface ownership.
1.12 Water features (including streams and springs), infrastructure, and surface/subsurface facilities within 500 feet of mining operations.
1.13 Access routes.
1.14 Previous mining/exploration impact in the disturbance area is shown on Figure 2.

105.2. Surface facilities maps (Figures 2 and **3) include the following information:**

2.11 Surface facilities
2.12 Disturbance boundary

105.3. Other maps that may be required:

3.11 There would be no re-graded slopes to be left steeper than 2H:1V
3.12 Plan, profile, X-section of any earthen structures to be left as part of post-mining land use.
3.13 There would be no water impounding structures >20 feet high.
3.14 There are no areas that will be left un-reclaimed as part of the post-mining land use.
3.15 There will be no diversion channels constructed.
3.16 Geology, tar sands cross sections, water features and vegetation communities are shown on Figures 5, 6, 7, and 8, respectively.
3.17 Reclamation treatments are shown on Figure 9.
3.18 Mine plan cross sections are provided as Figures 4a, 4b, and 4c.

105.4. Site photographs are included in Appendix F.

105.5. No underground development will occur: Surface mine development is shown on Figure 2.

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R647-4-106. Operation Plan

106.1. Mineral to be Mined

The type of mineral to be mined is tar sand. The tar sands occur generally in lenticular beds, with interbedded sandstone, siltstone, shale, mudstone and calcareous marl. The tar sand beds have been defined as the 'D' or upper bed, and the 'C' or secondary bed. Tar sand beds below the C bed are not as well defined based upon drill logs, resistivity testing and modeling. Although current mine plans under this NOI are to a depth of approximately 145 feet, the maximum lease depth is 500 feet.

106.2. Operations to be Conducted

Throughout operations at the PR Spring location, Mine Safety and Health Administration (MSHA) safety requirements and guidelines will be followed, and the operating plan as described in this document will be followed. While operations include both pit backfilling and the use of external overburden/interburden storage areas, where conducive to properly sequenced ore bed depletion and efficient material handling (after threshold opening pit size is established), clean produced sand/clay fine tailings will be preferentially replaced in the depleted mine areas versus discharged in overburden dumps. Further, operations covered in this NOI will minimize any re-handling of material as operations expand. The overburden/interburden storage piles are located in areas devoid of oil sand, and pits will be depleted before refilling and reclamation commence. Surface facilities are constructed on oil sand bearing areas, but these areas are limited; and relocation of the plant facility and ultimate development of the underlying bitumen resource is incorporated within future expansion plans, for which additional permitting would be needed.

The acreages associated with the individual components of these operations are described in Section 106.3. The types of operations to be conducted include the following:

SURFACE PREPARATION/ STORAGE OF OVERBURDEN AND TOPSOIL

Surface preparation will include the clearing of vegetation and removal of topsoil for storage in designated topsoil storage areas, as described further in Section 106.5. Larger vegetation would be cleared by crushing, then pushing into slash piles. This material will be stockpiled within or on top of the salvaged topsoil, or used to form berms surrounding the topsoil piles (see Section 106.6); the estimated volumes of both topsoil and vegetative matter are also provided in Section 106.6. All of this vegetative matter will be redistributed along with the topsoil during reclamation in order to provide organic matter and help with surface roughness and soil moisture retention.

Where overburden must be removed, it will be scraped and deposited in the overburden/interburden storage areas shown on Figure 2. As mining proceeds, overburden and interburden, along with produced sand from extraction operations, will be back-hauled and re-contoured in the mined pit. These operations are discussed in more detail under the overburden/interburden storage areas and pit backfill subheadings below.

Access Roads

The main access to the PR Spring Mine site is via Uintah County Road 2810 (Figures 1 and 2). Onsite access roads to the mine pit and facilities area (Figure 2) have been designed to minimize grade. In general, they are located around the perimeter of the Affected Area, serving to confine disturbance and manage runoff. In part, these roads cross -- and are integral to -- the overburden/interburden storage areas. In those cases, those road segments will not be constructed until they are needed to access those features. Access roads will be surfaced with crushed overburden (rock) material and maintained with a grader and water truck. In total these roads will be approximately 13,050 feet in length by 80 feet wide.

Mining

Mining will be conducted using a self-contained mobile surface mining machine (e.g. Wirtgen 2200SM Surface Miner). Overburden and interburden will be removed by conventional drill/blast/muck or rip/muck methods. Initially, overburden will be removed on five acres of the initial mine site to expose the uppermost layer of oil sand. The surface miner will then mine through the first layer of oil sand by successively planing 8 to 10 inches of oil sand per pass. When the initial layer of oil sand has been mined, the interburden layer will be exposed and this will be removed to expose the next layer of oil sand.

As oil sand mining is taking place with the surface miner, the conventional mining equipment will be employed for concurrent overburden removal to expose new areas of the oil sand bed and allow oil sand mining to progress. As sufficient area comes available, the mining operation will transition to multiple benches of mining, where oil sand mining occurs on the top layer of newly exposed areas and previously mined areas are excavated to expose the next bed of oil sands. When all target oil sands beds have been mined and access to newly opened areas is established, backfilling of the depleted areas will commence.

Overburden and or interburden may be sufficiently friable to allow removal by ripping with dozers, rather than require blasting. However, where blasting is required to facilitate material removal, each program will be designed as a controlled blast, with adequate stemming to eliminate fly-rock, and minimize

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vibration and dust, while generating aggregate size conducive for removal from the mine area. The drill size, spacing and depth of blast holes, and the frequency of blasting, will vary depending upon the situation, but in all cases will be in accordance with local, state and federal rules. Peak particle velocities of any initial blasting operations will be monitored and appropriate blasting protocols refined at the time blasting commences. As typical for these types of operations, a series of test blasts will be monitored to determine the resultant peak particle velocities at specified distances from the blasting area. Blasting will not result in fly rock landing on the adjacent county road. However, warning signs advising the public of blasting protocols will be posted at 150-foot intervals along the fence line, placed at all ready access points, and in any other locations required by MSHA. These signs will include blasting schedules.

Regular and routine inspections will occur throughout the mine area to ensure that operating conditions remain safe, that MSHA safety guidelines are being followed, and that the mining plan stated herein is being followed. This will include inspections to verify that the pit wall slopes are at the correct angles and that they remain stable.

<u>Equipment</u>

Mining equipment will consist of the Wirtgen Surface Miner noted above, trackhoes, dozers, graders, rock drill, loader, water truck, and service trucks. Mining is anticipated to be conducted during the day shift only. A complete list of mining equipment is included in Appendix D.

Mined tar sands will be hauled to the process plant (Figure 3) and either discharged directly to the inlet hopper of the crusher (which is integral to the process train structure) or alternately placed in a storage pile adjacent to the processing facility for feed to the inlet hopper during the night shift. Generally, a two-week reserve supply of ore will be maintained in stockpiles at the processing facility. The mined tar sands storage pile or piles (also known as the reserve ore pile) is not expected to exceed 40,000 yd cubic yards at any time and is typically expected to amount to 30,000 cubic yards of ore. The dimensions of this pile (or combined smaller piles) will not exceed 100 yards by 100 yards by 4 yards in height

It is expected that the mining process will intercept shales and sandstone in addition to the tar sand beds. Interburden material will be placed in the overburden/interburden storage areas defined on Figure 2 and used as pit backfill. These operations are described below.

<u>Pit Design</u>

The 62-acre initial mine pit is delineated on Figure 2, and is designated as the North (Opening) Pit. It is designed with a perimeter highwall, which in all locations (during operations) will be higher than the highest elevation of the pit floor. In this manner, all precipitation falling within the mine pit boundaries will collect within precipitation collection sumps located in the bottom of the pit and thereby prevent runoff from leaving the mine site. These collection sumps are simply low areas within the working mine pit where precipitation falling directly within the pit perimeter will drain and collect. The accumulated precipitation will be removed from the pit along with the solid materials and processed along with the bitumen bearing sands. As needed, it will also be pumped from the mine and used for dust suppression on mine and plant roads. The active mining area will be a pit at all times (concave to incident precipitation). No pit configurations are planned where storm water will be allowed to egress the active mine workings. Further, the highwall safety berms will prevent runoff from outside the pit perimeter from entering the pit (the pit's location atop the slope minimizes this potential even without the presence of the safety berms).

The pit will be mined at an operating pit slope of 2H:1V. The planned pit design configuration can be achieved using the above-noted mining methods. In addition, the planned pit design will be geotechnically stable and will not create any safety or environmental concerns. Use of 2H:1V pit slopes represents Earth Energy's desire to facilitate pit reclamation, and to provide conservatively designed slopes to compensate for the lack of detailed knowledge regarding the extent of localized faulting or fracture planes that could cause instabilities at steeper slopes than will be used. Site-specific information indicates that much steeper slopes could be justified: numerous existing road cuts and excavations in the area (including Earth Energy's 2005 production test pit) are stable with slopes steeper than 1H:1V. The use of 2H:1V pit wall slopes will also prevent rock falls. Back-break near the highwall will be controlled or eliminated by smooth transition grading. Any required blasting along the highwalls of the pit will be accomplished with small controlled blasts to eliminate over-break and weakening of the remaining material on the face of the slope.

The North (Opening) Pit has approximately 7.9 million cubic yards of material to be mined. Of this, approximately 10-12 percent (by weight of ore) is processed out as bitumen product, which leaves 3,944,228 cubic yards of processed sand that will be disposed of (along with 3,506,465 cubic yards of overburden and interburden as described below). Applying a bulkage factor of 1.3 to the over/interburden and processed sand, this will result in 9.7 million cubic yards of waste material to be disposed of. Filling overburden/interburden storage areas 1 and 2 to their maximum capacity of 4.9 million cubic yards will result in approximately 4.8 million cubic yards to be back-filled in the mine pit.

After the North (Opening) Pit is mined, and assuming that conditions are favorable, Earth Energy would extend mining to the southwest, to a contiguous area designated at the West Pit. Details on the West Pit design are conceptual at this stage; once coring has been accomplished and analyzed, this pit design will be developed more fully. These details will be submitted to DOGM as a Plan Amendment prior to the initiation of mining. At this time, general estimates as needed to provide bonding calculations have been made; these will also be revised as needed and provided in a subsequent amendment.

Anticipated yearly mined tonnages include: 920,000–1,200,000 tons of oil sand ore mined per year and 1,000,000–1,400,000 tons of overburden/interburden mined per year. The life of the mine is expected to be between 6 and 13 years for both the North (Opening Pit) and the West Pit, depending on the amount of time the processing equipment is on-stream and the number of process trains employed. (Only one process train is covered under this NOI; should additional trains be needed, they would be covered in a permit amendment.) Expansion into the West Pit may occur in the future depending upon numerous factors; at this time, the best estimate of when that might realistically occur is approximately 5 years after the North (Opening) Pit mining has begun.

<u>Hauling</u>
Mined ore will be hauled via the main haul road to the process area and either discharged directly to the inlet hopper of the process unit or placed in a temporary storage pile (see above for pile size information) for off-shift processing. The distance from the approximate center of the North (Opening) Pit to the plant is approximately 2,000 feet. Figure 3 shows the location of the temporary storage pile; the inlet hopper feeds to the east end of the process train, which is also shown on Figure 3.

PROCESSING

<u>General Facility Description</u>
The processing facility will be located adjacent to Uintah County Road 2810 in the area shown on Figure 3. As shown on this plant site diagram, this would be an area of approximately 15 acres including a mine office and associated parking area; a maintenance shop, warehouse, power plant, equipment parking and service area; process equipment, sand de-watering equipment, a tank farm, tank truck loading area, and water retention/storage pond; and stockpiles for processed sand, reject materials (ore loads that contain too much interburden or overburden to be viable for processing), and ore.

The tank farm will be constructed with secondary containment sufficient to meet applicable Spill Prevention Control and Countermeasure Plan (SPCC) regulations for tank farm construction (total volume of the bermed area greater than 110% volume of the largest tank contained in the farm, for example). Tanks will be erected on compacted gravel bases underlain by impermeable (HDPE) liners to prevent migration of spilled or leaked hydrocarbons off of the plant site. HDPE liners will be integrated with secondary containment berms.. The SPCC Plan will cover new and spent fuel, oil, and lubricants, as well as any other hydrocarbons including the processed bitumen. If any hydrocarbon spills occur during mining these will be dealt with as outlined in the SPCC Plan. Other non-hydrocarbon liquids will be similarly managed.

The remainder of the plant site will be constructed to be a self-contained area, through the use of perimeter berms or ditches where needed. The specific locations where berms will be used, as opposed to where ditches will be used, will be determined during final site design and will be based upon best engineering practices. These locations will be indicated on the final site design drawings, which will be submitted to DOGM once they are available as replacement drawings to take the place of the conceptual drawings currently herein. All ditches will be designed to pass the 10-year, 6-hour precipitation event. They will be triangular in cross section with side slopes approximately 2H:1V; depth including freeboard will be less than 2 feet or equivalent in cross section. Berms will generally be 2 feet high, with a two-foot top width and 2H:1V side slopes. Final designs for these structures will be produced concurrent with final engineering designs, and will be submitted to DOGM. However, standard engineering practices will be used to determine these final designs: for example, riprap will be used when or if modeled design runoff velocities indicate that riprap is needed to maintain the structure integrity. All precipitation incident on the site will be collected in the water retention/storage pond located at the low point of the plant site (See Figure 3 for pond location). As the PR Spring operation is located primarily along a fairly flat interfluve with little or no up-gradient, off-site runoff flowing onto the site, the pond will collect only runoff generated from precipitation falling upon the plant site itself. It will also be used to store fresh make-up water, however no process water will be routed to this pond. Any sediments collected in the pond will be removed as needed in order to maintain its design capacity. It will be designed to contain the runoff from the 10-year, 24-hour precipitation event as well as sediment storage and make-up water. The pond would also be HDPE-lined to prevent loss to infiltration (it is not needed as a water quality protection measure). Once final designs are completed, this information will be submitted to DOGM.

The mine office will be a modular building placed on a gravel pad. The process equipment will be skid-mounted and also located on gravel pad, as would the parking areas. The warehouse and maintenance shop will be 'Sprung-type" semi-permanent structures on concrete pads. A list of equipment, buildings, and tanks planned for use in the facilities area is included in Appendix D.

The facility would operate 24 hours per day, approximately 350 days per year, not including unscheduled shutdowns/outages.

<u>Process Flow Details</u>
The process train is designed to accommodate 3,000-3,500 tons of ore per day, producing approximately 2,000 bbl/day of bitumen. The extraction process begins when the mined and conditioned tar sand ore is sent through a crusher/ delumper and reduced to a 2 inch-minus aggregate size. From there, the crushed ore is augered or conveyed to a heated slurry mixer where the cleaning emulsion is introduced and the ore slurried to the consistency of a thick gritty

milkshake. The oil sand slurry is then moved by screw conveyor to the slurry tank where primary separation of the bitumen from the sand occurs. The produced sand with residual bitumen is then pumped through a series of separation towers where the last traces of bitumen are removed. All of the liberated bitumen is captured, polished with cyclones and/or centrifuges and then pumped to a storage tank. The cleaning chemical is then removed from the bitumen by distillation and recycled to the front of the process. Produced bitumen is pumped to a product (sales) tank for heated storage prior to transport.

The clean produced sand is de-watered on a shale shaker (or similar device) and the recovered water is pumped to a holding tank for recycling to the front of the process. Additional cleaning agent is added to the recycled water to bring it back to full strength. De-watered sand and clay fines are then conveyed to a stockpile for loading and backhaul to the mine pit. At this point, the discharged sand and clay fines contain between 10 and 20 percent water.

Water is expected to be consumed at a rate of approximately 1.5-2 barrels for each barrel of produced bitumen. The 2,000 bbl/day operation would use approximately 4,000 barrels of water, or 116 gallons per minute (gpm) based upon 24-hour processing. The majority of the water "consumed" in the process is simply returned to the environment as un-recoverable entrained moisture in the pore spaces of the produced sand and clay fines. All of this residual water is anticipated to evaporate from the loosely consolidated produced sand/fines mix with no free-water run-off. (This subject is described in greater detail in Appendix B, within correspondence requesting Permit-by-Rule coverage under the Utah Division of Water Quality's (DWQ) groundwater protection program.) The process flow diagram is included in Appendix D.

Process Chemical Storage & Handling

The process chemical, in its neat form (without additives), will be transferred from the distillation unit into storage tanks noted on Figure 3, and from the storagé tanks to the blending area using appropriate pumps to mitigate the risk of fire or explosion. These factors will be considered fully during engineering of the commercial production unit. There are no other waste streams that might get into the solids or tailings and the chemical is not changed as a result of processing – it acts as a diluent and a cleaning agent, but is not itself altered by bitumen extraction operations.

The process chemical is stable, colorless, evaporates rapidly when exposed to air, and has negligible solubility in water. (This subject is described in greater detail in Appendix B, within correspondence requesting Permit-by-Rule coverage under the Utah Division of Water Quality's (DWQ) groundwater protection program.) When blended into the cleaning emulsion form required for use in the process stream, it has low flammability and presents low risk. The cleaning emulsion's biodegradability has not been determined, but related chemicals are known to be biodegradable. It will be stored and handled according to regulation.

Power Source
Generators located at the plant site (one natural gas, one diesel) will be used to supply all the electrical requirements for the process train. Under Exploration Notice #E0190053, a three conductor, heavy gauge, armored power supply cable will be buried in the water line trench (described below) to convey power to the nearby water well.

Water Source
Water for processing would be obtained from a well drilled nearby on BLM land, and piped to the site along existing roadways (Figure 2). Correspondence with BLM and the State Engineers Office regarding right-of-way and approval to drill the well are included in Appendix B.

The well is expected to be completed in aquifers that are approximately 1,000 – 2,600 feet below the surface; ground elevation at this location is approximately 8,260 feet. The well would have a bore diameter of 12 inches and would be cased with 12-inch diameter steel casing pipe that is perforated in the water bearing sandstone aquifers. It would be housed within an 8-foot by 8-foot frame building, located on a concrete pad, and surrounded by a chain link fence.

The supply pipeline will be 12,650 feet in length and constructed of 6-inch HDPE pipe. It will be buried to a depth of 5-6 feet for insulation and protection, except at crossings, where it will be buried to a depth of 8-10 feet. The line will be sized and rated to supply 223 gpm at less than 100 pounds per square inch. It will be fitted with valves, hydrants, and air intakes. The initial trench width will be 12-24 inches wherever possible, though in certain areas may need to be wider as required by ground conditions; BLM right-of-way covers a 15-foot corridor width. A three conductor, heavy gauge, armored power supply cable will also be buried in the trench to supply power to the well, as noted above. Gauges will be installed in the pipeline during construction so that any leaks can be detected. Note that the well and pipeline are permitted separate from this NOI, and the above description is provided for descriptive purposes only.

At the terminal end (the plant site), water would be stored onsite in a lined pond adjacent to the tank farm, as shown on the Plant Site diagram (Figure 3); it may also be stored in tanks, which would be outfitted with manifolds and valves. The pond will be lined with a synthetic (HPDE) liner simply to retain water; this lining is not required for any water quality purpose and any infiltration of contained water due an inadvertent leak or tear would not impact surface or groundwater quality.

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A 360 acre-foot portion of water right number 41-3523 has been allocated to Earth Energy from the Uintah County Water Conservancy District. A copy of the agreement is contained in Appendix B.

PIT BACKFILL

As mining progresses in the North (Opening) Pit, produced (clean) sand will be used to backfill it. It is estimated that 20 to 25 percent of the 62-acre pit would need to be open in order to begin backfilling. Dump points will vary as needed in order to fill the pit at the desired sequence. Detailed mine plans are developed to ensure that the produced (clean) sand is replaced in the pit in a sequential layered and compacted manner to eliminate potential slope stability concerns.

The discharged sand will contain 10 to 20 percent water and less than 4,000 ppm residual hydrocarbons (principally near-inert asphaltenes). The blended solid tails will have an overall moisture content of about 15 percent (80-85% sand at 12-15% moisture content, 15-20% fines at 20% moisture content) and will be a relatively plastic material that will readily compact to a load-bearing surface for operation of the haul trucks. The "sand" fraction of the tails can be characterized as primarily quartz material in the 80-1,000 μm range (d_{50} = 117 μm), and the "fines" fraction is the sub-80 μm (d_{50} = 18 μm) material comprised of quartz, shale and clays. The density of the damp sand is roughly 2,850 pounds per cubic yard. The nature of the pit backfill materials are described in greater detail in Appendix B, within correspondence requesting Permit-by-Rule coverage under the Utah Division of Water Quality's (DWQ) groundwater protection program.

When the logistics of the mine/truck haul are optimized in the early stages of operations, it is anticipated that over/inter-burden materials from adjacent removal operations will be alternately combined (blended) with the sand tails to result in a stable, compactable, bulk replacement material. Thus, when placed in compactable lifts (compaction primarily from haul trucks), the replacement material will be a more homogenous mixture. Drainage from this fill will be comparable to in-situ materials. The noted level of moisture content of the blended solids tails is near optimal for compaction and will not lead to liquefaction. Blended sand/clay fine tailings will be placed in relatively thin lifts (estimated at 1-3 feet) and in conjunction with the arid climate of the mine area, the deposited tailings will readily dry out to even lower ultimate moisture content. Pore water pressures will not be a concern. In addition to promoting maximum drying, the specified lifts will enhance compaction and subsequent stability.

The volume of the North (Opening) Pit is 7,900,000 cubic yards and approximately 4.8 million cubic yard of overburden, interburden, and tailings (sand and fines) will be replaced in this pit. A bulkage factor of 30 percent has been applied to the replaced material in replacement volume calculations even though commingled produced sand and fines replaced in the pit will compact to a much lower bulkage factor (estimated to be less than 1.1). Upon completion of a pit backfill, that area

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of the pit will be reclaimed. As described in the Reclamation Section below, final pit slopes angles will be 2.5-3H:1V; during operations, maximum slope angle will be 2H:1V.

OVERBURDEN/INTERBURDEN STORAGE AREAS

During initial mine development, where overburden and interburden must be removed, it will be scraped and deposited in one of two overburden/interburden storage areas shown on Figure 3. The material will primarily consist of broken sandstones and shales mixed with lesser amounts of fines. Grain sizes will vary from fine to coarse rock rubble (run-of-mine) materials potentially as large as one cubic yard. Once mining has opened a large enough excavation to allow equipment movement and backfilling, these storage areas will no longer be used; instead these materials will be re-deposited in the pit along with the clean produced sand tailings. The volume of overburden and interburden placed in these two overburden/interburden storage areas combined will be approximately 4.9 million cubic yards.

Both of the overburden/interburden storage areas will be constructed outside of the pit limits on the side-slopes of ephemeral draws above Main Canyon. The overall slopes of the land on which the overburden/interburden storage areas will be constructed ranges from 16.5 to 40 percent (10° to 22°). During mining, these overburden/interburden storage areas will be sloped at the angle of repose: 1.5-1.7H:1V (30° to 34°). Upon reclamation the slopes will be graded down to between 2.5H:1V to 3H:1V (18° to 22°). Overburden/interburden storage area No. 1 will be constructed on a 40 percent slope (2.5H:1V) that is concave, grading to a slope angle of about 10 percent (10H:1V) near its base. Overburden/interburden storage area No. 2 will be constructed on a 6H:1V slope. Both overburden/interburden storage areas will be designed and constructed to be stable within standard engineering parameters. Dump points will vary with time and will be chosen to facilitate the desired end configuration as described in this plan. While it will not be necessary to key overburden in to the slopes in all locations or as a matter of general design, on the steepest areas of overburden placement, the toes of fills may be keyed into existing slopes as deemed necessary in the field at time of placement. Exposed faces will be protected with coarse/low sediment potential material, effectively armouring the faces.

Initially produced sand tailings will be impounded in storage cells constructed of coarse overburden materials in the upper reaches (flattest) areas of the overburden/interburden storage areas (Figure 2a). Tailings containment cells will not be constructed on slopes steeper than 20 percent (11 degrees). 15-20 foot high cells will be constructed as compacted berms of overburden material and then filled with commingled clean sand/clay fine tailings. When the first level of cells is filled to capacity, successive tiered levels will be constructed until the mine pit has sufficiently advanced to permit direct replacement of the tailings back into the mine in the method described above. Five to six levels of tiered cells are anticipated to be required before backfilling of the mine pit can be undertaken. Finished containment cells will prevent erosion of the fine tailings and result in a stable fill structure. Tailings storage in the upper reaches of the overburden/interburden storage areas will ultimately become fully encapsulated within the finished and reclaimed overburden/interburden storage areas.

The top surfaces of these storage areas will be maintained with a very slight grade away from the outslope so as to minimize runoff running over the outslope, thus controlling erosion. Runoff generated from the outslopes of the overburden/interburden storage areas will be controlled by facing the steepest sections of the finished slopes with coarse overburden material and dedicated armoring placed within the contact between the pile and the native slope (essentially forming a triangular channel-type feature), and by installing a rip-rapped energy dissipater at the toe (Figure 2b). Broken rock material has a very low siltation potential and will effectively encapsulate the finer material initially placed in the upper reaches (flatter areas) of the overburden/interburden storage areas, as noted above. The coarser materials will typically end up near the toe of the expanding fills as the dump sites are filled to their maximum capacity. The concentration of coarse materials at the toe of the fills provides a natural energy dissipater for storm runoff from the faces of the dumps. Typical design drawings are included in Figure 2b. These structures, as with all site best management practices (BMPs), will be maintained to ensure that they are functional. See further discussions below in Section 109.4.

When the overburden/interburden storage areas are filled to capacity, their exposed faces will be contoured (to an overall slope of 2.5-3H:1V) to blend in with adjacent canyon wall slopes as indicated on the Reclaimed Mine Contour Plan (Figure 9). Short segments within the overall slope will be steeper than the overall slope, however no portion of the reclaimed slopes will be steeper than 35°. Both the overall slope and any individual slope segments will be well below 45°.

106.3. Disturbance

The following acreages will be disturbed by mining (see Figure 2 for their locations):

Table 1: Disturbance Areas

Facility	Area
Plant Site including Office and Processing facilities	15 acres
Plant perimeter road	5.5 acres
Haul Road Segment #1	5.5 acres
Haul Road Segment #2	0 acres*
Haul Road Segment #3	3.0 acres

Facility	Area
Haul Road Segment #4	0 acres**
Haul Road Segment #5	3.0 acres
North (Opening) Pit	62 acres
West Pit	31 acres
Overburden/interburden storage area 1	36 acres
Overburden/interburden storage area 2	34 acres
Topsoil storage areas	18 acres
Total	213 acres

* Acres for Haul Road Segment #2 are integral to Overburden/interburden storage area 1;
** Acres for Haul Road Segment #4 are integral to Overburden/interburden storage area 2.

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Table 2: Disturbance by Year (approximate)

Year	Planned Disturbance (acres)	Type of Disturbance	Cumulative Disturbance (acres)
Year 1	100	Plant site, roads, topsoil storage, portion of North (Opening) Pit, portion of overburden/interburden storage areas	100
Year 2	30	Expansion of North (Opening) Pit, expansion of overburden/interburden storage area	130
Year 3	35	Expansion of North (Opening) Pit, expansion of overburden/interburden storage area	165
Year 4	15	Expansion of overburden/interburden storage area	180
Year 5	5	Expansion of overburden/interburden storage areas	185
Year 6	20	Begin West Pit	205
Year 7	8	Expansion of West Pit	213
Total	213	Disturbance includes all areas bonded under this NOI	213

Notes: (1) After year 7, mining and processing may continue, but no additional disturbance would occur. (2) While year-to-year disturbance given above may change as conditions warrant, in no case will total disturbance exceed the permitted 213 acres.

Deleterious materials and their management during operations are described above within the operating descriptions in Section 106.2.

106.4. Nature and Amount of Materials to be Mined

The materials to be mined are tar sands. In the Uinta Basin of Utah, the tar sands deposits are overlain by the Green River Formation containing lenticular beds of lacustrine sandstone saturated with bitumen separated by intervals of barren sandstone, siltstone, shale, mudstone and calcareous marl. The overburden materials are comprised of siltstone and sandstone with interbedded shale; interburden layers between the tar sand deposits are expected to have the same characteristics as the overburden materials. Figure 5 provides a geology map showing surface formations in the area, and Figure 6 provides a geologic cross section that focuses on the tar sands beds within the Douglas Creek member.

Areas to be mined within the overall pit layout are categorized by geology and presence of overburden/interburden, as shown in the following table. The mining areas have been characterized into layers including overburden, tar sand layers in the 'D' bed and 'C' bed, and interburden. Overburden varies from 0 to 50 foot depth and averages 20 foot depth. Interburden thickness averages 15 feet. The "D" bed averages 21 feet in thickness and the "C" bed averages 24 feet in thickness. This is a ratio of 1.25:1, ore:overburden.

Table 3 provides per-acre and total volumes of material to be mined. The overall material balance is as follows:

	1,996,082 cubic yards of overburden
+	1,510,383 cubic yards of interburden
=	3,506,465 cubic yards of overburden and interburden removed
+	4,382,476 cubic yards of tar sands mined
=	7,888,941cubic yards total volume extracted
-	10 percent (conservative, by weight of tar sands) bitumen
=	3,944,228 cubic yards of sand after processing
+	3,506,465 cubic yards of overburden and interburden
=	7,450,693 cubic yards of material to be disposed of
x	1.3 bulkage factor
=	9.7 million cubic yards of material to be disposed of
-	4.9 million cubic yards put in overburden/interburden storage areas
=	4.8 million cubic yards to be back-filled in the mine pit

Table 3: Material to be Mined from the North (Opening) Pit Exclusive of the West Pit (61.51 acres)

	Total Volume in yd^3	Overburden in yd^3	Tar Sands - D Bed in yd^3	Interburden in yd^3	Tar Sands C - Bed in yd^3
Per Acre Average	128,255	32,451	33,195	24,555	38,053
Total	7,888,941	1,996,082	2,041,807	1,510,383	2,340,669

The material volumes in Table 3 do not include the potential material mined from the West Pit. Anticipated yearly mined tonnages from the North (Opening) Pit include: 920,000 – 1,200,000 tons of oil sand ore mined per year and 1,000,000 - 1,400,000 tons of overburden/interburden mined per year. Once the mining process is underway, it will be determined whether or not to continue the mining of the North (Opening) Pit into the West Pit. The expected life of the mine is expected to be between 6 and 13 years, depending on the amount of time the processing equipment is on-stream and the number of process trains employed. (Only one process train is covered under this NOI; should additional trains be needed, they would be covered in a permit amendment.)

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106.5. Existing Soil Types/Location and Extent of Topsoil

EXISTING SOIL TYPES

Soil types in the Study Area include the Seeprid-Utso complex, 4 to 25 percent slopes, on the upper flats, and Tosca gravelly sandy loam, 25 to 40 percent slopes below this, where the terrain starts to drop off into the drainages. The Gompers-Rock Outcrop complex, 50 to 80 percent slopes, lies on the steep, lower sideslopes of significant drainages and may be affected by overburden/interburden storage areas at the heads of drainages, or if mining continues significantly to the north. The Saddlehorse-Rock outcrop-Pathead association, 50-80 percent slopes, is found on south-facing slopes on the north end of the Study Area. It will not be affected in the next five-year development plan, thus it is not discussed further here.

The *Seeprid-Utso complex* is found from 8,100 to 9,200 feet elevation and occurs on the shoulders and summits of hills in the Mountain Stony Loam (browse) ecological site. It is derived from Aeolian deposits over residuum derived from sandstones and shales. Bedrock is generally 40-60 inches from the surface. The top 4 to 18 inches are loam to clay loam. Below 18 inches the soil becomes very channery. The soil is well drained and pH ranges from 6.6 to 7.8 in the top 18 inches. There is some calcium carbonate accumulation below 24 inches. Sodium levels and SAR are very low. The soil supports shrubs with a grass understory.

The *Tosca gravelly sandy loam*, 25 to 40 percent slopes occurs from 7,500 to 8,200 feet elevation on the backslopes of plateaus in the Mountain Stony Loam (browse) ecological site. It is derived from slope alluvium derived from sandstone and shale. Bedrock is generally 40-60 inches deep. Topsoil includes up to 2 inches of organic material underlain by a gravelly sandy loam to 11 inches. Below this the soil is very gravelly to cobbly. The pH ranges from 5.1 to 8.4 in the top 11 inches and from 7.9 to 9.0 below this. Calcium carbonate increases with depth, with the highest percentage between 11 and 39 inches. This soil has very little sodium.

The *Gompers-Rock outcrop complex*, 50 to 80 percent slopes is found from 6,500 to 7,400 feet elevation on cliffs, erosional remnants, escarpments and ledges in the Upland Very Steep Shallow Loam. It is derived from colluvium over shale residuum. Bedrock is within 4-8 inches of the surface. The top 8 inches is a very channery silt loam to loam. It is well-drained; the pH is 7.9 to 9.0. It has a calcium carbonate percent up to 30, and an SAR up to 10.

Table 4: Soil Types

Soil Series	Ecological site	Topsoil depth (inches)	pH	CaCO3 %	Gypsum %	SAR	Precipitation (inches)
Seeprid-Utso complex, 4- to 25% slopes	Mountain Stony Loam (browse)	4-18 *(avg. salvage depth 6 inches, assumed)*	6.6 to 7.8	To 75%	0	0	16-22
Tosca gravelly-sandy loam, 25-40% slopes		0-11 *(avg. salvage depth 4 inches, assumed, slope permitting)*	5.1 to 8.4	To 40%	0	5.0	16-22
Gompers-Rock outcrop complex, 50-80% slopes	Upland Very Steep Shallow Loam	0	7.9-9	To 30	0	5-10	12-16

LOCATION AND EXTENT OF TOPSOIL

Topsoil occurs to some extent on all of the mining area and is suitable for plant growth and reclamation. However, based upon site development to date under the small mine permit, the actual salvageable topsoil depths found on site are less than those reported above. Of the 213 acres that will be affected under this NOI, approximately 18 acres will be used for topsoil storage and topsoil will not be salvaged from this area. On the remaining 195 acres of disturbance, topsoil will be salvaged prior to mining from all areas where it is practical to salvage topsoil (slopes flatter than or equal to than 2H:1V), and it will be stored for reclamation. For the purposes of the topsoil volume summary discussed below, it is assumed that topsoil will be salvaged from 175 acres (142 acres of Seeprid-Utso complex soils and 33 acres of Tosca soils from slopes flatter than 2H:1V). The remaining Tosca soils (20 acres) that occur on slopes steeper than 2H:1V will not be salvaged.

Based upon previous site development, topsoil depth varies from approximately 2 to 4 inches on the ridgetops and 0 to 3 inches on sideslopes. About two-thirds of the Affected Area would occur in the deeper, ridgetop, Seeprid-Utso complex soils. With an average topsoil salvage depth of 6 inches on 142 acres of this soil type, an estimated 114,550 cubic yards of topsoil will be salvaged and stored for future reclamation. For the remaining disturbances where Tosca soils occur on slopes flatter than 2H:1V (33 acres), an average salvage depth of 4 inches is assumed feasible. An estimated 17,700 cubic yards of topsoil will be salvaged and stored for reclamation from these areas. Therefore, the total topsoil salvage for this operation is estimated to be 132,250 cubic yards.

However, it is important to note that this is an estimate only; actual soil salvage volume could be more or less than this amount. The actual amount salvaged would be dependant upon what is encountered in the field: all available topsoil would be salvaged (with the exceptions noted above for the topsoil storage piles), which in some areas may reflect a lesser thickness than assumed and in other areas may be a greater thickness than assumed. The amount calculated above is the amount upon which reclamation is based and for which bonding will be in place.

106.6. Plan for Protecting and Re-depositing Existing Soils

Salvaged topsoils will be collected with a 631 scraper and a D8 dozer used in combination depending upon the gradient and the presence of rock. It will be stored in topsoil storage areas shown on Figure 3. These storage areas are located on flat to gently sloping ground along the margins of the mining and processing areas. This will minimize haul distance, facilitate isolation and protection of the soil resource, and reduce contact with storm water run-on from outside the storage footprint. Topsoils will be protected by seeding with a fast growing cover grass, such as slender wheatgrass and/or Sandberg bluegrass seeded at a total of 10 PLS (pure live seed) pounds per acre. Topsoil piles will be bermed at the outer edges for runoff control, using the salvaged and compacted woody vegetation that is removed prior to topsoil salvage activities. These berms will be trapezoidal in cross section: two feet high, with a two-foot wide top width and approximately 1.5H:1V sideslopes. A sign will be placed at each topsoil storage area, which will read "Topsoil Storage Area – Do Not Disturb". The estimated 93,170 cubic yards of salvaged vegetation will be placed adjacent to or on top of the salvaged soil.

Topsoil will be deposited on areas prepared for reclamation once mining and/or backfilling is complete in an area and the surface is at final grade. It is hoped that 6 inches of soil can be salvaged from the 142 acres of Seeprid-Utso complex soils, and that about 4 inches of soil can be salvaged from approximately 33 acres of the shallower Tosca soils. Soils on the steeper slopes (those greater than 2H:1V) of the Tosca soils covering approximately 20 acres of the total 55 acres of Tosca soils that will be disturbed will not be salvaged. An estimated 132,250 cubic yards of soil will be available for reclamation by the end of development of this mining area. This averages out to a re-spread depth of about 5 inches of topsoil over 195 acres of disturbance (This does not include the 18 acres of disturbance associated with topsoil stockpiles where salvage would not occur and thus would not need topsoiling).

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106.7. Existing Vegetative Communities

The Study Area elevations range from 8,222 feet on the ridgetop to 7,560 feet in the drainages. Existing vegetation in the Study Area includes mixed shrub and sagebrush/grassland communities on the ridgetops, with junipers on slopes upper slopes, trending to a Doug fir community as elevation decreases. There are some aspen patches in the drainages. The Affected Area is primarily within the mixed shrub and sagebrush/grassland communities.

Vegetation Cover Levels Sufficient to Establish Re-vegetation Success Standards
On August, 16, 2007 a quantitative vegetation survey utilizing 13 one-meter-square quadrats was conducted on plateaus and slopes located between 7,720 feet and 8,880 feet elevation within the Study area, including within and immediately adjacent to the Affected Area. (See Figure 8 for quadrat locations, and Appendix C for vegetation survey data). On May 16, 2007 a qualitative vegetation survey listing all species noted was conducted on plateaus, slopes, and upper canyon sites located between 7,440 feet and 8,840 feet elevation on hilltops and hillsides within the mine area. Results of the vegetation surveys are summarized in Tables 5 and 6 below.

Table 5: Results of 13 cover transects surveyed August 17, 2007 to determine revegetation success standards.

Life Form	Average Cover (percent)
Shrubs & Trees	*50.3*
Grasses	*14.7*
Forbs	*2.7*
Total vegetation cover	*67.7*
70% of cover value	***47.4***
Litter	*12.7*
Rock	*16.7*
Bare Ground	*21.0*
TOTAL	***100.0***

These results indicate that the post-reclamation vegetative cover for upland areas must be at least 47 percent to meet bond release standards.

Table 6: Species List of all species noted on May and August field trips to EERI Study Area

Scientific name	Common name	Relative abundance
Shrubs, Trees, and Sub Trees		
Quercus gambelii	Scrub oak	Common at mid-hi elev
Cercocarpus montanus	Birchleaf mountain mahogany	Common at mid-hi elev
Purshia tridentata	bitterbrush	Common at mid-hi elev
Amelanchier alnifolia	Utah serviceberry	Abundant at mid-hi elev
Symphoriocarpus albus	Snowberry	Abundant at mid-hi elev
Artemisia tridentata	Big sagebrush	Abundant at mid-hi elev
Artemisia filifolia	Fringed sage	Occasional at mid-hi elev
Artemisia ludoviciana	Herbaceous sage	Occasional at mid-hi elev
Chrysothamnus nauseosus	Rubber rabbitbrush	Occasional at mi-hi elev
Juniperus osteosperma	Utah juniper	Common at mid elev
Pinus edulis	Pinyon pine	Occasional at mid elev
Pseudotsuga menziesii	Douglas fir	Common at lower elev.
Populus tremuloides	Aspen	Common in drainages
Berberis repens	Oregon grape	Occasional at lower elev
Rosa woodsii	Woods rose	Occasional at lower elev
Ribes sp.	Currant	Occasional at lower elev
Pachistima myrsinites	Mountain boxwood	Occasional at lower elev
Forbs		
Opuntia sp.	Prickly pear	Occasional at mid-hi elev
Collinsia parviflora	Blue-eyed Mary	Occasional at mid-hi elev
Taraxicum officionale	Dandelion	Occasional at mid-hi elev
Astragalus beckwithii	Beckwith astragalus	Occasional at mid-hi elev
Phlox longifolia	Long-leafed phlox	Occasional at mid-hi elev
Erigeron pumulis	Shaggy daisy	Occasional at mid-hi elev
Senecio sp.	Senecio	Occasional at mid-hi elev
Delphinium bicolor	Larkspur	Occasional at mid-hi elev
Aquilegia sp.	Columbine	Occasional at lower elev
Frasera speciosa	Monument plant	Occasional at mid-hi elev
Lithospermum incisum	Puccoon or Fringed gromwell	Occasional at mid-hi elev
Stanleya pinnata	Wallflower	Occasional at mid-hi elev
Cryptantha glomerata	Popcorn flower	Occasional at mid-hi elev
Phacelia linearis	Narrow-leafed phacelia	Occasional at mid-hi elev
Antennaria sp.	Pussy toes	Occasional at mid-hi elev
Saxifraga sp	Brook saxifrage	Occasional at mid-elev
Osmorhiza beteroi	Mountain sweet cicely	Occasional at mid-elev
Erodium cicutarium	Red stem filaree	Common under aspen
Achillea millefolium	Yarrow	Occasional under aspen
Maianthemum stellatum	False Solomon's seal	Occasional under aspen
Urtica dioica	Stinging nettle	Occasional under aspen
Descurainia pinnata	Flixweed	Common under aspen
Circium arvense	Canada thistle	Occasional under aspen
Grasses & Grass-likes		
Poa sandbergii	Sandberg bluegrass	Common at mid-hi elev
Pseudoroegneria spicata	Bluebunch wheatgrass	Common at mid-hi elev
Achnatherum hymenoides	Indian ricegrass	Occasional at mid-hi elev

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Scientific name	Common name	Relative abundance
Pascopyron smithii	Western wheatgrass	Common at mid-hi elev
Carex sp.	Dry-land or mountain sedge	Common under firs
Calamagrostis purpurascens	Purple Reedgrass	Occasional under firs
Bouteloua gracilis	Grama grass	Occasional at mid-elev
Poa pratensis	Kentucky bluegrass	Common under aspen
Leymus cinereus	Ryegrass	Occasional under aspen
Carex aquatilis	Water sedge	Seasonally
Scirpus sp.	Rush	Seasonally

106.8. Depth to Groundwater

The depth to the regional groundwater table in the vicinity of the Study Area is expected to be 1,500 feet or more (Price and Miller 1975). Nearby springs or seeps (shown on Figure 7) provide evidence of very localized, shallow groundwater, likely representing isolated perched aquifers. Previous geologic exploration drilling at the site, at maximum depths of approximately 150 feet below ground surface, did not encounter groundwater. This drilling consisted of 25 wells drilled under the previously mentioned DOGM exploration permits. Six of these wells were drilled under E/019/052, along Seep Ridge Road south of the County line within Earth Energy's lease area, but just east of main Affected Area. The remaining wells were drilled under E/019/053, also located along Seep Ridge Road, spanning the County line, and within the eastern part of the 213-acre Affected Area. Maps from DOGM exploration permits that show these locations are included in Appendix B. Depth to groundwater is also discussed in Appendix B, within correspondence requesting Permit-by-Rule coverage under the Utah Division of Water Quality's (DWQ) groundwater protection program.

<u>Extent of Overburden Material</u>

The tar sand beds crop out in PR Canyon to the northeast of the mine area, and in Main Canyon to the southwest of the mine area (Murphy, Leonard A., 2003 private report).

Twenty-five holes drilled by Earth Energy in 2005 penetrated to the highest, or "D" bed, of the tar sands. Average depth to mineable ore was 20 feet, with areas near the outcrop having virtually no overburden, and areas on the southwest side having up to 50 feet of overburden.

Between the two beds that will be mined (the higher D bed and lower C bed) there is a layer of interburden that averages 15 feet in thickness (total average thickness of waste rock = 35 feet) (Figure 6). The "D" bed averages 21 feet thickness and the "C" bed averages 24 feet in thickness (total average thickness of ore = 45 feet). This is a ratio of 1.25:1 (ore:waste rock). As noted in Table 3 above (see Section 106.4), it is estimated that there will be 1,996,082 cubic yards of overburden and 1,510,383 cubic yards of interburden salvaged to mine the 62-acre North (Opening) Pit.

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Geology

Rocks on Earth Energy lands include thick, buff-to-cream, rim-forming, cross bedded sandstone cropping out in the bottom of Main Canyon. These rocks were mapped by Gaultieri (1988) as the Renegade Member of the Wasatch Formation consisting of medium to thick, indistinctly banded sandstone with sparse shale. These beds are overlain by the Green River Formation containing lenticular beds of lacustrine sandstone saturated with bitumen separated by intervals of barren sandstone, siltstone, shale, mudstone and calcareous marl. Five distinct asphalt impregnated sands, labeled "A", "B", "C", "D" and "E" with "E" the highest strata, occur in the upper portion of the Douglas Creek Member of the Green River Formation (Byrd, William D. 1970) and (Clem, K. 1984). The "E" bed is regionally known, but is not present locally. The beds crop out in PR Canyon to the northeast and Main Canyon to the southwest of County Road 2810 (Seep Ridge Road). All four beds occur in an interval 240 to 290 feet thick (Murphy, Leonard A., 2003 private report). Figure 5 provides a geology map and Figure 6 provides a geologic cross section that focuses on the tar sands beds within the Douglas Creek member. In the area of the opening pit, the strike of the beds is N 20° E, and the dip is 1.2-1.7° NW. The axis of the San Arroyo Anticline trends N 60 W veering to a S 45 W trend 1-2 miles east of the Affected Area (Figure 5). The strike and dip of the ore beds vary slightly throughout the planned mine area as the host formations are part of a gentle anticlinal structure, but dip probably averages about 1.5°.

Twenty-five holes drilled by Earth Energy in 2005 penetrated only the highest or "D" bed. Moderate-to-well saturated tar sand was cut at depths ranging from 10 feet to 40 feet with an average depth of 19 feet, ranging in thickness from 10 feet to 30 feet. Information from these holes and work by authors previously mentioned confirm mineable tar sands may be expected in the area.

106.9. Ore and Waste Stockpiles

The mined tar sands will be stockpiled adjacent to the processing facilities in areas shown on Figure 3. Generally, the operator will maintain a two-week supply of ore at the processing facility. It is expected that no more than approximately 40,000 cubic yards of tar sands will be stockpiled at any one time, awaiting processing. This material would be piled within loader range of the inlet feed hopper (about 200 to 500 feet). It would have a maximum footprint of about 100 yards by 100 yards, and a maximum height of four yards, and may be placed within one or more piles in this area whose combined footprint does not exceed that noted above. In addition, up to 2,500 cubic yards of reject material (rejected material barren of bitumen (rocks) and/or loads of ore that have been hauled to the plant site, but which contain too high a percentage of barren material (stringers) to be viable for processing) would be piled at any one time in a location near the ore stockpiles, prior to being returned to the pit as backfill or disposed of in the overburden/interburden storage areas.

Waste sand from the processing operation would contain 10 to 20 percent water and will be fairly neutral chemically. Recent process equipment evaluations indicate the moisture content of the blended sand/clay fine tailings will be in the order of 15%. As noted above, this level of moisture content is near optimal for compaction and will not lead to liquefaction or cause pore water pressures that would be a concern. Earth Energy has received Permit by Rule coverage under DWQ's Groundwater Protection Program, due to the *de minimus* impact of the project, including the planned pit backfills with processed tar sands, on groundwater resources. Copies of related correspondence are included in Appendix B.

Initially, produced sand will be discharged in the upper reaches of the overburden/interburden storage areas until there is sufficient room available in the opened mine pit to permit commencement of backfill to the pit. Once mining has opened a large enough excavation to allow equipment movement and backfilling, produced sands would be re-deposited in the pit.

Runoff from the overburden/interburden storage areas will be controlled in armored (rip-rapped) areas at the margins and energy dissipation at the toes of their slopes. Typical design drawings for these BMPs are shown in Figure2b. These structures, as with all site BMPs, will be maintained to ensure that they are functional.

TAILINGS FACILITIES

There would be no liquid tailings ponds associated with this mining operation.

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WATER STORAGE/TREATMENT PONDS

Water for processing would come from a deep water well (1,000 to 2,600 feet deep) drilled approximately 1 mile east of the production facility. A water right transfer with the Uintah Water Conservancy District allows Earth Energy to use up to 360 acre-feet per year of Green River basin water (currently allocated under Water Right No. 41-3523). Approval must be granted from the State Engineer to approve the well location. Well water would be pumped and piped via deep-buried and/or insulated 6-inch-diameter, HDPE pipeline, and stored in the retention pond described below. As noted above, gauges will be installed in the pipeline during construction so that any leaks can be detected. This well and pipeline is permitted separately under Exploration Notice #E0190053). In addition, recycled process water will be stored in an insulated storage tank with an approximate capacity of 4,000 barrels.

There would be no treatment ponds located on the site. However, a retention/storage pond will be located at the low point of the plant site, and will collect all plant site runoff and runoff-transported sediments; it will also be used to store clean reserve make-up water (approximately 10,000 barrels, which equates to a 2.5-day supply. This pond will be lined in order to preserve the availability of make-up water. Lining is not needed to prevent water quality impacts. Any sediments that collect in this pond will be removed as needed to maintain design capacity. All precipitation collected within the working mine pits and process areas will be used in the process or for dust suppression on mine and plant roads.

106.10. Amount of Material to be Extracted, Moved

As illustrated in Table 3 (Section 106.4), over the next five years approximately 4,382,475 cubic yards of tar sand ore will be removed from the mine for processing into bitumen. To accomplish this, approximately 132,250 cubic yards of topsoil will be removed from lands to be disturbed and set aside for reclamation purposes. Approximately 3,506,465 cubic yards of overburden and interburden will be removed during the course of mining, to access the ore. Ore will be mined at a rate of approximately 3,000-3,500 tons of per day, producing approximately 2,000 bbl/day of bitumen from the initial process train.

The total volume of tar sand ore plus overburden and interburden to be extracted from the North (Opening) Pit is therefore approximately 7,900,000 cubic yards (4,382,476 plus 3,506,465). Approximately 4.8 million cubic yards of overburden, interburden, and tailings (sand and fines) will be replaced in this pit. A bulkage factor of 30 percent has been applied to the replaced material (although the replaced sand tailings are expected to have a bulkage factor of <1.1).

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R647-4-108. Hole Plugging Requirements

All exploration holes drilled by Earth Energy have been plugged according to the requirements of R647-4-108. Future drill holes, should there be any, would be plugged according to the same requirements. Drill holes would not be left unplugged for more than 30 days unless approved by UDOGM.

Closure of the water well is handled under Exploration Notice #E0190053 and is not part of this NOI.

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R647-4-109. Impact Assessment

109.1 Surface and Ground Water Systems

SURFACE WATER

The Study Area is located on the Tavaputs Plateau along the southeastern rim of the Uinta Basin. Hydrologically, it is within the Green River watershed (in HUC 14060005), which is part of the Colorado River system. The 2,255-acre Study Area includes the relatively flat interfluve between PR Canyon and Main Canyon, as well as the headwaters of those canyons and adjacent tributaries. Figure 7 shows watershed boundaries in the Study Area, as well as other water features such as streams and springs or seeps.

The disturbances will be located on this drainage divide and extend southwestward into the Main Canyon watershed. Previous activities associated with an approved Small Mine Operation at this site have modified local natural surface drainage patterns over about five acres. Among those existing disturbances, is a small open pit in which collected runoff and precipitation is impounded.

Main Canyon and several of its tributaries (including Trail and Meadow Canyons) drain the majority of the Study Area. There are several small springs or seeps that issue in the headwater reaches of Main Canyon and support perennial flow for some distance along its main stem. Main Canyon flows generally west and northwest, entering Willow Creek several miles west of the Study Area. Willow Creek in turn flows into the Green River near Ouray. PR Canyon and a tributary named Jacks Canyon drain northward, conveying snowmelt and runoff from the northeast part of the Study Area. Although there is a small spring complex located in PR Canyon, flow in these channels is intermittent or ephemeral. PR Canyon is tributary to Sweet Water Canyon, Bitter Creek, and the White River, prior to the White River entering the Green River near Ouray.

Precipitation in this area is estimated at about 12 inches annually (Price and Miller 1975), which is generally not sufficient to sustain perennial flow in the smaller watersheds in this region. Instead, much of the Study Area is dissected by numerous ephemeral drainages that, although channels themselves are small, are located within larger canyons with steep slopes. Because the majority of mining and mining-related surface disturbance will be located on the relatively flat interfluve, there is negligible up-gradient watershed area that could contribute run-on. The small headwater drainages that will be filled with overburden/interburden storage areas flow ephemerally, contain very small active-channel cross sections, and typically show no evidence of live water or riparian vegetation.

Overburden/interburden storage area No. 2, the western-most overburden/interburden storage area, will be located on the area that contains a water right (49-1567) for a spring near the east edge of its fill footprint. However, a May 16, 2007 reconnaissance trip to pin-point this water source and determine a flow rate found no evidence of active flow at the site listed by the State Engineer. A very minor seep, with flow too small to be measured, was found approximately 100 vertical feet down from, and ¼ mile west of the spring identified with the water right. It is in the arroyo on top of an aquitard, and only appears following heavy runoff that has migrated down along fractures. It appeared to be associated with a contact point between a shale layer and a more porous overlying area. This is outside of the Affected Area. No other water was found during this survey other than those seeps identified in Figure 7.

The plant site will be constructed to be a self-contained area, through the use of perimeter berms or ditches where needed. Ditches will be designed to pass the 10-year, 6-hour precipitation event. They will either be triangular in cross section with side slopes approximately 1.5H:1V; depth including freeboard will be less than 2 feet; or will have an equivalent cross section. Berms will generally be 2 feet high, with a two-foot top width and 1.5H:1V sideslopes. In some areas, the roads form the perimeter berm or ditch. All precipitation incident on the site will be collected in the water retention/storage pond located at the low point of the plant site (Figure 3) and used in the extraction process or for dust suppression on mine and plant roads. This pond will also be used to store clean reserve process water. If sediments accumulate in the pond, it will be cleaned as needed to maintain its design capacity. The lining used in this pond will prevent loss to infiltration so as to maximize Earth Energy's storage volume; this lining is not needed for any water quality protection purpose, and any inadvertent leak or tear that results in infiltration would not impact surface or groundwater quality. As noted, more detail on the use of all of these structures (berms, ditches, and the water retention/storage pond) will be provided when final engineering designs are available.

The mine pit is constructed with a highwall around the workings, which in all locations (during operations) will be higher than the highest elevation of the pit floor. In this manner, all precipitation on the mine pit will collect in precipitation collection sumps located in the bottom of the pit. These collection sumps are simply low areas within the working mine pit where precipitation falling directly within the pit perimeter will drain and collect. Collected precipitation will be transported to the processing site with mined ore or pumped separately and added to the process stream as part of the make-up water. The active mining area will be a pit at all times (concave to incident precipitation and run-on). No pit configurations are planned where storm water will be allowed to egress the active mine workings.

Runoff and sediment from the outslopes of the overburden/interburden storage areas will be controlled by facing the steepest portions of the slopes with coarse overburden material (similar in appearance to existing natural scree slopes) dedicated armoring placed within the "channel" formed by the contact between the pile and the native slope, and by installing a rip-rapped energy dissipater at the toe. Due to the size of overburden/interburden/ storage area materials (broken sandstones and shales mixed with lesser amounts of fines, with particles varying from fine to coarse rock rubble (run-of-mine) materials potentially as large as one cubic yard), these outslopes will not produce significant amounts of sediment. The minimal erosive potential of the proposed design slopes has been confirmed through monitoring of the similarly constructed overburden storage piles adjacent to the Company's 2005 production test pit. Typical design drawings are included in Figure2a. Runoff and erosion will be minimal from the overburden/interburden storage area top surfaces, because these will be maintained with a gentle grade away from the outslope.

SPCC

All BMPs will be inspected regularly and maintained in operable conditions. These types of BMPs are also described in a Storm Water Pollution Prevention Plan (SWPPP) developed to comply with a State of Utah Multi-Sector General Permit for Industrial Discharges (and/or the analogous EPA permit). That Permit also requires quarterly visual monitoring of storm water. All of these measures would reduce the likelihood of inadvertent discharges of process waters or erosion-produced sediments. This SWPPP is included with the NOI as Appendix G. This subject is discussed further in Section 109.4 below.

GROUNDWATER

The tar sands deposit that would be mined during this project is located in the Green River Formation. The Parachute Member of the Green River Formation is the uppermost bedrock formation found throughout the Study Area. This Formation includes various water bearing zones (including the Birds Nest and Douglas Creek aquifers), though they are apparently of limited extent and yield. The State Water Plan (Utah Division of Water Resources 1999) doesn't include any Green River Formation aquifers as significant enough to be target for groundwater development, and information from wells and springs indicates generally low yields (Price and Miller 1975).

Most springs in the area, including PR Spring, are reported to discharge from the Parachute Creek Member of the Green River Formation (Price and Miller 1975). The BLM (1984) notes that known springs within the combined Hill Creek and PR Spring Special Tar Sands Area (STSA) typically discharge at less than 50 gpm, with most discharging at less than 10 gpm. They range from fresh to moderately saline, with total dissolved solids (TDS) ranging from about 300 mg/L to 6,100

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mg/L (BLM 1984). Generally, the springs are freshest near the southern extent of the STSA, in the vicinity of the Study Area, with TDS concentrations of less than 500 mg/L (Price and Miller 1975). In 1964, PR Spring was discharging at 5.6 gpm and had a dissolved solids concentration of 380 mg/L (Price and Miller 1975). These springs are not predicted to be impacted by Earth Energy's operation.

Underlying the Green River Formation at depth are the Wasatch Formation and the Mesa Verde Group, which are likely aquifer targets for Earth Energy's water supply well (which is permitted separately under Exploration Notice #E0190053). Price and Miller (1975) indicate that the potentiometric surface in the general area is 1,500 feet or greater below ground surface, with a gradient to the north. Generally, these bedrock sources are thought to be of low permeability and relatively poor water quality (Price and Miller 1975) and thus insufficient for major groundwater development. At its maximum depth of 140 feet, the North (Opening) Pit would not be expected to encounter this regional groundwater table, nor would it be expected to approach it or affect its gradient or quality.

Based upon review of drill logs obtained for a nearby abandoned (watered out) exploratory gas well, a local aquifer is anticipated to yield a sufficient quantity of groundwater for project requirements. The abandoned well of interest is located approximately 1 mile east of the plant site (on BLM land) with the target aquifer at least 1,000 feet below ground (Earth Energy personal communication). An application to the BLM for drilling of a test well at the subject location has been approved. Pending results of this test well, additional permitting through DOGM, the State Engineer's Office, and BLM may be required. Use of this deep groundwater would not affect the nearby springs.

As noted above, Earth Energy has received Permit by Rule coverage under DWQ's Groundwater Protection Program, due to the *de minimus* impact of the project, including the planned pit backfills with processed tar sands, on groundwater resources. Copies of related correspondence are included in Appendix B.

WATER RIGHTS

According to online records of the State Engineer's Office, (Utah Division of Water Rights) there are a number of water rights in and near the Study Area, as shown in Table 7 and on Figure 7. The only one of these that would potentially be affected by Earth Energy's operations would be 49-1567. This right is in the application phase, and has not yet been granted by the State Engineer's Office. It was first filed on in 1995, by Alameda Corporation and their attorney Pruitt-Gushee. The applicant stated that the use of the water would be in conjunction with several other area sources for domestic and livestock uses; these other sources were filed on at the same time as the 49-1567 water right. The quantity of water filed on at this spring was approximately 4.5 gpm. (As noted above, a field visit did not find

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any evidence to indicate that a spring of this size exists at this location; it may represent a mis-plotted water right).

The water right application (and others similarly filed by Alameda) was protested by SITLA and Utah Division of Wildlife Resources (DWR), among others, in 1995. A hearing was held in 2004, at which time Alameda was apparently asked to provide additional information. The rights were neither granted nor rejected.

In early 2007, the State Engineer's Office requested that Alameda Corporation supply information on these applications and their intentions regarding them within 90 days. If this was not done, the state indicated that it would reject the applications. In early April of this year, Alameda's current attorney (Mabey and Wright) notified the State Engineer that they were pursuing some of water rights, including 49-1567, and dropping others. They further indicated that they have obtained SITLA's permission to develop the water sources on state land, including 49-1567. They have requested that the State Engineer grant these water rights ASAP.

As explained in the Surface Water section above, the May 16, 2007 reconnaissance trip to GPS the location of this spring or seep and determine a flow rate found no evidence of active flow or hydrophytic vegetation at the site listed by the State Engineer.

Table 7: Water Rights

Water Right No.	Water Source	Quantity (cfs)	Use	Water Right Owner
49-55	Unnamed Spring	0.002	Stock watering	John S. Purdy
49-57	PR Springs	0.002	Stock watering	John S. Purdy
49-193	Unnamed Spring	0.025	Stock watering	Alameda Corp.
49-196	PR Springs	0.021	Stock watering	Alameda Corp.
49-262	PR Springs	0.011	Domestic & stock watering	BLM
49-378	East Fork Jacks Canyon Spring	0.015	Stock watering & wildlife	BLM
49-495	Meadow Spring	0.015	Stock watering & wildlife	SITLA
49-496	South PWR Meadow Spring	0.015	Stock watering & wildlife	SITLA
49-497	North PWR Meadow Spring	0.015	Stock watering & wildlife	SITLA
49-504	Jacks Canyon Spring	0.015	Stock watering & wildlife	BLM
49-1508	Unnamed Spring	0.05	Stock watering	SITLA

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Water Right No.	Water Source	Quantity (cfs)	Use	Water Right Owner
49-1566*	Unnamed Spring	0.027	Domestic & stock watering	Alameda Corp.
49-1567*	Unnamed Spring	0.01	Domestic & stock watering	Alameda Corp.
49-1572*	Unnamed Spring	0.004	Domestic & stock watering	Alameda Corp.
49-1581*	Unnamed Spring	0.004	Domestic & stock watering	Alameda Corp.

* Application phase – water right not yet approved

An additional water right of importance is that which will be used by Earth Energy to provide water for processing the ore. Through an agreement with the Uintah Water Conservancy District, Earth Energy's long-term plan is to use Green River Water (currently allocated under Water Right No. 41-3523) via a water rights transfer of about 360 acre-feet/year. Initially, approximately 200 acre-feet/year of groundwater will be pumped from a deep water well (1,000 to 2,600 feet deep) drilled within 1-2 miles of the production facility. This deep well is being permitted by the Utah State Engineer's Office, the BLM, and DOGM (under Exploration Notice #E0190053).

109.2 Wildlife Habitat and Endangered Species

As noted in Section 106.7, the Study Area is on the top of a flat-lying plateau above Main Canyon and PR Spring Canyon. Ephemeral drainages drop steeply off the plateau into these canyons. Existing vegetation in the Study Area includes mixed shrub and sagebrush/grassland communities on the ridgetops, with juniper on upper slopes and sideslopes, trending to a Doug fir community as elevation decreases. There are some aspen patches in the drainages.

The Utah Natural Heritage Program (NHP) of the Division of DWR was contacted directly for information about known occurrences of any species of concern. Their response letter, attached in the correspondence section (Appendix B), listed occurrences of Mexican Spotted Owls (*Strix occidentalis lucida*) and greater sage grouse (*Centrocercus urophasianus*) in the vicinity of Study Area. The Mexican spotted owl was listed as a threatened species on 15 April 1993 (USFWS 2007). Sage grouse are not protected by Federal law, but as a "wildlife species of concern", it is expected that conservation actions may be needed to preclude the need to list sage grouse under the Endangered Species Act. Sage grouse are also currently listed as a sensitive species by the Utah DWR.

GIS Shape files of Mexican Spotted Owl nesting habitat, acquired from the Bureau of Land Management (BLM) Vernal Field Office indicate that there is no known such nesting habitat within 1.5 miles of the Study Area boundary, or within 3 miles of the Affected Area. It is possible, however, that owls may move up the canyons

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This page is a reference page used to track documents internally for the Division of Oil, Gas and Mining

Mine Permit Number M/047/0090 Mine Name ______________________

Operator ______________________ Date ________ ____________

TO ______________________ FROM ______________________

X CONFIDENTIAL __BOND CLOSURE __LARGE MAPS __EXPANDABLE
__MULTIPUL DOCUMENT TRACKING SHEET __NEW APPROVED NOI
__AMENDMENT __OTHER ______________________

Description YEAR-Record Number

X NOI __Incoming __Outgoing __Internal __Superceded

Page 45 is Confidential

CONFIDENTIAL

__NOI __Incoming __Outgoing __Internal __Superceded

__NOI __Incoming __Outgoing __Internal __Superceded

__NOI __Incoming __Outgoing __Internal __Superceded

__TEXT/ 81/2 X 11 MAP PAGES __11 X 17 MAPS __LARGE MAP

COMMENTS: ______________________

CC: ______________________

inches high, comprised of three or four strands barbed wire, topped with a log rail. It will be anchored with T-posts.

The UCD website also includes a list of plant and animal species that are Federally listed as Threatened, Endangered, or are Candidates for T&E designation in Utah, or are listed as Sensitive Species by the DWR. Those that are listed as present in the southern portions of Uintah and/or the northern portions of Grand Counties are listed below in Table 7 (with the exception of listed fish species, since there is not adequate live water to support fish on or near the Study Area). The information was taken from the UCD website on May 11, 2007.

Table 7: Threatened, Endangered, and Candidate Species that may be present at Earth Energy Resources Tar Sands Mine

Common Name	Scientific Name	Status	Elevation in Feet / Habitat	Chance of Presence at Project Site
Shrubby Reed-mustard	*Glaucocarpum suffrutescens*	E	6000-7000	None due to elevation
Clay Reed-mustard	*Schoenocrambe argillacea*	T	4725-5750	None due to elevation
Uinta Basin Hookless Cactus	*Sclerocactus glaucus*	T	4500-6500	None due to elevation
White River Beardtongue	*Gila cypha*	C	5000-6680	None due to elevation
Black-footed Ferret	*Mustela nigripes*	T	Prairie dog towns	None due to lack of prairie dogs
Brown (Grizzly) Bear	*Ursus arctos*	T -Extirpated	Mountain timber	None
Southwestern Willow Flycatcher	*Empidomax traillii extimus*	E	Riparian areas with willows	None due to lack of riparian habitat

Shrubby Reed-mustard, *Glaucocarpum suffrutescens,* is a Federally listed endangered plant. This perennial, clump-forming mustard produces yellow flowers in May and June. It grows on shaley, fine textured soils of the whitish, semi-barren Green River Formation, Evacuation Creek Member. It is associated with mixed desert shrub and pinyon-juniper communities at elevations of 6000 ft to 7000 ft. The Study Area elevation is generally above, and the soils thicker and deeper than those noted above, making it highly unlikely that this species would be encountered within the Study Area.

Clay Reed-mustard, *Schoenocrambe argillacea,* is a Federally threatened plant. This mustard produces white, purple-veined flowers that bloom from mid-April to mid-May. The plant is hairless with a stout, woody base. It occurs on the Green River Formation, Evacuation Creek Member, where it prefers precipitous slopes consisting of bedrock or scree mixed with fine-textured soils in mixed desert shrub communities at elevations of 4725 ft. to 5750 ft. It is unlikely that this plant would be present within the Study Area due to elevation and site characteristics.

Uinta Basin Hookless Cactus, *Sclerocactus glaucus,* is a Federally listed threatened plant that is known to occur in central and southern Uintah counties just north of the Study Area. This cactus has a solitary, egg-shaped stem that is 3-12 inches long. Pink flowers are produced late April to late May. It is found on xeric, fine textured soils overlain by cobbles and pebbles on river benches, slopes, and rolling hills of the Green River and Mancos formations from 4500 ft. to 6500 ft. elevation. It is associated with salt desert shrub and pinyon-juniper communities. It is highly unlikely that this plant would occur on the Study Area due to the higher elevation and moister site characteristics of the mine site.

White River Beardtongue, *Penstemon scariosus,* is a candidate for Federal listing as threatened or endangered. It is found in Duchesne and Uintah counties in Utah and Rio Blanco County in Colorado. This figwort has lavender to pale blue flowers that bloom in late May to June. It is found on semi-barren areas on white (infrequently red) soils that are xeric, shallow, fine-textured, and usually mixed with fragmented shale from 5000 ft. to 6680 ft elevation. It is highly unlikely that this plant would occur on the Study Area due to the higher elevation and moister site characteristics of the mine site.

The **Black-footed ferret**, *Mustela nigripes*, is Federally listed as endangered. Thought to be extinct, the species was re-discovered near Meteetse, Wyo. in the 1980's. Since then a captive breeding program has allowed introduction of populations classified as "non-essential-experimental" by the US Fish and Wildlife Service (USFWS) in the Coyote Basin area of Uintah County in 1999, as well as at other locations in the west. There are also unconfirmed sightings of naturally occurring black-footed ferrets in eastern Utah.

Black-footed ferrets are nocturnal and rely on prairie dogs for their primary food, thus they are closely associated with prairie dog towns. Loss of prairie dogs (by plague, poisoning or habitat loss) directly threatens the survival of the ferrets. Due to the lack of prairie dog colonies in the Study Area, no black-footed ferrets would be expected to occur in this area.

The **Grizzly or brown bear,** *Ursus arctos,* was extirpated (eliminated) from Utah in the 1920s. Because of the drastic decline in brown bear numbers and distribution, the U.S. Fish and Wildlife Service has listed it as threatened in the lower 48 states. The last known sighting of a grizzly bear in the state of Utah was over 50 years ago, thus it is highly unlikely this animal would be seen on or near the Study Area and no evaluation is necessary.

The **Southwestern willow flycatcher**, *Empidonax traillii*, is Federally listed as endangered. It is a rare summer resident of southern Utah up to the northern border of Grand County. It prefers riparian habitats with willows. It eats insects, seeds, and berries. It breeds in late spring and early summer in the vertical fork of a willow or other riparian tree. The Study Area is at the northern edge of the range for this bird; the lack of developed riparian habitat in the Study Area makes it highly unlikely that this bird would occur in the Study Area.

As noted in Section 106.7, the Study Area is on the top of a flat-lying plateau above Main Canyon and PR Spring Canyon. Ephemeral drainages drop steeply off the plateau into these canyons. Existing vegetation in the Study Area includes mixed shrub and sagebrush/grassland communities on the ridgetops, with juniper on upper sideslopes, trending to a Doug fir community as elevation decreases. There are some aspen patches in the drainages.

109.3 Existing *Soil and Plant Resources*

SOILS

Existing soil types in the Study Area are described in Section 106-5 above and are shown on Appendix C. Associated disturbance related to mining and processing at PR Spring mine includes approximately 15 acres to be disturbed by the plant site and 17 acres to be disturbed by the plant perimeter road and the haul road segments that are not integral to the overburden/interburden storage areas. These disturbances will remain un-reclaimed for the life-of-mine. Approximately 62 acres will be disturbed for mining the North (Opening) Pit, 31 acres will likely be disturbed by mining in the West Pit, and 70 acres will be disturbed with two overburden/interburden storage areas. The topsoil storage areas will take up approximately 18 acres of land and will not be stripped. This is a total disturbance footprint of 213 acres.

Of this acreage, 160 acres are within the Seeprid-Utso complex of soils, located on the tops and shoulders of the plateau, while 53 acres are within the shallower Tosca soils, located on the slopes below the plateau.

Reclamation will remain as concurrent as possible as mining advances and produced sand is replaced in the excavated pit. This will allow regrading, topsoiling, and seeding of some lands including portions of the mined-out pit. Thus, the total volume of topsoil stored at any one time will never reach the full 132,250 cubic yards. All salvaged soils will be used on-site in reclamation.

PLANTS

The Study Area intersects four plant communities: Sagebrush-grass, Mixed tall shrub, Pinyon-juniper-Douglas fir, and Aspen glade (Figure 8). All but the Aspen glade community were sampled, as no mining will occur in the aspens. Within the Study Area there are 1,638 acres of Sagebrush-grass community, 1482 acres of Mixed tall shrub community, 1203 acres of Pinyon-juniper-Douglas fir community, and 43 acres of Aspen glade community. Within the Affected Area included in this NOI, approximately 70 percent are within the Mountain tall shrub community, 20 percent are within the Sagebrush-grass community, and 10 percent are within the Pinyon-juniper-Douglas fir community. Further information about existing plant resources is included in Section 106.7, Table 3, and in Appendix C.

109.4 Slope Stability, Erosion Control, Air Quality, Public Health & Safety

SLOPE STABILITY

Generally speaking, for many open-pit mines, slope stability is a concern at the rim and floor of pits, the ground surface on which overburden/interburden storage areas are constructed, and on the slopes of constructed overburden/interburden storage areas and topsoil stockpiles. Earth Energy has specifically considered slope stability in the design of the PR Spring Mine and has ensured -- by applying a conservative approach to design grades -- that the operation will be safe and environmentally sound. The bulk of each mining pit would be constructed within the relatively flat-lying terrain of the plateau top, minimizing slope-related risks. Overburden/interburden storage areas 1 and 2 would be constructed on the steeper side slopes between the plateau top and the base of Main Canyon. Although these overburden/interburden storage areas inherently have a higher potential risk of slope stability issues, the use of flatter-than-needed grades eliminates this risk. All slopes, both interim and final, have been designed to be stable.

Regular and routine inspections will occur throughout the mine area to ensure that operating conditions remain safe; that MSHA safety guidelines are being followed, and that the mining plan stated herein is being followed. This will include inspecting to verify that the pit wall slopes are at the correct angles and that they remain stable.

PITS

The North (Opening) Pit will be incised into the terrain, with the highest walls of the pit being the highwall on the northwest and the sidewall on the northeast. The lowest walls of the pit (low walls) would be located on the southwest and southeast sides of the pit at the head of a natural, ephemeral drainage. All pit walls would be maintained at approximately 2H:1V for stability. Use of this slope represents Earth Energy's desire to facilitate pit reclamation, and to provide conservatively designed pit wall slopes to compensate for the lack of detailed knowledge regarding the extent of localized faulting or fracture planes that could cause instabilities at steeper slopes than those used here. Numerous existing road cuts and excavations in the area (including Earth Energy's 2005 production test pit) are stable with slopes steeper than 1H:1V, providing evidence of the conservative nature of Earth Energy's design. Use of 2H:1V pit walls slope will prevent rock falls. Back-break near the top rim of the pits will be controlled or eliminated by smooth transition grading. Any required blasting along the walls of the pit will be accomplished with small controlled blasts to eliminate over-break and weakening of the remaining material on the face of the slope.

The maximum depth of the North (Opening) Pit would be approximately 140 feet. The minimum depth on the low wall side of the pit would be 20 feet. The thickness of the undisturbed bank of land between the low wall of the pit and the outer side of the native slope would be approximately 100 feet. Exploratory drill hole data did not encounter any groundwater, thus it is highly unlikely that water-bearing strata in the Parachute Member of the Green River Formation would be significant enough to create ponding behind the low-wall.

The West Pit would expand the highwall about 1500 feet to the southwest and the pit floor to approximately 7860 ft. elevation, starting from the northwest corner of the North (Opening) Pit. No water or stability problems are anticipated with the highwalls or low-walls in this pit extension.

As noted above, regular and routine inspections will occur to verify that the pit wall slopes are at the correct angles and that they remain stable.

OVERBURDEN/INTERBURDEN STORAGE AREAS

Overburden/interburden storage areas No. 1 and No. 2 will be constructed during the mining of the North (Opening) Pit and the west extension of this pit (designated as the West Pit). Both overburden/interburden storage areas will be constructed outside of the pit limits on the side-slopes of ephemeral draws above Main Canyon. The overall slopes of the land on which the overburden/interburden storage areas will be constructed ranges from 16.5 to 40 percent (10° to 22°) (see Table 8 below). During mining, the overburden/interburden storage areas will be sloped at 1.5-1.7H:1V. Upon reclamation the slopes will be graded down to between 2.5H:1V to 3H:1V.

Table 8: Slope Angles of Native Lands and Overburden/interburden storage areas

Overburden /interburden Storage Area **Number**	**Total Height in Feet of** Overburden/interburden storage areas **from toe of** Overburden/interburden storage area **to top of** Overburden/interburden storage area* ***(During Mining / Post-Reclamation)**	**Average Native Slope Angle (H:V)**	**During Mining Average Slope Angle of Outer** Overburden/interburden storage area **Slope (H:V)**	**Post-Mine: Reclaimed Average Slope Angle of Outer** Overburden/interburden storage areas **Slope (H:V)**
1	350 / 390	2.7:1	1.5:1	2.5-3:1
2	240 / 270	6:1	1.5:1	2.5-3:1

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The native slopes on which the overburden/interburden storage areas will be constructed are made up of lacustrine sandstone, siltstone, shale, mudstone and calcareous marl overlain by sandstone and shale alluvium and colluvium, with scattered small escarpments and ledges. The surface material is gravelly to cobbly toward the top of the overburden/interburden storage areas with intermittent rock outcrops along the slope, and the bedrock exposed at the base of the overburden/interburden storage areas. Overburden/interburden storage area No. 1 will be constructed on a 40 percent slope (steeper than 3H:1V) that is concave, grading to a slope angle of about 10 percent (10:1) near its base. Overburden/interburden storage area No. 2 will be constructed on a 6H:1V slope. Both overburden/interburden disposal areas will be designed and constructed to be stable within standard engineering parameters.

Erosion Control

Erosion control at the site will in part be accomplished by measures inherent in the design and siting of the facilities. However, some runoff and erosion control at specific locations is expected to be necessary to prevent off-site impacts. Generally, surface water will be restricted to that generated by on-site precipitation: little or no up-gradient runoff will enter the site. What surface water runoff does occur will be controlled such that erosion is minimized.

A few of the specific means of handling runoff and controlling erosion are described below, with reference to specific typical drawings. The exact placement of most of the features will hinge upon either the final engineered plans for the development, or the specific nature of observed instances of runoff/sediment problems once the site is developed, or both. As committed to, final engineering drawings will be submitted to DOGM once they are available. In addition, should the specific means of handling runoff and controlling erosion that are described in this section be ineffective, Earth Energy would replace them with another type of BMP. These structures will be industry standard, using similar materials, installation techniques, and maintenance protocols as specified in DOGM's reclamation guide (DOGM 2008).

Only minor amounts of runoff will be generated on the outslope faces of the overburden/interburden storage areas, because up-gradient runoff will be kept away from the outslopes, outslope gradients are not excessively steep, and material makeup of outslopes will allow for infiltration. Further, runoff will be controlled by facing the steepest portions of the slopes with coarse overburden material, dedicated armoring placed within the "channel" formed by the contact between the pile and the native slope, and by installing a rip-rapped energy dissipater at the toe. Typical design drawings are included in Figure 2a. Controlling runoff will minimize sediment production, and the energy dissipaters will also serve as sediment traps, causing at least some of the sediments to drop out. Further, as these materials will primarily consist of broken sandstones and shales mixed with lesser amounts of fines, their grain sizes will vary from fine to coarse rock rubble (run-of-mine) materials potentially as large as one cubic yard. The coarser materials will typically end up near the toe of the expanding fills as the dump sites are filled to their maximum capacity. The minimal erosive potential of the proposed design slopes has been confirmed through monitoring of the similarly constructed overburden storage piles adjacent to the Company's 2005 production test pit. The concentration of coarse materials at the toe of the fills provides a natural energy dissipater for storm runoff from the faces of the dumps. This broken rock material has a very low siltation potential and will effectively encapsulate the finer material initially placed in the upper reaches of the waste dumps. Last, the top surfaces of these overburden interburden storage areas will generate very little runoff or sediment as they will be maintained with a gentle grade away from the outslope (toward the plant site and the pit, from which there will be no runoff and/or sediment discharge). Through the dumping mechanism, both outslopes and top surfaces will generally have roughened surfaces to further reduce runoff velocities and encourage material trapping.

All topsoil piles will be bermed to catch eroded material and prevent run-on and run-off of storm water. As noted in Section 106.6, these berms will either be comprised of topsoil, or built using the salvaged and compacted woody vegetation that is removed prior to topsoil salvage activities. These berms will be trapezoidal in cross section: two feet high, with a two-foot wide top width and approximately 1.5H:1V sideslopes. Figure 2d provides a typical cross section for these types of berms.

The active mining area will be a pit at all times (concave to incident precipitation and run-on). No operational pit configurations are planned where storm water will be allowed to egress the active mine workings. Thus, no specific erosion controls are needed for the pit area.

Most of the haul roads will be integral or adjacent to the pit and overburden/interburden storages areas and will not require separate erosion control. As needed, however, certain haul roads will be ditched, and if the grade increases to above two percent, water turn-outs will be constructed to prevent erosion of the road base. A typical ditch is shown in Figure 2c and a typical rolling dip turnout is shown in Figure 2f. Additionally, these ditches may also be outfitted with small coir rolls, silt fences, or other check features if needed; a typical installation is also shown on Figure 2e.

The facilities site will be constructed to be a self-contained area through the use of perimeter berms or ditches (see Figure 2c-2f for typicals) as needed to direct runoff. All precipitation incident on the site will be collected in the water retention/storage pond located at the low point of the plant site (Figure 3) and used in the extraction process or for dust suppression on mine and plant roads. This pond will also be used to store clean reserve process water. Sediment production from the plant site will be negligible, due to gradient and surfacing; any transported in runoff would eventually make its way to the water retention/storage pond. This pond will be cleaned of sediments as needed.

All BMPs will be regularly inspected, and maintained in operable condition. These above-noted types of BMPs are also described in a Storm Water Pollution Prevention Plan (SWPPP) developed to comply with a State of Utah Multi-Sector General Storm Water Permit for Industrial Discharges (and/or the analogous EPA permit). The Permit also requires quarterly visual monitoring of storm water discharges. These measures would reduce the likelihood of inadvertent discharges of process waters or erosion-produced sediments. This SWPPP is included with the NOI as Appendix G.

AIR QUALITY

Potential air quality issues include the following:

- Fugitive dust from stripped lands, the mine pit, overburden/interburden storage areas, and topsoil stockpiles.
- Fugitive dust from the plant site area and ore stockpiles
- Emissions from the equipment used to mine, haul and process the ore
- Fugitive dust from newly reclaimed lands

Fugitive dust will be minimal from ore piles. Overburden and interburden may or may not be moist, depending on current weather conditions. However, consistency of raw ore is massive to granular and thus does not readily become airborne.

Once the tar is removed from the ore, clean sands are left to be used as backfill. This sand material will hold approximately 10 to 20 percent moisture. Waste sands and over/interburden will be alternated in construction of the overburden/interburden storage areas and backfill of the pits, to increase stability and reduce wind-blown sand, should it become dry.

Haul roads will be sprayed regularly with water from a water truck. Water will be obtained from the well associated with Exploration Notice #E0190053 and for which Earth Energy retains a water right that allows use of water for this purpose.

Earth Energy has coordinated with EPA on air permitting to sufficiently address the above air quality issues, including those associated with equipment emissions.. (EPA has taken the lead on air permitting for this operation given its Tribal Land location.) Earth Energy intends to comply with the conditions set forth by EPA; documentation is included in Appendix B.

PUBLIC HEALTH AND SAFETY

The following measures are in place to protect public health and safety:

- MSHA safety guidelines will be followed in all aspects of this project.
- There are no shafts or tunnels within the Affected Area and therefore none that require closing or guarding.
- All trash, scrap metal, and wood, and extraneous debris will be temporarily stored at a designated location prior to being routinely hauled offsite to a licensed facility. Further, volumes of material such as product, waste oil, etc. will be periodically removed from the site as needed so that their allocated storage is not exceeded.
- Any exploratory or other drill holes will be plugged or capped as set forth in Rule R647-4-108.
- Warning signs will be posted in locations where public access to operations is readily available, including at the points of exit/entry from the main access road (Co. Road 2810) to the open pit and processing facilities.
- All blasting materials are kept in locked, ATF-approved magazines.
- Warning signs advising the public of blasting protocols will be posted at the access road to the pit area at the appropriate locations as required by MSHA from the time a blast begins to be set until the all-clear is given. These signs will include blasting schedules.
- The opening pit highwall will be bermed and fenced along the County Road. As recommended by the Utah DWR (personal communication with Brian Williams, DWR Northeast Region), this fence will be between 38 and 48 inches high, comprised of three or four strands barbed wire, topped with a log rail. It will be anchored with T-posts. Signs will be placed along the fence line every 150 feet to warn the public of the mining activity, including the potential for blasting. These signs will include blasting schedules.
- During all Earth Energy mining work in the vicinity of the Canyon Gas natural gas pipeline, Earth Energy would operate safely and in cooperation with Canyon Gas to ensure safety of both operations and the public.
- Containers stored on-site will be labeled so that wastes are clearly identified. Salvageable materials and other wastes will be stored at the plant site within the fenced area. No hazardous materials or hazardous wastes will be generated or used during this operation, thus none will be stored.

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R647-4-110. Reclamation Plan

110.1 Current Land Use and Post Mining Land Use

The current land use is mining, exploration, and wildlife habitat/open space. Due to the nature of exploration and ongoing activity in the Uinta Basin, the post mining land use is likely to include exploration (by entities other than Earth Energy who may be exploring for oil and gas), as well as wildlife habitat and open space. While recognizing that oil and gas exploration may occur in the future, no further exploration is currently planned by Earth Energy, and the stated objective of reclamation planning in this NOI is to reclaim the site in order to provide for future post mining land uses of wildlife habitat and open space. In order to ensure an environmentally safe and stable condition for the wildlife in the area that meets the objectives of the Utah Mined Land Reclamation Act 40-8-12, Earth Energy will leave safe, stable topography; establish native vegetation suitable for habitat; remove man-made structures, including tanks, ponds, etc.; and cause no degradation or harm to water sources.

CULTURAL RESOURCES

Cultural resources were reviewed and inventoried onsite. No previously documented or new cultural resources were recorded (See Appendix B).

110.2 Reclamation of Road, Highwalls, Slopes, Etc.

If economics allow, mining may continue in other portions of the Study Area. In this case, facilities, and some roads may be maintained for access, and all new disturbances and operations would be subject to new permit approvals, either through amendments to this NOI or otherwise as required by DOGM. (These amendments or revisions would address how any mine expansion would occur, including details on any limited need for re-handling of materials, alterations to the processing plant, etc.) At this time, however, the mine/reclamation plan and associated bond estimate are based upon initial North (Opening) Pit mining, the West Pit, and associated disturbance. Also, for the purposes of the reclamation plan and bond estimate, it is assumed that all facilities and roads within the 213-acre Affected Area will be reclaimed as stated herein.

The overall objective of the reclamation plan described herein is to reclaim the entire Affected Area so as to allow postmining land uses of wildlife habitat and open space to resume. This objective will be met in part by removing facilities and structures that have been brought to the site, regrading, topsoiling, and reseeding, as described in more detail below. The intent is to meet the requirements of the

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Utah Rules at R647-4, as stated in Section 110.6 below, and to meet the objectives of 40-8-12 of the Utah Mined Land Reclamation Act which include provisions for a safe, stable, environmentally functioning site.

Safety will be managed at reclamation by continuing to follow safe operating conditions while using equipment and continuing to follow the appropriate MSHA guidelines and regulations. Throughout the reclamation activities, visual inspections will be made at the site, under the terms of the Storm Water Permit(s) issued by either EPA or DWQ (depending upon Tribal Land jurisdictional decisions), which must remain active until bond release has been obtained. This will focus on erosion and sediment control, further ensuring that reclamation goals can be met. Further, visual inspections will also be made by DOGM, and will include ensuring that all reclamation activity obligations under the Utah Mined Land Reclamation Act and associated rules are being met. These inspections will continue until such time as DOGM approves the reclamation work and releases the surety.

Various types of equipment will be used to accomplish the reclamation objectives, as detailed in the surety calculations (Appendix E). This equipment includes: D6 and D8 dozers, Caterpillar 14 grader, Caterpillar 631 scraper, 65-ton crane, hand power tools, 35-ton dump truck, 950 loader, semi- and low-boy trailers, 100 bbl water truck, trackhoe, backhoe, seeder, and manure spreader. The water truck will be used to provide dust suppression as needed, and water will come from the well associated with Exploration Notice #E0190053 and to which Earth Energy has a water right for such uses.

ROADS

During operations, interim reclamation, and on-going reclamation and while on-site roads are still needed to access Affected Areas during final reclamation, Earth Energy will maintain roads as needed to minimize erosion and off-site sedimentation. Such road maintenance will continue until the roads are fully reclaimed.

There are approximately 17 acres attributed to roads that are not integral to the overburden/interburden storage areas (approximately 9,260 feet in length by 80 feet wide). During final reclamation, these roads would be deep-ripped to relieve compaction, regraded to blend with site topography, topsoiled, and seeded. Except where bedrock is encountered, ripping will be 24 inches deep, with ripper shanks spaced no more than 24 inches apart. In shallow bedrock areas, ripping depth may be less than 24 inches, by necessity. Roads that are integral to the overburden/interburden storage areas will be reclaimed as part of those features.

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HIGHWALLS

No highwalls would remain at the end of mining as pits would be backfilled and/or graded off to blend with the existing surrounding topography.

SLOPES

All overburden/interburden storage areas (covering approximately 70 acres) and backfilled pits will be regraded to a 2.5-3H:1V or flatter slope to achieve a stable, natural-looking landscape. While short segments may exceed this overall slope, no areas will be so steep as to be unstable, cause safety hazards, encourage erosion, or hinder successful revegetation. The overburden/interburden storage areas will be re-contoured by dump-top rounding, toe extension and surface recontouring to create an undulating, roughened surface that will blend with the surrounding terrain, provide a site amenable to revegetation, and minimize runoff and erosion. The steepest portions of slopes will be faced with coarse overburden material to minimize erosive potential. This will be done with a trackhoe, backhoe, and/or dozer prior to topsoil placement. Safety and erosion control will be of primary focus during reclamation activities. As described further in Section 110.5, available salvaged topsoil will be applied to all areas with the exception of the armoured drainage channels. The entire area will be seeded with native species to stabilize the soil, and provide for the post-mining land use.

As noted, drainage will not be an issue on these regraded areas as there is little to no run-on and infiltration capacity will be high on reclaimed slopes.

PITS

Pits (approximately 93 acres) would be backfilled to approximately 60-65% of their original volume, primarily with produced sand, inter-mixed with overburden/interburden. Since the pit floor will be backfilled as part of the cast-back mining process, it will not need to be ripped. The final cut during mining will create a 3:1 slope to blend with surroundings. This will create a near-level surface (see cross-sections), thus no additional backfilling will be required during reclamation of the mined-out pits. The rough backfilled surface will be finish-graded and contoured with a road grader to assure the land blends with surroundings.

Remaining pit walls will be graded down to blend with the backfilled materials. The resulting contours would be graded to blend with surrounding topography, topsoiled, and seeded. The pit will not be an impounding feature upon final reclamation.

DRILL HOLES

No drill holes would remain at the end of mining.

FACILITIES AND MATERIALS

Some of the facilities on the 15-acre facility site would be taken apart and hauled away for disposal. Others would be buried onsite. As described further in the surety calculations (Appendix E), the maintenance building, warehouse, power plant, process train, distillation unit, sand dewatering unit, pond liner, Atco trailer, and 22 tanks would be hauled away. The facilities for which on-site burial will occur include the following: gravel from the parking area; foundations of Sprung structures; and reserve ore, sand, fines, and reject materials. Prior to any on-site burial activities, Earth Energy will obtain a solid waste disposal permit, if one is found to be necessary.

The maintenance building and warehouse are "Sprung" aluminum structures and are easily dismantled using hand power tools and crane. The mine office is a one-piece modular "Atco" office structure mounted on I-beams. Atco, which has been in business since 1947, includes removal of the structure in the purchase price, so no reclamation cost is included for this. The Power Plant is approximately 2,500 ft^2 and 20 tons, and consists of 1 gas generator, 1 diesel back-up, and 1 boiler. The process train, including piping, hoses, etc. is skid-mounted and is approximately 480 ft. long by 75 ft. wide by 20 ft. high, with a void volume of 30% for an assembled volume of 8,000 CY of material. Cut up, the volume would be roughly 25% of this, or 2,000 CY. The sand dewatering unit weighs approximately 30 tons.

All process materials will be removed from the train, prior to its being removed from the containment area, disconnected to individual skids, and hauled away. All of the residual process material will be separated into a solid, aqueous, or hydrocarbon phase. The solid phase can be discharged on site to the mined-out pits, as it consists of the same materials that have already been placed in that area. The aqueous phase will be discharged to the water storage/retention pond where it will evaporate or be pumped to a tank or container for off-site disposal. That pond will have been used for similar liquids during operations. Any remaining hydrocarbon phase that is not sold to a refinery will be recovered with a vacuum and hauled off site. No process materials that are hazardous or represent an impact to public health and safety will be disposed on site.

The re-bar reinforced concrete foundation under the warehouse and maintenance shop (each 10,000 ft^2) will be ripped up and broken into chunks using the D8 dozer.

The water/storage pond liner (60 mil) will be removed and hauled to the Uintah County Landfill on a flatbed as part of other loads. Gravel from the equipment parking and service area (approximately 2.6 acres in size, or 1,396 CY of gravel) will be pushed into water retention pond after removal of liner with dozer. Reserve, sand and fine tails, and reject ore stockpiles (approximately 60,000 CY, total) will be loaded into trucks and hauled back to pit where an opening will be made to place unused ore in the backfilled pit. The 15-acre facilities area will be ripped, topsoiled, and reseeded.

Trash removal will occur after all buildings and facilities are removed; it will involve collection of all refuse, litter, stray metal, pipe, wood, insulation, and other debris. The 213-acre area will be inspected to check for and collect trash.

There would be no shafts or adits, or similar structures that would require reclamation. As noted above under the Pits subheading, the operating pit that forms an impoundment will not be impounding after backfilling and reclamation. Further, as described, the water retention pond will be reclaimed and thus will not remain an impounding feature.

110.3 Surface Facilities to Remain

The processing plant, all associated support facilities, and mining equipment would be removed from the site, unless economic conditions allow for continued mining, in which case the site processing facilities would remain intact on the 15-acre processing site.

Approximately 4,000 feet of fence with a wooden top rail (as per DWR request) will be in place when reclamation commences, as well as two metal safety gates, and safety signs. The fence and signs located along the county road will be left in place until bond release, at which time they would be removed.

110.4 Treatment, Location and Disposition of Deleterious Materials

During operations, all new and spent fuel, oil, and lubricants will be stored within secondary containment as required by the SPCC Plan, as further described in the operations Section 106.2. These containers and their contents will be removed to a licensed disposal facility prior to reclamation of the process facility. If any hydrocarbon spills occur during mining these will be dealt with as outlined in the SPCC Plan, and thus will not pose a problem during reclamation. Any fuel spills that occur during the reclamation process would be similarly managed.

Any other chemicals, including the process chemical, present during operations, would be consumed during mining and processing. Any of the stored substances remaining onsite at the end of mining would be properly removed and disposed of, prior to final reclamation. Any remaining fuels would be used to fuel equipment used in reclamation work. Fuels and liquids remaining after reclamation will be

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removed for disposal or re-use by a company such as Tri-State Recycling. No acid forming or deleterious material would be left on-site.

110.5 Revegetation Planting Program and Topsoil Redistribution

Table 9, below, shows that all of the 213 acres of Affected Areas will be reclaimed by various methods. This includes redistributing topsoil on all areas except those associated with the armored drainage channels and the topsoil storage areas (soils will not have been salvaged on those areas, so original topsoil will remain).

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Table 9 Reclamation Treatment Acres

Facility	Affected Area (acres)	Acres to be graded	Acres to be ripped	Acres to be topsoiled	Seeded Acres
Plant Site including Office and Processing facilities	15	0	15	15	15
Plant Perimeter Road	5.5	5.5	5.5	5.5	5.5
Haul Road Segment 1	5.5	5.5	5.5	5.5	5.5
Haul Road Segment 3	3.0	3.0	3.0	3.0	3.0
Haul Road Segment 5*	3.0	3.0	3.0	3.0	3.0
North (Opening) Pit	62	62	0	62	62
West Pit	31	31		31	31
Overburden/interburden storage area 1	36	36	0	36	36
Overburden/interburden storage area 2	34	34	0	34	34
Topsoil storage areas	18	0	18	0 (topsoil already in place)	18
Total	213	180	50	195	213

*Haul Road Segments 2 and 4 are integral to overburden/interburden storage areas and reclamation treatments are included within those facilities.

Soil Material Replacement

Once final grading is complete, as described above, topsoil will be replaced using scrapers and dozers. Topsoil would be placed on the backfilled and regraded surfaces of the pit and overburden/interburden storage areas (with exceptions as noted previously) as the mining/processing/ backfilling sequence allows. Approximately 132,250 cubic yards of topsoil will be redistributed to about a 5-inch depth with a scraper and dozer assist, over approximately 195 acres of the mine. Topsoil storage areas will not be topsoiled.

The graded/topsoiled surfaces would be ripped with a road grader on the contour to provide a greatly roughened surface to retain seed and to enable root penetration. Vegetative matter gathered during the topsoil salvage operations and stockpiled as a component of those piles would also be spread along with the topsoil, providing organic matter and helping with soil moisture retention. Any additional salvaged vegetation that was stored in slash piles will be placed and redistributed on reclaimed areas in order to provide organic matter and surface roughness.

Equipment used for this task is likely to be a dozer, scraper and farm tractor/ implements.

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SEED BED PREPARATION

As described above, the topsoil will be spread and left in a very roughened surface that will be loose but not erodible. Ripper shanks on a road grader will be used to stabilize soil, depending on field conditions. The ripper will be used with shanks spaced approximately 36 inches apart and 18 inches deep. The salvaged topsoil will provide a reasonable growth medium for the site. No mulch or fertilizer will be used in reclamation efforts. The final surface will be rough, creating small depressions for water retention sites and habitat niches.

Seed Mixture

A single seed mix (below) will be used for all reclaimed surfaces and is based on sampling results and NRCS ecological site data. Any alterations beyond what is included in the list would require agency approval. All 213 acres affected will be seeded with a D6 tractor-pulled broadcast seeder.

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Table 10: Seed Mix

SPECIES	SEEDS/LB	PLS* LB/AC
Forbs -		
Blue flax (*Linum lewisii*)	293,000	0.50
Rocky Mountain penstemon var. Bandera (*Penstemon strictus*)	592,000	0.25
Small burnet (*Sanguisorba minor*)	55,000	1.00
Lupine (*Lupinus caudatus* or *L. alpestris*)	27,600	1.00
Total forbs in seed mix		2.75
Grasses -		
Muttongrass (*Poa fendleriana*)	890,000	2.00
Canby bluegrass (*P. canbyi*)	926,000	1.00
Indian ricegrass (*Achnaetherum hymenoides*)	150,000	2.00
Great basin wildrye var. Magnar (*Leymus cinereus*)	130,000	2.00
Bluebunch wheatgrass (*Pseudoroegneria spicata ssp. spicata*)	140,000	3.00
Western wheatgrass (*Pascopyrum smithii*)	110,000	3.00
Total grass in seed mix		13.00
Shrubs -		
Sagebrush – Wyoming or Mountain (*Artemisia tridentata wyomingensis or vaseyana*)	2,500,000	0.25
Bitterbrush var. Lassen (*Purshia tridentata*)	15,000	2.00
Serviceberry (*Amelanchier alnifolia*)	25,800	1.00
Snowberry (*Symphoricarpos oreophilus* or *S. albus*)	75,000	1.00
Total in shrubs in seed mix		4.25

Total pounds of seed applied per acre: 20.0 PLS lb/ac

* PLS = Pure Live Seed

Seeding Method

The seed mix would be broadcast seeded on all areas that will be reclaimed, including regraded overburden/interburden storage area slopes and pit slopes. Revegetation work, including both seedbed preparation and seed application will take place in the late fall season and seed would be spread as soon as possible following seedbed preparation.

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Other Revegetation Procedures

As noted throughout this document, all reclaimed slopes will be stabilized by regrading to 2.5H:1V or flatter and leaving them in a very roughened form to maximize infiltration and minimize runoff. It is important to note that there will be little to no run-on on these reclaimed surfaces. Further, in regard to the overburden/interburden storage area slopes, the coarser materials will typically end up near the toe of the expanding fills as the dump sites are filled to their maximum capacity. The concentration of coarse materials at the toe of the fills provides a natural energy dissipater for storm runoff from the faces of the dumps. The broken rock material has a very low siltation potential and will effectively encapsulate the finer material initially placed in the upper reaches of the overburden/interburden storage areas.

Earth Energy would monitor for noxious weeds, and would provide weed control measures according to County directives should noxious weeds pose a potential problem. This would be done in the early summer months each year after reclamation until bond release has occurred. The monitoring would consist of a site visit by a biologist familiar with the potential noxious weeds, and a simple visual walk around the 213-acre area would be sufficient for this small area. If any noxious weeds are identified, the County would be informed of their extent, and actions taken as directed by them.

Further, Earth Energy would qualitatively and visually monitor revegetation success for the first two years after reclamation, during the growing season. During the third summer, quantitative surveys, following the appropriate Division guidelines, will be conducted to assess revegetation success. This will determine whether revegetation has achieved 70 percent of the pre-mining cover, and survived after three growing seasons, as required by R647-4-111.13.11.

110.6 Statement

Earth Energy would conduct reclamation as required under the Utah Rules R647-4.

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R647-4-112. Variance

No variances are being requested for this mining operation.

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R647-4-113. Surety

A reclamation surety estimate is being provided to the Division and is summarized below. See Appendix E for the spreadsheet and backup information. The bond is for 213 acres and is shown as "Affected Area" acres on Figures.

1)	Clean-up and removal of structures	$ 244,744.
2)	Backfilling, grading and contouring	$ 18,740.
3)	Soil material redistribution and stabilization	$ 120,281.
4)	Revegetation (preparation, seeding, mulching)	$ 174,387.
5)	Safety gates, berms, barriers, etc.	$ 14,208.
6)	Demolition, removal or burial of facilities/structures, regrading/ripping of facilities areas	$ 127,697.
7)	Regrading, ripping of waste dump tops and slopes (overburden/interburden storage areas)	$ 362,549.
8)	Regrading/ripping of topsoil stockpile areas	$ 1,788.
9)	Ripping access roads	$ 4,834.
10)	Drainage reconstruction	$ 0.
11)	Mulching, fertilizing and seeding the Affected Area	$ 0.
12)	General site clean-up and removal of trash and debris	$ 18,791.
13)	Removal/disposal of hazardous materials	$ 275.
14)	Equipment mobilization	$ 9,721.
15)	SUBTOTAL 1 Base cost for reclamation	$ 1,098,014.
	15.1 Supervision during reclamation	$ 109,801.
	15.2 Revegetation monitoring & weed control	$ 119,361.
16)	SUBTOTAL 2 Reclamation, Supervision, & Monitoring	$1,327,176.
	16.1 Contingency (5%)	$ 66,359.
17)	SUBTOTAL 3:	$1,393,535.
	17.1 Escalation (for 5 years at 3.8% per yr.)	$ 285,675.
18)	TOTAL: Reclamation liability estimation	$1,679,210.
	ROUNDED TOTAL:	$1,679,200.

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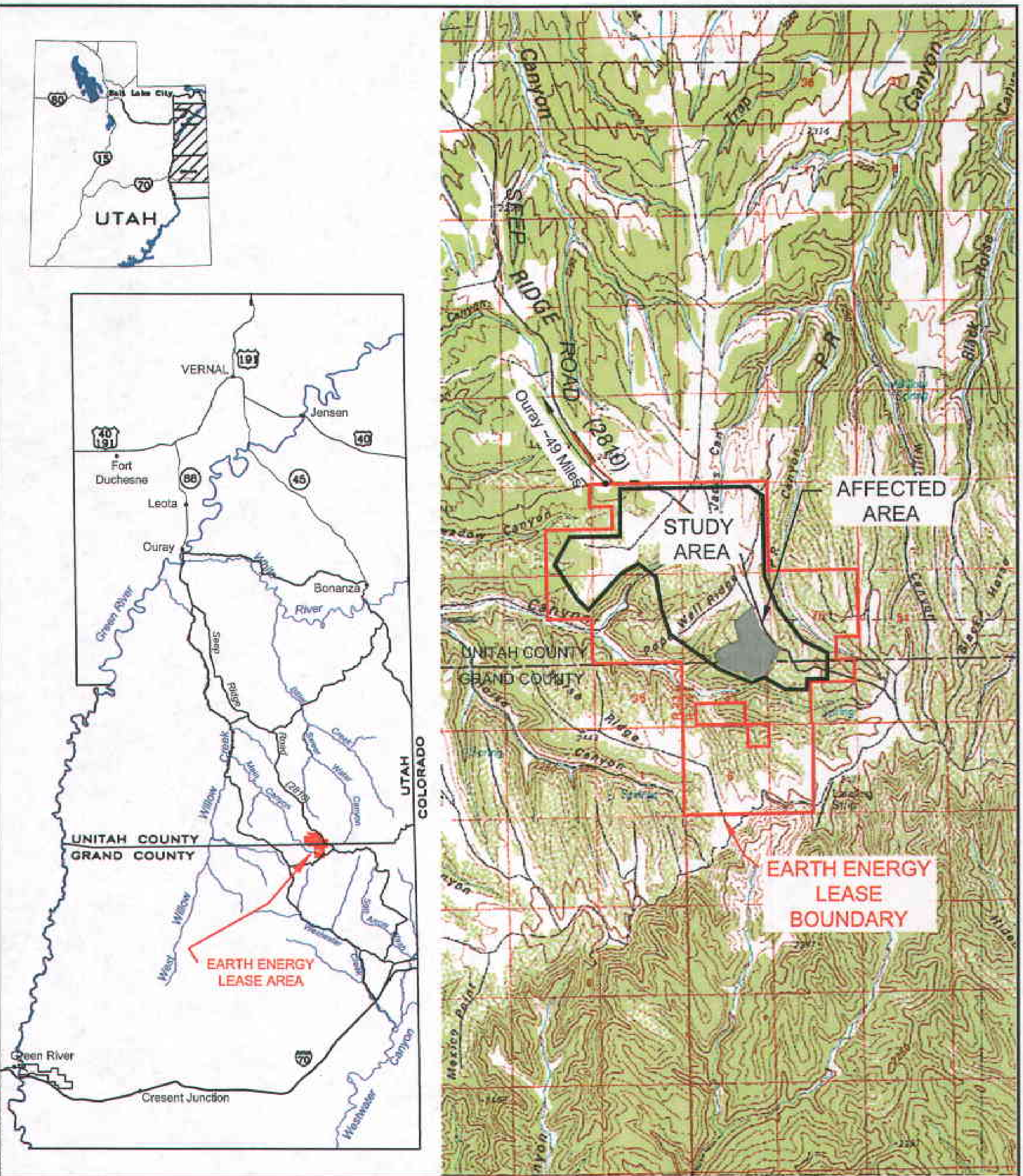
Figures



Base from USGS 1:100,000-scale *metric* topographic map of: Seep Ridge, Utah-Colorado, 1981 and Westwater, Utah-Colorado, 1980.

N

1 0 1 2 3 4 KILOMETERS

1 0 1 2 MILES

Contour Interval 50 Meters

EARTH ENERGY RESOURCES, INC.

PR SPRING TAR SANDS DEVELOPMENT PROJECT

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FIGURE 1
PROJECT LOCATION MAP

jbr environmental consultants, inc.

DESIGN BY	LM	DRAWN BY	CP	CH'D BY		SCALE	1:100,000	DATE DRAWN	9/11/07
								REVISION	3/31/08
									10/30/08

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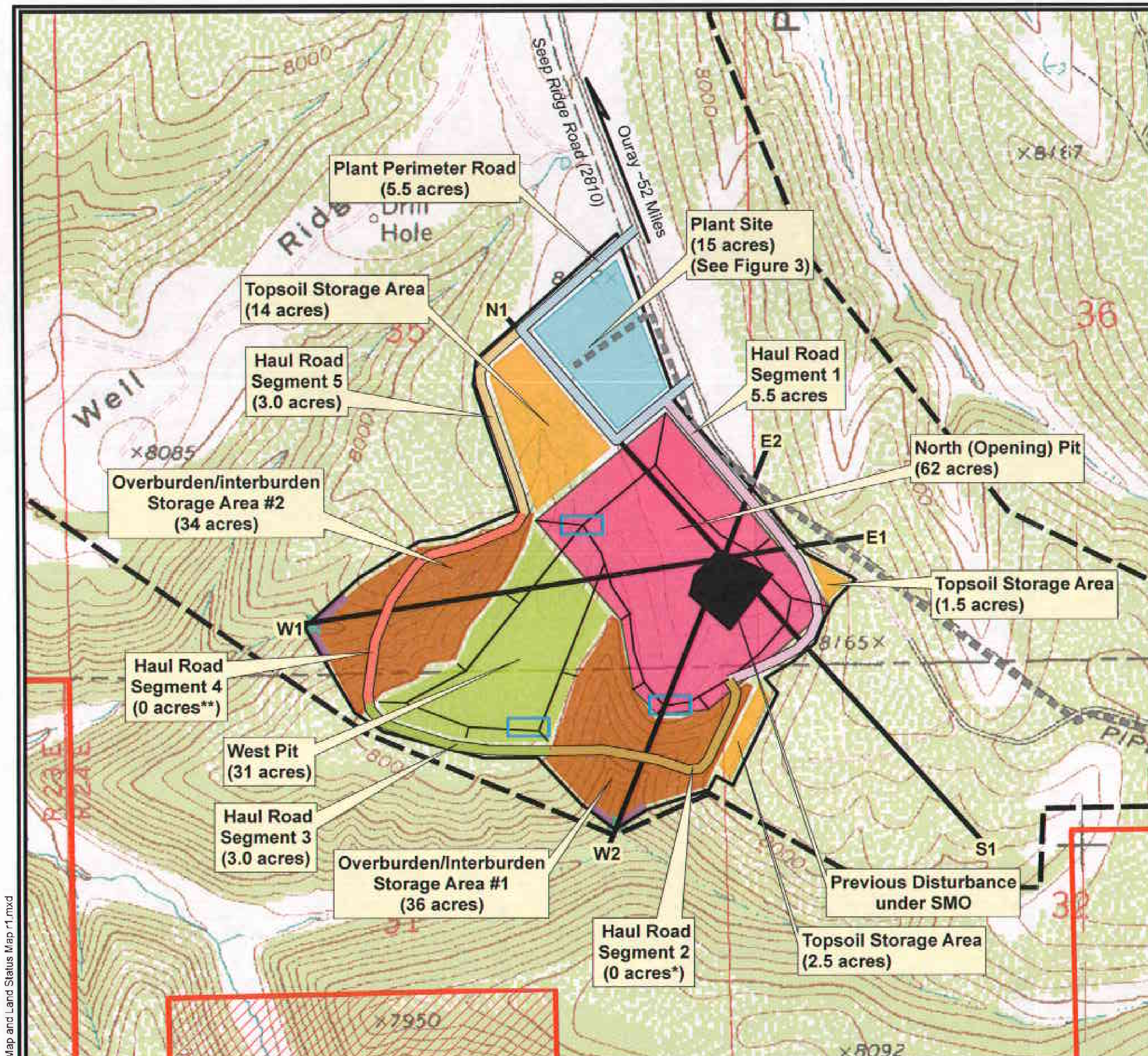
drawings\EarthEnergy\Fig1 Location Map r1.dwg



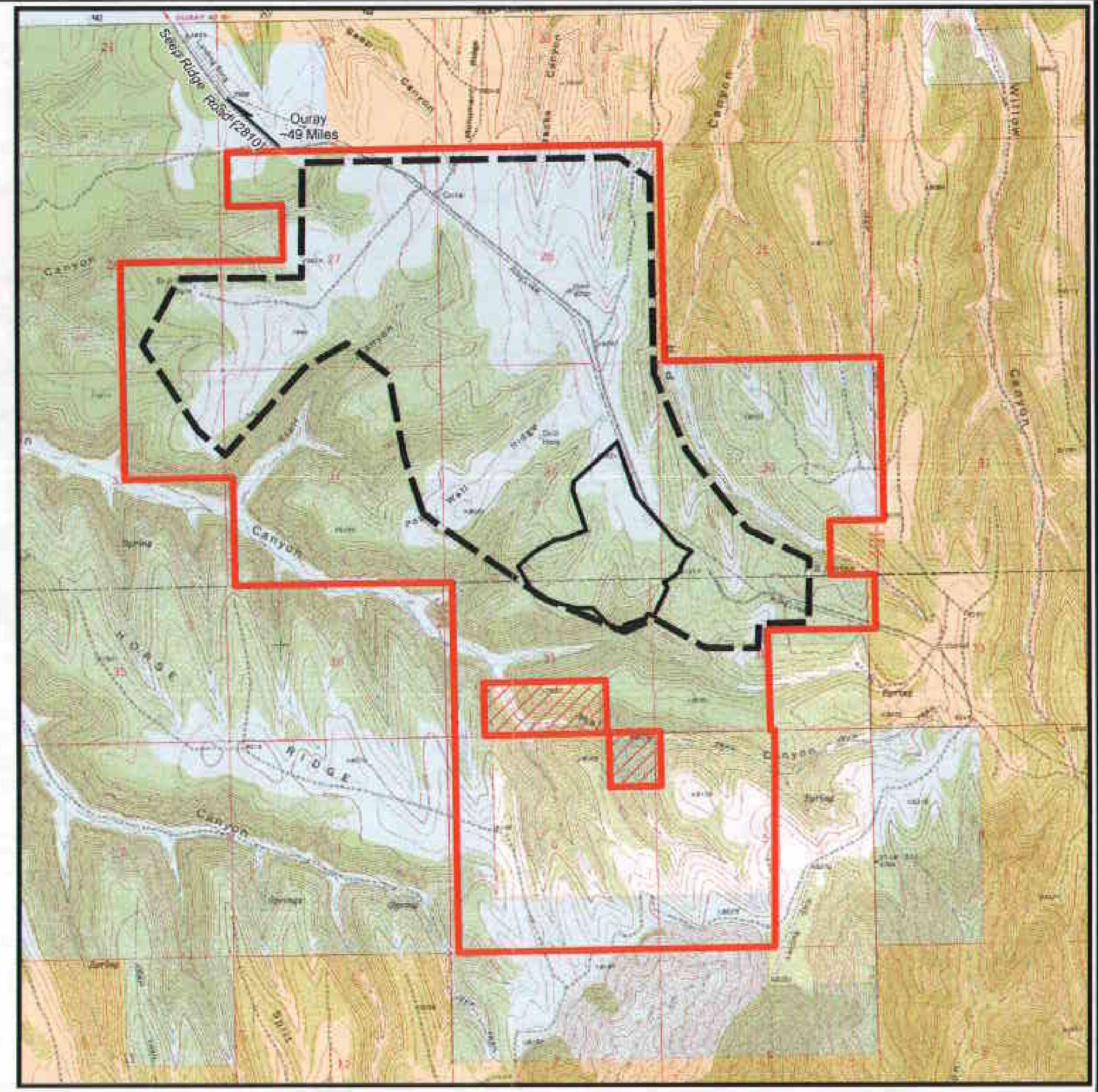
1:12,000

Legend

Earth Energy Lease Boundary	Previous Disturbance under SMO	Collection Sump (inflow)	Haul Road Segment 3
Property Excluded from Lease	Plant Site	Rip-Rap Energy Dissipater	Haul Road Segment 4**
Affected Area	Topsoil Storage Areas	Rip-Rap Armoured Channel Bed	Haul Road Segment 5
Study Area Boundary	West Pit	Plant Permimter Road	
Cross Section Line	Overburden/Interburden Storage Areas	Haul Road Segment 1	
Water Pipeline (Water line not part of this NOI - permitted under Exploration Notice #E0190053)	North (Opening) Pit	Haul Road Segment 2*	

* Acreage Intergal with Overburden/Interburden Sorage Area #1

** Acreage Integral with Overburden/Interburden Storage Area #2



Legend

- Affected Area
- Study Area Boundary
- Earth Energy Lease Boundary
- Property Excluded from Lease

Land Status

- BLM
- State

1:48,000

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FIGURE 2
MINE SURFACE FACILITIES
AND LAND STATUS MAP

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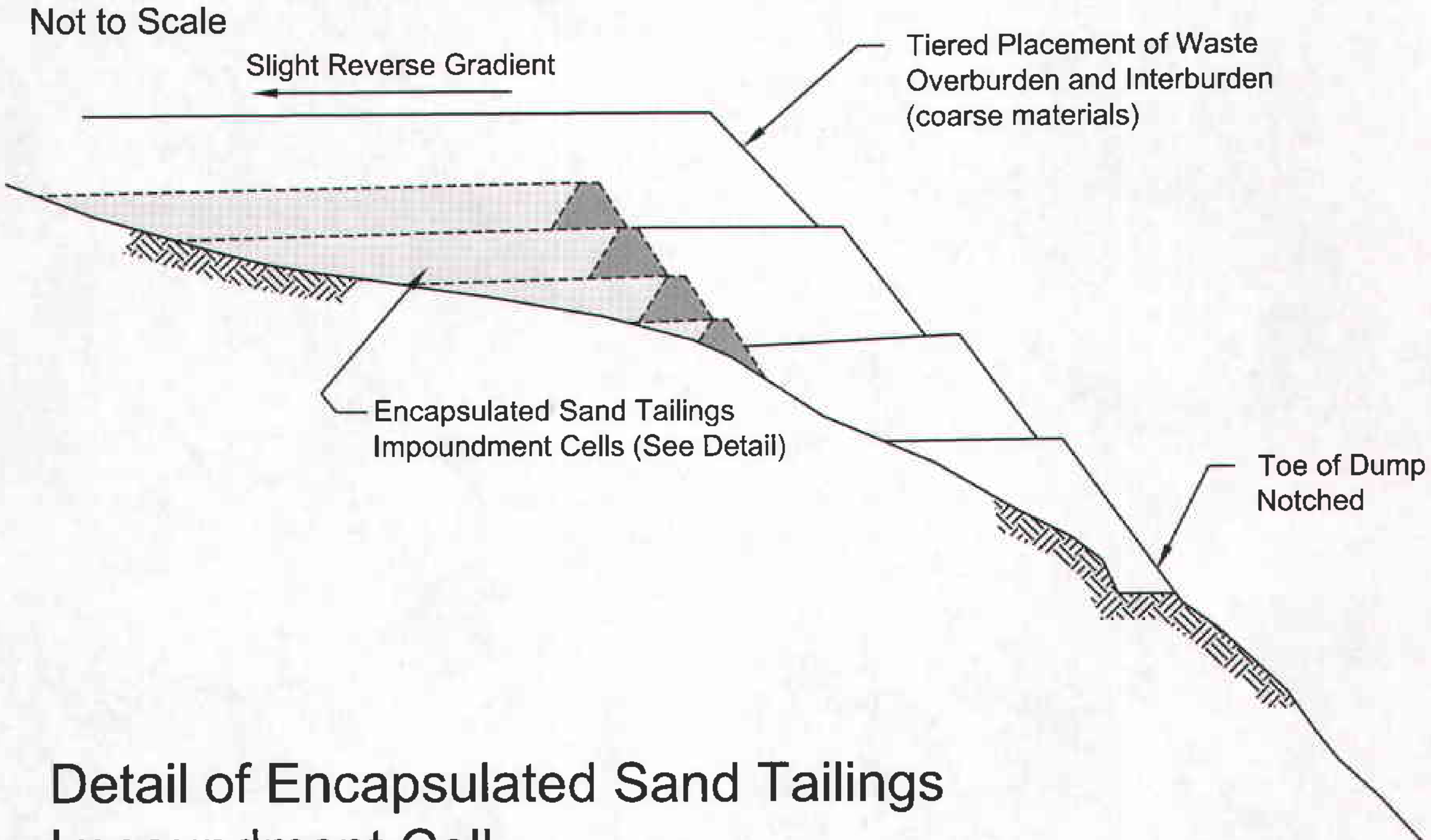
DESIGN BY	LM	DRAWN BY	CP	SCALE	As Shown	DATE DRAWN / REVISIONS	9/11/07, 3/31/08, 5/08/08, 10/30/08

drawings\Earth Energy\Fig2 Mine Surface Facilities Map and Land Status Map r1.mxd

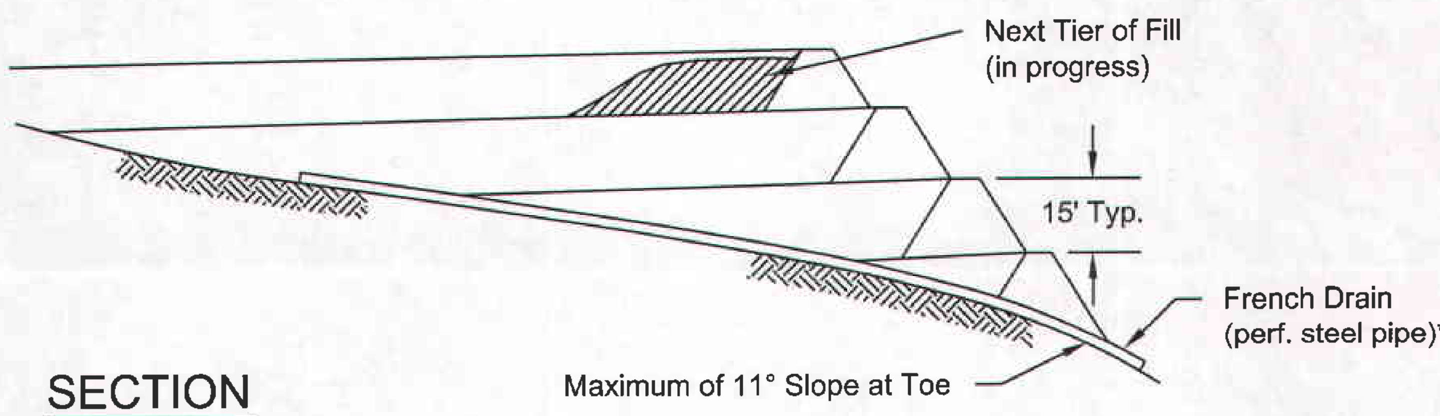
General Arrangement of Overburden Dump and Sand Tailings Encapsulation Cells

Not to Scale

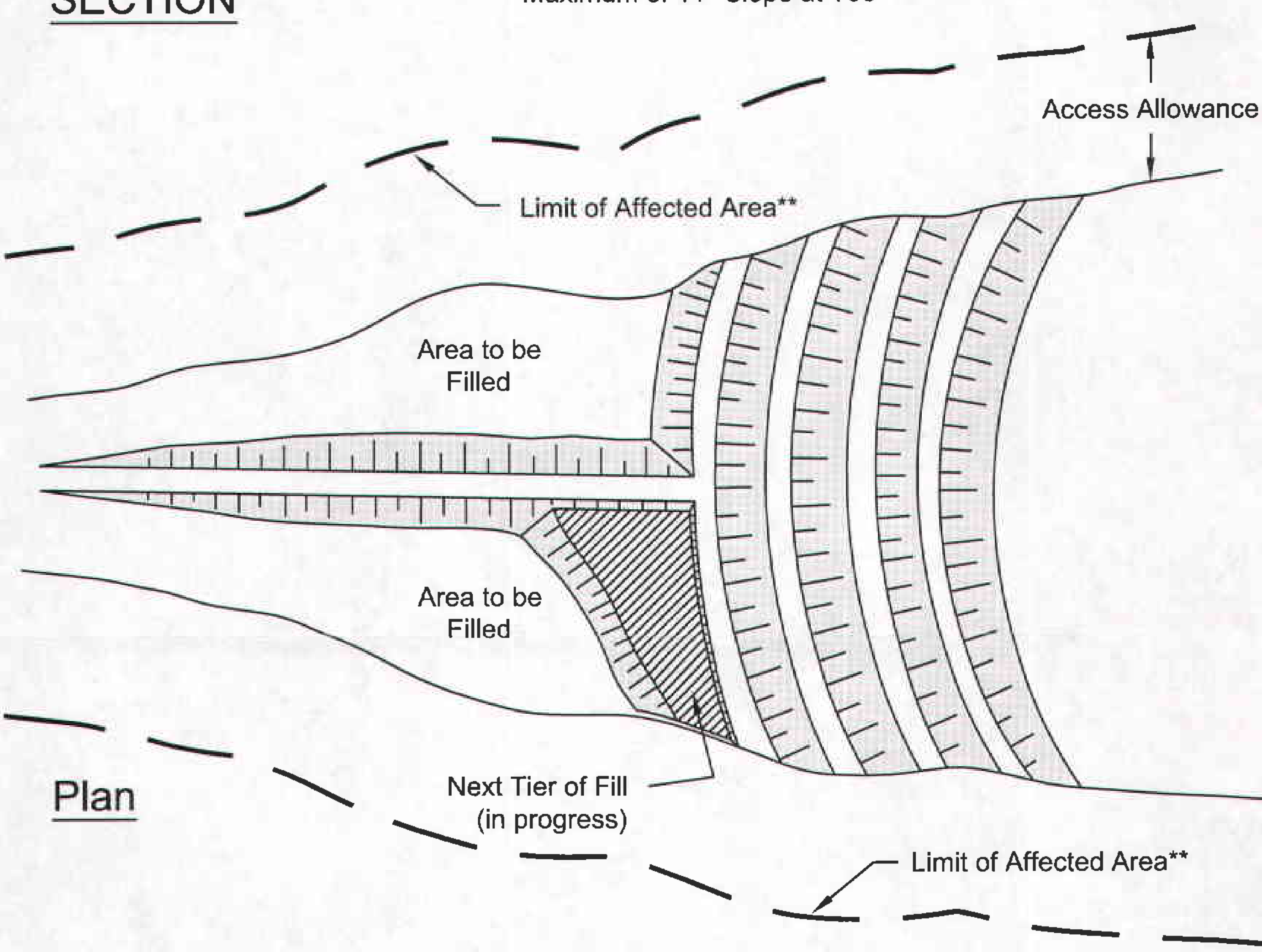


Detail of Encapsulated Sand Tailings Impoundment Cell

Not to Scale



SECTION



Plan

*Or similar means to provide drainage.
**Sufficient acreage maintained to allow truck access to the lower areas of the overburden/interburden storage area.

Note: Construction access will be within defined affected area boundary.

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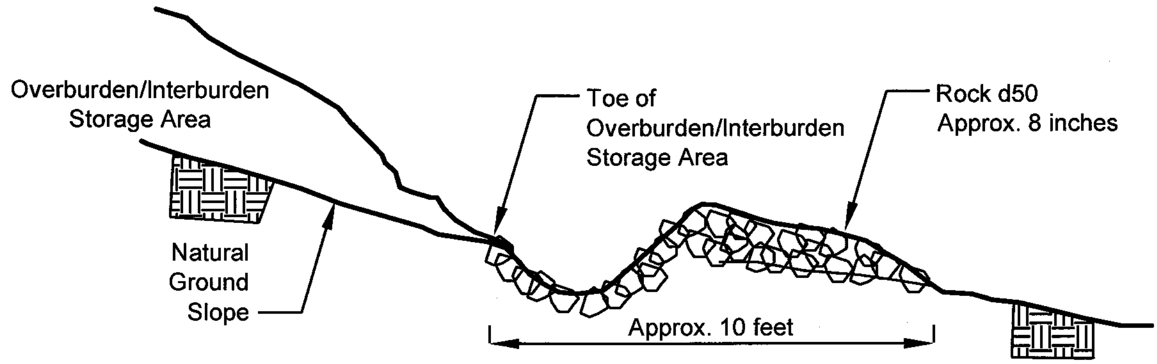
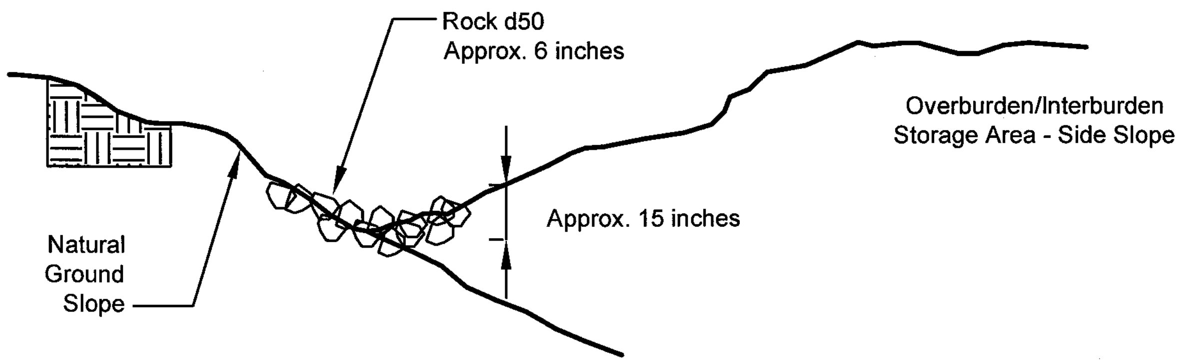
FIGURE 2a
GENERAL ARRANGEMENT OF OVERBURDEN STORAGE AREA AND SAND TAILINGS ENCAPSULATION CELLS

jbr environmental consultants, inc.

DESIGN BY	Earth Energy	DRAWN BY	CP	SCALE	NTS	DATE DRAWN	03/09/09
						REVISION	05/07/09



Energy Dissipater Schematic
Cross-Section (not to scale)



Overburden/Interburden Storage Area
Side Slope Contact with Natural Ground Slope
Schematic Cross-Section (not to scale)

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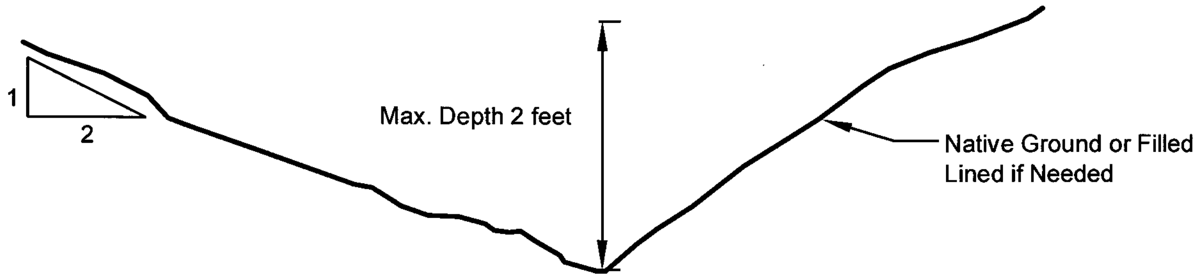
FIGURE 2b
OVERBURDEN/INTERBURDEN STORAGE AREAS
RUNOFF AND EROSION CONTROL STRUCTURES

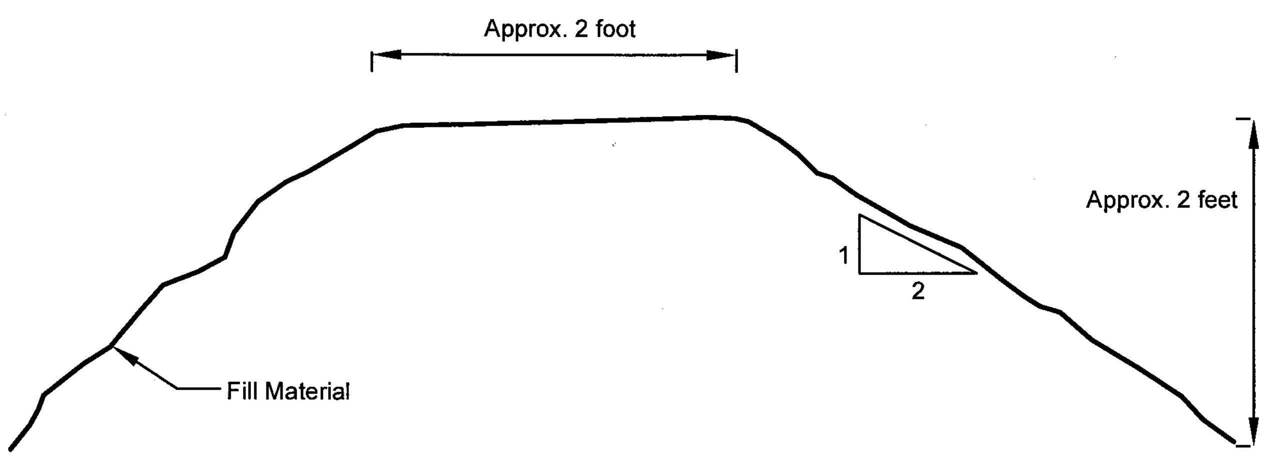
jbr environmental consultants, inc.

DESIGN BY	KK	DRAWN BY	RD	CH'D BY		SCALE	NTS	DATE DRAWN	05/07/08	REVISION	

drawings\EarthEnergy\Fig2b Overburen Interburden Storage Areas Runoff Erosion Control Structures.dwg



Typical Perimeter Ditch
Schematic Cross-Section (not to scale)



Typical Perimeter Berm
Schematic Cross-Section (not to scale)

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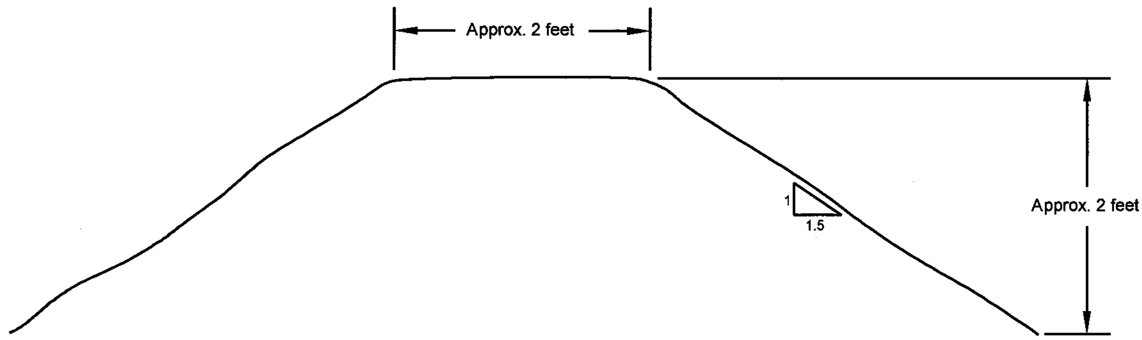
FIGURE 2c
PLANT SITE RUNOFF AND
EROSION CONTROL STRUCTURES

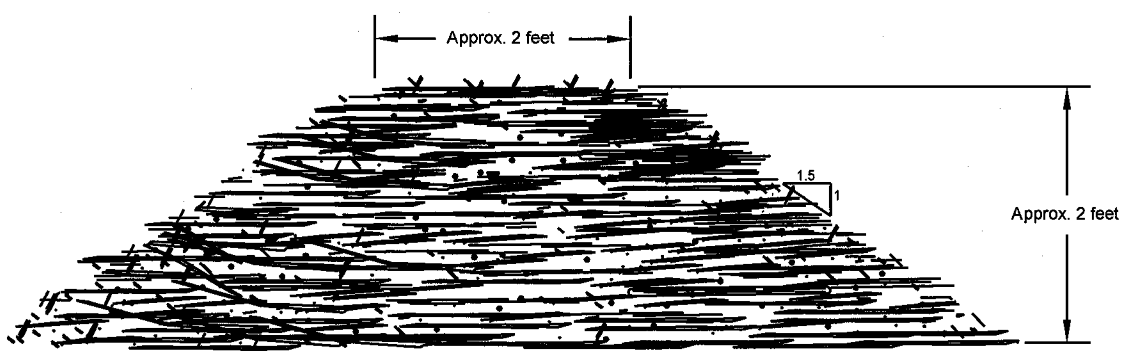
jbr environmental consultants, inc.

DESIGN BY	KK	DRAWN BY	RD	CH'D BY		SCALE	NTS	DATE DRAWN	05/07/08
								REVISION	05/07/08

drawings\EarthEnergy\Fig2c Plant Site Runoff and Erosion Control Structures_r1.dwg



Typical Topsoil Storage Area Berm
Schematic Cross-Section (not to scale)



Typical Woody Material Berm
Schematic Cross-Section (not to scale)

drawings\EarthEnergy\Fig2d Plant Site Runoff and Eronsion Control Structures.dwg

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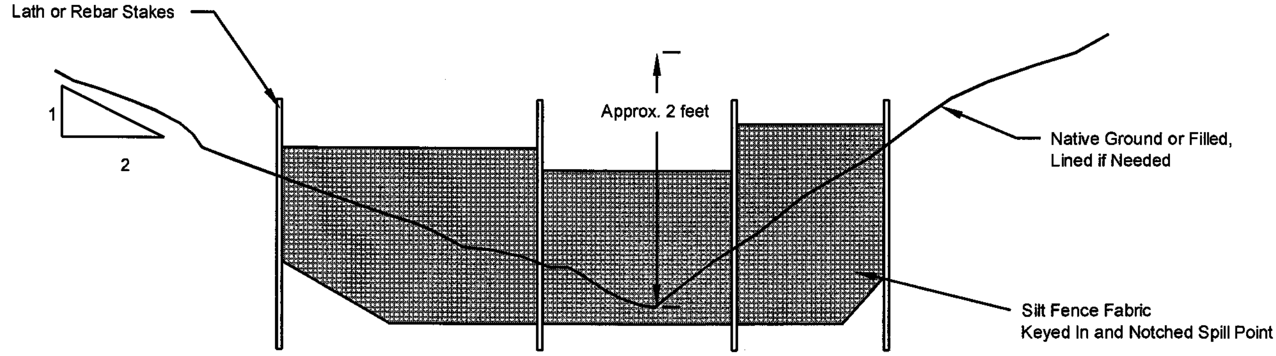
PR SPRING TAR SANDS DEVELOPMENT PROJECT

FIGURE 2d
PLANT SITE RUNOFF AND
EROSION CONTROL STRUCTURES

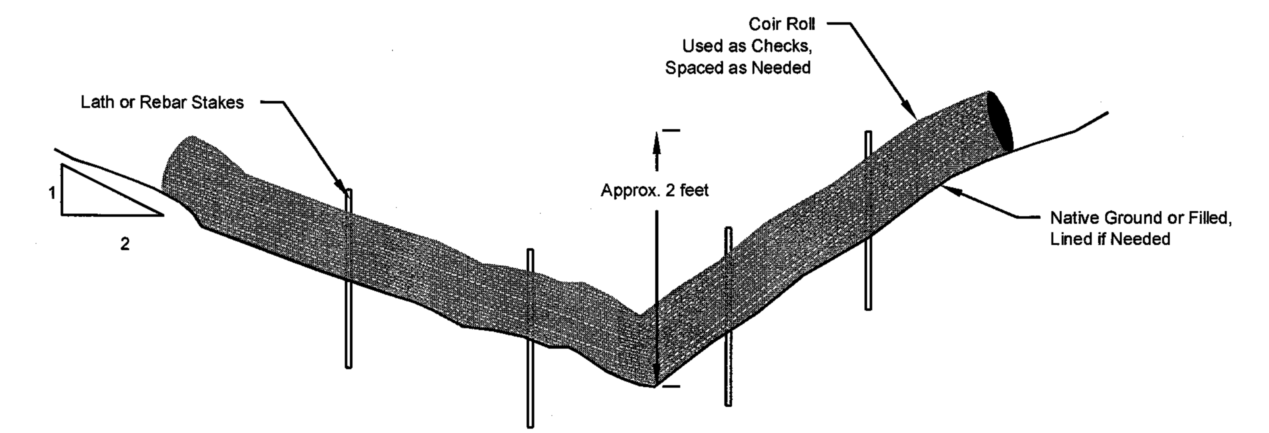
jbr environmental consultants, inc.

DESIGN BY	KK	DRAWN BY	CP	CH'D BY		SCALE	NTS	DATE DRAWN	10/27/08

REVISION



Typical Perimeter Ditch with Silt Fence
Schematic Cross-Section (not to scale)



Typical Perimeter Ditch with Coir Roll
Schematic Cross-Section (not to scale)

drawings\EarthEnergy\Fig2e Plant Site Runoff and Eronsion Control Structures.dwg

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FIGURE 2e
PLANT SITE RUNOFF AND
EROSION CONTROL STRUCTURES

jbr environmental consultants, inc.

DESIGN BY	KK	DRAWN BY	CP	CH'D BY		SCALE	NTS	DATE DRAWN	10/27/08

REVISION

drawings\EarthEnergy\Fig2f Plant Site Runoff and Eronsion Control Structures.dwg

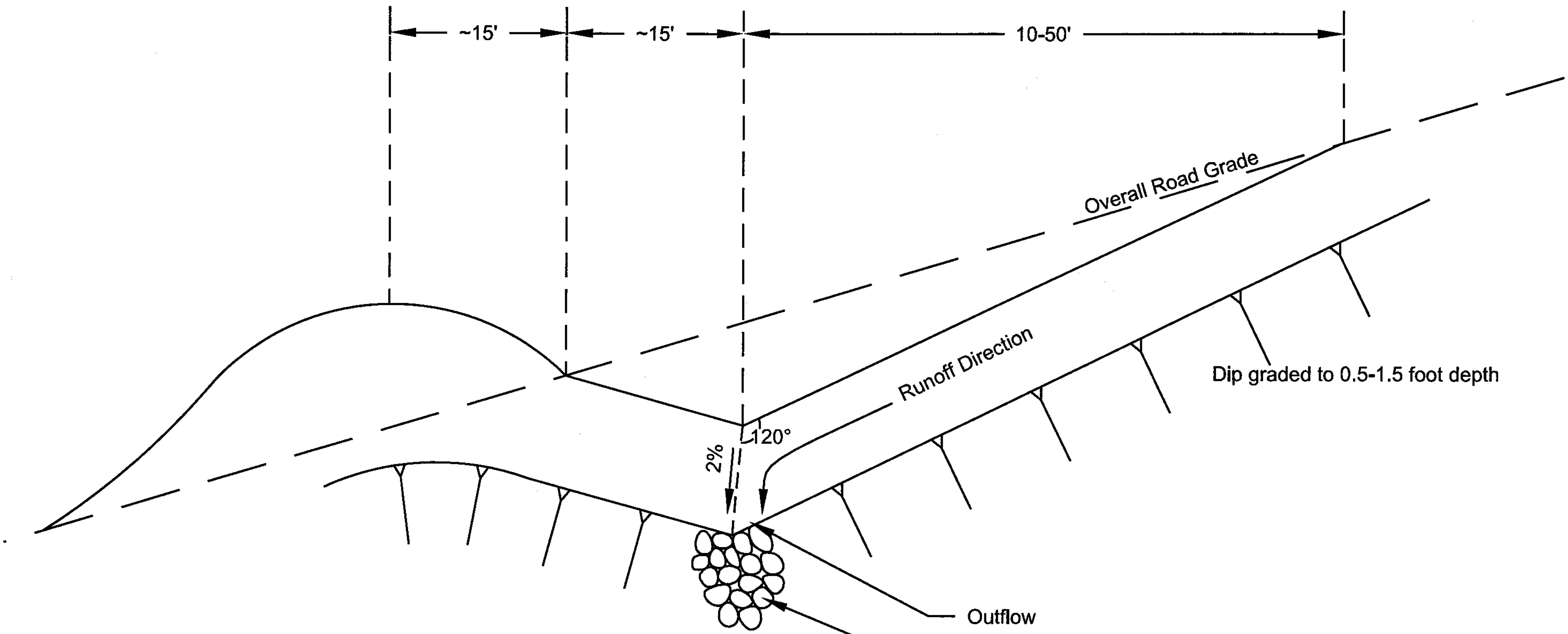

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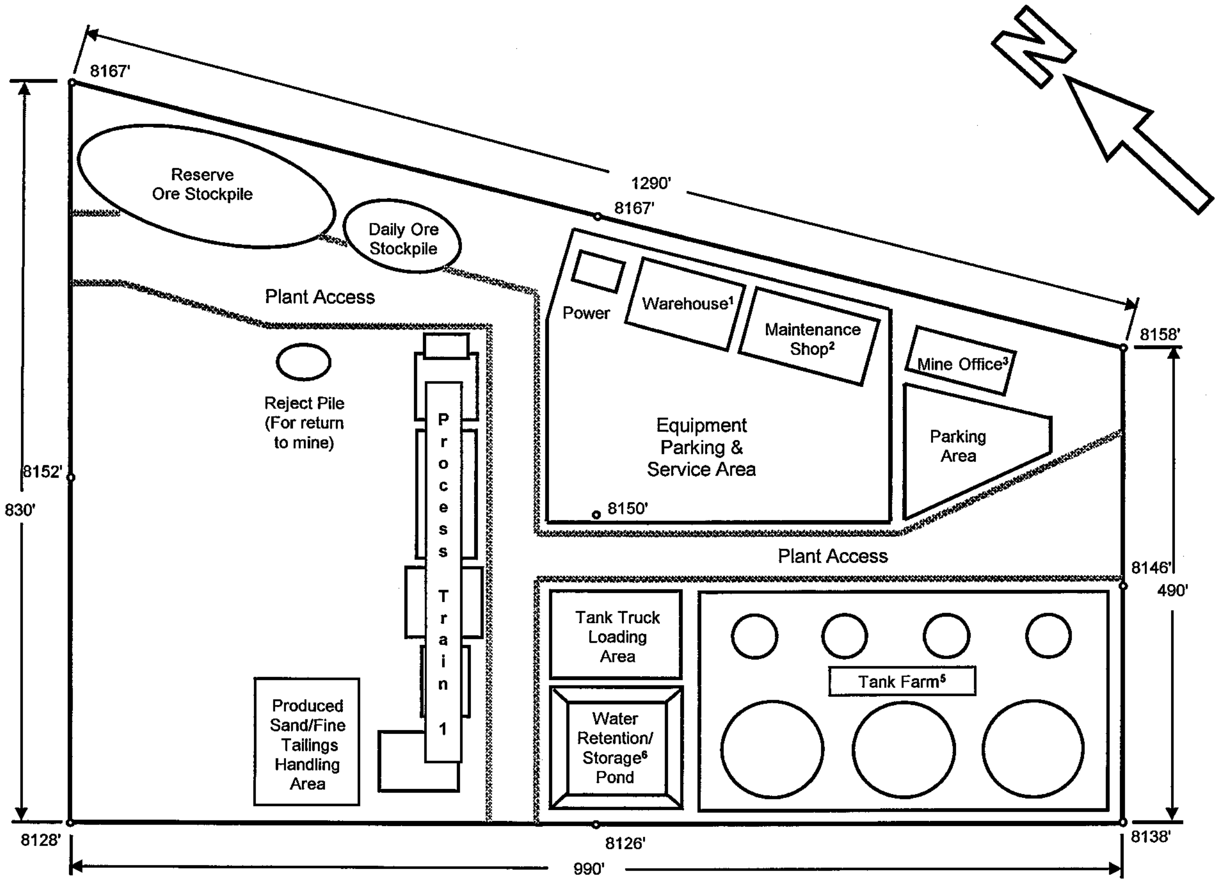
FIGURE 2f
TYPICAL HAUL ROAD
ROLLING DIP TURNOUT

jbr environmental consultants, inc.

DESIGN BY	KK	DRAWN BY	CP	CH'D BY		SCALE	NTS	DATE DRAWN	10/27/08



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NOTES:

1) "Sprung type" structure on concrete pad
2) "Sprung type" structure on concrete pad
3) "Atco type" modular office (2-3 unit) on gravel pad
4) All process equipment skid-mounted c/w sill plates
5) Actual size and no. of tanks may vary from that shown
6) All site drainage to be collected in retention/storage pond
7) Area of Plant Site: ~15 acres
8) Spot Elevations: ft. ASL (from BigTopo)

EARTH RESOURCES

Earth Energy Resources

Figure 3

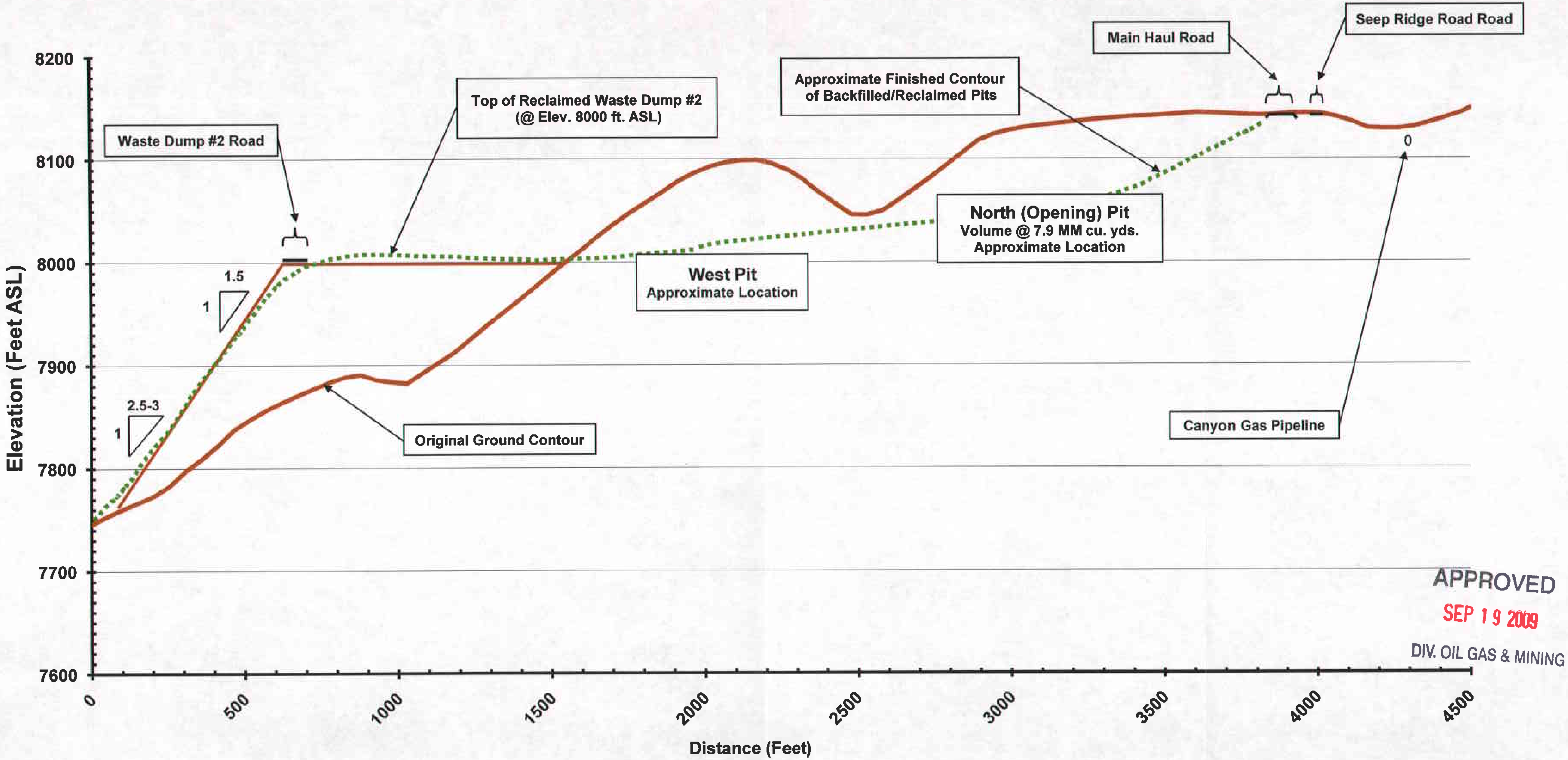
PR Spring Plant Site - Plot Plan

Preliminary Equipment Layout - Rev.4

Drawing Not to Scale

Drawn by: TJW **Date: Feb 13, 2008**

Figure 4a
Earth Energy Resources Inc. - PR Spring Oil Sand Mine
Transverse Mine Section W1-E1 Rev.3



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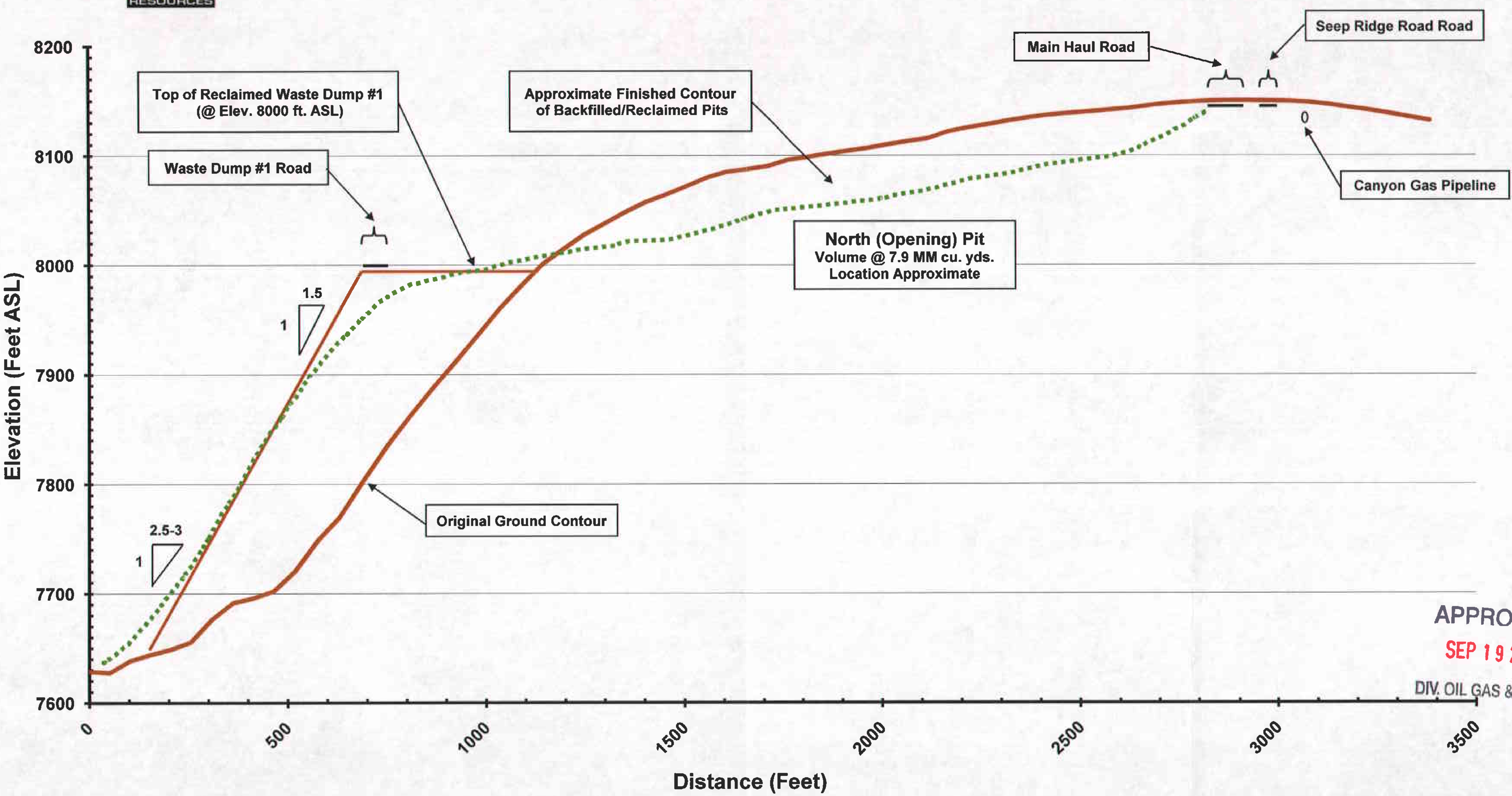
Drawn by: TJW Date: Sept 20, 2007
Revised by: CLP Date: March 3, 2009

Figure 4b
Earth Energy Resources Inc. - PR Spring Oil Sand Mine
Transverse Mine Section W2-E2 Rev.3



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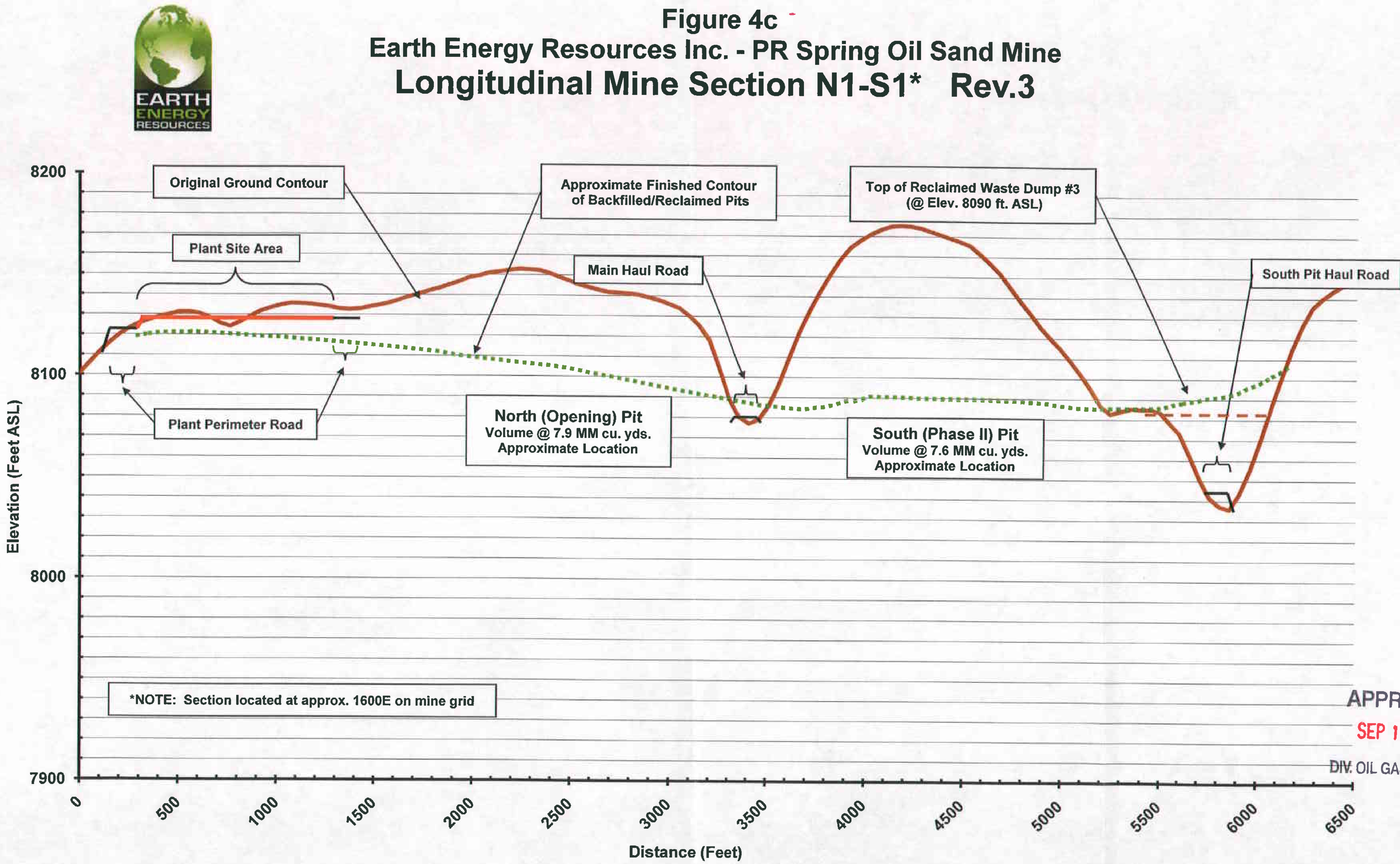
Drawn by: TJW Date: Sept 20, 2007
Revised by: CLP Date: March 3, 2009

Figure 4c
Earth Energy Resources Inc. - PR Spring Oil Sand Mine
Longitudinal Mine Section N1-S1* Rev.3



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Drawn by: TJW Date: Sept 20, 2007
Revised by: CLP Date: March 3, 2009

This page is a reference page used to track documents internally for the Division of Oil, Gas and Mining

Mine Permit Number M/047/0090 Mine Name PR Springs
Operator EARth Energy Date MARCH 23 2010
TO ____ FROM ____

X CONFIDENTIAL __BOND CLOSURE __LARGE MAPS __EXPANDABLE
__MULTIPUL DOCUMENT TRACKING SHEET __NEW APPROVED NOI
__AMENDMENT _OTHER ____

Description YEAR-Record Number

X NOI __Incoming __Outgoing __Internal __Superceded

NOI

__NOI __Incoming __Outgoing __Internal __Superceded

__NOI __Incoming __Outgoing __Internal __Superceded

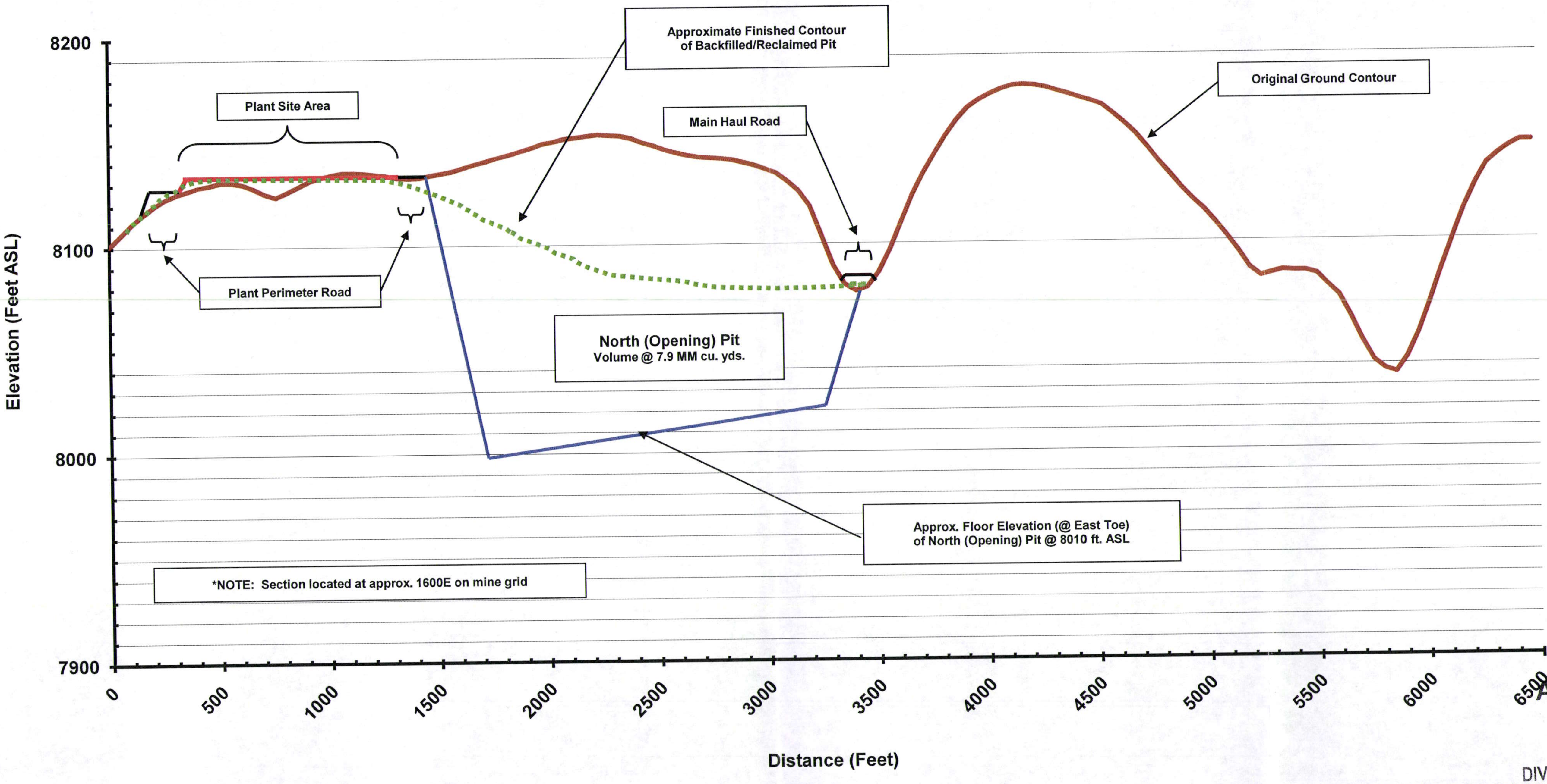
__NOI __Incoming __Outgoing __Internal __Superceded

__TEXT/ 81/2 X 11 MAP PAGES __11 X 17 MAPS __LARGE MAP

COMMENTS: ____

CC: ____

Figure 4c
Earth Energy Resources Inc. - PR Spring Oil Sand Mine
Longitudinal Mine Section N1-S1* Rev.4



Drawn by: TJW Date: Feb 25, 2008
Revised by: CLP Date: March 17, 2010

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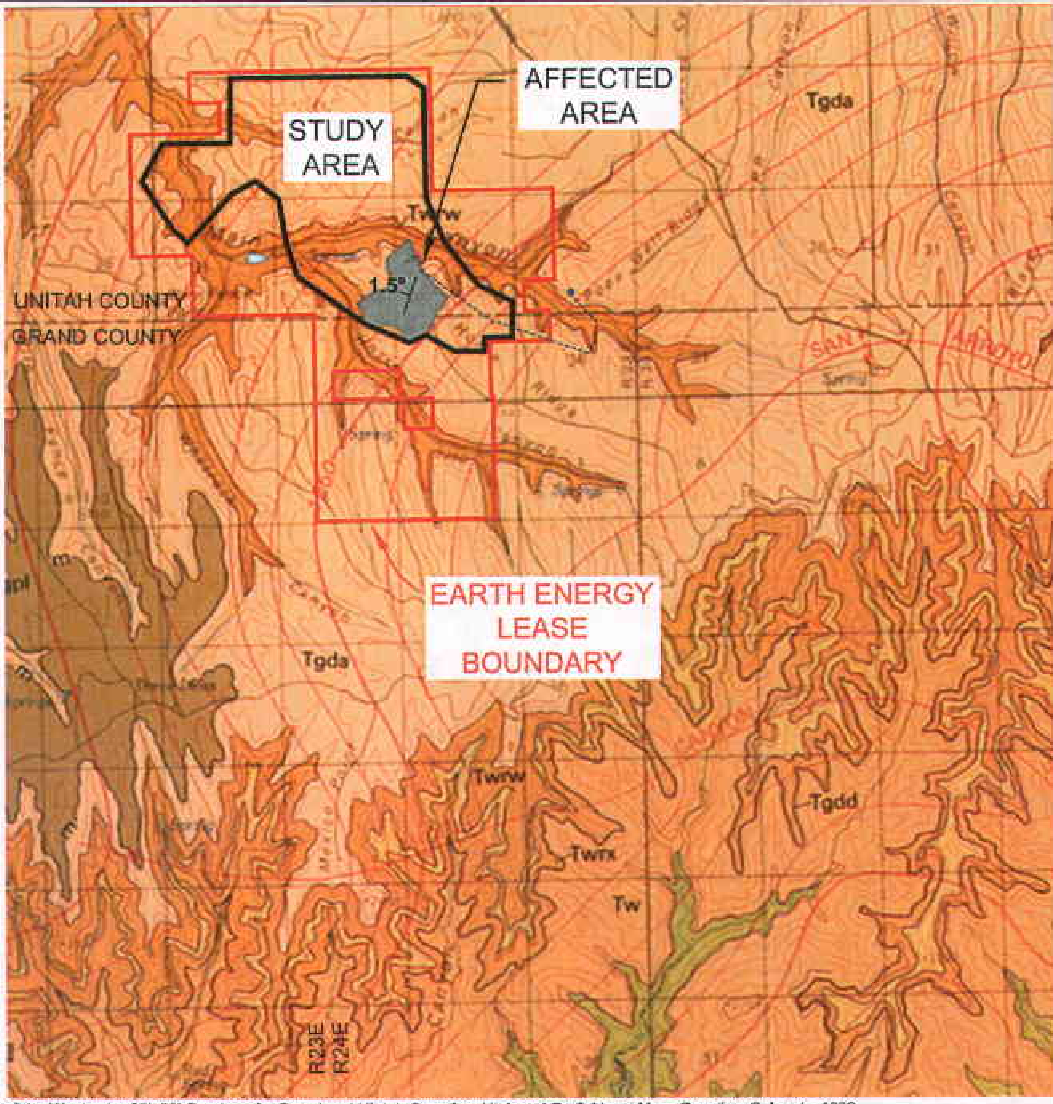
T15S
T16S



Geology from J. L. Gualtieri, Geologic Map of the Westwater 30'x60' Quadrangle, Grand and Uintah Counties, Utah and Garfield and Mesa Counties, Colorado, 1988

DESCRIPTION OF MAP UNITS

Green River Formation (Eocene)

Tgpl	Parachute Creek Member, lower part
	Douglas Creek Member
Tgda	Tonque a
Tgdc	Tontue c
	Wasatch Formation (Eocene and Paleocene)
Twrw	Unit w of Renegade Tongue
Twrx	Unit x of Renegade Tongue
Tw	Wasatch Formation, main body
Kt	**Tuscher Formations (Upper Cretaceous)**
Kf	**Farrer Formation (Upper Createaceous)**

- Contact
- Fault
- Anticline
- Syncline
- 1000 Structure Contours

N

1 0 1 2 3 4 KILOMETERS
1 0 1 2 MILES
Contour Interval 50 Meters

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EARTH ENERGY RESOURCES, INC.
PR SPRING TAR SANDS DEVELOPMENT PROJECT

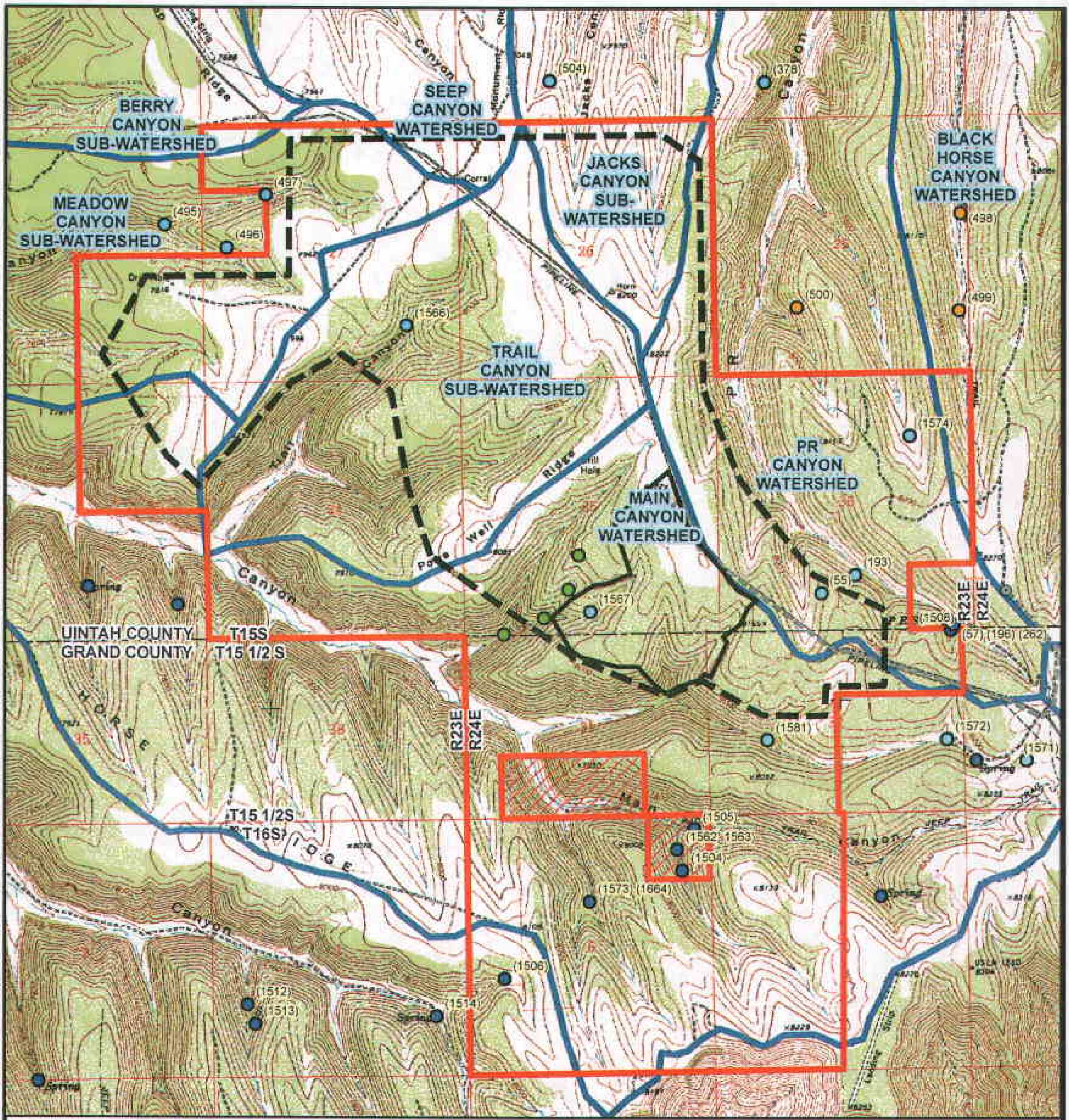
FIGURE 5
GEOLOGY MAP

jbr environmental consultants, inc.

DESIGN BY	KK	DRAWN BY	CP	CH'D BY		SCALE	1:100,000	DATE DRAWN	4/1/08
								REVISION	10/01/08

drawings\EarthEnergy\Fig5 Geology Map.dwg

FIGURE 6 IS LOCATED IN THE CONFIDENTIAL BINDER



N

1,000 0 4,000 Feet

1,000 0 1,000 Meters

Contour Interval 40 Feet

Legend

- Earth Energy Lease Boundary
- Property Excluded from Lease
- Study Area Boundary
- Affected Area
- Watershed Boundary
- USGS Mapped Spring
- Water Right Filing for Seep or Spring
- Surface Water Right Point of Diversion
- Seep Identified in Field
- (1506) Water Right Number

drawings\Earth Energy\Fig7 Water Features

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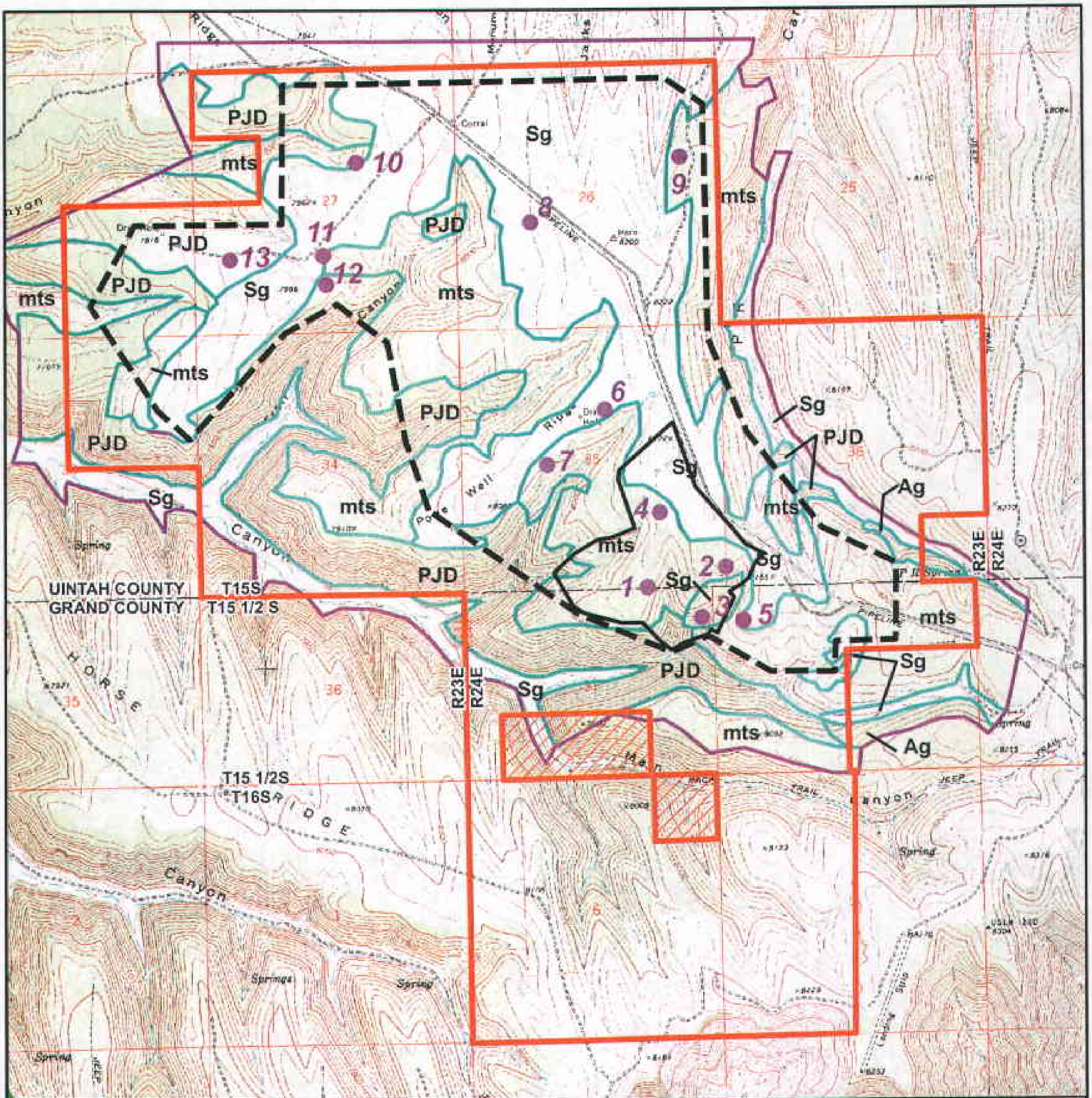
EARTH ENERGY RESOURCES, INC.
PR SPRING TAR SANDS DEVELOPMENT PROJECT

FIGURE 7
WATER FEATURES

jbr environmental consultants, inc.

DESIGN BY KK	DRAWN BY CP	SCALE 1:36,000	DATE DRAWN 9/11/07
			REVISIONS 4/03/08
			10/31/08



Legend

- Earth Energy Lease Boundary
- Property Excluded from Lease
- Study Area Boundary
- Affected Area
- Limit of Vegetation Survey
- Vegetation Community Boundary
- • 1 Quadrat Location and Number

Vegetation Types

Sg	Sagebrush - grass (1638 acres)
mts	mixed tall shrub (1482 acres)
PJD	Pinyon-Juniper-Douglas fir (1203 acres)
Ag	Aspen glade (not sampled) - (43 acres)

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1,000 0 4,000 Feet
1,000 0 1,000 Meters
Contour Interval 40 Feet

N

EARTH ENERGY RESOURCES, INC.
PR SPRING TAR SANDS DEVELOPMENT PROJECT

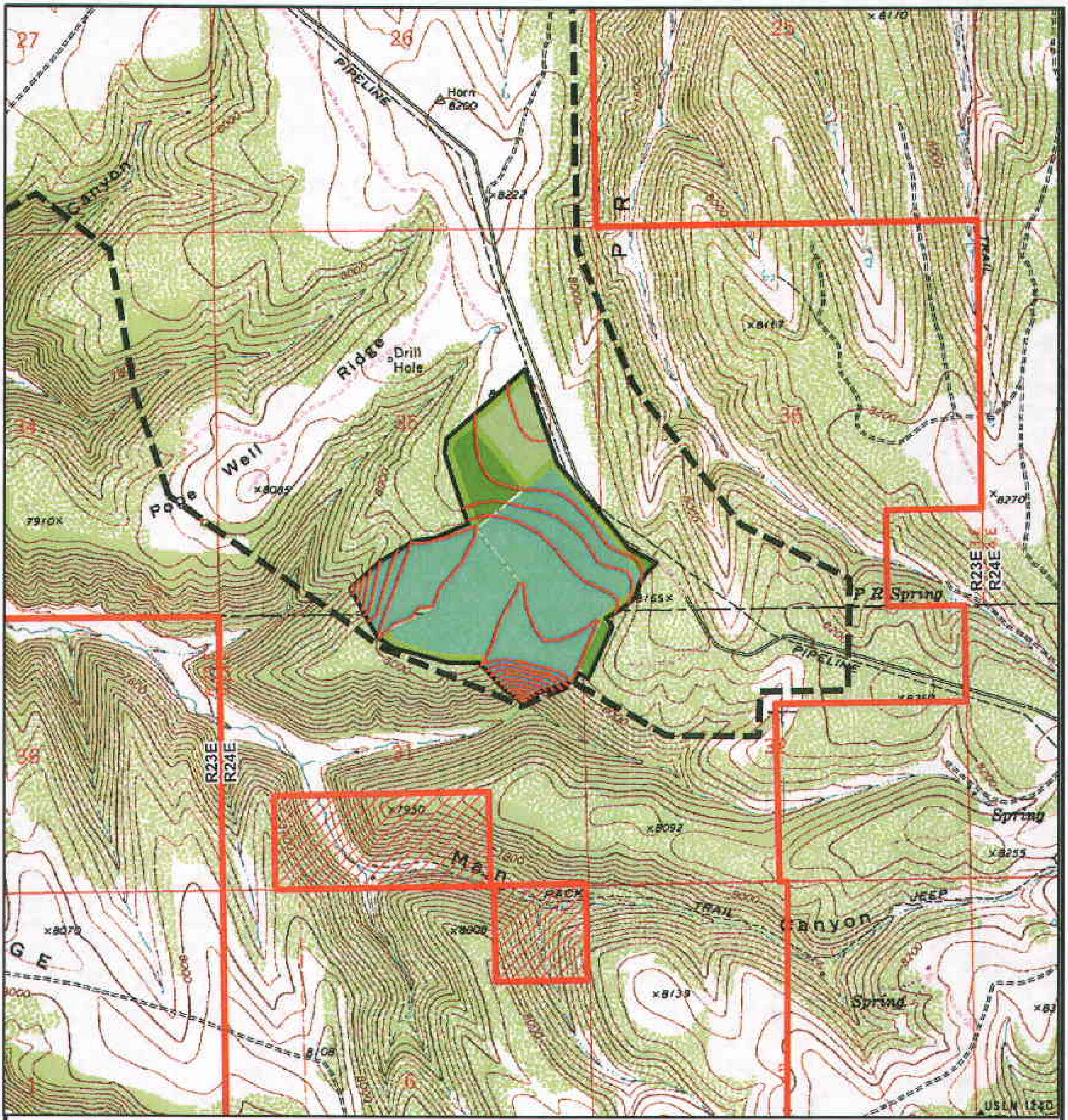
FIGURE 8
VEGETATION MAP

jbr environmental consultants, inc.

DESIGN BY	MS	DRAWN BY	CP	SCALE	1:36,000

DATE DRAWN	9/11/07
REVISIONS	4/02/08
	10/31/08

drawings\Earth Energy\Fig8 Vegetation Map.mxd



drawings\Earth Energy\Fig9 Reclamation Map r1.mxd

Legend

- Earth Energy Lease Boundary
- Property Excluded from Lease
- Study Area Boundary
- Affected Area

Reclamation Treatments

- Regrade, Topsoil, and Seed (163 acres)
- Rip and Seed (18 acres)
- Rip, Topsoil, and Seed (15 acres)
- Regrade, Rip, Topsoil, and Seed (17 acres)
- Reclamation Contours

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N

2,000 0 2,000 Feet
500 0 500 Meters
Contour Interval 40 Feet

EARTH ENERGY RESOURCES, INC.
PR SPRING TAR SANDS DEVELOPMENT PROJECT

FIGURE 9
RECLAMATION MAP

jbr environmental consultants, inc.

DESIGN BY	KK	DRAWN BY	CP	SCALE	1:24,000

DATE DRAWN	9/14/07
REVISIONS	4/02/08
	10/31/08

Appendix A
Site Exploration & Summary of Lands Under Lease

Earth Energy Resources, Inc.
Summary of lands under lease
Date prepared: 22 June 2006

Mineral Lease No.	Date	Expiry	Location	Description	Acreage	Royalty*
49579 - OBA	01 January 2005	2 years	Grand County State of Utah	T. 15.5 S, R. 24 E., SLB&M Section 32: Lots 1 and 6 (E1/2NE1/4)	50.42	6.50%
49927 - OBA	01 June 2005	10 years	Uintah/Grand Counties State of Utah	T. 15 S., R. 23 E., SLB&M, Uintah County Section 26: All (640.00 Acres) Section 35: All (640.00 Acres) Section 36: N1/2, SW1/4, N1/2SE1/4, SW1/4SE1/4 (600.00 Acres) T. 15.5 S, R. 24 E., SLB&M Grand County Section 31: Lots 1-6, NE1/4SW1/4, N1/2SE1/4, SE1/4SE1/4 (352.65 Acres) Section 32: Lots 2-5, SW1/4 (279.01 Acres) T. 16 S., R. 24 E., SLB&M, Grand County Section 4: Lots 3 - 7, SE1/4NW14, E1/2SW1/4 Section 5: Lots 1 - 6, SW1/4NW1/4, W1/2SW1/4 Section 6: Lots 2 - 7, S1/2NE1/4, SE1/4NW1/4, E1/2SW1/4, SE1/4 (all) Section 7: Lots 1 and 2, NE1/4, E1/2NW1/4 Section 8: Lots 1 and 2, NW1/4, S1/2NE1/4	4,319.87	6.50%
49280 (Sublease)	31 March 2005		Uintah County State of Utah	T. 15 S., R. 23 E., SLB&M, Uintah County Section 27: NE1/4, N1/2NW1/4, SE1/4NW1/4, S1/2 Section 28: SE1/4	760.00	
49281 (Sublease)	31 March 2005		Uintah County State of Utah	T. 15 S., R. 23 E., SLB&M, Uintah County Section 33: NE1/4 Section 34: All	800.00	
Sub-total					5,930.29	

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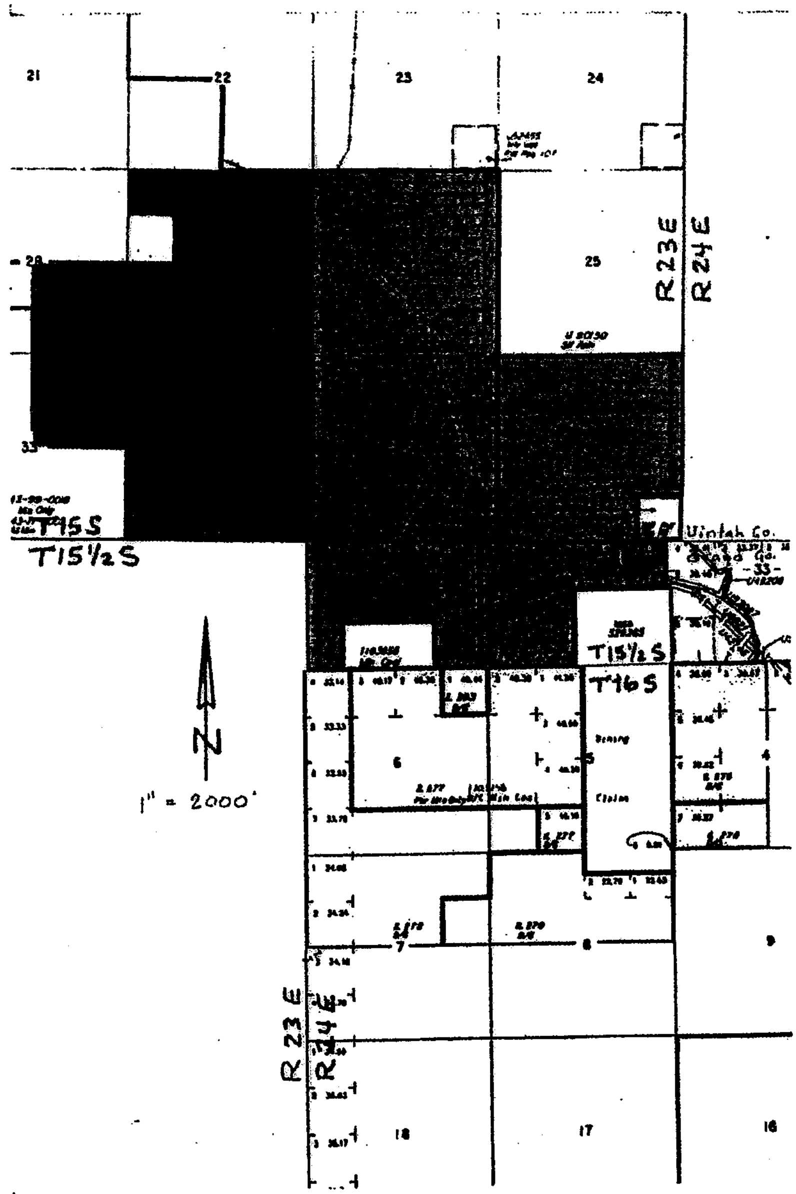

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IR - 000132

State of Utah

Department of Natural Resources

MICHAEL R. STYLER
Executive Director

Division of Oil, Gas & Mining

JOHN R. BAZA
Division Director

JON M. HUNTSMAN, JR.
Governor

GARY R. HERBERT
Lieutenant Governor

August 23, 2005

Mr. Page van Loben Sels
Earth Energy Resources, Inc.
One Beechwood Drive
Oakland, California 94618

Subject: Complete Notice of Intention to Commence Small Mining Operations; Earth Energy Resources, Inc.; Leonard Murphy #1 Mine; S/019/059; Grand County; Utah

Dear Mr. van Loben Sels:

The Division has reviewed your Notice of Intention to Conduct Exploration for the referenced project received May 23, 2005, and finds it to be complete. We are prepared to issue final approval when we receive your reclamation surety in the amount of $32,100 and a reclamation contract.

The reclamation surety can be submitted in one of several forms, including a certificate of deposit, a letter of credit, and a surety bond. Please contact Beth Ericksen at 801-538-5318 for further information regarding the surety. We have enclosed a reclamation contract for your use. Please send/fax a "draft" copy of the contract for our review before it is signed.

In addition, you must adhere to the requirements of the Division of Water Quality. As we discussed with Lyle Stott, the mine will process the smallest amount of tar sand that can be run through your equipment. The waste sand will then be placed on a liner and a sample taken and analyzed using a synthetic leach test. Results will be forwarded to Water Quality who will then decide whether additional permitting is needed.

If you have questions or concerns regarding this letter, please contact Paul Baker at 538-5261. We look forward to receiving your surety bond and completed reclamation contract.

Sincerely,

Susan M White

Susan M. White
Mining Program Coordinator
Minerals Regulatory Program

SMW:PBB:jb
Enclosure: Reclamation Contract form
cc: Will Stokes, SITLA
O:\M019-Grand\S0190059-LeonardMurphy1\final\condapp-08222005.doc

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SEP 19 2009
IR - 000133
DIV. OIL GAS & MINING

JON M. HUNTSMAN, JR.
Governor

GARY R. HERBERT
Lieutenant Governor

State of Utah

Department of Natural Resources

MICHAEL R. STYLER
Executive Director

Division of Oil, Gas & Mining

JOHN R. BAZA
Division Director

June 16, 2005

Mr. Page van Loben Sels
Earth Energy Resources, Inc.
One Beechwood Drive
Oakland, California 94618

Subject: Deficient Notice of Intention to Commence Small Mining Operations; Earth Energy Resources, Inc.; Leonard Murphy No. 1 Mine; S/019/059; Grand County; Utah

Dear Mr. van Loben Sels:

The Division of Oil, Gas and Mining received the referenced Notice of Intention to Commence Small Mining Operations on May 19, 2005, and forwarded a copy to the Division of Water Quality. We have not yet received their comments but anticipate they will need further information.

The notice is mostly complete, but in order for us to calculate an accurate reclamation surety we would like a list of equipment that will be used to process the tar sands. We need any information that would help us make a reclamation cost estimate. For example, you indicated in a telephone conversation that the equipment will be on skids. Please provide this and other pertinent information in writing. You and the Division will probably want to have some buffer in the bond amount so it doesn't have to change if you bring in additional equipment.

Please provide this information by June 30, 2005. If you have questions about the type of information needed, please call Paul Baker at (801) 538-5261. Thank you for your cooperation.

Sincerely,

Susan M. White

Susan M. White
Mining Program Coordinator
Minerals Regulatory Program

SMW:PBB:jb
cc: Will Stokes, SITLA
P:\GROUPS\MINERALS\WP\M019-Grand\S0190059-LeonardMurphy#1\final\def-06132005.doc

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DIV. OIL GAS & MINING

State of Utah

Department of Natural Resources

MICHAEL R. STYLER
Executive Director

Division of Oil, Gas & Mining

JOHN R. BAZA
Division Director

JON M. HUNTSMAN, JR.
Governor

GARY R. HERBERT
Lieutenant Governor

June 2, 2005

Mr. Page van Loben Sels
Earth Energy Resources, Inc.
One Beechwood Drive
Oakland, California 94618

Subject: Complete Notice of Intention to Conduct Exploration, Earth Energy Resources, Inc.; EER PR Spring #2 Project; E/019/053; Grand County; Utah

Dear Mr. van Loben Sels:

The Division has reviewed your Notice of Intention to Conduct Exploration for the referenced project received May 10, 2005, and finds it to be complete. We are prepared to issue final approval when we receive your reclamation surety in the amount of $9200 and a reclamation contract.

The reclamation surety can be submitted in one of several forms, including a certificate of deposit, a letter of credit, and a surety bond. Please contact Beth Ericksen at 801-538-5318 for further information regarding the surety. We have enclosed a reclamation contract for your use. Please send/fax a "draft" copy of the contract for our review before it is signed.

If you have questions or concerns regarding this letter, please contact Paul Baker at 538-5261. We look forward to receiving your surety bond and completed reclamation contract.

Sincerely,

Susan M. White
Mining Program Coordinator
Minerals Regulatory Program

SMW:PBB:jb
Enclosure: Reclamation Contract form
cc: Will Stokes, SITLA
O:\M019-Grand\E0190053-PRSprings#2\final\condapp-06022005.doc

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SEP 19 2009

DIV. OIL GAS & MINING

IR - 000135

State of Utah

Department of Natural Resources

MICHAEL R. STYLER
Executive Director

Division of Oil, Gas & Mining

JOHN R. BAZA
Division Director

JON M. HUNTSMAN, JR.
Governor

GARY R. HERBERT
Lieutenant Governor

May 26, 2005

Mr. Page van Loben Sels
Earth Energy Resources, Inc.
One Beechwood Drive
Oakland, California 94618

Subject: Acceptance of Notice of Intention to Conduct Exploration and Approval of Reclamation Bond and Reclamation Contract, Earth Energy Resources, Inc.; EER PR Spring 1 Project; E/019/052; Grand County; Utah

Dear Mr. van Loben Sels:

On May 24, 2005, John Baza, Director of the Division of Oil, Gas and Mining, signed the reclamation contract for the referenced exploration operation. ***The Division finds your exploration notice of intention complete and approves the reclamation surety for the PR Spring #1 project***. Copies of the fully signed and executed documents are enclosed for your files.

We have received notification from the Division of State History that no historic properties should be affected by your operation, but if you encounter cultural resources, you are asked to immediately cease operations and notify both the Division of Oil, Gas and Mining and the Division of State History.

The acceptance of this notice and surety is for an exploration operation only, **not to exceed 0.5 acres**. You are not authorized to disturb additional areas without first amending your notice, adjusting the bond amount and receiving written acceptance from this office.

If you have questions or concerns regarding this letter, please contact me at (801) 538-5258 or Paul Baker at (801) 538-5261. Best wishes with your exploration operation.

Sincerely,

S.M. White
Susan M. White
Mine Program Coordinator
Minerals Regulatory Program

SMW:PBB:jb
Enclosure: Copy of RC & surety forms
O:\M019-Grand\E0190052-PRSprings1\final\appvl-05252005.doc

1594 West North Temple, Suite 1210, PO Box 145801, Salt Lake City, UT 84114-5801
telephone (801) 538-5340 • facsimile (801) 359-3940 • TTY (801) 538-7458 • *www.ogm.utah.gov*

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Appendix B
Correspondence

RECEIVED MAR 15 2010
913R

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

Ref: 8ENF-AT

MAR 10 2010

Barclay Cuthbert
Vice President
Earth Energy Resources
Suite #740
404 – 6 Avenue S.W.
Calgary, AB T2P 0R9 Canada

Subject: Subpart Ja Applicability Determination Request – Earth Energy Resources, Inc., Oil Sand Mining and Processing – PR Spring Mine

Dear Mr. Cuthbert:

I am responding to your May 29, 2009, letter requesting an applicability determination for the Earth Energy Resources, Inc. (Earth Energy) PR Spring Mine with regards to New Source Performance Standard (NSPS) Subpart Ja.[1] Earth Energy proposes to operate an oil sand mine and processing facility (i.e., mill) in eastern Utah. The operation will include mining of the naturally occurring oil sands and extraction of the bitumen from these sands. As discussed below, EPA does not believe that the Earth Energy PR Spring Mine is subject to NSPS Subpart Ja.

Your May 29, 2009, letter explains that the Earth Energy PR Spring Mine extraction process will be as follows: (1) mined and conditioned oil sand ore is sent through a crusher/delumper and reduced to 2 inch-minus aggregate size; (2) crushed ore is augured or conveyed to a heated slurry mixer where the cleaning emulsion is introduced and the ore slurried to the consistency of a thick gritty milkshake; (3) oil sand slurry is then moved by screw conveyor to the slurry tank where primary separation of the bitumen from the sand occurs; (4) produced sand with residual bitumen is pumped through a series of separation towers where the last traces of bitumen are removed; (5) all the liberated bitumen is captured, polished with cyclones and/or centrifuges, and pumped to a storage tank; (6) the cleaning chemical is then

[1] Subpart Ja, 40 C.F.R. §§60.100a et seq., is entitled "Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After May 14, 2007."

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IR - 000138

removed from the bitumen by distillation and recycled to the front of the process[2]; and (7) produced bitumen is pumped to a product (sales) tank for heated storage prior to transport.[3]

NSPS Subpart Ja applies to certain affected facilities in petroleum refineries. The definition of "petroleum refinery in 40 C.F.R. 60.101a reads: "Petroleum refinery means any facility engaged in producing gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricants, asphalt (bitumen) or other products through distillation of petroleum or through redistillation, cracking, or reforming of unfinished petroleum derivatives." Even though the Earth Energy PR Spring Mine will be producing bitumen, the operation will not be producing the bitumen "through distillation of petroleum or through redistillation, cracking, or reforming of unfinished petroleum derivatives." Although distillation will be occurring at the Earth Energy PR Spring Mine, it will be for the purpose of recovering the cleaning chemical from the bitumen and not to upgrade the bitumen to a refined product. Additionally, the produced bitumen will be sent off-site to a petroleum refinery for further processing. Therefore, EPA does not believe the Earth Energy PR Spring Mine would be considered a "petroleum refinery" and subject to NSPS Subpart Ja.

The above discussion is consistent with EPA's December 22, 2008 proposed revision to the definition of "petroleum refinery" in NSPS Subpart Ja (73 FR 78522). In the December 22, 2008 proposal notice (at 78526), EPA indicated that "Facilities that only produce oil shale or tar sands-derived crude oil for further processing using only solvent extraction and/or distillation to recover diluent that is then sent to a petroleum refinery are not themselves petroleum refineries. This is because they are only producing feed to a petroleum refinery as a product and not refined products. Facilities that produce oil shale or tar sands-derived crude oil and then upgrade these materials and produce refined products would be a petroleum refinery." The revised definition of "petroleum refinery" proposed on December 22, 2008, reads:

> Petroleum refinery means any facility engaged in producing gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricants, asphalt (bitumen) or other products through distillation of petroleum or through redistillation, cracking, or reforming of unfinished petroleum derivatives. A facility that produces only oil shale or tar sands-derived crude oil for further processing at a petroleum refinery using only solvent extraction and/or distillation to recover diluent is not a petroleum refinery.

---

[2] Electronic communication (email) on November 2, 2009, from Mr. Erin Hallenburg, JBR Environmental, to Carol Smith, EPA, indicates that "any light ends from the bitumen that may accumulate in the TAI [cleaning chemical] would be recovered through a second stage distillation process. This process would distill any light boiling fractions from the TAI and these recovered fractions would be blended into our sales bitumen tank."

[3] In the email referenced in footnote 2, Mr. Hallenberg also indicated that "no further processing is performed on site. The final product, bitumen, will be headed to an oil refinery for further processing."

If you have any questions or concerns regarding this letter, please contact Laurie Ostrand of my staff at (303) 312-6437 or by email at ostrand.laurie@epa.gov.

Sincerely,

Cynthia J. Reynolds

Cynthia J. Reynolds, Director
Technical Enforcement Program

cc: Donald Law, EPA Region 8

Mr. Erin Hallenburg, QEP, P.E.
JBR Environmental Consultants, Inc.
8160 S. Highland Dr.
Sandy, UT 84093

EARTH ENERGY RESOURCES

www.earthenergyresources.com

May 29, 2009

Ms. Cynthia Reynolds
USEPA Region 8
1595 Wynkoop St., 8ENF-AT
Denver, CO 80202

Re: Subpart Ja Applicability Determination Request – Earth Energy Resources, Inc., Oil Sand Mining and Processing – PR Spring Mine

Earth Energy Resources, Inc. (Earth Energy) is requesting an applicability determination for the Earth Energy PR Spring Mine with regards to CFR 40 Part 60 Subpart Ja - Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced after May 14, 2007.

Earth Energy has proposed to operate an oil sand mine and processing facility (i.e. mill) in eastern Utah. The operation will include mining of the naturally occurring oil sands and extraction of the bitumen from these sands. Earth Energy originally submitted a Notice of Intent (NOI) to the Utah Division of Air Quality (UDAQ) for a Permit to Construct (PTC) in October of 2007. After several months, the UDAQ informed Earth Energy in January of 2008 that the facility location was on Indian Jurisdictional lands and thus the EPA would be the permitting authority. There have been extensive conversations with the EPA, and several consultant-based determinations submitted, as well as a face-to-face meeting (July 15, 2008) at the EPA Region 8 offices, initiated by Earth Energy.

At the July meeting in Denver, Earth Energy and their consultant representatives were told that a determination would be made in regard to Subpart Ja and other issues in October 2008. Earth Energy and their consultants pressed for an answer from EPA in October 2008. As a result, Earth Energy was informed by the EPA Region 8 that a "determination request" in regards to the applicability of Subpart Ja would be need to be submitted to the EPA's Compliance Division. The following information is being provided to EPA Compliance Division, in response to this request for a compliance determination on the applicability for 40 CFR Part 60 Subpart Ja.

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Process Description

The extraction process begins when the mined and conditioned oil sand ore is sent through a crusher/ delumper and reduced to a 2 inch-minus aggregate size. From there, the crushed ore is augured or conveyed to a heated slurry mixer where the cleaning emulsion is introduced and the ore slurried to the consistency of a thick gritty milkshake. The oil sand slurry is then moved by screw conveyor to

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MAR 23 2010
DIV. OF OIL, GAS & MINING

the slurry tank where primary separation of the bitumen from the sand occurs. The produced sand with residual bitumen is then pumped through a series of separation towers where the last traces of bitumen are removed. All of the liberated bitumen is captured, polished with cyclones and/or centrifuges, and pumped to a storage tank. The cleaning chemical is then removed from the bitumen by distillation and recycled to the front of the process. Produced bitumen is pumped to a product (sales) tank for heated storage prior to transport.

The clean produced sand is de-watered on a shale shaker (or similar device) and the recovered water is pumped to a holding tank for recycle to the front of the process. Additional cleaning agent is added to the re-cycled water to bring it back to full strength. De-watered sand and clay fines are then conveyed to a stockpile for loading and backhaul to the mine pit. At this point, the discharged sand and clay fines contain between 10 and 20% water.

When the cleaning emulsion contacts the bitumen in the oil sand, the limonene and emulsifier partition into the hydrocarbon phase to promote the stripping and extraction of the bitumen from the solids matrix of the ore. Once the hydrocarbon phase is separated from the water phase and solids (both coarse sand and clays and fines), it is distilled to recover the limonene. The limonene is re-used in the process, while the emulsifier remains in the bitumen, which exits the process as the residual from the distillation step.

The composition of the cleaning emulsion is:

Component	Weight percent
D-Limonene	35.82%
Water	63.97%
Emulsifier	0.21%
Anti-foam	0.00%
Total	100.00%

The emulsifier is an alkylbenzenesulphonate, branched and straight chain and the anti-foam is a silicone based antifoam (such as those used in Jacuzzi spas).

Earth Energy has examined the applicability requirements and associated definitions in Subpart Ja and provided comments about the facility in italics.

60.100a Applicability, designation of affected facility, and reconstruction.

(a) The provisions of this subpart apply to the following affected facilities in petroleum refineries: fluid catalytic cracking units (FCCU), fluid coking units (FCU), delayed coking units, fuel gas combustion devices, including flares and process heaters, and sulfur recovery plants. The sulfur recovery plant need not be physically located within the boundaries of a petroleum refinery to be an affected facility, provided it processes gases produced within a petroleum refinery.

The PR Springs Mine does not have FCCU or FCU, or a delayed coking unit. In addition, the processes at the facility including process heaters are not fueled by gases produced at the plant and the plant will not be involved in sulfur recovery. As such, there are no sources at the PR Spring Mine to which Ja is applicable.

§ 60.101a Definitions

Petroleum refinery means any facility engaged in producing gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricants, asphalt (bitumen) or other products through distillation of petroleum or through redistillation, cracking, or reforming of unfinished petroleum derivatives.

The process does not produce gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricants, or other products through distillation or redistillation of petroleum. The only distillation process involved is recovery of the d-limonene which does not result in a petroleum product.

There have been concerns raised about data that suggested that 3% of the bitumen light ends might be fractionated off during the solvent distillation. Earth Energy performed an assay on a sample of bitumen from the PR Spring mine site. The initial boiling point of the bitumen is 213°C/415°F [ASTM D2892/D5236], which is well above the distillation temperature used to recover the d-limonene. The data from the assay show good agreement with physical properties of PR Spring bitumen measured by the Utah Heavy Oil Center, University of Utah, where volatiles distilling below 204°C/399°F is less than 0.4%.

Fuel gas means any gas which is generated at a petroleum refinery and which is combusted. Fuel gas includes natural gas when the natural gas is combined and combusted in any proportion with a gas generated at a refinery. Fuel gas does not include gases generated by catalytic cracking unit catalyst regenerators and fluid coking burners, but does include gases from flexicoking unit gasifiers. Fuel gas does not include vapors that are collected and combusted to comply with the wastewater provisions in §60.692, 40 CFR 61.343 through 61.348, 40 CFR 63.647, or the marine tank vessel loading provisions in 40 CFR 63.562 or 40 CFR 63.651.

The process does not involve the use of gas produced at the facility to operate any equipment.

Earth Energy has been working with the EPA for over 2 1/2 years to determine the permitting requirements for this facility. Based on previous communications with the EPA, the Subpart Ja applicability determination can only be performed by EPA and requires a formal request. It was our impression that EPA Region 8 Task Force was in the process of making the determination after our July 15, 2008 meeting and would decide by October, 2008. Since all future permitting and project feasibility is dependant on this determination, we respectfully request the EPA Compliance Division to inform us of the requirements for the PR Spring oil sand mine and processing facility in the very near future. Additional information on the process, permitting and/or timeline can be found either in your files, by contacting JBR Environmental (801-943-4144) or by contacting me directly.

Yours truly,
Earth Energy Resources, Inc.

Barclay Cuthbert

Barclay Cuthbert
Vice President

Enclosures (2)

cc: Tim Wall, Earth Energy Resources, Inc.
File

DOGM Correspondence and Related Information

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DIV. OIL GAS & MINING

Response to Fourth REVIEW OF NOTICEOF INTENTION TO COMMENCE LARGE MINING OPERATIONS

Earth Energy Resources
PR Spring Mine

M/047/0090
May 7, 2009

105.3 - Drawings or Cross Sections (slopes, roads, pads, etc.)

Comm ent #	Sheet/Page/ Map/Table #	Comments	Initials	Review Action
	Figure 2a / Page 20	Figure 2a and paragraph 4 say the containment "cells will not be constructed on slopes greater than 20 percent (11 degrees)" yet Figure 2a notes "maximum of 20 degrees slope at the toe." Please correct or clarify the text or figure to reflect slope stability model that used for mine planning from the engineer of record.	lah	Figure 2a has been corrected.
	General	It is DOGM's recommendation that slope designations (percent, degrees or horizontal:vertical) are consistent throughout the document.	lah	Thank you for the recommendation. No change has been made to the plan at this time.
	Figure 2a	Upper drawing, berm should not be shown as the same material as the sand tailings.	lah	Figure 2a has been revised.

106.6 - Plan for protecting & re-depositing soils

Comm ent #	Sheet/Page/ Map/Table #	Comments	Initials	Review Action
	Omission	Please include a statement in the NOI that all available topsoil will be salvaged (include page number, as a new page 26-27 was not submitted)	lah	This statement occurs in the NOI on page 26, in the paragraph prior to Section 106.6.

R647-4-113 – Surety

Comment #	Sheet/Page/ Map/Table #	Comments	Initials	Review Action
	Page 62	Include on surety summary sheet "Bond is for 213 acres and is shown as 'Affected Area'" acres as shown on Figures.	lah	The noted statement has been added to the Surety summary sheet on page 62.

JON M. HUNTSMAN, JR.
Governor

GARY R. HERBERT
Lieutenant Governor

State of Utah

DEPARTMENT OF NATURAL RESOURCES

MICHAEL R. STYLER
Executive Director

Division of Oil, Gas and Mining

JOHN R. BAZA
Division Director

April 28, 2009

Barclay Cuthbert
Earth Energy Resource Inc.
Suite 740, 404-6 Avenue S. W.
Calgary, Alberta, Canada T2P 0R9

Subject: Fourth Review of Notice of Intention to Commence Large Mining Operations, Earth Energy Resources, PR Springs Mine, M0470090, Uintah County, Utah

Dear Mr. Cuthbert:

The Division has completed a review of your Notice of Intention to Commence Large Mining Operations for the PR Springs Mine, which was received March 25, 2009. The attached comments will need to be addressed before tentative approval may be granted.

The comments are listed under the applicable Minerals Rule heading; please format your response in a similar fashion. We anticipate the plan will be complete after we receive this submittal, so please submit two complete, clean (redline/strikeout removed) copies of the plan. The Division will stamp both copies approved and return one to you. We will also begin the process of issuing tentative approval, including public notice and notification of the Resource Development Coordinating Committee.

The Division will suspend further review of the Notice of Intention until your response to this letter is received. If you have any questions in this regard please contact me at 801-538-5261 or Leslie Heppler, at 801-538-5257. Thank you for your cooperation in completing this permitting action.

Sincerely,

Paul B. Baker
Minerals Program Manager

APPROVED
SEP 19 2009
DIV. OIL GAS & MINING

PBB:lah:vs
Attachment: Review
cc: SITLA – WStokes@utah.gov
P:\GROUPS\MINERALS\WP\M047-Uintah\M0470090-PRSpringMine\final\REV4-2929-04092009.doc

Fourth REVIEW OF NOTICE OF INTENTION TO COMMENCE LARGE MINING OPERATIONS

Earth Energy Resources
PR Springs Mine

M/047/0090
April 28, 2009

105.3 - Drawings or Cross Sections (slopes, roads, pads, etc.)

Comment #	Sheet Page Map Table #	Comments	Initials	Review Action
	Figure 2a Page 20	Figure 2a and paragraph 4 say the containment "cells will not be constructed on slopes greater than 20 percent (11 degrees)" yet Figure 2a notes "maximum of 20 degrees slope at the toe." Please correct or clarify the text or figure to reflect slope stability model that used for mine planning from the engineer of record.	lah	
	General	It is DOGM's recommendation that slope designations (percent, degrees or horizontal:vertical) are consistent throughout the document.	lah	
	Figure 2a	Upper drawing, berm should not be shown as the same material as the sand tailings.	lah	

106.6 - Plan for protecting & re-depositing soils

Comment #	Sheet Page Map Table #	Comments	Initials	Review Action
	Omission	Please include a statement in the NOI that all available topsoil will be salvaged (include page number, as a new page 26-27 was not submitted)	lah	

R647-4-113 – Surety

Comment #	Sheet Page Map Table #	Comments	Initials	Review Action
	Page 62	Include on surety summary sheet "Bond is for 213 acres and is shown as 'Affected Area'" acres as shown on Figures.	lah	

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SEP 19 2009
DIV. OIL GAS & MINING

April 28, 2009

Barclay Cuthbert
Earth Energy Resource Inc.
Suite 740, 404-6 Avenue S. W.
Calgary, Alberta, Canada T2P 0R9

| Subject: ~~Initial~~ Fourth Review of Notice of Intention to Commence Large Mining Operations, Earth Energy Resources, PR Springs Mine, M0470090, Uintah County, Utah

Dear Mr. Cuthbert:

The Division has completed a review of your Notice of Intention to Commence Large Mining Operations for the PR Springs Mine, which was received March 25, 2009. The attached comments will need to be addressed before tentative approval may be granted.

The comments are listed under the applicable Minerals Rule heading; please format your response in a similar fashion. Please address only those items requested in the attached technical review by sending replacement pages of the original mining notice using **redline and strikeout** text, so we can see what changes have been made. After the notice is determined technically complete and we are prepared to issue final approval, we will ask that you send us two clean copies of the complete and corrected plan. Upon final approval of the permit, we will return one copy stamped "approved" for your records.

The Division will suspend further review of the Notice of Intention until your response to this letter is received. If you have any questions in this regard please contact me at 801-538-5261 or Leslie Heppler, at 801-538-5257. Thank you for your cooperation in completing this permitting action.

Sincerely,

Paul B. Baker
Minerals Program Manager

PBB:lah:vs
Attachment: Review
cc: SITLA – WStokes@utah.gov
O:\M047-Uintah\M0470090-PRSpringMine\draft\REV4-2929-04092009.doc

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SEP 19 2009
DIV. OIL GAS & MINING

Fourth REVIEW OF NOTICEOF INTENTION
TO COMMENCE LARGE MINING OPERATIONS

Earth Energy Resources
PR Springs Mine

M/047/0090
April 28, 2009

105.3 - Drawings or Cross Sections (slopes, roads, pads, etc.)

Comment #	Sheet/Page/ Map/Table #	Comments	Initials	Review Action
	Figure 2a / Page 20	Figure 2a and paragraph 4 say the containment "cells will not be constructed on slopes greater than 20 percent (11 degrees)" yet Figure 2a notes "maximum of 20 degrees slope at the toe." Please correct or clarify the text or figure to reflect slope stability model that used for mine planning from the engineer of record.	lah	
	General	It is DOGM's recommendation that slope designations (percent, degrees or horizontal:vertical) are consistent throughout the document.	lah	
	Figure 2a	Upper drawing, berm should not be shown as the same material as the sand tailings.	lah	

106.6 - Plan for protecting & re-depositing soils

Comment #	Sheet/Page/ Map/Table #	Comments	Initials	Review Action
	Omission	Please include a statement in the NOI that all available topsoil will be salvaged (include page number, as a new page 26-27 was not submitted)	lah	

R647-4-113 – Surety

Comment #	Sheet/Page/ Map/Table #	Comments	Initials	Review Action
	Page 62	Include on surety summary sheet "Bond is for 213 acres and is shown as 'Affected Area'" acres as shown on Figures.	lah	

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DIV. OIL GAS & MINING

EARTH

www.earthenergyresources.com

March 25, 2009

STATE OF UTAH
DIVISION OF OIL, GAS AND MINING
1594 West North Temple, Suite 1210
Salt Lake City, Utah 84114-5801
Telephone: (801) 538-5261
Facsimile: (801) 359-3940

For the attention of: Mr. Paul Baker, Minerals Program Manager

REFERENCE: **Notice of Intent To Commence Large Mining Operations**
M0470090, Task 2386

Dear Mr. Baker:

Earth Energy Resources is herewith transmitting the revised pages of the above-noted Notice of Intent (NOI). This version addresses DOGM's 3rd review comments, which were transmitted on January 12, 2009. The submittal includes the NOI replacement pages formatted in track changes mode (minus appendices in which no changes have been made), a response document that lists each DOGM comment with a direct response, and a separate packet of information that we request be held confidential. The enclosed packet of confidential information is intended to fully replace the contents of the confidential binder included with the November 2008 submittal. Specific pages of confidential information include:

1. Figures
    a. Figure 4 (a-c) – Mine Cross Sections (an edited version has been retained in the publically available NOI; the confidential version includes ore bed information)
    b. Figure 6 – PR Spring North (Opening) Pit Showing Tar Sands Beds at Section 715 N
2. Appendix B
    a. Analytical data appended to DWQ PBR submittal
    b. Ophus Process, Process Flow Diagram appended to DWQ PBR submittal
3. Appendix D
    c. Demonstration Unit PFD, Rev. 2
    d. Ophus Process, Process Flow Diagram

We have identified the above noted information as materials that the public at large has no interest in, in its evaluation and/or interest in our NOI as it might affect the general public.

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EARTH ENERGY RESOURCES

www.earthenergyresources.com

We feel that the release of the above-noted information, submitted to support our NOI, to persons or entities outside of the relevant government agencies required to review such information in connection with the approval of our NOI, will constitute a release of confidential information. After your review of this request, should you determine that any of the above noted pages are, in your opinion, not confidential, please so advise in advance of the release of such information, as we would appreciate the opportunity to explain our position. If this matter requires any additional clarification or information, please contact me at your convenience.

We look forward to your review of this version of the NOI and hope to receive your final approval for our operations very soon. We understand that you are still in the process of reviewing the previous bond submittal; as such, the surety section of the NOI has not yet been revised.

Yours truly,
Earth Energy Resources, Inc.

J. Wall P.Eng.
for
Barclay Cuthbert
Vice President

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SEP 19 2009
DIV. OIL GAS & MINING

Suite #740, 404 – 6 Avenue S.W., Calgary, AB T2P 0R9 Canada Office: 403.233.9366 Fax: 403.668.5097

EARTH ENERY RESPONSE TO
REVIEW OF NOTICE OF INTENTION TO COMMENCE LARGE MINING OPERATIONS

Earth Energy Resources
PR Springs Mine
M0470090
March 25, 2009

Review Action Key: **A = Comment noted by Earth Energy, but no requirement for changes to current version of NOI**
B = Changes made to current version of NOI in response to comment

General Comments:

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
1	General	Submittal should be formatted to easily incorporate additional revisions and amendments. (lah)	A	This comment was carried over from the Initial Review. It was thoroughly and completely addressed by Earth Energy in the response to that review, and the May 9, 2008 2nd draft NOI was significantly reformatted to meet the Division request. On September 11, lah indicated that the comment was left in simply as a reminder. Accordingly, the reformatting changes have been continued with the current version of the NOI.
2	General Page i	Table of Content page numbers do not match page numbers, Format document to incorporate revisions, page numbers can be "tied" to info in the Table of Contents. (lah)	B	We will ensure that the page numbers indicated in the table of contents match the page number where the relevant information is located.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
3	General Page ii	List of figures shown doesn't note the actual location of the Figure, specifically it is not clear what figures are in the confidential notebook. (lah)	B	For any figure that is deemed confidential, it's location in the confidential notebook will be noted in the List of Figures. A place holder or non-confidential version of the figure will be inserted in the Notice of Intention.
4	Intro Page 1	Page numbers are not consistent, ie pages listed as "ii, 1, ii, 3" Keep pages consistent and format document for revisions…check all page numbers. (lah)	B	The page number for page 2 of the text is reformatted correctly.
5	Intro Page ii – Para 2	As written "second half of 2008…" Where are the results of the drilling and geophysical data? Where will it be incorporated into the document? (lah)	B	The time period for the drilling and geophysical work is changed to 2009. It is not Earth Energy's intention to include the grade and tar sand bed thickness data in the Notice of Intention.
6	General - All	Some of the information in the confidential folder does not appear to meet the criteria in R647-4-115 for keeping it confidential. Information about the general location of the mine and the mine plan should be public. More specific information relating to ore quality and location, such as seam thickness, and also proprietary information can be kept confidential. (lah and PBB)	B	All information in the confidential folder has been reviewed. Following this review, the following information was deemed non-confidential and included within the Notice of Intention: Figure 1 – Location Map; Figure 2 – Surface Facilities Map; Figure 3 – Plant Sit Layout; Figure 5 – Geology Map; Figure 7 – Watersheds Map; Figure 8 – Vegetation Map; Figure 9 – Reclamation Map; List of tankage and buildings located within the Processing Site, Rev.2; List of Equipment for Utah DAQ Emissions Inventory, Rev. 6; and the EER PR Spring Mine Site photo. Further, for confidential Figures 4a-4c; the confidential information was removed from and the "sanitized" versions of these figures are included in the Notice of Intention.

R647-4-104 – Filing Requirements and Review Procedures

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
7	Page 6	Grand County CUP (Conditional Use Permit) will be required for the approved NOI by DOGM, as written when the CUP is received this page will have to be amended. Consider rewording statement, so this page would not have to be revised. (lah)	B	Changes have been made to the current version of the NOI (in the introduction and on page 6 in Section 104.1) to read as if both CUPs are in Appendix B. A place holder for the Grand County CUP, which cannot be obtained until the DOGM NOI is approved, has been added to the appendix.

R647-4-105 - Maps, Drawings & Photographs

General Map Comments

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
8	Conf - Figure 2	Rip-rap armored channel – As shown channels will be difficult to build without disturbance outside the "affected area". (lah)	A	Rock rubble riprap will be placed in erosion prone drainage channels with as little disturbance to adjacent land as possible. All disturbance will however be contained within the perimeter of the disturbance boundary. Should construction of erosion controls be required outside the present limits of the disturbed area boundary, Earth Energy will seek an amendment to the NOI.
9	Conf - Figure 3	Great figure to tie to the bond calc sheet. (lah)	A	As discussed during the meeting of January 14, 2009, the description of facilities in Figure 3 matches the descriptions used in the bond calculation sheet. We feel that additional revisions to Figure 3 to attempt to tie the Figure to the bond calculation sheet will not be informative or helpful.

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R647-4-106 – Operation Plan

106.2 Type of operations conducted, mining method, processing etc.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
10	Page 13 – para 3	List of mining equipment is noted in Appendix D, but it is actually in confidential notebook, it is unclear why a list of Mining Equipment is confidential?? (lah)	B	The list of mining equipment is included in Appendix D, and has been removed from the confidential folder.
11	General	It was noted in a site visit that water ponds on top of the oil sands. Please include a discussion indicating how this aquitard situation will affect the mining method. (lah)	A	Discussions of the collection of incident precipitation and the uses of this collected precipitation are discussed on pages 14 and 36 of the Notice of Intention.
12	Page 17 – Para 3 & 5	DWQ Permit by Rule determination is required for the approved NOI by DOGM, as written when the determination is received this page will have to be amended. Consider rewording statement, so this page would not have to be revised. (lah)	A	Earth Energy has received Permit by Rule designation from DWQ and information about this approval is included in Appendix B. Sections of the Notice of Intention that refer to the documentation submitted to DWQ in order to obtain the Permit by Rule designation are accurate and do not require amendment to reflect that the Permit by Rule is included in Appendix B.
13	Page 19 – para 2	"Earth Energy will supply…" perhaps rewrite to note 'processed sand will be placed to eliminate potential slope stability failure surfaces' or wording that is similar. This would eliminate the need to revise text in a future amendment. (lah)	B	The text has been modified to the following: "Detailed mine plans are developed to ensure that the produced (clean) sand is replaced in the pit in a sequential layered and compacted manner to eliminate potential slope stability concerns."

106.6 Plan for protecting & redepositing soils

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
14	Page 26 - 27	After a site visit it noted that greater 24" of topsoil was noted on the ridge top. As noted topsoil depth varies. Document should reflect the variable amount (lah)	A	As noted on page 27 of the Notice of Intention: "However, it is important to note that this is an estimate only; actual soil salvage volume could be more or less than this amount. The actual amount salvaged would be dependant upon what is encountered in the field: all available topsoil would be salvaged (with the exceptions noted above for the topsoil storage piles), which in some areas may reflect a lesser thickness than assumed and in other areas may be a greater thickness than assumed."

R647-4-109 - Impact Assessment

109.1 Impacts to surface & groundwater systems

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
15	49	The SWPPP plan must be incorporated into the Notice of Intent prior to approval. (TM)	B	The SWPPP is now included with the NOI as Appendix G.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
16	47	It appears that the majority of runoff will occur as snowmelt or short duration thunderstorms. The slopes on the overburden interburden storage areas are 400 feet long with no proposed slope breaks. This not standard engineering practice and fails to provide the assurance needed that these slopes will be an erosional problem. The plan describes the coarse nature of these overburden and interburden storage areas yet 50 percent of the dumps will be constructed of the processed sand with a 20 percent clay component which if exposed would probably tend to be very erosive. Therefore the construction of these overburden/interburden storage areas will define whether impact to the surface water systems will occur. Please elaborate on how the containment pens, mixing of the overburden and interburden with the sand will provide a stable surface free of fines. (TM)	B	As described in Section 106, subsection OVERBURDEN/INTERBURDEN STORAGE AREAS, initial quantities of commingled sand/clay fine tailings will be impounded in storage cells constructed of coarse overburden materials in the upper reaches (flattest) areas of the proposed overburden/interburden storage areas. 15-20 foot high cells will be constructed as compacted berms of overburden material and then filled with commingled clean sand/clay fine tailings. When the first level of cells is filled to capacity, successive tiered levels will be constructed until the mine has sufficiently advanced to permit direct replacement of the tailings back into the pit, in the layered method described in Section 16.2 Subsection PIT BACKFILL. Five to six levels of tiered cells are anticipated to be required before backfilling of the mine pit can be undertaken. Tailings storage cells in the upper reaches of the overburden/interburden storage areas will ultimately become fully encapsulated within the finished and reclaimed overburden/interburden storage areas as described in Section 110.2 Subsection RECLAMATION OF SLOPES. Tailings containment cells will be not be constructed on slopes steeper than 20 percent (11 degrees). A figure (2a) has also been added to the NOI to depict these tiered cells.

109.4 Slope stability, erosion control, air quality, safety

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
17	20	Runoff will be controlled on the exposed faces of the overburden/interburden storage areas with coarse/low sediment potential material. Since the dumps will be constructed or sloped at the angle of repose (30 degrees to 34 degrees). Please give a better description of how these waste dumps will be constructed (end dumping, bulldozed, etc). Please show a typical drawing of the containment pens and how this method of construction will be accomplished on a 40 degree slope and will fit with the dump construction methods. Are the waste dump slopes going to be constructed by end dumping, alternating between the overburden and the sand and clay waste stream material? How will the clay and sand waste be mixed and placed with the overburden when the overburden will be a totally different composition? Would it not be better to build these dumps in lifts, creating more stability and making reclamation easier at the end of mine life? (TM)	B	As described in Section 106, Subsection OVERBURDEN/INTERBURDEN STORAGE AREAS, initial quantities of commingled sand/clay fine tailings will be impounded in storage cells constructed of coarse overburden materials in the upper reaches (flattest) areas of the proposed overburden/interburden storage areas. 15-20 foot high cells will be constructed as compacted berms of overburden material and then filled with commingled clean sand/clay fine tailings. When the first level of cells is filled to capacity, successive tiered levels will be constructed until the mine pit has sufficiently advanced to permit direct replacement of the tailings back into the mine in the layered method described in Section 16.2 Subsection PIT BACKFILL. Five to six levels of tiered cells are anticipated to be required before backfilling of the mine pit can be undertaken. Finished containment cells will prevent erosion of the fine tailings and result in a stable placement as pointed out in the reviewer's comments. Tailings storage cells in the upper reaches of the overburden/interburden storage areas will ultimately become fully encapsulated within the finished and reclaimed overburden/interburden storage areas as described in Section 110.2 Subsection RECLAMATION OF SLOPES . Tailings containment cells will not be constructed on slopes steeper than 20 percent (11 degrees).
18	Page 49 Omission	Air Quality – Most of the written discussion is in regards to dust and equipment emissions. What Air Quality issues will be addressed regarding the process facilities? (lah)	A	All air quality issues, including those regarding the process facilities, are addressed in the documentation submitted to EPA and the documentation received from EPA with regard to air quality permitting will be included in Appendix B.

R647-4-110 - Reclamation Plan

110.2 Roads, highwalls, slopes, drainages, pits, etc., reclaimed

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
19	44	This page describes concurrent reclamation of the pit areas but does not discuss the waste dump topsoil placement. Please provide how these overburden interburden storage areas will be topsoiled and reclaimed. (TM)	B	Topsoil salvaged from disturbed areas will be spread on the recontoured faces of overburden/interburden storage areas with the exception of rock armoured drainage courses or other areas deemed to have higher erosion potential, that will be similarly protected with coarse rock material. Further detail is provided in Section 110.2 Subsection RECLAMATION OF SLOPES and in Section 109.4 Subsection EROSION CONTROL.

110.5 Revegetation planting program

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
20	Pg. 59 Seedmix	The seed mix provided is not specific as to what is actually planned. (i.e only 11 of the 17 species listed will be used). Please indicate which species are the preferred species and omit the rest (if at the time of reclamation, the preferred species are not available then substitutions can be made at that time, with species that are available). It is suggested that both forb species and all shrub species be used (for a total of 14 species). (LK)	B	Both forb species and all shrub species will be included in the seed mix. In addition, a specific seed mix is now listed in the Notice of Intention so that there is no ambiguity in the Notice of Intention.

R647-4-113 – Surety

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
21	Page 62	Item 15&16 – Post mine monitoring is not a subtotal, escalation applies. (lah)	A	The Subtotals are additive. Subtotal 1 - Item 15 in the Surety section of the NOI - is a total of all the reclamation items above it. Subtotal 2 - Item 16 in the Surety section of the NOI- includes Subtotal 1 plus the reclamation Supervision and Monitoring. Once the 5% contingency is added to Subtotal 2 (the Base Reclamation cost (Subtotal 1) + Supervision and Monitoring), then the escalation is applied to this entire amount.
22	Appendix E	DOGM standardized Spread Sheet will be supplied. (WHW)	A	Thank you for supplying the standardized spreadsheet. However, from recent discussions with DOGM, we understand that the previously developed spreadsheet for surety calculations will be used in the Notice of Intention.
23	Appendix E - Page 3	Bond Calculation is to assume the worst-case scenario, calc needs to assume the pit has not been backfilled and the slope s will need to be bonded. (lah)	A	The bond calculation as presented is associated with a worst case scenario for reclamation of the site. As mining operations progress, Earth Energy will commence with concurrent reclamation of the overburden storage areas and of depleted areas of the mine pit. However, the bond calculation includes reclamation for the entire Affected Area; at no point would reclamation of all 213 acres be required. In regard to an unplanned scenario where operations cease prior to backfill beginning, please note that this does not represent worst-case. At most, only the very initial stages of the pit would be opened, without backfilling occurring. During that, and all times, the operational pit slope angle is 2h:1v. At no time will the pit walls be at or near the 45-degree angle stipulated at R647-4-111, so filling or laying back these slopes would not be needed. Therefore, no additional measures would be required to attain stability of these highwall slopes in the event the pit is developed and abandoned prior to backfilling.
24	Appendix E - Page 3	As noted "mine will be backfilled 50-60%..." Does this statement reflect Figure 9? (lah)	A	Figure 9 does reflect the final contour of the mine pits upon backfilling of however, a revision has been made to increase the percentage of pit backfill to 60-65% of the original volume.

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DIV. OIL GAS & MININ

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
25	General	The Division is pleased with the Reclamation Map figure 6, but we would like a "Bond" map that would associate the site with the bond calc that is a worst-case scenario. (lah)	A	See response to Comment 23 above. Note that the Figure 5 Reclamation Map therefore is a bond map representing the worst-case scenario.
26	General	More comments will be forthcoming when standardized spread sheet is utilized. (lah)	A	From recent discussions with DOGM, we understand that the previously developed spreadsheet for surety calculations will be used in the Notice of Intention.

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SEP 19 2009
DIV. OIL GAS & MINING

EARTH ENERY RESPONSE TO
REVIEW OF NOTICE OF INTENTION TO COMMENCE LARGE MINING OPERATIONS

Earth Energy Resources
PR Springs Mine
M0470090
November 10, 2008

Review Action Key: **A = Comment noted by Earth Energy, but no requirement for changes to current version of NOI**
B = Changes made to current version of NOI in response to comment

General Comments:

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
1	General	Based on the content of the submittal, it appears there may be expansions that will require revisions to the permit in time. Because of the change dynamics, the submittal should be formatted to easily incorporate into future revisions or amendments. Further discussion with the Division is suggested. (BE)	A	This comment was carried over from the Initial Review. It was thoroughly and completely addressed by Earth Energy in the response to that review, and the May 9, 2008 2nd draft NOI was significantly reformatted to meet the Division request. On September 11, lah indicated that the comment was left in simply as a reminder. Accordingly, the reformatting changes have been continued with the current version of the NOI.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
2	General	It has been noted in the submittal that there maybe additional resource reserves, yet the plan does not indicate how an expansion would be incorporated into the plan. Ie something would have to be rehandled, processing plant, the moving of a dump etc. (lah)	B	Development of additional resources will be dealt with through future NOI applications to DOGM. Changes to the current version of the NOI (in the introduction and on page 51 in Section 110.2) have been made to clarify this commitment. It is beyond the scope of Earth Energy's proposed operations to develop detailed plans for any expansions at this time or in this NOI. Such expansions will be dependant upon the results of the initial development and continuing market conditions. Note that Earth Energy's operations are planned to minimize any re-handling of material as operations expand. The overburden/interburden storage piles are located in areas devoid of oil sand and mines will be depleted before refilling and reclamation commence. Surface facilities are constructed on oil sand bearing areas, but these areas are limited; and relocation of the plant facility and ultimate development of the underlying bitumen resource is incorporated within our future plans. Changes have been made to page 11 in Section 106.2 to explicitly state this intent.

R647-4-104 – Operator's, Surface and Mineral Ownership

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
3	General	Once the conditional use permit from Grand County is granted, please include this as an appendix to the plan. (BE) Provide Appendix number and a place holder for the permit to be inserted (lah)	B	Changes have been made to the current version of the NOI (in the introduction and on page 6 in Section 104.1) to reference the appendix in which the Grand County CUP will be placed when available. A place holder for the document has been added to the appendix.

R647-4-105 - Maps, Drawings & Photographs

General Map Comments

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
4	General	There is no shown and labeled public access route from nearest highway. (BE)	B	The public access route, Seep Ridge Road, was previously shown and labeled on Figure 2 in the May 9, 2008 2nd draft of the NOI. The nearest highways were previously shown on Figure 1 in that 2nd draft. In the current version of the NOI, these features continue to be shown and labeled on these two figures, and additional labeling has been added to them as well. In addition, a reference to Figure 2 has been included on page 12 in Section 106.2.

Specific Map Comments

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
5	General	The below review comments are specific to the identified maps. The items will require clarification and updates, improvements, or corrections. These should be made to each of the maps accordingly. Do not assume this information is all-inclusive as other changes may result once clarity is established. (BE & lah)	A	This comment does not appear to require a response.
6	Figure 2	Label permit area, include pipeline disturbance, include acres to match Bonded acres (lah)	B	The term "Permit Area" is not used in the May 9, 2008 2nd draft of the NOI or the current version; instead, the term used to describe the 213-acre area which will be disturbed by the operations, bonded for, and subsequently reclaimed is "Affected Area". Figure 2 in the 2nd draft previously properly labeled this area. Bonded acres have been added to this figure as well, however please note that the initial review indicated that figures were too cluttered, and thus acreage labels were removed for the May 9, 2008 2nd draft NOI. Also, note that the 4.4 acres of water well and pipeline disturbances are now being permitted separate from this project, under Exploration Notice #E0190053. As a result, the Affected Area (and total bonded acres) no longer includes the water well and pipeline, and bonding for those is covered by the Exploration Notice.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
7	Figure 2	The word proposed mine operations shows several colors of hatching, however none of them are identified using a key. There is no indication of what they mean. Please correct. (BE)	A	This comment was carried over from the Division's Initial Review. In response to the comment, the figure was removed from the May 9, 2008 2nd draft NOI and information was presented in other figures. Thus, the comment is irrelevant to the current version of the NOI, and no further response is needed.
8	Figure 2a	Include either plan view of feature or more description of where feature will be used. Nothing has been included catch basins, sediment ponds, etc (lah)	B	These features will be used at locations shown on Figure 2. They will function as sediment traps/energy dissipation at the toe of the overburden/interburden storage areas. By design and by nature, these areas are not expected to generate large quantities of sediment or runoff: they will not collect up-gradient runoff, they are constructed at moderate gradient, and their substrate is coarse and porous. Therefore, large sediment ponds are not needed to control either runoff or sediment from these overburden/interburden storage areas. See the text in Section 109.4 of the May 9, 2008 2nd draft of the NOI, and the current version of the NOI for additional discussion of this issue. Further, as was indicated in numerous locations in the May 9, 2008 2nd draft of the NOI, a water retention/sediment pond is planned to prevent sediments from moving off the plant site; that pond was shown on Figure 3. Please refer to responses detailed in sections 42, 43, 55 & 58 that follow below.
9	Figure 2a	Overburden should be keyed into natural slope for stability FOS (lah)	B	Earth Energy mine engineers do not feel that it is necessary to key overburden in to the slopes in all locations or as a matter of general design. However, on the steepest areas of overburden placement, the toes of fills may be keyed into existing slopes as deemed necessary in the field at time of placement; a statement to this effect has been added to the NOI, but figure changes have not been made. Also see the response to Comment #51, which discusses the conservative nature of the overburden/interburden storage area design.
10	Figure 2b	Include either plan view of feature or more description of where feature will be used. Where will a unlined ditch be used as opposed to a rip rap lined ditch, where will the berm be used in the plan (lah)	B	Earth Energy does not believe that a plan view of a typical berm or a typical ditch is needed; the cross sections provided in Figure 2b are fully understandable and these features are common, typical, and standard. Cross sections are a standard way to describe such structures. In regard to exactly where they will be used, and additional descriptions, please see changes that have been made to pages 16 in Section 106.2 in the current version of the NOI.
	Figure 3	Define 203 acres listed in text and in bonded area. (lah)	B	Please see the response to Comment #6. Also note that acreage values have been refined throughout the current version of the NOI.

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Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
12	Figure 3	Label figure 3 - features to be tied to surety bond (lah)	A	There is no good way to add all of the surety information onto this figure. The surety table includes references to these features and the assumptions used therein and does not need to be duplicated on this figure.
13	Figure 3	The facilities map should include the dimensions of the buildings, ponds, piles etc. These dimensions can be part of the legend and referenced appropriately. The map should show roads, including access and haul roads; utilities and power lines (water, gas, power, telecommunications etc); and drainage control devices. (BE) Maximum size of the facilities are needed for bonding calculation purposes. (lah)	A	Earth Energy respectfully disagrees that dimensions should be placed on Figure 3 for every specific structure, for the following reasons. First, with the additional labeling already added to this figure in response to Comment 12, the figure is simply too cluttered to contain the additional information. Second, the figure is meant to represent the conceptual plans for the surface facility, as they are currently known; detailed engineering designs have not yet been prepared and Earth Energy has committed to submit those detailed designs, which will include dimensions, once they are available. Third, the figure as is contains overall site dimensions, from which the relative and general sizes of the specific features within the site can be generally and easily inferred. Last, Earth Energy recognizes that dimensions are important for surety purposes; to that end, the bond calculation worksheets spell out the presumed maximum sizes for specific structures.
14	Figure 4a,4b,4c,6	FYI only, best if drawn with no vertical exaggeration, best if all x-sections are the same scale, engineering standards for drawing are lacking (lah)	A	Earth Energy respectfully disagrees that these cross sections are best shown without vertical exaggeration. Necessary detail would be lost if scales were equivalent, and vertical exaggeration is a standard practice to solve this problem. No changes to the scale of these drawings have been made.
15	Figure 4a,4b,4c	Slope angles shown on x-section are incorrect. (lah)	A	Earth Energy believes that the shown slope angles on all three of these figures are correct. Please note that a replacement for Figure 4b was submitted to the Division on May 15, 2008 to correct an error in the May 2008 2nd draft NOI submittal.
16	Figure 5	As per 105.3.16 A geology map is required, include Geomechanical data; include orientation of bedding and structural features include faults, and joint sets orientations to demonstrate pit wall stability . (lah)	B	In response to a comment in the Division's Initial Review, the best available geologic map was provided as Figure 5 in the May 9, 2008 2nd draft NOI. The response letter accompanying that 2nd draft stated that it was the best available map. As requested by Comment # 40, generalized strike/dip information for bedding has been added to Figure 5. The other more detailed geologic information that the Division is requesting is simply not available, to Earth Energy's best knowledge, so it cannot be added to the map.
17	Figure 5-d	There may be related issues within the other figures and more information may be required. (BE)	A	Figure 5-d was taken out of the May 9, 2008 2nd draft NOI. No further response to this comment is warranted.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
18	Figure 5-d	Is this figure to remain in the plan? Why is it labeled proprietary & confidential? (lah)	A	Figure 5-d was taken out of the May 9, 2008 2nd draft NOI, and remains withdrawn. Thus, its labeling is not relevant to either the 2nd draft or the current version of the NOI.
19	Figure 9	Good regrading plan. Better scale and more detail needed (match to surety bond) needed (lah)	B	Changes have been made to Figure 9 in the current version of the NOI., however we believe the scale as-is is adequate.
20	General	As per 105.3.16 A geology map is required, include Geomechanical data; include orientation of bedding and structural features include faults, and joint sets orientations to demonstrate pit wall stability. (lah)	B	This comment is identical to #16 above. See Earth Energy's response to that comment.
21	General	A map should be submitted that shows adjacent land owners, including access road from the nearest public state road. (BE) As per 105.3.18 County road is not labeled on Figure 1 as written in text page 10 para 5 (lah)	A	Land ownership and access road information was previously provided on Figure 2 of the May 9, 2008 2nd draft NOI; please refer to that figure. Also, please see response to Comment #4.

R647-4-106 – Operation Plan

106.2 Type of operations conducted, mining method, processing etc.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
22	Page 11 para 4	FYI – Caterpillar performance handbook provides ripper performance chart for dozers based on Seismic Shear Wave Velocities. (lah)	A	Earth Energy appreciates the Division providing the information, however we do not believe it is relevant to our project. No changes have been made to the current version of the NOI in response to this comment.
23	Page 11 para 4	Safety items regarding blasting such as closure distances and times should not be committed to in the Mine permit., as loading specifics are not known. Give minimums or maximum as each apply. (lah)	B	The noted paragraph has been rewritten in the current version of the NOI to address these blasting comments, including deleting reference to closure distance and times. Peak particle velocities of initial blasting operations (if blasting is required) will be monitored and appropriate blasting protocols refined at the time blasting commences. As typical for these types of operations, a series of test blasts will be monitored to determine the resultant peak particle velocities at specified distances from the blasting area.
24	Omission	Include posting of sign with Blasting schedules on public roads. (lah)	B	The current version of the NOI has been modified on page 13, Section 106.2 and pages 53, Section 109.4 to include signage information.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
25	Page 11 para 4	"Blasting is not expected...." As per Public Safety R647-4-109 4. NO FLY WILL BE TOLERATED ON PUBLIC ROADS (lah)	B	The noted paragraph and elsewhere in the current version of the NOI have been changed to eliminate the mitigation for fly rock on public road. This information had only been added to the May 9, 2008 2nd draft of the NOI in specific response to a Division Initial Review comment to address migration of materials during blasting.
26	Page 12 Para 3	Why is the processing procedure listed under equipment? (lah)	A	This text was included to assist the reader in understanding the utilization of the mining equipment. As Earth Energy believes that it is useful, it remains in the current version of the NOI.
27	Page 13 Para 1	Slope stability and Blasting are related, perhaps info should adjacent in text. (lah)	A	Earth Energy believes that the discussion on slope stability and blasting is coherent as written; no changes have been made to the current version of the NOI in response to this comment.
28	Page 13 Para 1	Controlled Blasting is not normally done on slopes of 2H:1V (lah)	A	Earth Energy appreciates the Division providing the information. However, we continue to believe that controlled blasting on 2H:1V slopes is a feasible and effective way to mine these pits. No changes have been made to the current version of the NOI in response to this comment.
29	Page 14 Para 4	Show locations of water retention/storage ponds on a map.(lah)	B	The only planned water retention storage pond was previously shown on Figure 3 in the May 9, 2008 2nd draft of the NOI. It remains shown on that Figure in the current version of the NOI. A reference to that figure has been added to the current version of the NOI on page 15 in Section 106.2. The small in-pit collection areas were, and are, shown on Figure 2.
30	Page 15 Para 5 & 6	It is unclear if slope stability will have an adequate Factor of Safety in the unconsolidated waste dumps with the increased pore water pressures proposed. (lah)	A	Earth Energy has designed the pit and the overburden/interburden storage areas with very conservative slopes to compensate for the lack of available geotechnical data in order to ensure that slopes will be stable. Please also refer to responses detailed in sections 42, 43, 55 & 58 that follow below.
31	Page 16 Para 6	Most ground water wells have a minimum of 4" of gravel pack around the OD of the well screen. (lah)	A	Earth Energy appreciates the Division providing the information. No changes to the well design or to the relevant NOI text have been made in response to this comment. The well will meet all of the requirements imposed by the Utah State Engineers Office, who is the regulating authority for groundwater wells in the state. Further, note that the well is now included with the Exploration Notice #E0190053 and not the current NOI.
32	Page 17 Para 2	Is there any monitoring or gages planned for the pipeline to monitor for leaks? (lah)	B	Gauges will be included in the pipeline construction to monitor for leaks. Information to that effect has been added to the current version of the NOI on page 19 in Section 106.2 and page 34 in 106.9.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
33	Page 17 Para 5	Has there been any triaxial shear tests run on "discharge sands" to determine cohesion and phi angle? (lah)	A	No, no such tests have been run and none are planned. Triaxial shear tests are intended for clay and similar materials much finer than the discharge sands and would not be relevant for the discharge sands. The noted soil testing has not been carried out on the sand tailings as placement will be in a manner as described in sections 42, 43, 55 & 58 that follow below.
34	Page 17, 18 General	General Engineering parameters should be defined, such as FOS's used (lah)	A	Earth Energy has designed the pit and the overburden/interburden storage areas with very conservative slopes to compensate for the lack of available geotechnical data in order to ensure that slopes will be stable. Also see responses to comments 42, 43, 55 and 58.
35	Page 18 Para 5	Reference drawing detail for runoff detail. (lah)	B	The requested reference was already included in that paragraph in the May 9, 2008 2nd draft of the NOI, however another reference has been added in the current version of the NOI.
36	Page 19 General	Maximum slope angles have been noted for waste piles but nothing noted for pit slope angles (lah)	B	The May 9, 2008 2nd draft NOI included the maximum operating pit slope angle of 2H:1V on page 13 and the backfilled/reclaimed pit slope angle of 2.5-3H:1V on page 49. Additional references to these maximum slope angles have been added to the current version of the NOI page 20 under the pit backfill subheading in Section 106.2. Also refer to Figures 4a, 4b, and 4c for slope angle information during operations and after reclamation.

106.6 Plan for protecting & redepositing soils

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
37	Page 23	The plan says on page 23 that soil will not be salvaged from the water well pad or the pipeline corridor because these areas are within previously disturbed corridors. Please explain further. What type of disturbance or corridors are in this area? (PBB)	B	As noted in the response to Comment 6, the 4.4 acres of water well and pipeline disturbances are now being permitted separate from this project, under Exploration Notice #E0190053. As a result, soil salvage in those areas is covered by that Notice and is not addressed herein.

106.8 Depth to groundwater, extent of overburden, geology

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
38	Page 28 omission	No geologic setting is provided for ephemeral spring noted on page 29 para 4 (lah)	B	The relevant text in the current version of the NOI has been revised to note that the observed feature is at most a seep and not a spring, and is outside of the planned affected area. Other than the overall geologic description of the area, a specific geologic setting for the feature associated with the water right and covered by the overburden/interburden storage area is not provided; no contact, mass movement, fault, or other explanation for its occurrence at this specific location has been noted by Earth Energy's contract geologist, and no water feature was observed to mark this location. The lack of such an occurrence may in fact provide some evidence that the supposed spring feature is simply associated with a mis-identified water right location. For the location identified as a seep, outside of the direct disturbance area, a short description of the geologic setting has been added to Section 109.1 in the current version of the NOI.
39	Page 28 Para 2	"Geologic Setting" is NOT the correct title for the paragraph (lah)	B	Because the paragraph was not particularly important to the narrative, it and the heading were simply deleted in the current version of the NOI.
40	Page 28 para 3	Add strike and dip, and fault to Figure 5 (lah)	B	Strike/dip associated with the general bedding has now been added to Figure 5. The published geologic maps do not show any faults within the area of concern. Mention in the text in the May 9, 2008 2nd draft of the NOI, regarding a fault that was noted by other observers, has been removed because it could not be substantiated; as geologic exploration work continues in the area, evidence of faulting would be among the types of data that would be recorded.

106.9 Location & size of ore, waste, tailings, ponds

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
41	General	The Division appreciates the efforts of obtaining information to follow DWQ guidelines for minimize impact of ore and waste stockpiles on groundwater. Specific design information and control measures should be provided in the plan. (BE)	B	The May 9, 2008 2nd draft NOI was intended to have included the DWQ information in Appendix B. It may have been inadvertently left out of the submittal, but has been included in the current version of the NOI. Final site designs will be provided to the Division of Oil, Gas and Mining when available.

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
42	Page 29 Para 2	Note "waste sand would be nearly dry"..page 17 notes discharged sand to contain 10 to 20 percent water (lah)	B	Text on page 33 in Section 106.9 of the current NOI has been changed to indicate that waste sand will contain 10-20% water. Recent process equipment evaluations are indicating the moisture content of the blended sand/clay fine tailings will be in the order of 15%. This level of moisture content is near optimal for compaction and will certainly not lead to liquefaction. Blended sand/clay fine tailings will be placed in relatively thin lifts and in conjunction with the arid climate of the mine area, the deposited tailings will readily dry out to even lower ultimate moisture content. Pore water pressures will not be a concern. Relevant portions of the current NOI also includes this information.
43	Page 29 Para 3	Provide phase maps to show the backfilling of the pit sequence (lah)	A	Phase maps are not included at this time. Earth Energy will gladly commit to supplying a greater level of detail with regard to sequencing of tailings replacement when a detailed mine plan and truck operation is fully developed. In general terms however, clean produced sand/clay fine tailings will be placed in relatively thin lifts (estimated at 1-3 ft thickness) to promote maximum drying, compaction and subsequent stability. Where conducive to properly sequenced ore bed depletion and efficient material handling (after threshold opening pit size is established), clean produced sand/clay fine tailings will be preferentially replaced in the depleted mine areas vs discharged in overburden dumps. The current version of the NOI incorporates this information and the commitment to supply additional design information when it is developed.
44	Page 29 Para 4	Provide drawing for avoiding ephemeral spring (lah)	B	Field observations have shown the ephemeral spring to be outside of the Affected Area, and that the supposed spring associated with the water right location (which is within the affected area) is not present. Thus, construction of some form of diversion structure is not warranted. References to it have been removed from the current version of the NOI.
45	Page 30 Para 4	Note steel pipeline, elsewhere HDPE is noted (page 17 para 1) (lah)	B	Text on page 31 in Section 106.9 of the current NOI has been changed to indicate that the pipeline will be HDPE.
46	Page 30 Para 2	Provide drawing for storage pond, include location and design standards (lah)	A	The location and general size of the water storage pond are shown in Figure 3. The facilities plan is preliminary and will be finalized upon completion of detailed engineering, at which time a drawing of the pond will be provided to the Division. Design standards were included on pages 14 and 15 in Section 106.2 of the May 9, 2008 2nd draft of the NOI.

106.10 Amount of material to be moved

R647-4-107 - Operation Practices

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
47	General	The plan states that there will not be a problem with drainage, and page 20 says, 'Surface water resources will be protected during operations as described above in Section 107.' There is **no** section 107 in the plan. The Division requires that the BMPs to be used on site be described in the plan and a typical drawing submitted of how the BMP will be installed and a figure showing where on the ground it will be implemented referencing the BMP. Temporary BMPs are not recommended for long term operations as they are not always maintained. The Division recommends the use of berms to direct runoff to small catch basins that can be cleaned out after storm events, since the maintenance of these controls is more predicable. Provide this additional information. This ensures the proposed controls will be effective and there will not be any problems with offsite drainage. (TM & lah)	B	This comment is repeated verbatim from the Division's Initial Review. In the response letter to that review, regarding the first two sentences, Earth Energy stated: "*The reference to Section 107 was a misprint and has been corrected. As described in R647-4-103, that section is not required to be addressed in NOIs for Large Mining Operations, however the content asked for in the Section 107 rules is provided in other sections of the NOI.*" That response fully addressed the Division concern and no additional response is warranted. In response to the remaining sentences in the comment, Earth Energy provided additional typical drawings and discussions in the May 9, 2008 2nd draft of the NOI, including incorporating the reviewer's recommendation to use berms to route site runoff to a storage/retention pond. Because of the topography, locating such ponds at the toe of the overburden/interburden storage piles are not practical because could not be readily accessed or cleaned out with equipment. Instead, other means of reducing runoff and providing sediment control were described in the May 9, 2008 2nd draft of the NOI. Earth Energy has provided yet more discussion of this issue in Section 109.4 of the current version of the NOI.

R647-4-108- Hole Plugging Requirements

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
48	Page 31 Para 2	The plan states SITLA?...it was my understanding the well will be on BLM land and also noted on page of this report and shown on Figure 1. (lah)	B	The text in the current version of the NOI has been revised in several locations, as the well is now being handled under separate permitting actions (DOGM Exploration Notice #E0190053 and BLM ROW Grant UTU-86004, in particular.)

R647-4-109 - Impact Assessment

109.1 Impacts to surface & groundwater systems

Comment #	Sheet/Page #	Comments	Review Action	Earth Energy Responses
49	Page 34 Para 2	The plan does reference any sort of sediment control other than BMPs included in the SWPPP plan by reference. The SWPP needs to be included in the plan when approved. Since the term BMPs references a large variety of sediment control devices, the Division requires that the operator specify what specific BMP controls are going to be used and a typical design drawing included in the plan. There is no reference to any sediment controls such as sediment ponds, etc. The plan says the mine is on flat ground in the headwaters of main canyon, inferring there is no runoff. The pits are likely to catch a major amount of drainage from rain and snow, and this water needs to be factored into the site plan. Therefore, a plan must be provided on how this runoff water will be handled operationally both in the pits and running off waste piles. Please include these plans and designs in the mine plan. (TM) Provide drawing with hydrology detail. As you have noted on page 34, "the SWPPP will be added" Provide a place holder for the permit to be inserted (lah)	B	This comment is repeated verbatim from the Division's Initial Review. In the response letter to that review, and in the May 9, 2008 2nd draft of the NOI, Earth Energy committed to including the SWPPP in the plan once was available, and provided discussions of specific BMPs including sediment controls, management of runoff water, and the other requested information. As also noted in the 2nd draft, additional detail will be provided once final engineering designs are completed. In Section 109.4 of the current version of the NOI, Earth Energy has provided additional information on BMPs and provided additional schematics as Figures 2c-e. As noted in a meeting with lah on September 11, 2008, the Division's preference is to have Earth Energy provide a set (so-called "tool kit") of structures that can be used in many situations should one type of structure fail or underperform. Earth Energy has attempted to do that in the referenced section. In addition, a place holder has been added for the SWPPP. In addition, and as indicated in other sections of this NOI, the mine pits have been designed as catchments to prevent run-off of water (that has traversed active mine workings) from moving off the mine area. Impounded run-on water will be collected and used for dust suppression on mine roads or used directly as make-up in the extraction process in place of groundwater pumped from the supply well.

109.4 Slope stability, erosion control, air quality (fugitive dust control plan), safety

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
50	Page 46 Para 1	The plan says Earth Energy is in the process of obtaining an Approval Order from the Division of Air Quality. Please include a copy of this Approval Order in the plan once it has been issued. (PBB) Provide Appendix number and a place holder for the permit to be inserted (lah)	B	Page 47 in Section 109.4 of the May 9, 2008 2nd draft of the NOI indicated that EPA had taken over the air permitting issues for this project due to its location within Tribal Land. Thus, no Utah DAQ Approval Order will be needed or issued. As was noted previously on that page, the EPA approval will be placed in Appendix B once it has been obtained. A place holder has been provided in the current NOI.
51	Page 42 Para 1	Will the valley fill dumps be keyed into the slopes? (lah)	B	No, Earth Energy does not feel that keying of the overburden/interburden storage areas is needed; from a geotechnical standpoint the design slopes will be stable as is without this additional measure. Note also that these features are placed above the steepest portions of these drainages. Changes have been made in multiple locations in the current version of the NOI, notably in Section 109.4, to provide assurances that stable slopes are being used.
52	Page 46 all	See comments listed above regarding public safety (lah)	B	The public health and safety subsection in the current version of the NOI has been edited to eliminate the Division's concerns regarding language about blasting.
53	Page 46 Bullet 9	Fly rock is bad blasting…the proper blast design has no fly rock, the use of adequate stemming is the solution. (lah)	B	Bullet 9 in the public health and safety subsection in the current version of the NOI has been edited to eliminate the Division's concerns regarding language about fly rock

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R647-4-110 - Reclamation Plan

110.1 Current & post mining land use

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
54	General	Exploration cannot be a post mining land use. Closure plans should be dependent on the area being used as open space/habitat. (BE & lah)	B	Page 49 in Section 110.2 of the May 9, 2008 2nd draft of the NOI stated "While recognizing that exploration may occur in the future, the stated objective of reclamation planning in this NOI is to reclaim the site in order to provide for future post mining land uses of wildlife habitat and open space." Thus, as the comment requested, the closure plan already is dependant upon the area being used as open space/habitat. The reason that exploration was listed as a potential postmining use of the land after reclamation is simply to acknowledge that it is a potential future use. Changes have been made to the current version of the NOI in this portion of the text to clarify that no such postmining exploration uses are contemplated by Earth Energy themselves.

110.2 Roads, highwalls, slopes, drainages, pits, etc., reclaimed

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
55	Page 50 Para 2	"pits (approx 92 acres….)" It is unclear which part of the 92 acres will be back filled, please, submit phasing as plan view diagrams. (lah)	A	The 93 acres refers to the North (Opening) Pit and West Pit, all of which will be backfilled (see cross sections in Figures 4a, 4b and 4c.) Phase maps showing backfilling of the pits will be prepared as part of the detailed mine planning; they will be provided to DOGM at that time. It is currently premature to prepare them because the final pit configurations and detailed plans cannot be finalized until the high density coring program and core assays are completed on the proposed mine area. In conceptual terms however, mining will commence in the "D" bed at the S.W. limit of the north (opening) pit and will advance north into the "D" bed until a sufficient bench area is established to begin mining the "C" bed. Overburden/ interburden and produced sand tailings from this threshold opening area of the North pit will be discharged in the upper reaches of Overburden/ Interburden Storage Area #1. When a sufficient area of the North pit has been depleted of ore, sand tailings will be backhauled to the mine pit for direct replacement in the mine (onset of concurrent reclamation operations). Percentages of overburden removed ahead of the advancing active pit face may be co-mingled with the replaced sand tailings to minimize discharge to Overburden/ Interburden Storage Area #1and further stabilize the replaced fill material by creating a broader gradation.

110.3 Description of facilities to be left (post mining use)

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
56	Page 51 Para 6	As stated water well is to revert to SITLA. Well is located on BLM land and other documentation refer to reverting to BLM. Please clarify (lah)	B	Please see response to Comment #48.

110.5 Revegetation planting program

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
57	Page 52 Para 3	It is unclear why pipeline construction is "except" from redistribution of topsoil. (PB & lah)	B	Please see response to Comment #6. Pipeline reclamation is now handled under Exploration Notice #E0190053.

R647-4-111 - Reclamation Practices

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
58	General	The plan says on page 36 that no significant drainages will be disturbed so none will be reconstructed. The plan needs to address landform and final drainage on waste dump faces. Please show how waste pile outslopes and reclaimed pit slopes will be stabilized, water directed off the slope, erosion controlled, and how sediment will be kept from leaving the site. (TM) According to Plan, the dumps will contain a significant amount of fine grained material, not just waste overburden, address how fine grained sediments will be kept from leaving the site…siltation basins ?, sediment ponds (lah)	B	Exposed waste dump faces will be protected with coarse/low sediment potential material, effectively armouring the faces. Initially produced sand tailings required to be discharged to Overburden/ Interburden Storage Area #1 (prior to direct discharge back to the depleted mine pit) will be placed within containment "pens" formed by initial placement of coarse overburden materials. In this manner, resultant waste dump fills end up being "celled" with a buried internal framework of interlocked coarse overburden materials. Dumps constructed as a series of interlocking deposition cells can be made very stable and sequenced effectively as the waste materials are generated. Section 106.2 in the current version of the NOI now contains this additional explanation. Note that this comment (which remains from DOGM's initial review) was also addressed in the May 9, 2008 response document, though the current reviewer apparently did not have access to that.

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R647-4-113 – Surety

Reclamation:

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
60	General	This review cannot capture every omission and make a statement accordingly. It is anticipated that communications will occur in the interim and the dialog will provide elaboration on the generalities made within the scope of this review. (BE)	A	This comment does not appear to require a response. Note that the DOGM comments appear to skip from 58 to 60, with no comment #59.
61	General	On the sub sections within each category on the cost estimation, please include the dollar amount. (BE)		Subtotal dollar amounts were included in the surety table in the May 8, 2008 2nd draft of the NOI within each subsection for all categories except Category 1. Subtotal dollar amounts for Category 1 have been added to the surety table in the current version of the NOI.
62	-	Category 1. The spread sheet dollar amount of $210,627 is different than the category one summary amount of $263,427. (BE)		This error has been corrected in the surety table in the current version of the NOI.
63	Page 50	Page 50 of the draft indicates that some of the demolition activities will require burial. Have these costs been accounted for? If so, an explanation of that should be provided in the spread sheet or within a surety summary narrative. (BE)		The current version of the NOI text has been clarified in regard to items that will be buried (see response to Comment 65). Because the items will simply be buried in-place, costs are accounted for in the other tasks such as ripping, grading and topsoiling. A notation to this effect has been added to the surety table.
64	Page 50 Para 5	Page 50 the new text uses the word proposed. Please remove the use of the word and write the narrative as though the Division has approved. (BE)		The noted occurrence of the word "proposed" has been removed from the current version of the NOI. Further, that word has not been used elsewhere in the current version of the NOI.
65	Page 50 Para 5	The first sentence of the Facilities and Materials paragraph requires some clarification and requires specific action outline. When reading it lends the impression that either burial or dismantling will occur. In reality dismantling will occur with the exception of the mentioned burial work. (BE)		The current version of the NOI includes clarifications to the noted paragraph.
66	-	Although the surety spreadsheet identifies the equipment used in category one reclamation. It is extremely helpful to provide the equipment within the reclamation narrative as well. (BE)	B	A paragraph that lists reclamation equipment has been added to page 56 in Section 110.2 of the current version of the NOI.

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
67	Page 51 Para 1	Page 51, the process train indicates process materials will be drained. Please elaborate on where the drainage will occur, and explain if the process materials are hazardous and/or are an impact to public health and safety. (BE)	B	The requested elaboration has been added to page 52 in Section 110.2 of the current version of the NOI. Additional costs have been added to the surety. Hazardous materials have been previously discussed.
68	General	There is indication that there are two process trains. It appears there are reclamation costs for only one. Page 2 of the summary surety draft does not show costs for two process trains. Please correct and/or explain. (BE)	B	Page 14 in Section 106.2 of the current version of the NOI has been revised to state that only one process train will be permitted under this NOI. Additional clarifications to this end have also been made, including removing the optional process train from Figure 3.
69	General	Please provide the weight of one cubic yard of cut up process train. (BE)	A	There is no reason to discuss or calculate the weight of one cubic yard of cut up process train. The surety calculation was based upon weight, not density, and thus its density is irrelevant. No changes have been made to the NOI narrative or surety for this comment.
70	Page 49 Para 1	Page 49, reclamation activities will involve the Division. Surety release will not occur until the Division approves the reclamation work, which typically requires 'visual inspections'. It may be helpful to include narrative that indicates the reclamation activity obligations under the Act and rules. (BE)	B	Page 56 in Section 110.2 of the current version of the NOI has been revised to include the requested information.
71	Page 49 Para 2	Page 49, during interim and on going reclamation, a commitment should be made that indicates that maps will be submitted to the Division showing 'active roads' or a reference that the roads shown on the reclamation activities map are active during the early reclamation phases. (BE)	B	A statement has been added to page in Section of the current version of the NOI to clarify that all roads or portions of them remain active during the early reclamation phases.
72	Genaral	What are the road dimensions? (BE)	B	Road dimensions have been added to page 56 in Section 110.2 of the current version of the NOI.
73	General	What is the water source for the water truck? (BE)	B	A statement has been added to page 52 in Section 109.4 in the current version of the NOI to reiterate that Earth Energy will use water from the water well that will be drilled and for which a water right has been obtained.

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
74	Page 49 Para 5	Page 49, correction is required, there is a comment that indicates that a variance is required for slopes exceeding 45°. That 45° rule is for highwall remediation. By rule, slopes are to be regraded to a stable configuration, and sloped to minimize safety hazards and erosion while promoting successful revegetation. Please remove/re-write the comment. (BE)	B	Page 51, Section 110.2 in the current version of the NOI has been revised to eliminate the variance reference. Please note that the reference was put in to the May 9, 2008 2nd draft of the NOI specifically because of the following statement quoted from the Division's Initial Review "It appears the waste slope angles are greater than 45°, transverse mine sections W1-E1 & W2-E2 reclaimed waste slope angles are 60° or greater. Therefore a highwall variance will be required. (BE)" To clarify, neither the 2nd draft nor the current version of the NOI call for any slopes greater than 45° on any feature.
75	Page 49 Para 5	Spelling comment: regarding should be 'regrading', page 49. (BE)	B	The requested correction has been made.
76	General	What is the remaining height of the pits once sand mix has been placed? (BE)	A	The pits will be backfilled, and their backfilled contours are shown in Figures 4a-4c.
77	Page 50 Para 3	Page 50, for clarity and to eliminate oversight, please relocate the comment under the title "DRILL HOLES', 2nd paragraph about the 'impounding pit'. (BE)	B	The current NOI has been revised on pages 51 and 52 in Section 110.2 to delete the statement from page 51 and insert it on page 52.
78	General	If on site burial of facility components occurs, a solid waste permit may be required. Please make a statement to that affect. (BE)	B	A statement to this effect has been added to page 52 of Section 110.2 in the current version of the NOI.
79	-	Page 1/Surety Estimation under items to be removed, the mine office building is not included. Although ATCO removes it, please include it in the table and make that statement there as well. (BE)	B	The office building has been added to the surety table in the current version of the NOI, along with an explanatory comment about its fate.
80	General	For clarification purposes, does ATCO remove the mine office building without any prep work by operator? Does the mine office building have contents that must be removed? It is assumed gutting is required for this building and others. However, there is no cost. Please explain or include gutting costs.(BE)	B	Prep work will consist of disconnecting the hoses. Gutting will not be required, as it is assumed that ATCO will reuse the building at another site. The surety table in the current version of the NOI now includes this information.

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
81	General	The 'rates and seed mix' sheet shows that labor hourly rates are on pg 629 of the 2008 Means Heavy Construction Cost Data book. That page is an overview of 'new titles'. Please correct and reference the right pages from the book. (BE)		The rate reference from Means has been revised in the current version of the NOI.
82	General	Clarification is required on the bond estimate summary for the following statements: Laborers, assumes 4/laborers per crane hour. If there is a total of 8 crane hours for removal of the water storage pond liner, then a multiplier (number of laborers/crane hour) is missing and should be included before multiplying by the dollars/hour. (BE)	B	The missing multiplier has been added to the surety table in the current version of the NOI.
83	General	Please place the cost (hourly/weekly rate) of the crane on the equipment costs table. (BE)	B	The crane rate has been added to the equipment portion of the surety table in the current version of the NOI. .
84	General	Page 1/6 of the bond summary worksheet shows a crane being used for the removal of several items, however the hourly equipment cost associated with the water storage pond liner is $55.82. The item to be removed description specifically states that a crane will be used. Please clarify/correct. (BE)	B	A correction has been made to the equipment cost line associated with the water storage pond liner, in the surety table in the current version of the NOI. .
85	General	Please check subtotal columns, especially the first one in each sub category. There appears to be consistent errors. Example, tanks (22): 49X47.05 = 2305.45, the cell shows 2290.00. There are more of these errors, please review and correct. (BE)	B	Summations have been checked and corrected where needed.
86	General	What is the basis for the crane hours/laborer hours relationship? (BE)	B	A notation has been added to the surety table in the current version of the NOI to indicate that the basis is professional judgment and past experience.
87	General	Page 2 of the bond estimate summary, please use standard the cost reference number format: NOT: 31 23.23.18 4700 but 31 23-23.18-4700. (BE)	B	The requested DOGM-preferred punctuation has been used throughout the surety table in the current version of the NOI.
88	General	Page 2 of the bond estimate summary, Please reference the $/mile cost of $2.04 (BE)	A	The $/mile cost was already included at the appropriate line at the base of the rows which use that rate. No further changes have been made to the current version of the NOI.

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
89	General	Page 2, bond estimate summary, there is a dedicated water truck, but no costs. Please correct. (BE)	B	The water truck is not needed for the Task 1 components, so that portion of the table has been removed from the current version of the NOI, rather than have it included with a $0 cost, as was done in the May 9, 2008 version.
90	-	Page 2 of bond estimate summary, ripping of concrete foundation in less than an hour is inaccurate. What is the concrete thickness? Is the concrete reinforced? Area is typically square feet and not acres for concrete ripping/burying. (BE)	B	Revisions have been made to the surety table in the current version of the NOI to increase the time to rip concrete. Notes have been added to indicate that the concrete thickness is 6 inches and that standard rebar reinforcement will be used. Acres are the correct unit in this case because the production rate is acre-based; however, note that total square feet was also listed in the May 9, 2008 version of the NOI in the heading of the concrete ripping table.
91	-	Why is there just the equipment operator for concrete ripping? No laborers? No additional equipment? Please reevaluate these costs. (BE)	A	There are no other laborers planned or needed for this task, nor is there additional equipment needed. No changes have been made to the current version of the NOI.
92	-	Page 3 of the bond estimate summary (2), indicates 61.5 acres will be graded. It is unclear how this number has been derived from the explanation given.	B	All acreage numbers in the bond estimate can easily be tied to features shown on Figure 2, reclamation treatments shown on Figure 9, and in tables in the current version of the NOI.
93		page 6/6 15.1, the monitoring and weed control plan should be better defined and should describe specifically the tasks and actions associated with the plan. The cost for a second seeding of 100% or something reasonable. (BE)		Costs have been added to Section 15.1 in the bond estimate, along with a description of what the costs can be attributed to.
94		page 6/6 15.1, the costs associated with weed control should be included. (BE)		Costs have been added to Section 15.1 in the bond estimate, along with a description of what the costs can be attributed to.
95		page 6/6 15.1, there should be an administrative costs for reporting/recording. (BE)		Costs have been added to Section 15.1 in the bond estimate, along with a description of what the costs can be attributed to.
96		page 6/6 15.1, the cost of gas should be included. (BE)		Costs have been added to Section 15.1 in the bond estimate, along with a description of what the costs can be attributed to.
97		page 6/6 15.1, the number of trips/year should increase during post mining monitoring. (BE)		Costs have been added to Section 15.1 in the bond estimate, along with a description of what the costs can be attributed to.
98		page 5/6 12, general site clean up indicates 3 laborers will be involved, however the costs are for one laborer. Please correct. (BE)	B	The correction has been made to the surety table in the current version of the NOI to provide costs for 3 laborers rather than 1.
99	General	Plan needs a map that clearly defines perimeter of bonded area (lah)	A	This outline is shown on Figures 2 and 9 in the current version of the NOI.
100	General	Plan needs a map that ties surety spreadsheet to physical locations (lah)	B	Figures 2, 3 and 9 of the current version of the NOI are sufficient to tie spreadsheet information to physical locations.

Comment #	Sheet/Page #	Comments From Initial Review	Review Action	Earth Energy Responses
101	General	Example surety spread sheet is available from DOGM (lah)	A	This comment does not appear to require a response.

Linda Matthews

From: Leslie Heppler [lheppler@utah.gov]
Sent: Wednesday, July 30, 2008 8:29 AM
To: Linda Matthews
Subject: @LMO-review
Attachments: Second review_M0470090.doc

slie Heppler
ah Division of Oil, Gas & Mining
01) 538-5257 (Mon thru Thur)
eppler@utah.gov

APPROVED
SEP 19 2009
DIV. OIL GAS & MINING

IR - 000185

July 22, 2008

Barclay Cuthbert
Earth Energy Resources
Suite 740, 404-6 Avenue S. W.
Calgary, Alberta, Canada T2P 0R9

Subject: Second Review of Notice of Intention to Commence Large Mining Operations, Earth Energy Resources, PR Springs Mine, M0470090, Task 2386, Uintah County, Utah

Dear Mr. Cuthbert:

The Division has completed a review of your Notice of Intention to Commence Large Mining Operations for the PR Springs Mine, located in Uintah County, Utah, which was received May 9, 2008. The attached comments will need to be addressed before tentative approval may be granted.

The comments are listed under the applicable Minerals Rule heading; please format your response in a similar fashion. Please address only those items requested in the attached technical review by sending replacement pages of the original mining notice using **redline and strikeout** text, so we can see what changes have been made. After the notice is determined technically complete and we are prepared to issue final approval, we will ask that you send us two clean copies of the complete and corrected plan. Upon final approval of the permit, we will return one copy stamped "approved" for your records.

The Division will suspend further review of the Notice of Intention until your response to this letter is received. If you have any questions in this regard please contact me at 801-538-5320 or Leslie Heppler at 801-538-5257. Thank you for your cooperation in completing this permitting action.

Sincerely,

Dana Dean P.E.
Associate Director -Mining

DD:lah:eb
Task # 2386
Attachment: Review
cc: Will Stokes, SITLA
P:\GROUPS\MINERALS\WP\M047-Uintah\M04700090-PRSpringMine\draft\Second review_M0470090.doc

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SEP 19 2009
DIV. OIL GAS & MINING
IR - 000186

REVIEW OF NOTICE OF INTENTION TO COMMENCE LARGE MINING OPERATIONS

Earth Energy Resources
PR Springs Mine
M0470090
July 16, 2008

General Comments:

Comment #	Sheet/Page #	Comments	Review Action
1	General	Based on the content of the submittal, it appears there may be expansions that will require revisions to the permit in time. Because of the change dynamics, the submittal should be formatted to easily incorporate into future revisions or amendments. Further discussion with the Division is suggested. (BE)	
2	General	It has been noted in the submittal that there maybe additional resource reserves, yet the plan dose not indicate how an expansion would be incorporated into the plan. Ie something would have to be rehandled, processing plant, the moving of a dump etc. (lah)	

R647-4-104 – Operator's, Surface and Mineral Ownership

Comment #	Sheet/Page #	Comments	Review Action
3	General	Once the conditional use permit from Grand County is granted, please include this as an appendix to the plan. (BE) Provide Appendix number and a place holder for the permit to be inserted (lah)	

R647-4-105 - Maps, Drawings & Photographs

General Map Comments

Comment #	Sheet/Page #	Comments	Review Action
4	General	There is no shown and labeled public access route from nearest highway. (BE)	

Specific Map Comments

Comment #	Sheet/Page #	Comments	Review Action

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IR - 000187

Comment #	Sheet/Page #	Comments	Review Action
5	General	The below review comments are specific to the identified maps. The items will require clarification and updates, improvements, or corrections. These should be made to each of the maps accordingly. Do not assume this information is all-inclusive as other changes may result once clarity is established. (BE & lah)	
6	Figure 2	Label permit area, include pipeline disturbance, include acres to match Bonded acres (lah)	
7	Figure 2	The word proposed mine operations shows several colors of hatching, however none of them are identified using a key. There is no indication of what they mean. Please correct. (BE)	
8	Figure 2a	Include either plan view of feature or more description of where feature will be used. Nothing has been included catch basins, sediment ponds, etc (lah)	
9	Figure 2a	Overburden should be keyed into natural slope for stability FOS (lah)	
10	Figure 2b	Include either plan view of feature or more description of where feature will be used. Where will a unlined ditch be used as opposed to a rip rap lined ditch, where will the berm be used in the plan (lah)	
11	Figure 3	Define 203 acres listed in text and in bonded area. (lah)	
12	Figure 3	Label figure 3 - features to be tied to surety bond (lah)	
13	Figure 3	The facilities map should include the dimensions of the buildings, ponds, piles etc. These dimensions can be part of the legend and referenced appropriately. The map should show roads, including access and haul roads; utilities and power lines (water, gas, power, telecommunications etc); and drainage control devices. (BE) Maximum size of the facilities are needed for bonding calculation purposes. (lah)	
14	Figure 4a,4b,4c,6	FYI only, best if drawn with no vertical exaggeration, best if all x-sections are the same scale, engineering standards for drawing are lacking (lah)	
15	Figure 4a,4b,4c	Slope angles shown on xsection are incorrect. (lah)	
16	Figure 5	As per 105.3.16 A geology map is required, include Geomechanical data; include orientation of bedding and structural features include faults, and joint sets orientations to demonstrate pit wall stability . (lah)	
17	Figure 5-d	There may be related issues within the other figures and more information may be required. (BE)	
18	Figure 5-d	Is this figure to remain in the plan? Why is it labeled proprietary & confidential? (lah)	
19	Figure 9	Good regrading plan. Better scale and more detail needed (match to surety bond) needed (lah)	
20	General	As per 105.3.16 A geology map is required, include Geomechanical data; include orientation of bedding and structural features include faults, and joint sets orientations to demonstrate pit wall stability. (lah)	
21	General	A map should be submitted that shows adjacent land owners, including access road from the nearest public state road. (BE) As per 105.3.18 County road is not labeled on Figure 1 as written in text page 10 para 5 (lah)	

R647-4-106 - Operation Plan

106.2 Type of operations conducted, mining method, processing etc.

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Comment #	Sheet/Page #	Comments	Review Action
22	Page 11 para 4	FYI - Caterpillar performance handbook provides ripper performance chart for dozers based on Seismic Shear Wave Velocities. (lah)	
23	Page 11 para 4	Safety items regarding blasting such as closure distances and times should not be committed to in the Mine permit., as loading specifics are not known. Give minimums or maximum as each apply. (lah)	
24	Omission	Include posting of sign with Blasting schedules on public roads. (lah)	
25	Page 11 para 4	"Blasting is not expected…." As per Public Safety R647-4-109 4. NO FLY WILL BE TOLERATED ON PUBLIC ROADS (lah)	
26	Page 12 Para 3	Why is the processing procedure listed under equipment? (lah)	
27	Page 13 Para 1	Slope stability and Blasting are related, perhaps info should adjacent in text. (lah)	
28	Page 13 Para 1	Controlled Blasting is not normally done on slopes of 2H:1V (lah)	
29	Page 14 Para 4	Show locations of water retention/storage ponds on a map.(lah)	
30	Page 15 Para 5 & 6	It is unclear if slope stability will have an adequate Factor of Safety in the unconsolidated waste dumps with the increased pore water pressures proposed. (lah)	
31	Page 16 Para 6	Most ground water wells have a minimum of 4" of gravel pack around the OD of the well screen. (lah)	
32	Page 17 Para 2	Is there any monitoring or gages planned for the pipeline to monitor for leaks? (lah)	
33	Page 17 Para 5	Has there been any triaxial shear tests run on "discharge sands" to determine cohesion and phi angle? (lah)	
34	Page 17, 18 General	General Engineering parameters should be defined, such as FOS's used (lah)	
35	Page 18 Para 5	Reference drawing detail for runoff detail. (lah)	
36	Page 19 General	Maximum slope angles have been noted for waste piles but nothing noted for pit slope angles (lah)	

106.6 Plan for protecting & redepositing soils

Comment #	Sheet/Page #	Comments	Review Action
37	Page 23	The plan says on page 23 that soil will not be salvaged from the water well pad or the pipeline corridor because these areas are within previously disturbed corridors. Please explain further. What type of disturbance or corridors are in this area? (PBB)	

106.8 Depth to groundwater, extent of overburden, geology

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Comment #	Sheet/Page #	Comments	Review Action
38	Page 28 omission	No geologic setting is provided for ephemeral spring noted on page 29 para 4 (lah)	
39	Page 28 Para 2	"Geologic Setting" is NOT the correct title for the paragraph (lah)	
40	Page 28 para 3	Add strike and dip, and fault to Figure 5 (lah)	

106.9 Location & size of ore, waste, tailings, ponds

Comment #	Sheet/Page #	Comments	Review Action
41	General	The Division appreciates the efforts of obtaining information to follow DWQ guidelines for minimize impact of ore and waste stockpiles on groundwater. Specific design information and control measures should be provided in the plan. (BE)	
42	Page 29 Para 2	Note "waste sand would be nearly dry"..page 17 notes discharged sand to contain 10 to 20 percent water (lah)	
43	Page 29 Para 3	Provide phase maps to show the backfilling of the pit sequence (lah)	
44	Page 29 Para 4	Provide drawing for avoiding ephemeral spring (lah)	
45	Page 30 Para 4	Note steel pipeline, elsewhere HDPE is noted (page 17 para 1) (lah)	
46	Page 30 Para 2	Provide drawing for storage pond, include location and design standards (lah)	

106.10 Amount of material to be moved

<u>R647-4-107 - Operation Practices</u>

Comment #	Sheet/Page #	Comments	Review Action
47	General	The plan states that there will not be a problem with drainage, and page 20 says, 'Surface water resources will be protected during operations as described above in Section 107.' There is no section 107 in the plan. The Division requires that the BMPs to be used on site be described in the plan and a typical drawing submitted of how the BMP will be installed and a figure showing where on the ground it will be implemented referencing the BMP. Temporary BMPs are not recommended for long term operations as they are not always maintained. The Division recommends the use of berms to direct runoff to small catch basins that can be cleaned out after storm events, since the maintenance of these controls is more predicable. Provide this additional information. This ensures the proposed controls will be effective and there will not be any problems with offsite drainage. (TM & lah)	

R647-4-108- Hole Plugging Requirements

Comment #	Sheet/Page #	Comments	Review Action
48	Page 31 Para 2	The plan states SITLA?…it was my understanding the well will be on BLM land and also noted on page of this report and shown on Figure 1. (lah)	

R647-4-109 - Impact Assessment

109.1 Impacts to surface & groundwater systems

Comment #	Sheet/Page #	Comments	Review Action
49	Page 34 Para 2	The plan does reference any sort of sediment control other than BMPs included in the SWPPP plan by reference. The SWPP needs to be included in the plan when approved. Since the term BMPs references a large variety of sediment control devices, the Division requires that the operator specify what specific BMP controls are going to be used and a typical design drawing included in the plan. There is no reference to any sediment controls such as sediment ponds, etc. The plan says the mine is on flat ground in the headwaters of main canyon, inferring there is no runoff. The pits are likely to catch a major amount of drainage from rain and snow, and this water needs to be factored into the site plan. Therefore, a plan must be provided on how this runoff water will be handled operationally both in the pits and running off waste piles. Please include these plans and designs in the mine plan. (TM) Provide drawing with hydrology detail. As you have noted on page 34, "the SWPPP will be added" Provide a place holder for the permit to be inserted (lah)	

109.4 Slope stability, erosion control, air quality (fugitive dust control plan), safety

Comment #	Sheet/Page #	Comments From Initial Review	Review Action
50	Page 46 Para 1	The plan says Earth Energy is in the process of obtaining an Approval Order from the Division of Air Quality. Please include a copy of this Approval Order in the plan once it has been issued. (PBB) Provide Appendix number and a place holder for the permit to be inserted (lah)	
51	Page 42 Para 1	Will the valley fill dumps be keyed into the slopes? (lah)	
52	Page 46 all	See comments listed above regarding public safety (lah)	
53	Page 46 Bullet 9	Fly rock is bad blasting…the proper blast design has no fly rock, the use of adequate stemming is the solution. (lah)	

R647-4-110 - Reclamation Plan

110.1 Current & post mining land use

Comment #	Sheet/Page #	Comments From Initial Review	Review Action
54	General	Exploration cannot be a post mining land use. Closure plans should be dependent on the area being used as open space/habitat. (BE & lah)	

110.2 Roads, highwalls, slopes, drainages, pits, etc., reclaimed

Comment #	Sheet/Page #	Comments From Initial Review	Review Action
55	Page 50 Para 2	"pits (approx 92 acres….)" It is unclear which part of the 92 acres will be back filled, please, submit phasing as plan view diagrams. (lah)	

110.3 Description of facilities to be left (post mining use)

Comment #	Sheet/Page #	Comments From Initial Review	Review Action
56	Page 51 Para 6	As stated water well is to revert to SITLA. Well is located on BLM land and other documentation refer to reverting to BLM. Please clarify (lah)	

110.5 Revegetation planting program

Comment #	Sheet/Page #	Comments From Initial Review	Review Action
57	Page 52 Para 3	It is unclear why pipeline construction is "except" from redistribution of topsoil. (PB & lah)	

R647-4-111 - Reclamation Practices

Comment #	Sheet/Page #	Comments From Initial Review	Review Action
58	General	The plan says on page 36 that no significant drainages will be disturbed so none will be reconstructed. The plan needs to address landform and final drainage on waste dump faces. Please show how waste pile outslopes and reclaimed pit slopes will be stabilized, water directed off the slope, erosion controlled, and how sediment will be kept from leaving the site. (TM) According to Plan, the dumps will contain a significant amount of fine grained material, not just waste overburden, address how fine grained sediments will be kept from leaving the site…siltation basins ?, sediment ponds (lah)	

R647-4-113 – Surety

Reclamation:

Comment #	Sheet/Page #	Comments From Initial Review	Review Action
60	General	This review cannot capture every omission and make a statement accordingly. It is anticipated that communications will occur in the interim and the dialog will provide elaboration on the generalities made within the scope of this review. (BE)	
61	General	On the sub sections within each category on the cost estimation, please include the dollar amount. (BE)	
62	-	Category 1. The spread sheet dollar amount of $210,627 is different than the category one summary amount of $263,427. (BE)	
63	Page 50	Page 50 of the draft indicates that some of the demolition activities will require burial. Have these costs been accounted for? If so, an explanation of that should be provided in the spread sheet or within a surety summary narrative. (BE)	
64	Page 50 Para 5	Page 50 the new text uses the word proposed. Please remove the use of the word and write the narrative as though the Division has approved. (BE)	
65	Page 50 Para 5	The first sentence of the Facilities and Materials paragraph requires some clarification and requires specific action outline. When reading it lends the impression that either burial or dismantling will occur. In reality dismantling will occur with the exception of the mentioned burial work. (BE)	
66	-	Although the surety spreadsheet identifies the equipment used in category one reclamation. It is extremely helpful to provide the equipment within the reclamation narrative as well. (BE)	
67	Page 51 Para 1	Page 51, the process train indicates process materials will be drained. Please elaborate on where the drainage will occur, and explain if the process materials are hazardous and/or are an impact to public health and safety. (BE)	
68	General	There is indication that there are two process trains. It appears there are reclamation costs for only one. Page 2 of the summary surety draft does not show costs for two process trains. Please correct and/or explain. (BE)	
69	General	Please provide the weight of one cubic yard of cut up process train. (BE)	
70	Page 49 Para 1	Page 49, reclamation activities will involve the Division. Surety release will not occur until the Division approves the reclamation work, which typically requires 'visual inspections'. It may be helpful to include narrative that indicates the reclamation activity obligations under the Act and rules. (BE)	
71	Page 49 Para 2	Page 49, during interim and on going reclamation, a commitment should be made that indicates that maps will be submitted to the Division showing 'active roads' or a reference that the roads shown on the reclamation activities map are active during the early reclamation phases. (BE)	
72	Genaral	What are the road dimensions? (BE)	
73	General	What is the water source for the water truck? (BE)	
74	Page 49 Para 5	Page 49, correction is required, there is a comment that indicates that a variance is required for slopes exceeding 45°. That 45° rule is for highwall remediation. By rule, slopes are to be regraded to a stable configuration, and sloped to minimize safety hazards and erosion while promoting successful revegetation. Please remove/re-write the comment. (BE)	
75	Page 49 Para 5	Spelling comment: regarding should be 'regrading', page 49. (BE)	

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Comment #	Sheet/Page #	Comments From Initial Review	Review Action
76	General	What is the remaining height of the pits once sand mix has been placed? (BE)	
77	Page 50 Para 3	Page50, for clarity and to eliminate oversight, please relocate the comment under the title "DRILL HOLES', 2nd paragraph about the 'impounding pit'. (BE)	
78	General	If on site burial of facility components occurs, a solid waste permit may be required. Please make a statement to that affect. (BE)	
79	-	Page 1/Surety Estimation under items to be removed, the mine office building is not included. Although ATCO removes it, please include it in the table and make that statement there as well. (BE)	
80	General	For clarification purposes, does ATCO remove the mine office building without any prep work by operator? Does the mine office building have contents that must be removed? It is assumed gutting is required for this building and others. However, there is no cost. Please explain or include gutting costs.(BE)	
81	General	The 'rates and seed mix' sheet shows that labor hourly rates are on pg 629 of the 2008 Means Heavy Construction Cost Data book. That page is an overview of 'new titles'. Please correct and reference the right pages from the book. (BE)	
82	General	Clarification is required on the bond estimate summary for the following statements: Laborers, assumes 4/laborers per crane hour. If there is a total of 8 crane hours for removal of the water storage pond liner, then a multiplier (number of laborers/crane hour) is missing and should be included before multiplying by the dollars/hour. (BE)	
83	General	Please place the cost (hourly/weekly rate) of the crane on the equipment costs table. (BE)	
84	General	Page 1/6 of the bond summary worksheet shows a crane being used for the removal of several items, however the hourly equipment cost associated with the water storage pond liner is $55.82. The item to be removed description specifically states that a crane will be used. Please clarify/correct. (BE)	
85	General	Please check subtotal columns, especially the first one in each sub category. There appears to be consistent errors. Example, tanks (22): 49X47.05 = 2305.45, the cell shows 2290.00. There are more of these errors, please review and correct. (BE)	
86	General	What is the basis for the crane hours/laborer hours relationship? (BE)	
87	General	Page 2 of the bond estimate summary, please use standard the cost reference number format: NOT: 31 23.23.18 4700 but 31 23-23.18-4700. (BE)	
88	General	Page 2 of the bond estimate summary, Please reference the $/mile cost of $2.04 (BE)	
89	General	Page 2, bond estimate summary, there is a dedicated water truck, but no costs. Please correct. (BE)	
90	-	Page 2 of bond estimate summary, ripping of concrete foundation in less than an hour is inaccurate. What is the concrete thickness? Is the concrete reinforced? Area is typically square feet and not acres for concrete ripping/burying. (BE)	
91	-	Why is there just the equipment operator for concrete ripping? No laborers? No additional equipment? Please reevaluate these costs. (BE)	
92	-	Page 3 of the bond estimate summary (2), indicates 61.5 acres will be graded. It is unclear how this number has been derived from the explanation given.	
93		page 6/6 15.1, the monitoring and weed control plan should be better defined and should describe specifically the tasks and actions associated with the plan. The cost for a second seeding of 100% or something reasonable. (BE)	
94		page 6/6 15.1, the costs associated with weed control should be included. (BE)	

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Comment #	Sheet/Page #	Comments From Initial Review	Review Action
95		page 6/6 15.1, there should be an administrative costs for reporting/recording. (BE)	
96		page 6/6 15.1, the cost of gas should be included. (BE)	
97		page 6/6 15.1, the number of trips/year should increase during post mining monitoring. (BE)	
98		page 5/6 12, general site clean up indicates 3 laborers will be involved, however the costs are for one laborer. Please correct. (BE)	
99	General	Plan needs a map that clearly defines perimeter of bonded area (lah)	
100	General	Plan needs a map that ties surety spreadsheet to physical locations (lah)	
101	General	Example surety spread sheet is available from DOGM (lah)	

Linda Matthews

From: Beth Ericksen [bethericksen@utah.gov]
Sent: Thursday, May 15, 2008 2:45 PM
: Linda Matthews
bject: Re: Earth Energy PR Spring NOI (M/047/0090)

Attachments: Beth Ericksen.vcf

Beth Ericksen.vcf
(515 B)

Hi Linda,

I have received the attachments. You may have to eventually follow up with a more formal submittal. I will keep you posted. This information will get us by for now.

Thank you for being so prompt.

Beth

Beth Ericksen
State of Utah
Division of Oil, Gas and Mining

>> "Linda Matthews" <lmatthews@jbrenv.com> 05/15/2008 2:31 PM >>>
Beth:

Based upon our phone conversation this morning, I am attaching Figure 1 for the Earth Energy PR Spring NOI - which was unfortunately omitted in the May 9, 2008 submittal; and Figure 4b - which was revised to show the accurate horizontal to vertical alignment of the reclaimed waste dump slope at 1.5 H:1V. Please accept these Figures for the May 9, 2008 response to the Initial Review of NOI to Commence Large Mining Operations, Earth Energy Resources, PR Spring Mine (M/047/0090).

Thank you very much for bringing this to my attention.

Regards,
Linda

Pam - Please PRINT to color printer.
Thank you!

--
Linda J. Matthews
jbr environmental consultants, inc.
8160 S. Highland Drive, Sandy, Utah 84093 Ph. 801.943.4144 Fax. 801.942.1852

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IR - 000196

Linda Matthews

From: Linda Matthews
Sent: Thursday, May 15, 2008 2:31 PM
To: 'betherickson@utah.gov'; 'pamsandberg@utah.gov'
Cc: 'Barclay Cuthbert'
Subject: Earth Energy PR Spring NOI (M/047/0090)
Attachments: Fig4b Transverse Mine Section W2-E2.pdf; Fig1 Location Map Layout1 (1).pdf

Hi Beth:

Based upon our phone conversation this morning, I am attaching Figure 1 for the Earth Energy PR Spring NOI - which was unfortunately omitted in the May 9, 2008 submittal; and Figure 4b - which was revised to show the accurate horizontal to vertical alignment of the reclaimed waste dump slope at 1.5 H:1V. Please accept these Figures for the May 9, 2008 response to the Initial Review of NOI to Commence Large Mining Operations, Earth Energy Resources, PR Spring Mine (M/047/0090).

Thank you very much for bringing this to my attention.

Regards,
Linda

Pam - Please PRINT to color printer.
Thank you!

Li[illegible]. Matthews
or environmental consultants, inc.
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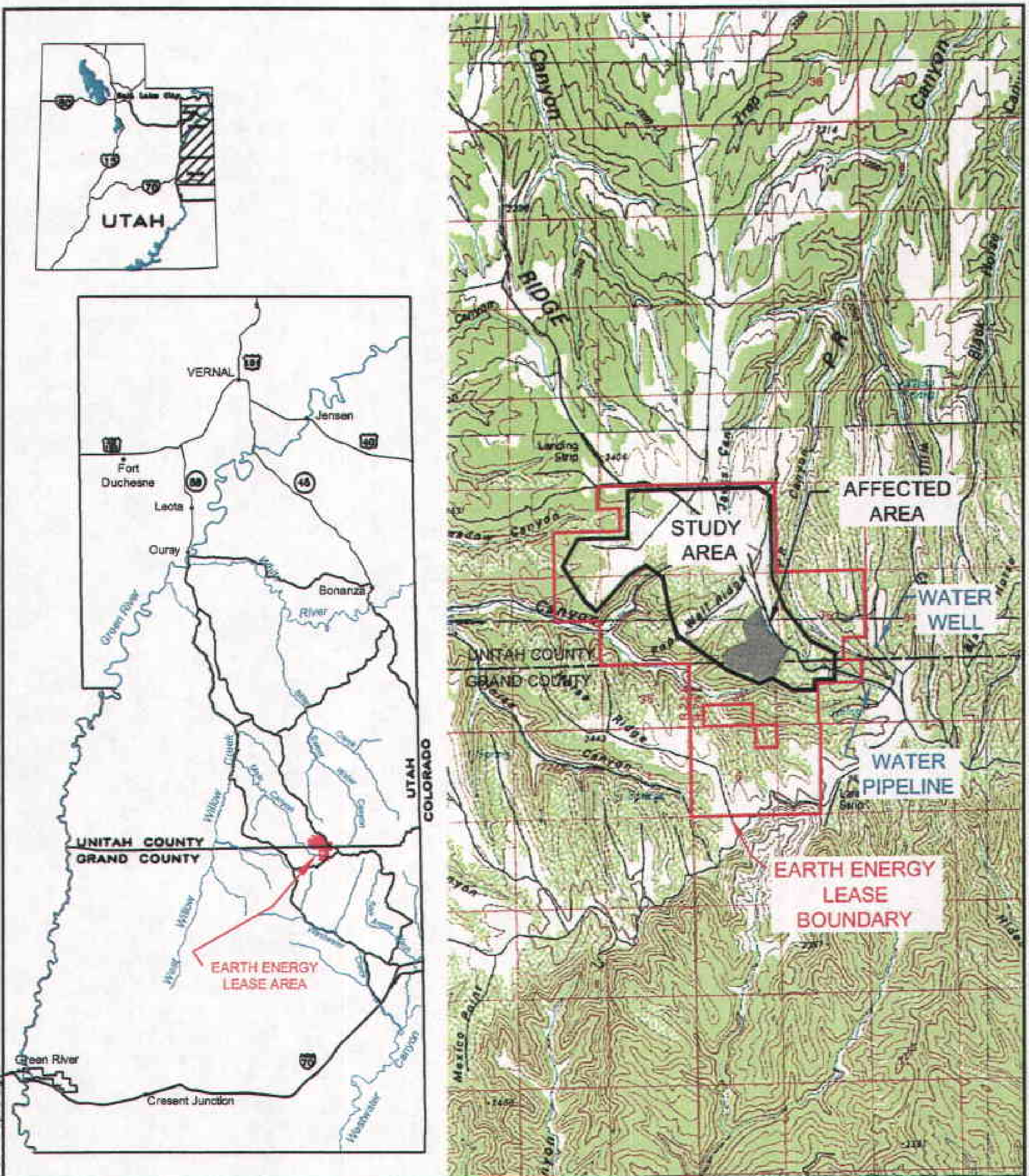

drawings\EarthEnergy\Fig1 Location Map.dwg

Base from USGS 1:100,000-scale *metric* topographic map of: Seep Ridge, Utah-Colorado, 1981 and Westwater, Utah-Colorado, 1980.

1 0 1 2 3 4 KILOMETERS

1 0 1 2 MILES

Contour Interval 50 Meters

EARTH ENERGY RESOURCES, INC.

PR SPRING TAR SANDS DEVELOPMENT PROJECT

FIGURE 1

PROJECT LOCATION MAP

jbr environmental consultants, inc.

DESIGN BY	LM	DRAWN BY	CP	CHKD BY		SCALE	1:100,000

DATE DRAWN 9/11/07

REVISION 3/31/08

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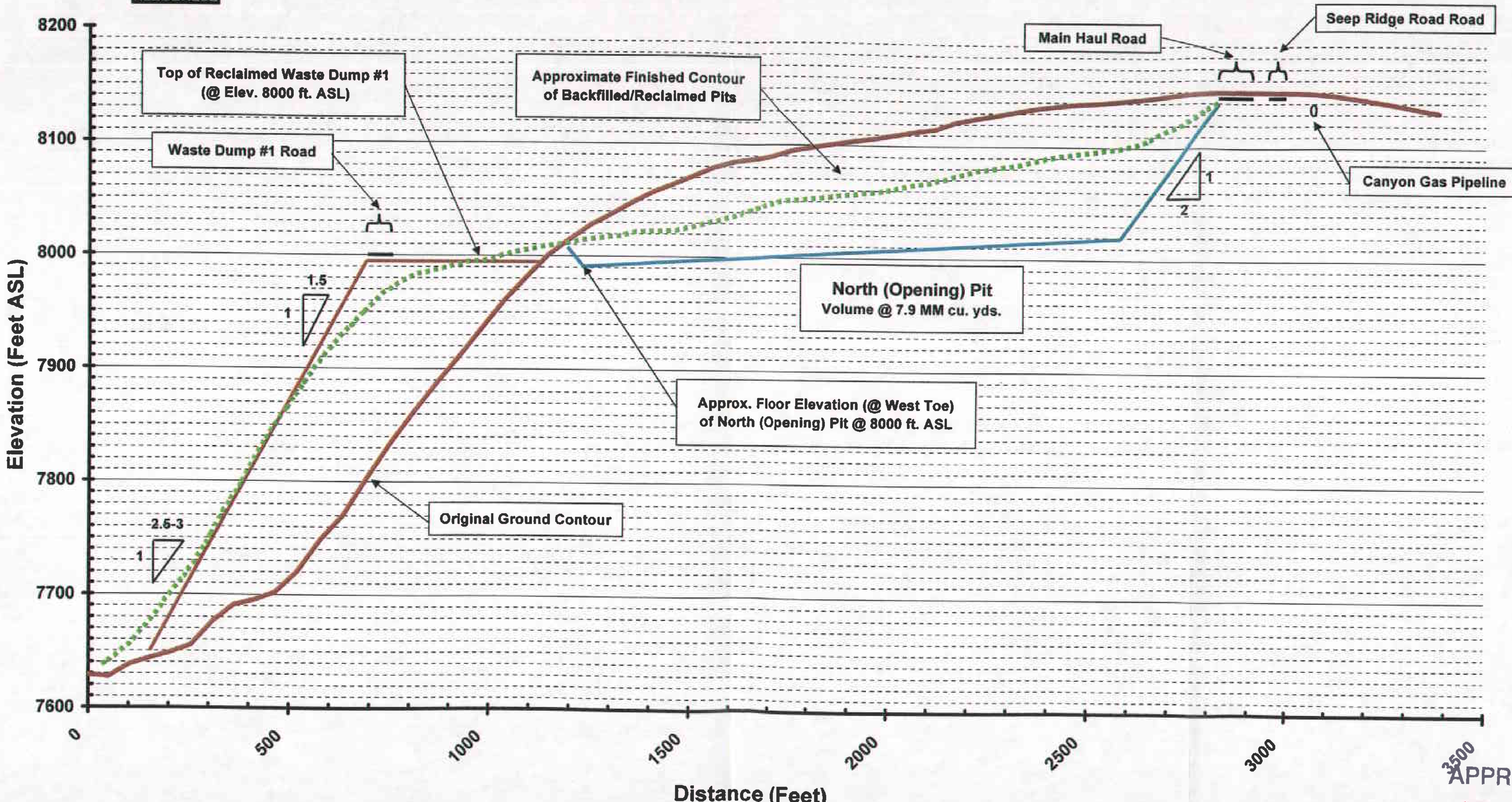
Figure 4b
Earth Energy Resources Inc. - PR Spring Oil Sand Mine
Transverse Mine Section W2-E2 Rev.2

EARTH ENERGY RESOURCES



Drawn by: TJW Date: Sept 20, 2007

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8160 South Highland Drive • Sandy, Utah 84093 [P] 801.943.4144 [F] 801.942.1852

May 9, 2008

Susan M. White
Mining Program Coordinator
Minerals Regulatory Program
Utah Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
Salt Lake City, UT 84114-5801

RE: Response to Review of NOI to Commence Large Mining Operations, Earth Energy Resources, PR Spring Mine (M/047/0090)

Dear Ms. White:

This letter is a response to the Division's January 10, 2008 review of Earth Energy Resources' NOI to Commence Large Mining Operations at the PR Spring Mine. In addition to the responses included in this letter, red-lined/strikeout pages are provided for the revised pages of the NOI text. JBR is submitting this response on behalf of Earth Energy Resources, Inc.

General Comments:
The September 28, 2007 NOI (in Section 101.3), as previously submitted to the Division, committed to comply with and conform to all aspects of the NOI as well as the applicable regulations. This implicitly includes operation and reclamation practices. The NOI did not include separate sections to address Operation Practices under R647-4-107 or Reclamation Practices under R647-4-111 because, as stated at R647-4-103, these are not required for NOI's for Large Mining Operations. However, in order to address this comment, an additional statement has been added to the April 2008 NOI that explicitly says that Earth Energy commits to conform to operation and reclamation practices that are contained within the NOI and that are required by regulation. Further, Earth Energy plans to comply with all of the relevant rules, and thus does not agree with the Division that variances would be required for either erosion control or slopes.

The word 'proposed' has been omitted from the NOI text and maps; the narrative in the April 2008 NOI has been written as though the Division approved this mining operation.

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Because there may be expansions that will require revisions to the permit over time, the April 2008 has been reformatted to easily incorporate into future revisions or amendments due to these change dynamics. In addition to the previous use of a three-ring binder, which inherently facilitates incorporating revisions or amendments, each major heading within the April 2008 NOI begins on a new page and in other selected locations, artificial page breaks or added spaces are inserted between subsections. These measures will facilitate the production of future replacement pages that so that they can be incorporated with minimal effects on pagination.

R647-4-101 – Filing Requirements and Review Procedures

The statement addressing when Earth Energy can begin mining has been rewritten in the April 2008 NOI to acknowledge that the reclamation contract and surety must receive Division approval before mining can commence.

Earth Energy has clarified text throughout the NOI and revised figure labels to clearly indicate the areas and activities that would be approved with this plan (and thus subject to bonding). Specifically, the North (Opening) Pit and the West Pit are both proposed for mining in the NOI. While details on the West Pit mining are not as well developed as for the North (Opening) Pit, pending coring results, sufficient assumptions have been made in order to calculate a bond amount for this area. Prior to actual mining of the West Pit, Earth Energy will submit a Plan Amendment to DOGM with more detailed pit designs for this area. The South (Phase II) Pit was included in certain of the September 28, 2007 NOI drawings as a future (more than five years away) plan; it has been removed from text and drawings in the April 2008 NOI.

Earth Energy agrees to notify the adjacent land owners (BLM and SITLA) in writing. Language has been revised in Section 104.2 of the April 2008 NOI.

R647-4-104 – Operator(s), Surface and Mineral Owner(s)

DOGM is correct: SITLA has the mineral rights to this area. Earth Energy's lease covers from the ground surface to a depth of 500 feet only. Section 104.2 of the NOI has been revised to clarify this.

In this section (104.2), all reference to acreage has been eliminated, and the surface owner is simply listed as required. Throughout the NOI, changes have been made to text and mapping to indicate the extent and acreage of the lease area, the Study Area (which reflects the area over which environmental resources were described in order to facilitate future NOI amendments as mining operations are proposed to be expanded), and the Affected Area (which is the same as the disturbed area and/or bonded area).

The Grand County conditional use permit will not be obtained until after Earth Energy receives approval of the NOI (the County has indicated that that is their preference). When available, Earth Energy will supply the Division with a copy of that conditional use permit. A reference to that effect has been added to this section.

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R647-4-105 – Maps, Drawings & Photographs

General Map Comments

Within the September 28, 2007 NOI, Figures 1, 2, 3, 5-d, 6, 7, and 8 all showed streams located within the area covered by the specific map. Also within that NOI, Figures 1, 3, 6, and 7 each showed springs as mapped by the USGS. The only "infrastructure" within the mapped areas is also already shown on these various figures. In order to highlight water features, the previously included Figure 6, Watersheds Map, has been modified to better show streams, USGS-mapped springs, and to also show other identified springs and water right locations (this figure has been renumbered as Figure 7 and re-titled as Water Features Map). Section 105.1 has been revised to note that these features are located on the relevant maps in the April 2008 version of the NOI.

The contour interval has been added on all maps in the April 2008 version of the NOI.

The public access route to the PR Spring operation from the nearest highway is shown and labeled on an inset that has been added to Figure 1 in the April 2008 version of the NOI.

A geologic map that shows the area geology has been added to the April 2008 version of the NOI as Figure 5. In addition, a geologic cross section that shows the five asphalt sands A-E detail within the Douglas Creek Member has been added as Figure 6.

Specific Map Comments
The specific comments have been addressed for each of the identified maps, and as required, clarification and updates, improvements, or corrections were made. Earth Energy understands that the reviewer may still require other changes.

Figure 2
The 2255.15-acre area that was labeled as NOI Permit Area in Figure 2 of the September 28, 2007 NOI has been relabeled as "Study Area" to reflect that this area was the subject area for resource descriptions. This change was also made to all other figures that included this boundary.

Figures 2 and 3 have been combined into a single Figure 2 to provide consistency and to reduce the DOGM confusion.

The April 2008 version of the NOI includes maps that show the mine operations area with necessary detail.

The word proposed has been removed from all figures, and acreages have been removed from maps to reduce clutter (but are described thoroughly in the text).

Page 6 of the September 28, 2007 narrative was modified to indicate that surface and subsurface facilities are shown on various figures.

Scale information has been modified and corrected.

Figure 2 has been modified to include the southern portion of the lease boundary. It is now all-encompassing, showing all boundaries.

Figure 3

In the September 28, 2007 version of this figure, the haul road acreage was included within the separate other mine components through which the road traversed. In the April 2008 NOI, as part of addressing other DOGM comments, including reducing clutter, all reference to acreage has been removed from figures. Instead, disturbance is discussed in detail within the NOI text. Further, Figure 3 has been combined with Figure 2.

Figure 4

This is now Figure 3. Where known, dimensions have been added; however it is key to note that the plant site and mine plan designs are still in the engineering phase and are somewhat conceptual. When engineering is complete, Earth Energy will provide additional detailed drawings; at this time, all disturbances will be confined within the areas stipulated, will be laid out generally as shown, and will not result in disturbances greater than or significantly different than indicated. The well site and water line/power cable corridor has been added to various figures, sediment and drainage control features have been added to Figures 2 and 3. Utility lines are not present, other than the already noted pipeline corridor that appears on Figure 2.

As noted above, to reduce map clutter, acreages are not being placed on figures; instead they are given in the NOI text.

Figure 5-d

DOGM simply states that "There may be related issues within the other figures and more information may be required." Earth Energy has no specific response to this item, other than to state that if more information is required, we will attempt to provide it once we know what is being asked for.

The locations of the three cross sections are now shown on Figure 2. Figures 4a, 4b, and 4c provide these cross sections.

The figure has been revised and a legend has been provided.

Figure 6

The previously included Figure 6, Watersheds Map, has been modified to better show streams, USGS-mapped springs, and to also show other identified springs and water right locations (this figure has been renumbered as Figure 7 and re-titled as Water Features Map. As with any topographic map, the direction of water flow is inherent in the drawing without directional areas, particularly in the steep country represented on this figure. The longest flow path is not relevant to this drawing. Earth Energy does not feel that it is necessary or appropriate to show vegetation on the map; the figure that follows this Water Features Map (Figure 8 Vegetation Map) clearly shows vegetation on a map at the same scale and on the same base. Other DOGM comments requested that figures be made less congested; unnecessarily adding to the congestion of this map is not warranted.

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Figure 8

This figure has been revised to show additional project information.

Figure 9

This figure now includes contour lines for the reclaimed area, storm water controls, and cross section locations. Springs are the same under both pre-mining and reclamation conditions; see Figure 7 for locations. The bonded area is the same as the Affected Area, which is outlined on this figure. Acreage is provided in the text, so as to not increase congestion.

The various reclamation treatments have been added to this figure.

The volume of topsoil is noted various places in the NOI text; it is not added to the figure in order to minimize congestion.

Nothing is proposed to be buried during reclamation, thus nothing indicating burial locations is provided on this figure. (The buried water line will remain during reclamation, and its location is shown.)

105.2 Surface Facilities Map

At the time of the September 28, 2007 NOI, the location of the water well and associated pipeline were not known, so they were not shown on any mapping. Now that these locations have been identified, they are shown on various NOI figures, and are included within the Affected (disturbed, bonded) Area.

A geology map is now provided as Figure 5. There is no more detailed geologic mapping available.

Pit contours have been added to Figure 2. The designed pit perimeter wall is simply meant to reflect the cut nature of the pit which results in the pit being an impounding structure during operations, as described in the NOI.

Figure 2 shows the pit and adjacent areas such as the topsoil piles, plant site, and overburden/interburden storage areas. Earth Energy does not believe that there is anything to indicate that there may be stability issues at the adjacent areas of the pit and dumps; this issue is discussed at greater length within this response letter and the March NOI.

The North (Operating) Pit is shown on various Figures.

R647-4-106 – Operation Plan

106.2 Type of operations conducted, mining method, processing etc.

Section 106.2 in the April 2008 version of the NOI has been modified to indicate that vegetation would either be included with soil stockpiles or stockpiled separately for later distribution, so as to add organic matter and help with surface roughness and soil moisture retention. The NOI text associated with the reclamation plan has also been modified to describe placement of vegetation slash piles.

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The volume of additional vegetal matter that will be stockpiled alongside, within, or on top of the topsoil piles is estimated to be 93,170 cubic yards; this quantity has been added to the soil stockpile volume estimates. It was conservatively derived by using the transect-measured ground cover for trees and shrubs, assuming an average height of 6 feet for trees and 2 feet for shrubs, an average void space of 50 percent, and an average compaction of 50 percent. Some of this slash will be contained within the stored topsoil, some will be stacked on top of the pile, and some will be used to form the berms around the base of the topsoil piles. This volume and a description have been added to Section 106.6, where the topsoil pile storage volumes are given.

Some of the requested information was previously included in Section 106.4 (Nature and Amount of Materials to be Mined). Additional tonnage and rate information has been added to that section, and has also been included in this section as requested by DOGM. These two sections now indicate that the anticipated yearly mined tonnages include: 920,000 – 1,200,000 tons of oil sand ore mined per year and 1,000,000 -1,400,000 tons of overburden/interburden mined per year. They have also been revised to state that the expected life of the mine is expected to be between 6 and 13 years, depending on the amount of time the processing equipment is on-stream and the number of process trains employed.

The timing of any planned expansion beyond the initial 62-acres North (Opening) Pit would be dependent upon many factors, as is typical of a mining operation. Earth Energy's best guess is that the West Pit may be planned for mining within about 5 years after mining is initiated in the North (Opening) Pit. This information has been added to this section of the NOI.

The distance from the pit to the processing plant (2,000 feet) has been added to this section of the NOI.

The tar sands stockpile and reserve ore pile refer to the same ore storage area. This amount of material is not expected to exceed 40,000 yd^3 at any time (as stated in the NOI previously under Section 106.9) and is typically expected to amount to 30,000 yd^3 of ore. The material may be stored in one or more piles within the same area as shown on Figure 3. The dimensions of the pile (or multiple piles) will not exceed 100 yards by 100 yards by 4 yards. This information has been added to Section 106.2 as well as being kept in 106.9.

Since the September 28, 2007 version of the NOI was submitted to the Division, Earth Energy has been able to define a well location for the water source. An approval to drill a test well at this location has been obtained from the State Engineers Office, and a right-of-way application is on file with the BLM for the well and associated pipeline. The location of this test well will hopefully be the location which is ultimately developed as the water source; it has been added to various NOI figures. The elevation of the test well site is approximately 8,260 feet; this, as well as additional descriptions of the well, has been added to the April 2008 version of the NOI.

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Now that the well location has been identified, the distance of the pipe run from the well to the site has been defined to be 12,650 feet. This information, as well as other descriptive information on the pipeline, has been included in the April 2008 version of the NOI.

Mining will be conducted using a self-contained mobile surface mining machine. Over- and inter-burden will be removed by conventional drill/blast/muck or rip/muck methods. Text in Section 106.2 has been clarified to indicate this. The surety estimate in the April 2008 NOI reflects these statements.

These mining methods will enable the pit design configuration that is shown in NOI figures to be achieved. A statement to that effect has been added to the discussion on mining methods.

Currently, it is not known if blasting will be required to fracture overburden/interburden to facilitate its removal. This material may be sufficiently friable to allow removal by ripping with dozers. If blasting is required, each program will be designed as a controlled blast to minimize fly-rock, vibration, and dust, and to generate aggregate size conducive for removal from the mine area. The drill size, spacing and depth of blast holes, and frequency of blasting will vary depending upon the situation, but in all cases would be in accordance with state and federal rules. Warning signs advising the public of blasting protocols will be posted at 150-foot intervals along the fence line, placed at all ready access points, and further, as required by MSHA. All of this information has been added to the April 2008 NOI, in Sections 106.2 and 109.4.

The mining method approach and general mining plan will be as follows: Initially, overburden will be removed on five acres of the initial mine site to expose the uppermost layer of oil sand. The surface miner will then mine through the first layer of oil sand by successively planing 8–10 inches of oil sand per pass. When the initial layer of oil sand has been mined, the interburden layer will be exposed and this will be removed to expose the next layer of oil sand. As oil sand mining is taking place with the surface miner, the conventional mining equipment will be employed for concurrent overburden removal to expose new areas of the oil sand bed and allow oil sand mining to progress. As sufficient area comes available, the mining operation will transition to multiple benches of mining, where oil sand mining occurs on the top layer of newly exposed areas and previously mined areas are excavated to expose the next bed of oil sands. When all target oil sands beds have been mined and access to newly opened areas is established, backfilling of the depleted areas will commence. This information has been added to the April 2008 NOI in Section 106.2.

The statement that the processing site area will be constructed to allow appropriate runoff and minimize erosion has been elaborated upon to indicate that it will be constructed to be a self-contained area and all precipitation incident on the site will be collected in the lined water storage pond and used in the extraction process. Further, the section on pit design now states that all precipitation on the mine pit will collect in the bottom of the pit, elaborating on the previous statement that runoff would be collected in the pit and used in the process. Runoff from the interburden/overburden storage areas will be controlled in armored (rip-rapped) channels with energy dissipation at the toes of those features, as now indicated in Section 106.9. These issues have also been addressed in Sections 109.1 and 109.4.

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The section on pit backfill has been expanded to state that the blended solid tails (80-85% sand at 12-15% moisture content, 15-20% fines at 20% moisture content) will be a relatively plastic material that will readily compact to a load-bearing surface for operation of the haul trucks. The "sand" fraction of the tails can be characterized as primarily quartz material in the 80-1,000 μm range and the "fines" fraction is the sub-80 μm material comprised of quartz, shale and clays. When the logistics of the mine/truck haul are optimized in the early stages of operations, it is anticipated that over/inter-burden materials from adjacent removal operations will be alternately combined (blended) with the sand tails to result in a stable, compact, bulk replacement material. Thus, rather than layering, the replacement material will be a more homogenous mixture.

The volume of the north pit is 7,900,000 yd^3 and approximately 6 million yd^3 of overburden, interburden, and tailings (sand and fines) will be replaced in this pit. A bulkage factor of 30% has been applied to the replaced material. This information has been added to the section on pit backfill in the April 2008 NOI, and to Section 106.10.

The density of the damp sand is roughly 2,850 lb/yd3. A bulkage factor of 30% has been used in replacement volume calculations. The combination of produced sand and produced fines will be mixed with overburden and interburden materials to create a stable compactable fill. Drainage from this fill will be comparable to in-situ materials. This information is now included in the pit backfill section of the NOI.

The "sand" fraction of the tails can be characterized as primarily quartz material in the 80-1,000 μm range (d_{50} = 117 μm), and the "fines" fraction is the sub-80 μm (d_{50} = 18 μm) material comprised of quartz, shale and clays. The particle size range of the mined overburden/interburden will vary from fine to coarse rock rubble (run-of-mine) materials potentially as large as one cubic yard.

106.3 Estimated acreages disturbed, reclaimed, annually.

Text, tables, and figures in the April 2008 version of the NOI have been revised to be consistent with the terminology for "pit" and "dump" features. The terms now in use are: North (Opening) Pit, West Pit, and overburden/interburden disposal site

An estimate of the disturbance expected by year has been added to the NOI in Section 106.3.

We do not understand why DOGM is requesting that statements regarding deleterious materials and their management be included in the acreage section of the NOI. However, we have added a statement to that section indicating that this subject is described in the NOI in Section 110.4 Treatment, Location, and Disposition of Deleterious Materials.

106.6 Plan for protecting & redepositing soils.

As noted in the September 28, 2007 NOI in Section 106.5, Earth Energy's experience during exploration drilling in the area indicates that actual topsoil depths are generally significantly less than that reported in the NRCS soil surveys. Therefore a more conservative depth of available material was used to calculate the topsoil balance in the NOI. However, Earth Energy commits to salvaging available topsoil to whatever

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depths are encountered during stripping. The April 2008 version of the NOI has been modified to reflect a salvage depth that is greater than was previously assumed, but still less than that available indicated by the NRCS. While these numbers (6 inches average over the Seeprid-Utso complex and 4 inches average over the Tosca soils) are now used in the balance calculations and for surety purposes, the actual salvage depths may be greater or less than these averages, depending upon field conditions. Appropriate text changes have been made.

Earth Energy agrees to salvage soil where it is available on slopes shallower than or equal to 2H:1V; appropriate text changes, including revised acreage and volume numbers, have been made.

Including the additional volume of salvaged soil does not require additional topsoil storage areas; as noted by the Division, height of topsoil piles will be increased instead, but will still be reasonable.

Earth Energy agrees to place topsoil on all disturbed areas during reclamation, with the exception of the 15 acres of topsoil stockpiles, from which topsoil won't have been previously salvaged. Figure 9 has been modified to indicate this, and text has been clarified to specify this as well.

The Tosca soils underlying the disturbed area cover 51 acres, as indicated in Section 109.3. Of this 51 acres, approximately 18 are on slopes steeper than 2H:1V and 33 are on slopes flatter than 2H:1V. These numbers have been added to this section of the April 2008 version of the NOI. (Numbers in the September 28, 2007 NOI were broken down differently because they were based upon 3H:1V cutoff for soil salvage.)

Topsoil will be salvaged with a 631 scraper and a D8 dozer used in combination depending upon the gradient and the presence of rock.

Topsoil storage areas are located on flat to gently sloping ground along the margins of the disturbed area. This will minimize haul distance, facilitate isolation and protection of the soil resource, and reduce contact with storm water run-on from outside the storage footprint. These descriptions have been added to Section 106.6 of the April 2008 version of the NOI.

Earth Energy agrees to place a sign at each topsoil storage area. The signs will read "Topsoil Storage Area – Do Not Disturb". Text has been added to Section 106.6 to reflect this commitment.

Topsoil storage pile berms will be formed using the crushed and compacted woody vegetation that will be salvaged. These berms will be essentially trapezoidal in cross section: two feet high, with a two-foot wide top width and approximately 1.5H:1V sideslopes. Appropriate descriptions have been added to the NOI.

106.8 Depth to ground water, extent of overburden, geology.

USGS-mapped springs were shown on several figures in the September 28, 2007 NOI; these have been highlighted on the revised watersheds figure (now titled Figure 7 Water Features). Further, springs whose locations are inferred based upon water rights filings are also shown on Figure 7, as are the seeps that were identified by JBR's wetland specialist and described in Section 109.1. As indicated by that figure,

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none of the USGS-mapped springs are within the 198-acre study area. Three of the springs that are inferred based upon water rights filings are within this 198-acre area, however at least one of these has no field evidence of a spring (as discussed in further in Section 109.1).

As stated in the September 28, 2007 NOI in this section (106.8) and according to Earth Energy, none of the Earth Energy exploration holes have encountered groundwater; this statement applies to the 25 exploration holes drilled in 2005. The first set of wells, drilled under DOGM exploration permit E/019/052, was located along Seep Ridge Road south of the County line within Earth Energy's lease area, but just east of the 198-acre study area. The second set of wells, drilled under E/019/053, was also located along Seep Ridge Road, spanning the County line, and within the eastern part of the 198-acre study area. This location description has been added to the NOI text in this section, and the maps that were part of the approved DOGM exploration permits have been added to the Appendix B information that includes correspondence on these permits.

In the area of the opening pit, the strike of the beds is N 20° E, and the dip is 1.2-1.7° NW. The axis of the San Arroyo fault is known to trend in an East-West orientation, approximately one mile to the north of the mine area. The strike and dip of the ore beds vary slightly throughout the planned mine area as the host formations are part of a gentle anticlinal structure. This information has been added to Section 106.8 of the NOI.

106.9 Location & size of ore, waste, tailings, ponds.

As yet, there is no other specific design information and/or control measures for the waste sands or ore stockpiles, other than that already contained in the NOI. Should further consultations with DWQ via the Permit-by-Rule request result in additional design measures, DOGM will be informed.

106.10 Amount of material to be moved.

This DOGM comment, regarding sediment control, appears to be mistakenly placed in this section on amount of material to be moved. The response is included here, however, changes in the NOI have been made in multiple locations throughout the NOI, including in Section 109.4. Earth Energy commits to including the SWPPP in the plan once it is complete. Specific BMPs and their locations are now shown on Figure 2, and include precipitation collection sumps, a retention/storage pond, armored channels, and riprapped energy dissipators. As noted, the PR Spring operation is located primarily along a fairly flat interfluve with little or no up-gradient, off-site runoff flowing onto the site. Precipitation collection sumps are simply low areas within the working mine pit where precipitation falling directly within the pit perimeter will drain and collect. The retention/storage pond will be located at the low point of the plant site, and will collect all plant site runoff; it will also be used to store clean reserve process water. All precipitation collected within the working mine pits and process areas will be used in the process or for dust suppression on mine and plant roads. Runoff and sediment generated from precipitation falling on the

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overburden/interburden storage areas will be controlled by armoring the "channel" formed by the contact between the pile and the native slope, and by installing a riprapped energy dissipater at the toe. Typical design drawings have been added to the NOI on Figure 2a.

R647-4-107 – Operation Practices

The reference to Section 107 was a misprint and has been corrected. As described in R647-4-103, that section is not required to be addressed in NOIs for Large Mining Operations, however the content asked for in the Section 107 rules is provided in other sections of the NOI. BMPs to be used on site are described through the April 2008 NOI, including in Section 109.4, figures showing where on the ground BMPs will be implemented are provided in Figures 2 and 3, and typical BMP drawings are provided in Figure 2a. In all cases, however, Earth Energy commits in the NOI to maintain all BMPs in operable conditions. As recommended by the Division, specified BMPs include the use of berms to direct runoff from the plant site to the water retention/storage pond. This pond will be cleaned of sediments as needed.

R647-4-109 – Impact Assessment

109.1 Impacts to surface & ground water systems.

All pit walls, including the lower wall side of the North (Opening) Pit are internally draining and stable. Therefore, their drainage, runoff potential, and sediment production is not an issue in regard to impacts to surface and ground water systems. As described throughout the April 2008 NOI, including in Sections 109.1 and 109.4, the pit floor will include precipitation collection sumps, which will collect precipitation, pit wall runoff, and sediments. This material and water will either remain in the pit or will be hauled out along with the ore and run through the process system. Upon reclamation, the pit walls will be covered because the pits will be backfilled as described throughout the NOI. The portions of the upper walls that would remain exposed if future mining does not occur will be stable and in rock, generating little, if any sediments. Any such sediments would be retained within the perimeter of the backfilled pit area.

The narrative in this section previously described the potential to impact a seep located within the footprint of an overburden/interburden storage area, and the management of that impact. There are no other impacts predicted to any springs or groundwater. A statement to that effect has been added to the April 2008 version of the NOI.

Rather than provide information in the narrative in this section (Impacts to surface and groundwater systems) about the sequencing of waste placement, it has been added to Section 106.2 Operations Description, in the April 2008 NOI. That information states that the blended solid tails (80-85 percent sand at 12-15 percent moisture content, 15-20 percent fines at 20 percent moisture content) will be a relatively plastic material that will readily compact to a load-bearing surface for operation of the haul trucks. The "sand" fraction of the tails can be characterized as the material in the 80-1000 μm range and the "fines" fraction is the sub-80 μm material. When the logistics of the mine/truck haul are optimized in the early stages of operations, it is anticipated that over/inter-burden materials from adjacent removal operations will

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be alternately combined (blended) with the sand tails to result in a stable, compact, bulk replacement material.

More information regarding how erosion control of the overburden/interburden storage areas and topsoil piles will be managed has been added to this and other sections of the NOI. As those sections indicate, erosion of overburden/interburden storage areas will be managed by controlling runoff from the top of the area, preventing it from running down the outslope and thus eroding it. Runoff from the outslope faces of the overburden/interburden storage areas will be controlled by armouring placed within the "channel" formed by the contact between the pile and the native slope, and by installing a riprapped energy dissipater at the toe. Controlling runoff will minimize sediment production, and the energy dissipators will also serve as sediment traps, causing at least some of the sediments to drop out. Topsoil storage area erosion will be managed by placing these features on flat to gently sloping ground along the margins of the mining and processing areas; protecting them by seeding; and berming their the outer edges for runoff control, using either topsoil or overburden.

Overburden/interburden/ storage area materials will primarily consist of broken sandstones and shales mixed with lesser amounts of fines. Grain sizes will vary from fine to coarse rock rubble (run-of-mine) materials potentially as large as one cubic yard. The coarser materials will typically end up near the toe of the expanding fills as the dump sites are filled to their maximum capacity. The concentration of coarse materials at the toe of the fills provides a natural energy dissipater for storm runoff from the faces of the dumps. As all of the topsoil will be salvaged for final reclamation, only minimal quantities of fine-grained particles will be placed in the dumps. Broken rock material has a very low siltation potential and will effectively encapsulate the finer material initially placed in the waste dumps. Active slopes will be at the angle of repose for the dumped materials (1.5-1.7H:1V). When the dumps are filled to capacity, their exposed faces will be contoured to blend in with adjacent canyon wall slopes (2.5-3H:1V) as indicated on the Reclaimed Mine Contour Plan (Figure 9). Indicated slopes on cross-sections apply to local slopes only and do not traverse (span) dumps and pit areas. No reclaimed slopes will be steeper than 30°.

Final designs for ditches and/or berms located at the process site can only be produced once final engineering designs are complete. For the current version of the NOI, Earth Energy provides conceptual information for these structures, as follows. All ditches will be designed to pass the 10-year, 24-hour precipitation event. They will likely be triangular in cross section with side slopes approximately 2H:1V; depth including freeboard will be less than 2 feet. Berms will generally be 2 feet high, with a one-foot top width and 1.5H:1V sideslopes.

Except for the very initial stages of operation, the pit will be an impounding structure. Therefore, drainage, runoff potential, and sediment production are not an issue in regard to impacts to surface and ground water systems. As described throughout the April 2008 NOI, including in Sections 109.1 and 109.4, the pit floor will include precipitation collection sumps, which will collect precipitation, pit wall runoff, and sediments. This material and water will either remain in the pit or will be hauled out along with the ore and run through the process system. The precipitation collection sumps are not the type of structures that require specific engineering or design storm calculations; if the sump is too small, collected water would simply overflow the

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sump but would still remain in the pit. If need be from an operational standpoint, the sump could easily be enlarged to provide more capacity.

Ditching/berming will be used at the plant site to direct runoff generated on the plant site to a water collection/retention pond located at the down gradient end of the plant site. These ditches will be designed to convey runoff from a 10-year, 24-hour storm event. The collection/retention pond will be used to supply reserve process water.

As the September 28, 2007 NOI previously stated, Earth Energy will prepare a Storm Water Pollution Prevention Plan as required by the terms of the State of Utah Multi-Sector General Storm Water Permit for Industrial Discharges. The April 2008 version of the NOI retains that commitment, and also commits to appending the SWPPP to the NOI once it is complete.

The April 2008 version of the NOI includes additional information about management of storm water. It also explicitly commits to ensuring that BMPs (which would include storm water management structures) would be maintained in a functional state. Further, the Storm Water Pollution Prevention Plan as required by the terms of the State of Utah Multi-Sector General Storm Water Permit for Industrial Discharges requires that BMPs be inspected and maintained, and requires quarterly visual monitoring of storm water.

More detailed descriptions of BMPs have been added to the April 2008 version of the NOI, as requested.

The depth to groundwater from the base of the pit is not known. However, using a conservative assumption that the regional water table is 1,500 feet below ground surface (see text in this section of the NOI for justification for this number), and knowing that at it's deepest point the pit would be approximately 140 feet deep (see text in Section 109.4 of NOI), by subtraction, the depth to groundwater from the base of the pit can be projected to be 1,300-1,400 feet. A statement to this effect has been added to the April 2008 version of the NOI.

109.2 Impacts to threatened & endangered wildlife/habitat.

The Division is correct. The Mexican spotted owl was listed as a threatened species on 15 April 1993 (USFWS 2007. Mexican Spotted Owl webpage at: http://www.fws.gov/southwest/es/mso/). The text has been changed to reflect this designation.

It is possible that Mexican spotted owls may move up the canyons from known habitat areas to forage in areas closer to the mine. There is concurrent gas well development in the area, which may have already acclimated the birds to industrial activities. Conversely, this existing and previous activity may have caused them to avoid the area already. If the former, once the mine is in operation, forage within the area affected by the mining operation would not be available for Mexican Spotted Owl to forage in. This loss would be temporary, as forage habitat would be reestablished after reclamation occurs. Additional information has been added to Section 109.2.

The US Fish and Wildlife Service and the BLM have been consulted regarding the planned use of water for this operation. The source for this water would be deep groundwater (greater than 1,000 feet). Use of groundwater that does not have a hydrological connection with surface waters is not considered to be a depletion under the Upper Colorado River Basin Recovery Program. The BLM has made the determination (at least in the Uintah Basin area) that water sources deeper than 500 feet do not have such a connection and thus do not represent a depletion for which mitigation fees are needed.

A lek, known as the Monument Lek, is located within the Study Area and approximately 3,000 feet due north of the initial mine development, but within 100 feet of the active Seep Ridge Road and a buried gas transmission line. The Seep Ridge Road is currently used as a thoroughfare for oil and gas development. During one visit in Summer, 2007 trucks passed the mine area approximately every 20 minutes. While the mine has no control over vehicles associated with gas development, during mining, impacts to grouse strutting on the Monument Lek can be mitigated. Prior to Spring 2009, Earth Energy will coordinate with DWR to see if the lek has been active in 2008 (it has not been active in recent years). If active in 2008, Earth Energy will commit to observe the Monument Lek three times in 2009 during early morning hours between March 15 and April 15 to see if it is active. During that time interval, they will cease mining between ½ hour before to 1 hour after sunrise, and 1 hour before to 1 hour after sunset. If no grouse are using the lek after three observations, mining can continue during those hours. If grouse are found to be using the lek, the twice-a-day mining cessation will continue until May 15th. This will be repeated on an annual basis, if the lek remains active. This commitment has been added to Section 109.2. Further, reclamation will reestablish the disturbed area to provide potential brood-rearing habitat.

109.4 Slope stability, erosion control, air quality (fugitive dust control plan), safety.

Earth Energy agrees to include a copy of the Approval Order from the Division of Air Quality once it has been issued.

Earth Energy has consulted with the Utah Division of Wildlife Resources in regard to the design of the fence between the highwall and the county road. As recommended by that agency, (personal communication with Brian Williams, DWR Northeast Region), this fence will be between 38 and 48 inches high, comprised of three or four strands barbed wire, topped with a log rail. It will be anchored with T-posts. Appropriate changes have been made to the April 2008 version of the NOI.

Earth Energy assumes that the comment is referring to storage volume, locations, and containers from a safety aspect. As such we have added statements to this section of the April 2008 version of the NOI to indicate the following. Volumes of material such as product, waste oil, etc. will be periodically removed from the site as needed so that their allocated storage is not exceeded. Containers stored on-site will be labeled so that wastes are clearly identified. Salvageable materials and other wastes will be stored at the plant site within the fenced area. No hazardous materials or hazardous solids wastes will be generated or used during this operation, thus none will be stored. Liquid hazardous wastes will be stored in an identified

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tank within the tank farm and periodically removed for disposal at an approved facility by local disposal companies (vacuum trucks). Further, produced sand and fines will typically remain at the facilities site during the night shift. The following day, the material will be removed and disposed in either waste dumps or in mine pit reclamation.

Earth Energy has considered that the placement of warning signs will be visible from more than one location. That is the reason that signs will be placed at 150-foot intervals along the fence line, placed at all ready access points, and further, as required by MSHA.

Blasting would take place within the confines of the pit and, by design, would not result in material (other than acceptable levels of fugitive dust) migrating outside the pit. Loose material within the pit will remain in the pit until it is removed as part of the orderly progression of the mining sequence. Should, by any unforeseeable event, blasting result in large loose material migrating outside of the pit and outside of the 198-acre affected area, it will be removed immediately. Blasting is not expected to result in fly rock landing on the adjacent county road. However, during blasting, the road will be closed for 1,000 feet on either site of the blast site. Flaggers will be posted to accomplish this, and resultant wait time for any travelers would not be expected to be more than 10-15 minutes. Statements to this effect have been added to the NOI text.

An ultimate pit mine plan, pit slope design sectors and geotechnical basis, pit dimensions (i.e. width, length, depth), plan of pit roads, and stockpiles etc. were all previously provided in the NOI. The April 2008 NOI has added information on annual production sequence, a geologic map with major structures, information on joint sets and bedding, dump points, and crusher dockets.

Pit wall height and other technical information regarding mine pit construction is included within the NOI narrative and Figures in a form expanded from what was previously provided.

Pit walls have been designed -- and are shown on supporting drawings -- with 2H:1V backslopes. In the September 28, 2007 NOI, the text mistakenly mentioned 1.5H:1V for these slopes, which was an error and was inconsistent with the slopes as portrayed on the figures. All text and figure references in the April 2008 version of the NOI correctly reflect Earth Energy's plans to construct all pit slopes at 2H:1V slopes. Use of this slope represents Earth Energy's desire to facilitate pit reclamation, and to provide conservatively designed pit wall slopes to compensate for the lack of detailed knowledge regarding the extent of localized faulting or fracture planes that could cause instabilities. Note that numerous existing road cuts and excavations in the area (including Earth Energy's 2005 production test pit) are stable with slopes steeper than 1H:1V. In the vicinity of the opening pit, the strike of the beds is at N 20° E and the dip is at 1.2-1.7° NW, raising no concerns with dip-related instability. A typical geologic cross-section from the middle of the opening pit (at Station 715N) has been included in the April 2008 NOI for reference.

Pit walls are designed at a 2H:1V slope to prevent rock falls. Back-break near the top rim of the pits will be controlled or eliminated by smooth transition grading. Any required blasting along the walls of the pit will be accomplished with small controlled blasts to eliminate over-break and weakening of the remaining material

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on the face of the slope. Similar techniques are commonly employed in the construction of rock cuts for highways, railways and pipelines.

Information has been added to Sections 106.2 and 109.4 to state that pit wall slopes will be monitored regularly for signs of instability. Further, numerous mentions are now made in the NOI that the area will be managed in accordance with MSHA safety guidelines and the plan.

It is not clear why DOGM believes that the waste slope angles are greater than 45°, and/or that transverse mine sections W1-E1 & W2-E2 reclaimed waste slope angles are 60° or greater. Neither the September 28, 2007 NOI text nor figures indicated such slope angles. Perhaps the reviewer did not account for the vertical exaggeration as reflected by the different x and y axis scales. No slopes in the overburden/interburden storage areas exceed 45°. When initially discharged, the angle of repose for the over/inter-burden is expected to be in the 1.5-1.7H:1V range translating to slope angles in the 30°-34° range. Final grading (after the overburden/interburden storage areas have been filled to capacity) will see the slopes contoured to blend with the adjacent canyon slopes (approx. 2.5-3H:1V). The transverse mine section W2-E2 indicates a portion of the slope at about 30°, but the overall slope would be much flatter than this, and in any case, does not come close to 45°, much less 60°. Therefore, there does not appear to be a need to request a variance for slope angle for this project.

R647-4-110 – Reclamation Plan

General

The statement that the Division notes as missing is not missing. It was, in fact, contained in the September 28, 2007 NOI under Section 110.6, which is the proper placement and section following the rules format. Please refer to the same section in the April 2008 version of the NOI, where this statement remains.

The table requested by the Division showing the acreages to be topsoiled and reseeded has been added to Section 110.5 of the April 2008 version of the NOI.

A new paragraph has been added to the April 2008 version of the NOI, in Section 110.2, to explicitly state the reclamation objectives. In addition, throughout the reclamation plan section, language has been clarified and expanded upon so that the Division can more readily understand Earth Energy's objectives.

Section 110.5 of the April 2008 version of the NOI has been revised to describe planned monitoring for reclamation success and noxious weeds. A paragraph has been added to Section 110.2 to describe other monitoring that will continue throughout the reclamation period as part of the Storm Water Permit.

In order to ensure an environmentally safe and stable condition for the various wildlife in the area that meets the objectives of the mined land reclamation act 40-8-12, Earth Energy has proposed to leave safe, stable topography; establish native vegetation suitable for habitat; remove man-made structures, including tanks, ponds, etc.; and cause no degradation or harm to water sources. All of these issues were addressed in the NOI, but a blanket statement to this effect has been added to Section 110.1 of the April 2008 version.

Safety will be managed at reclamation by continuing to follow safe operating conditions while using equipment and continuing to follow the appropriate MSHA guidelines and regulations. A statement to this effect has been added to Section 110.2.

110.1 Current & post mining land use.

Reclamation and closure plans have been developed with the intent of allowing post mining land uses of open space and wildlife habitat. While future exploration may also be one of the post mining land uses, Earth Energy acknowledges that reclamation and closure plans will not be based upon that use. The language in this section of the April 2008 version of the NOI now clarifies this.

110.2 Roads, highwalls, slopes, drainages, pits, etc., reclaimed.

Earth Energy agrees to commit to ripping roads to a depth of 24 inches, with ripper shanks placed no more than 24 inches apart, where depth to bedrock allows. A statement to that effect has been added to the April 2008 version of the NOI.

Earth Energy agrees to maintain on-site roads that are needed throughout the operations, interim reclamation, and reclamation phases of the project in order to minimize erosion until such time as they are no longer needed and are fully reclaimed. A statement to that effect has been added to the April 2008 version of the NOI.

Earth Energy has clarified that the reclamation and bond includes reclaiming all roads within the 198-acre affected area.

It is not clear why DOGM believes that the reclaimed waste slope angles are greater than 45°; perhaps the reviewer did not account for the vertical exaggeration as reflected by the different x and y axis scales. Neither the September 28, 2007 NOI text nor figures indicated such slope angles. No slopes in the overburden/interburden storage areas exceed 45°. Final grading (after the overburden/interburden storage areas have been filled to capacity) will see the slopes contoured to blend with the adjacent canyon slopes (approx. 2.5-3H:1V). The transverse mine section W2-E2 indicates a portion of the slope at about 30°, but the overall slope would be much flatter than this, and in any case, does not come close to 45°, much less 60°.

During reclamation, erosion will be minimized throughout the area by regrading slopes to gentler angles, leaving surfaces with roughened micro-topography, and reseeding in a timely fashion. The April 2008 NOI makes these commitments more apparent.

As stated throughout this response letter and the April 2008 NOI, there will be no slopes left steeper than 2.5:1, thus there is no concern about their long-term stability; with those final slopes, safety hazards are minimized, vegetation growth will be encouraged, and erosion will be reduced.

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When the final pit is reclaimed, the potential to form a pit water collection area will be eliminated.

The active mining area will be a pit at all times (concave to incident precipitation and run-on). No operational pit configurations are planned where storm water will be allowed to egress the active mine workings. Please refer to the revised figures in the NOI. Further, the NOI text has been revised to include a statement that explicitly states this.

110.3 Description of facilities to be left (post mining use).

The water will revert to SITLA once Earth Energy's operations have concluded. The surface facilities associated with the well will remain in place and unreclaimed (though the pipeline will be decommissioned as described). Changes have been made to this section of the April 2008 version of the NOI.

110.4 Description or treatment/disposition of delirious or acid forming material.

This section has been revised in the April 2008 NOI, including eliminating the term "berm" and referring to secondary containment by reference to the operation description.

110.5 Revegetation planting program.

Earth Energy agrees to provide a roughened surface to retain seed and to enable root penetration. This will include leaving numerous gouges and rips that will trap seed and moisture and provide erosion and sediment control. The April 2008 version of the NOI has been modified to show that the surface will be left very rough.

Additional details for grading and stabilization have been added to the April 2008 NOI. This includes discussion that the overburden/interburden storage areas will be re-contoured by dump-top rounding and surface recontouring to create an undulating, roughened surface that will blend with the surrounding terrain. This will be done with a dozer prior to topsoil placement. Seedbed preparation discussions have also been expanded to restate the development of a roughened surface.

By regrading the exposed pit walls and the overburden/interburden storage areas, several things will be accomplished: the regulatory requirements final slopes will be met; runoff and erosion considerations will be minimized; a surface amenable to revegetation will be created; and slopes will blend with the surrounding topography. As noted, drainage will not be an issue on these regraded areas as there is no run-on and infiltration capacity will be high on reclaimed slopes. The requested table has been added as Table 9.

R647-4-111 – Reclamation Practices

As noted throughout the April 2008 NOI, all reclaimed slopes will be stabilized by regrading to 2.5H:1V or flatter and leaving them in a very roughened form to maximum infiltration and minimize runoff. It is important to note that there will be little to no run-on on these reclaimed surfaces. Further, in regard to the overburden/interburden storage area slopes, the coarser materials will typically end up near the toe of the

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expanding fills as the dump sites are filled to their maximum capacity. The concentration of coarse materials at the toe of the fills provides a natural energy dissipater for storm runoff from the faces of the dumps. The broken rock material has a very low siltation potential and will effectively encapsulate the finer material initially placed in the waste dumps.

R647-4-112 – Variances

Earth Energy does not believe that there were any comments made in the September 28, 2007 NOI, or in the April 2008 NOI, that indicate that steep slopes will remain. A Division-approved variance is not needed.

R647-4-113 – Surety

Operations

A list of equipment used during the operational phase was provided in Appendix D of the April 2008 NOI. Equipment removal costs are included in Appendix E.

Reclamation

Earth Energy understands that some of the review comments may be general in scope.

Information on the acres in each reclamation category has been added to the reclamation plan and provided in the surety Appendix (E).

No drainages will be constructed, therefore no drainages will be reclaimed. The headwaters of two ephemeral drainages affected by mining will be filled with overburden/interburden storage areas. No drainage reconstruction will be required during reclamation.

Information on reclamation of the pond has been added to Section 110.2 and Appendix E.

Removal of equipment/materials associated with bitumen storage has been provided in Appendix E.

The costs to remove and dispose of the skid-mounted equipment, power plant, plant office and buildings are included in Appendix E, and described in Section 110.2.

The cost to remove the lining from the truck loading area is included in Appendix E.

Information has been added to the reclamation plan on how the facilities area will be reclaimed, including the cost for removing the contents of the tanks and buildings. Detail and references have been added to Appendix E.

A fence will be left between the Seep Ridge Road and the mine area until the site is ready for bond release, at which time all fences, gates, and signs will be removed.

Since the plant site borders the Seep Ridge Road there is essentially no access road. During final reclamation, on-site roads would be deep-ripped to relieve compaction, regraded to blend with site topography, and seeded. This description is included in Section 110.2, Roads. The reclamation costs are included in Appendix E.

The costs for topsoil relocation have been revised and are provided in Appendix E.

The pit is backfilled as part of mining, as explained in Section 106.2, Pit Backfill.

Associated disturbance as stated in 109.3, includes those disturbances related to mining and processing at PR Spring mine that are not mining specific and include approximately 15 acres to be disturbed by the plant site and 24 acres to be disturbed by haul roads. These disturbances will remain unreclaimed for the life-of-mine.

The clean-up estimate in the original submittal assumed that not all areas of the mine would have loose trash on them. However, for simplicity's sake the surety now contains a figure that assumes trash removal is required on all acres of the mine. The surety cost assumes that three laborers would be used to pick up trash and perform loading work. The cost for a front-end loader and other equipment includes operator costs. All assumptions are included in Appendix E.

An estimate of the volume of trash that will be found on the 98-acre site is included in the surety calculations. See below for definition of trash. Dump fees, and transport costs to the nearest licensed landfill, are now included in the reclamation surety, detailed in Appendix E.

The surety calculations separate "Trash" from "Demolition debris" and "Hazardous Materials".

"Trash" includes those items that missed the trash can, such as fast food wrappers, loose oil cans that sat out for a year before being discovered, lids, stray rags, office and food waste, stuff that fell off while loading skid structures onto the lowboy for removal from the mine, etc. The entire mine will be scoured for trash prior to preparing the seed bed. All trash collected will be disposed of at a licensed landfill.

"Demolition" and "facilities removal" includes organized demolition and/or removal of all buildings, tanks, skid structures and the like and has been separated out on the surety spreadsheet. After facilities removal the site will be checked for any small items (such as stray angle iron, cable, wood, insulation, paper), which will be treated as trash and removed accordingly.

Removal of "hazardous materials" (such as fuel tank contents) is now listed as a separate task in the surety spreadsheet. Fuel/lubricant removal by truck will be free, as quoted by Tri-State Recycling (307-746-3688)

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on April 1, 2008. A transport cost has been included to remove remaining contents of the process water, chemical additive, and cleaning emulsion tanks as these items may not have sufficient re-sale value. Cost per trip included in the revised surety calculations is based on 176 miles round trip, and $1.56 per mile.

Detail has been added to the description of the building demolition. The distance from Earth Energy's PR Spring mine to a licensed facility (Uintah County Landfill on east side of Vernal) is 88 miles. Cost to transport materials this distance is itemized in the surety calculations, Appendix E.

The tanks and everything else are being transported. The narrative and surety calculations have been re-worded to make this clearer.

All non-hazardous materials will be disposed of at the Uintah County Landfill.

Demolition debris consists of all buildings, equipment, tanks, etc. from the plant site, and includes modular office and maintenance buildings, tanks, processing structures, etc. as itemized in the revised surety calculations.

Dump fees are currently $30/load for a 10-12 yard dump truck, $50/load for a 35-50 yard dump truck, and $15/ton for materials brought in on other vehicles, such as trailers. These values are used and noted in the revised surety calculations.

The precise Means publication used is noted in each bulleted item.

An additional transport fee, based on 629 Means Heavy Construction Cost Data (2008) (31 23 23.18 4700) for the full 88 miles of haulage is included in the revised surety calculations.

An estimate of the volume of demolition material is included in the surety calculations. As noted above, Demolition material is not considered trash.

The only facilities with foundations are two aluminum-framed, semi-permanent, movable "sprung" structures (go to http://www.sprung.com/en/index.php for information on these structures, which are in use at Kennecott Utah Copper). These foundations cover 0.46 acres. Ripping and burial of the concrete is included as a line item in the revised surety calculations.

Tank contents have re-sale value. Tri State Recycling (307-746-3688) will remove fuel, gasoline, propane, etc. for free if quantities are over roughly 300 gallons. If the quantities are less, the company is currently charging $1.56/mile to remove these smaller quantities of fuels. The surety calculations assume that three trips would be required to remove remaining contents of the process water, chemical additive, and cleaning emulsion tanks as these items may not have sufficient re-sale value. The cost per trip included in the revised surety calculations is based on 176 miles round trip, and $1.56 per mile.

The source of information for the cranes is from the Cost Reference Guide (2008). Cost for the use of a lowboy trailer is included in the mob/demob costs as this equipment is used to transport dozers, etc. to the reclamation site. This equipment is then used to haul waste materials to the Uintah County Landfill. Costs for this activity is from 629 Means Heavy Equipment Construction Cost Data (2008) 31 23 23.18 4700. This information has been added to the revised surety calculations.

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A more detailed equipment list is included in the revised surety calculations, and the equipment to be used is listed under each item.

The facilities to be demolished and buried are described in Section 110.2. All other materials will be hauled to the Uintah County Landfill.

Tri State Recycling (307-746-3688) will remove fuel, gasoline, propane, etc. as described above.

A more detailed equipment list is included in the revised surety calculations, and the mob/demob. costs have been revised.

The referenced cost information by equipment type has been added to the surety section.

Unit costs have been reviewed and adjusted as necessary in the revised surety calculations.

A list of all facilities, generators, pipes, pumps, etc. has been provided and cost of removal is included in the revised surety calculations, Appendix E.

We look forward to your review and consideration of this response and additional information for Earth Energy's PR Spring NOI.

Thank you.

Regards,

Linda Matthews

Linda Matthews
JBR Environmental Consultants, Inc.

Cc: Barclay Cuthbert, Earth Energy

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Linda Matthews

From: Paul Baker [paulbaker@utah.gov]
Sent: Thursday, January 10, 2008 10:27 AM
Linda Matthews
Subject: Final Version
Attachments: rev1-prsprings-01102008.doc

rev1-prsprings-01102008.doc (8...

Attached is what I think will be the final version of our PR Springs review. There's not much difference between this and the review I sent previously. The most substantive change is one I made in the section on threatened and endangered species concerning the endangered fish of the Upper Colorado. I believe I mentioned this in our meeting.

January 10, 2008

Barclay Cuthbert
Earth Energy Resources
Suite 740, 404-6 Avenue S. W.
Calgary, Alberta, Canada T2P 0R9

Subject: First Review of Notice of Intention to Commence Large Mining Operations, Earth Energy Resources, PR Springs Mine, M0470090, Task 2032, Uintah County, Utah

Dear Mr. Cuthbert:

The Division has completed its initial of your Notice of Intention to Commence Large Mining Operations for the PR Springs Mine, received September 28, 2007. The attached comments will need to be addressed before tentative approval may be granted.

The comments are listed below under the applicable Minerals Rule heading. Send replacement pages of the original notice **using redline and strikeout text** and indicate how these are to be incorporated into the plan using Form-MR-REV-att found on the Divisions web page. After the notice is determined technically complete you will be asked to send us two final clean copies, one of which will be returned.

The Division requests that submittals are made according to the following format. Notices and changes should be three hole punched, maps folded and placed in a plastic 8 ½ by 11 sleeve, and binders provided for new notices, revisions, applications, or other changes of 30 pages or more (binders need only be provided once). An additional electronic copy is appreciated. You may request some proprietary information relating to the location, size, and nature of the mineral deposit to be kept confidential. Confidential information must be clearly marked and provided in a separate binder.

If you have any questions in this regard please contact me, Tom Munson, Paul Baker or Beth Ericksen of the Minerals Staff. If you wish to discuss this review, please contact us at your earliest convenience. Thank you for your cooperation in completing this permitting action.

Sincerely,

Susan M. White
Mining Program Coordinator
Minerals Regulatory Program

SMW:PBB:pb
cc: Will Stokes, SITLA
O:\M047-Uintah\M0470090-PRSpringMine\draft\rev1-prsprings-01102008.doc

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IR - 000223

REVIEW OF NOTICE OF INTENTION TO COMMENCE LARGE MINING OPERATIONS

Earth Energy Resources
PR Springs Mine
M0470090
January 10, 2008

General Comments:

The submitted notice does not address nor commit to conform to operation and reclamation practices. Variances may be required which will require an outline of the method or measure that is consistent with the Act. Variances related to erosion control and slopes would be necessary. Please look at the narrative within the impact assessment, as it may be as simple as providing more detail in the mitigation portion of the narrative. (BE)

The submittal uses the word 'proposed' within the context of the text and maps as well. Omit this word and write the narrative as though the Division approved this mining operation. (BE)

Based on the content of the submittal, it appears there may be expansions that will require revisions to the permit in time. Because of the change dynamics, the submittal should be formatted to easily incorporate into future revisions or amendments. Further discussion with the Division is suggested. (BE)

R647-4-101 - Filing Requirements and Review Procedures

Page two, number 3, indicates that the company can begin mining when the reclamation contract is completed and the *NOI is approved*. This statement is not true in its entirety, and the following applies: The reclamation contract and surety must receive Division approval before mining can commence. Please re-write that statement. (BE)

The mine plan shows a "possible" west pit extension, and Figure 5c contains a footnote, which states, "Any Phase II activities or areas depicted on this drawing are conceptual only and are not currently proposed under this NOI." On the other hand, Section 10.2, page 30, says the mining and reclamation plan and associated bond estimate are based upon initial North pit mining, the West extension, and associated disturbances. Please clarify these comments. Is the west pit part of the proposal? The plan needs to clearly delineate those activities that would be approved with this plan and those that are conceptual. (PBB)

The Division recommends that adjacent landowners be notified in writing. (PBB)

R647-4-104 – Operator's, Surface and Mineral Ownership

The minerals ownership section (104.2, page 3) says Earth Energy has a lease but does not say who owns the mineral rights. From the cover letter, this is understood to be the School and Institutional Trust Lands Administration (SITLA). Please state the mineral right owner. (PBB)

Page three of the submittal indicates the permit area is 2255 acres with the initial disturbance of 198 acres. The submittal, including the surety calculations contains information pertaining only to 198 acres.

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Further clarification is required since permit area is defined as just an area of land on the approved map, and to avoid confusion, Operator intent of the use of including this title on the map is requested. Please label the area "SITLA lease area" instead of permit area. (BE)

Once the conditional use permit from Grand County is granted, please include this as an appendix to the plan. (BE)

R647-4-105 - Maps, Drawings & Photographs

General Map Comments

There are no maps that show streams, springs, waterways, and infrastructure. (BE)

Please state the contour interval on all maps. (BE)

There is no shown and labeled public access route from nearest highway. (BE)

The narrative outlines the area geology, which should be shown on a geologic map. In addition to the geology map, the Division would like to see the five asphalt sands A-E detail within the Douglas Creek Member. (BE)

Specific Map Comments

The below review comments are specific to the identified maps. The items will require clarification and updates, improvements, or corrections. These should be made to each of the maps accordingly. Do not assume this information is all-inclusive as other changes may result once clarity is established. (BE)

Figure 2:

See comment under **R647-4-104 – Operator's, Surface and Mineral Ownership**. Figure 2 shows and labels the NOI permit area as 2255.15 acres, but unless complete information is submitted for this entire area, the NOI will not be approved for this acreage. Further discussion suggested. (BE)

The word proposed mine operations shows several colors of hatching, however none of them are identified using a key. There is no indication of what they mean. Please correct. (BE)

The mine operations area should be submitted in a map that shows necessary detail. Some information is contained in figure 8, please read those comments. (BE)

Please remove the word proposed from the 200-acre mine operation. For consistency, the disturbed area should be shown as 198 acres. (BE and PBB)

Be specific on the number of acres; do not use +/- in front of the number. (BE)

The narrative indicates that surface and subsurface facilities are shown on figure 2, however, they are missing. Please see Page 6 of the narrative. (BE)

The narrative indicates that figure 2 is at a scale of 1 inch = 2083 feet. The bar scale on the map does not correspond with the map scale. Please make adjustments. (BE)

The lease boundary on the bottom portion of the map is omitted (cut-off). It should be all-encompassing showing all boundaries. (BE)

Figure 3

The acreage is not shown for the gray mine haul road. Please label. (BE)

Figure 4

The facilities map should include the dimensions of the buildings, ponds, piles etc. These dimensions can be part of the legend and referenced appropriately. The map should show roads, including access and haul roads; utilities and power lines (water, gas, power, telecommunications etc); and drainage control devices. (BE)

Note the acreage on this map. (BE)

Figure 5-d

There may be related issues within the other figures and more information may be required. (BE)

This figure does not look like a cross section as the narrative indicates. It, however, does show the location of the cross sections but in addition it includes important information that would not be easily found because of its titling under the table of contents. Please consider changing. (BE)

This figure contains a lot of information; it is very congested. Can you adjust or split the map information in two maps? A legend is required. (BE)

Figure 6

Provide direction of water flow(s), ephemeral stream channels, show the longest flow path, and show vegetation areas on the watershed map. (BE)

Figure 8

More information that further clarifies the pit configuration may be required, which may include an additional map. (BE)

The reclaimed area should show topographic lines, which can be shown in different colors representing the waste areas and the pit area. They should be labeled and contour intervals identified. If there are any

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storm water controls, they should be shown as well as drainages, springs, etc. The cross section locations should be shown as well. Highlight the bonded area on this map as well, and include acreage. (BE)

The surety is partially determined by earthwork to be performed in the area. Please show areas that will be ripped, seeded, and contoured since the plan doesn't include each of these tasks over the entire area. (BE)

On this same map, perhaps in the legend, indicate the volume of topsoil available. (BE)

If materials are going to be buried, show locations. (BE)

105.2 Surface facilities map

The water well and associated pipeline need to be included as part of the disturbed area and need to be shown on a map. (PBB)

105.3.16 A geology map is required that identifies faults (strikes and dips), rock types, interbeds, and predominant joint (bedding and cross joints) orientations to help demonstrate generally stable pit wall configurations. (BE)

A map should be provided that shows the pit design with contours. It appears from the submitted maps that the pit may have a tendency to collect water. Please include the designed perimeter wall as described in the narrative. (BE)

The above-mentioned pit map should show adjacent areas such as the topsoil piles, plant site, and waste dumps. Based on the outlay, it appears there may be stability issues at the adjacent areas of the pit and dumps. (BE)

There is an explanation of the north pit on page 27. Please provide a specific map of this area for clarity. (BE)

105.3.18
A map should be submitted that shows adjacent land owners. (BE)

R647-4-106 - Operation Plan

106.2 Type of operations conducted, mining method, processing etc.

The plan says (Section 106.2, page 7) that vegetation would be cleared by pushing into piles for burning. The Division recommends that vegetation be included with soil stockpiles or stockpiled separately for later distribution. The vegetation adds organic matter and also helps with surface roughness and soil moisture retention. (PBB)

Per the above comment, ensure there are volume determinations identified and included which will increase the volume of the soil stockpiles, or indicate there will be an addition of vegetation piles separate from the topsoil stockpiles. (BE)

The narrative provides as an estimated volume of mineable material but more information is required such as anticipated yearly tonnages mined. In addition, please indicate the expected life of mine in years. (BE)

It is apparent that expansions beyond the initial 62-acre pit are planned. Please provide a date estimate of when any expansions will occur. (BE)

Provide the distance from the pit to the processing plant in feet or miles. (BE)

Provide the maximum footprint dimensions of the tar sands storage pile and reserve ore pile, include volumes too. (BE)

The narrative refers to the water source as being a well. Show the location of the well on one of the maps and refer to the map in the text including its elevation. (BE)

What is the distance of the pipe run from the well to the site? (BE)

The narrative indicates there will be one of two mining approaches used, and at this time it is unknown. It will be necessary to amend the plan once the mining method is certain. From a surety estimation standpoint, assumptions may need to be made that will influence the surety estimate. (BE)

In addition to the above comment, either mining method used should ensure the pit design configuration as shown can be achieved and a statement should be made to that effect. (BE)

If blasting will occur, then some blasting specifics will be required. (BE)

Provide information about the mining method approach and general mining plan. (BE)

The statement that the site area will be constructed to allow appropriate runoff and minimize erosion requires further elaboration. (BE)

The pit backfill plan requires additional information such as: the thickness of the various layers of interburden/fines. (BE)

What is the volume of the pit and comparatively, the volume of sand/interburden to be placed there? (BE)

What is the sand density? Will this material bulk? Will it be compacted when placed in the pit? Will it drain appropriately? (BE)

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What is the particle size range for the over/interburden and the sand? (BE)

106.3 Estimated acreages disturbed, reclaimed, annually.

Table 1 within the narrative refers to the north pit but figure 3 refers to it as initial pit. The table refers to overburden/interburden disposal site, and figure 3 refers to it as waste dumps. Please coordinate consistent titling. (BE)

Indicate the number of acres that will be disturbed on an annual basis. (BE)

Please make a statement that no deleterious are on site if that is the case. If not, provide a table and information identifying the materials. Elaborate on how they are managed. (BE)

106.6 Plan for protecting & redepositing soils

According to the plan, an average of three inches of soil will be salvaged from 132 acres of the Seeprid-Utso complex soils. This compares with the soil survey which says topsoil—note this is topsoil and not just soil—depth ranges from 4-18 inches (although the plan says soils in the mine area are anticipated to be shallower than stated in the soil survey). An average of two inches of soil will be salvaged from less steep portions of the Tosca soils. Topsoil in the Tosca soils is described in the soil survey as being 0-11 inches thick. Soils on slopes steeper than 3h:1v will not be salvaged.
Two to three inches of soil is not adequate for reclamation to the vegetation communities that exist in this area. The Seeprid-Utso soils, according to the soil survey, have 4-6 percent organic matter which probably qualifies them as Mollisols. These are ideal soils for reclamation, and the opportunity to salvage these soils and use them in reclamation must not be wasted. The Division anticipates a minimum of six inches of soil, and possibly twelve inches or more, could be salvaged from the Seeprid-Utso soils and used in reclamation. The Tosca soils are likely to be more variable, but the amount of soil salvaged, where available, should be maximized. If soil cannot be salvaged from some areas, there should be adequate soil available in others to make up the shortfall. (PBB)

In most cases, soil can be salvaged from slopes as steep as 2h:1v. Please modify the plan accordingly or include a request for a variance from this requirement with appropriate justification and alternate methods to be used. (PBB)

Soil storage for this increased volume should not be a problem since, 1. The amount of soil in the storage area can be doubled with the depth increasing to just under five feet which is not extreme, and 2. The operator will be doing concurrent reclamation, which will reduce the amount of soil needing to be stored at any one time. (PBB)

Figure 8 shows disturbed areas that will be reclaimed but that will not receive topsoil. This is logical for the topsoil storage area, but there should be adequate soil available that soil can be spread over the entire disturbed area (see preceding paragraphs). Please make the appropriate changes. (PBB)

How many acres comprise the steeper slopes of the Tosca soils? (BE)

What equipment will be used to scrape the topsoil? (BE)

Provide a description of the topsoil placement area considering adverse influencing factors. Are the placement areas on a relatively flat surface? (BE)

Consider placing signs at the topsoil areas. (BE)

What are topsoil pile berm materials? Provide basic berm design including materials used. (BE)

106.8 Depth to groundwater, extent of overburden, geology

The narrative indicates there are nearby springs. Are they located within the project area of 198 acres? More information is needed about the springs including their location on a map. See other related comments. (BE & TM)

Provide location information of where the exploration drilling occurred. Show on a map to clarify if necessary. Did any of the 25 holes drilled in 2005 encounter water? (BE)

Provide the strike and dips of the mine area and explain any folds and faults in the area. (BE)

106.9 Location & size of ore, waste, tailings, ponds

The Division appreciates the efforts of obtaining information to follow DWQ guidelines for minimize impact of ore and waste stockpiles on groundwater. Specific design information and control measures should be provided in the plan. (BE)

106.10 Amount of material to be moved

The plan does reference any sort of sediment control other than BMPs included in the SWPPP plan by reference. The SWPP needs to be included in the plan when approved. Since the term BMPs references a large variety of sediment control devices, the Division requires that the operator specify what specific BMP controls are going to be used and a typical design drawing included in the plan. There is no reference to any sediment controls such as sediment ponds, etc. The plan says the mine is on flat ground in the headwaters of main canyon, inferring there is no runoff. The pits are likely to catch a major amount of drainage from rain and snow, and this water needs to be factored into the site plan. Therefore, a plan must be provided on how this runoff water will be handled operationally both in the pits and running off waste piles. Please include these plans and designs in the mine plan. (TM)

R647-4-107 - Operation Practices

The plan states that there will not be a problem with drainage, and page 20 says, 'Surface water resources will be protected during operations as described above in Section 107.' There is **no** section 107 in the plan. The Division requires that the BMPs to be used on site be described in the plan and a typical drawing submitted of how the BMP will be installed and a figure showing where on the ground it will be implemented referencing the BMP. Temporary BMPs are not recommended for long term operations as they are not always maintained. The Division recommends the use of berms to direct runoff to small catch basins that can be cleaned out after storm events, since the maintenance of these controls is more predicable. Provide this additional information. This ensures the proposed controls will be effective and there will not be any problems with offsite drainage. (TM)

R647-4-109 - Impact Assessment

109.1 Impacts to surface & groundwater systems

The lower wall side of the North pit area toward waste dump #1 is laid out in such a way that high erosion potential is a concern. The drainage in that area is a concern as well as runoff potential. How is the pit floor designed to handle any sediment load during operations and at reclamation? (BE)

Provide a narrative that describes impacts to the springs and groundwater and explains management of those impacts. (BE)

Provide information in the narrative about the sequencing of waste placement. (BE)

Provide more information regarding how erosion control of the waste dumps and topsoil piles will be managed. There are detailed comments below. (BE)

Due to the placement location of the waste dumps, more information is needed regarding erosion control measures to be implemented in these areas. Describe the dump material characteristics; Figure 5-b shows the reclaimed waste dump at approximately 400-ft high without slope breaks and at a steep angle. The combination of these factors may result in high runoff velocity and a minimal catchment area that may result in failure or impact to streams and channels. This same figure shows the slope at 1H:1.5V but the narrative refers to 1.5H:1V. Please refer to comments under figure 5-b in conjunction with this comment. Table 8 uses averages for the native slope angle, average slope angle of outer dump slope, and the post mine slope, these averages are within what overall distances? The waste dump slope angles should be calculated independently and not be part of the north pit and main haul road distances and then used to determine a slope angle. (BE)

More information is needed regarding the ditch and berm designs among other erosion control measures. Provide material source if applicable, dimensions of berms and ditches along with designed storm event information. (BE)

Please explain how erosion, storm water, sediment etc. will be managed within the pit at initial phase of operations. What are the calculations used to determine the sizing of the storm control structures? (BE)

Does the ditched areas flow to a catchment basin or any drainage catch points? (BE)

A storm water pollution prevention plan is suggested. (BE)

Provide information about management of storm water including monitoring events to ensure all water controls are being managed effectively. (BE)

Provide a complete overview of site specific BMP's. (BE)

What is the depth to groundwater from the base of the planned excavation? (BE)

109.2 Impacts to threatened & endangered wildlife/habitat

In Section 109.2, page 23, the plan says Mexican spotted owls are not protected by federal law and that conservation actions may be needed to preclude the need to list them under the Endangered Species Act. This is not correct. Mexican spotted owls are officially listed as threatened, and the plan should be modified to reflect this status. (PBB)

The plan says that, according to GIS shape files obtained from the BLM, there is no known Mexican spotted owl nesting habitat within 1.5 miles of the permit boundary or within three miles of the proposed affected area.
Please discuss whether there is foraging habitat within the project area. If there is, the plan should discuss potential impacts to the birds and measures that will be taken to mitigate these impacts. (PBB)

It is expected that the mine will use 116 gallons of water per minute on a 24-hour basis which equates to approximately 180 acre-feet per year.
Water use is considered to adversely affect the four endangered fish species in the Upper Colorado River Basin. Please discuss this effect and how it will be mitigated. If this project was on federal land, mitigation would consist of a one-time payment for the Fish and Wildlife Service. (PBB)

The plan also discusses sage grouse habitat in the area. This species is not listed as threatened or endangered but has been listed as a sensitive species by the Utah Division of Wildlife Resources. In an electronic mail message dated November 1, 2007, Brian Maxfield, sensitive species biologist with Wildlife Resources, stated:

> The area for the mine will impact brooding and possibly nesting sage-grouse habitat. The ridge tops on the Book Cliffs are the primary habitat for the sage-grouse. Grouse have been known to nest and brood-rear in this area.

> On-site mitigation will be difficult with the nature of the project. When the mine is in production grouse will avoid the entire area. They do not tolerate heavy traffic, buildings, or noise. As you can tell, we know little about the grouse in this area. It is far from anywhere and lek counts are difficult. No research has been conducted on the grouse in this area. We have just started a research project on sage-grouse in the area (main focus is East Bench - north of this project) but we are trying to expand the study to include all the sage-grouse in the Book Cliffs area. The more we learn the better we can help mitigate for projects like this one. If there is a possibility for funding to help with this research it would be very appreciated. Funding is what is holding the work up.

Rules R647-4-109.2 and -109.5 only require impact analyses and mitigation plans for threatened and endangered species, not for sensitive or other uncommon species. The Division, therefore, requests that the operator consider the probable impacts to sage grouse from the mine and contact Wildlife Resources about providing funding for this research as discussed in the e mail message. (PBB)

109.4 Slope stability, erosion control, air quality (fugitive dust control plan), safety

The plan says Earth Energy is in the process of obtaining an Approval Order from the Division of Air Quality.
Please include a copy of this Approval Order in the plan once it has been issued. (PBB)

The opening pit highwall will be bermed and fenced along the county road.
Please contact the Division of Wildlife Resources for recommended fence designs. (PBB)

Identify lengths of time and allowed volumes of materials will be left on site before removal. Indicate that containers will be labeled so wastes are clearly identified. Indicate in the narrative storage locations of salvageable and hazardous wastes. (BE)

Please consider that the placement of warning signs will be visible from more than one location. (BE)

If blasting occurs a statement should be included that indicates loose material that migrates will be removed immediately. (BE)

As an overview, the Division expects an ultimate pit mine plan, annual production sequence, pit slope design sectors and geotechnical basis, geologic map with major structures, joint sets, bedding etc., pit dimensions (i.e. width, length, depth), plan of pit roads, dump points, crusher dockets, stockpiles etc. (BE)

Comments about slope stability have been captured elsewhere within this review. There is limited information regarding the pit walls height nor is there a design map that incorporates this information. The profile sections provide some indication, however there a complete pit overview is missing. (BE)

Keeping the pit walls at 1.5H:1V will not necessarily maintain stability. Stability is material dependent and additional design considerations should be made that include a geologic profile that includes strikes, dips etc. (BE)

Provide information about how rockfalls and backbreak will be managed. This information is especially important if blasting. (BE)

Information should be included that quarry slopes will be monitored regularly for signs of instability and that the area will be managed in accordance with MSHA safety guidelines and the plan. (BE)

It appears the waste slope angles are greater than 45°, transverse mine sections W1-E1 & W2-E2 reclaimed waste slope angles are 60° or greater. Therefore a variance will be required. (BE)

R647-4-110 - Reclamation Plan

General:

There is no statement that reclamation will occur according to state regulations, specifically the Utah Mined Land Reclamation Act and its associated rules. Please provide this statement. (BE)

Please provide a table that outlines each area, its acres, and the number of acres within the area that will be revegetated and topsoiled. (BE)

The reclamation objectives are not stated very clearly, basic information is provided, but more is needed in the narrative. (BE)

Provide information about the monitoring control at reclamation. (BE)

Outline actions that will be implemented to ensure an environmentally safe and stable condition for the various wildlife in the area that meets the objectives of the mined land reclamation act 40-8-12. (BE)

How will safety be managed at reclamation? (BE)

110.1 Current & post mining land use

Exploration cannot be a post mining land use. Closure plans should be dependent on the area being used as open space/habitat. (BE)

110.2 Roads, highwalls, slopes, drainages, pits, etc., reclaimed

According to the plan, onsite roads will be deep ripped.
Please specify the depth of ripping and the distance between ripper shanks. Roads should be ripped 24 inches deep with ripper shanks spaced no more than 24inches apart. (PBB)

Roads left while reclamation is occurring will require maintenance to minimize erosion. Please make such a statement. (BE)

There is a statement that mining may occur in other areas of the permit, but for the sake of this NOI, indicate that all roads will be reclaimed. The plan can be changed at any time in the future. (BE)

The reclamation plan indicates slopes will be regraded to a 2.5-3:1 or flatter, however the profiles reveal the waste dumps slopes are greater than 45°. (BE)

There are no methods outlined that cover how erosion will be minimized throughout the area. This information should be included. If there are portions of the NOI that apply to reclamation, please state that. (BE)

There is concern about the slopes in the area and to assure long-term stability, the slopes should be regraded in such a way that safety hazards are minimized and to encourage vegetation growth while reducing erosion. Please outline a plan that incorporates this information. The reclamation map is unclear and there is limited information about the long term management and control. (BE)

The final pit appears as though there is a potential to form a pit water collection area, please elaborate on how it will be managed. (BE)

There is an area on the upper north west portion of the pit where runoff may occur, and information should be provided that outlines the management of it although clarification showing topographic lines may help understand the topography. (BE)

110.3 Description of facilities to be left (post mining use)

Will the water well remain upon mine closure? (BE)

110.4 Description or treatment/disposition of deleterious or acid forming material

Describe the berm design parameters and how they will be managed at final reclamation. (BE)

110.4 Revegetation planting program

According to the plan, the topsoiled surface will be lightly scarified to provide a roughened surface to retain seed and to enable root penetration.
It is important that the surface be left very rough, and this is often accomplished by a smart, experienced equipment operator at the time of reclamation. However, the description in the plan that the topsoiled surface will be "lightly scarified" is not consistent with the concept of leaving numerous gouges and rips that will trap seed and moisture and provide erosion and sediment control. Please modify the plan to show that the surface will be left very rough. (PBB)

There is no information in the plan that includes grading and stabilization procedures and seed bed preparation for the site. There is indication that once final grading is complete, topsoil will be placed, but there is no elaboration on procedures used. This information is important and should be included. (BE)

Describe what you intend to accomplish with grading efforts. How is drainage considered? Provide a table that includes areas that will be graded, ripped, topsoiled, pocked, etc. Include acres of each. (BE)

R647-4-111 - Reclamation Practices

The plan says on page 36 that no significant drainages will be disturbed so none will be reconstructed. The plan needs to address landform and final drainage on waste dump faces. Please show how waste pile outslopes and reclaimed pit slopes will be stabilized, water directed off the slope, erosion controlled, and how sediment will be kept from leaving the site. (TM)

R647-4-112 – Variance

There have been comments made within the submittal that indicate that steep slopes will remain. A Division approved variance must be granted. (BE)

R647-4-113 – Surety

Operations:

Provide a list of all equipment used in the operational phase. (BE)

Reclamation:

This review cannot capture every omission and make a statement accordingly. It is anticipated that communications will occur in the interim and the dialog will provide elaboration on the generalities made within the scope of this review. (BE)

The reclamation plan should include the number of acres associated with each reclamation category within the narrative. (BE)

Please explain how affected drainages will be reclaimed. (BE)

Provide information about how the pond will be reclaimed. (BE)

Where is the cost associated with removing any equipments and/or materials associated with the bitumen storage? (BE)

What is the cost to remove and dispose of all the skid mounted equipment, power plant, plant office and buildings? (BE)

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What is the cost to remove the lining from the truck loading area? (BE)

Information is required on how the facilities area will be reclaimed. Including the cost for removing the contents of the tanks and buildings (if applicable). (BE)

Overall, the surety bond estimate lacks detail in the form of reference and other factors such as production rate, any correction factors, material densities, average distances, terrain grade. (BE)

There should be costs associated with the removal of gates, signs, fencing unless they are to remain in place after reclamation. (BE)

Costs are not provided for reclamation of roads. Please provide. (BE)

Detail the costs for topsoil relocation to demonstrate $1.62/yd^3 . (BE)

Where are the costs to backfill the pit with fines/interburden? (BE)

Cost Summary 9.2, Explain and describe associated disturbance. (BE)

Justify the statement 'estimate five out of fifteen acres for clean up'. How and what contributes to this estimate? Where is the amount of $75/acre for trash removal obtained? There is no reference in the Cost Summary. The same applies to the loading/trucking. There is an estimate for number of trips, but the trash must be gathered and loaded on the equipment. There are no costs for that work including costs for workers to perform the loading work. In addition, there is no information about the vehicles used in the Cost Estimate; one has to refer back to the text to see what equipment is being used. What is the quantity of trash (and your definition of trash)? There is no indication of dump fees. Generally speaking, these estimations are too vague. (BE)

In continuation of the above comment, the surety narrative includes cleaning and demolition within the trash category, so does the definition of trash consist of cleaning and demolition in addition to regular trash? (BE)

The building demolition lacks appropriate detail. What is the distance in miles to the 'licensed facility'? Why are the tanks only being transported to a facility? Where and how will the demolished materials be disposed of? What does the demolished debris consist of (metal, siding, gypsum etc)? What are the dump fees? There is a reference to 'Means 2007', which Means publication is being used? There are several and the one used should be referenced. If Heavy Construction Cost Data manual 2007 was used, there is only an allowance for a 20-mile haul within the reference used in the Cost Summary. It is suspected that the haul distance is greater than 20 miles. Confirmation or additional information is needed. (BE)

What is the estimated volume of the demolished material and is demolished material considered trash (see above related comment)? (BE)

Do the facilities have foundations? Information must be provided and made clear. If there are any foundations or concrete pads, a table must be provided with dimensions included thickness and volume. The costs should be determined that includes break-up the concrete and the disposal of it. (BE)

The tank and building demolition lacks information about costs to remove the contents. (BE)

Is it true that a crane can be rented for only 3 days? What is the daily rate and where has the rate been obtained? This statement applies to the lowboy as well. Why is the lowboy rate on a per load basis and the crane on a per day basis? Provide source and cost information. (BE)

The statement in the surety narrative that other equipment will be available as needed, is not acceptable. Identify the equipment, its application and possible scenarios of when it will be needed. (BE)

There is a reference that some of the demolished material will be buried, but the narrative does not identify what is going to be buried, nor is there any elaboration on the method of the materials buried or where the burial will take place. There is no volume of buried materials stated estimated either. (BE)

There are 22 tanks, but there is no information regarding how the contents will be handled or where they will be emptied. (BE)

The equipment list has no basis for $2000/pc of equipment for mob/demob. Where is the cost for the lowboy on the equipment list? If it is contracted out, then the costs listed that involve the use of the lowboy should indicate that it includes the mob and demob. In addition, the lowboy should be on the equipment list and reference that the mob/demob is included in the contractor statement (if that is even the case). What size crane and track hoe will be used? (BE)

There is no referenced cost information by equipment type. This information is required with a reference. (BE)

Part 6 of the surety narrative indicates the cost for clean up, demolition and structure removal, however the stated cost of 0.30 per cubic yard should be 0.30/cubic *foot*. There are other sections in the narrative that use these incorrect units and they should be corrected. (BE)

What are the infrastructure removal costs? It is expected there are costs associated with the removal of generators, pipes, pumps, gates and signs etc. They must be listed and show costs. Part 9.1 of the surety estimate show $0 removal for gates and signs, there should be a cost shown for removal. (BE)

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EARTH

www.earthenergyresources.com

September 28, 2007

Ms. Susan White, Mining Program Coordinator
Department of Natural Resources
Utah Division of Oil, Gas and Mining
P.O. Box 145801
Salt Lake City, Utah 84114-5801

RE: Earth Energy Resources, Inc. Notice of Intent to Commence Large Mining Operations, PR Spring Mine

Dear Susan:

Enclosed is Earth Energy Resource's Notice of Intent to begin tar sand mining and processing operations at the PR Spring Mine, Uintah and Grand Counties, Utah. Per the requirements of Form MR-LMO, the initial submission fee of $850 ($1,000 fee less $150 fee previously tendered for small mine permit S/019/059) will be forwarded by mail today from our offices in Calgary. By my signature below, I hereby certify that the information in the enclosed Notice is true and correct as of the time of this submittal. Confidential information is included in this Notice, and is labelled as such.

We look forward to your review and would like to meet with you sometime in mid-October to discuss your initial questions or concerns regarding the proposed operations. We will be in contact with you to schedule an October meeting.

If you have any questions, feel free to give me a call at 403.233.9366. Thank you.

Yours truly,
Earth Energy Resources, Inc.

Barclay Cuthbert

Barclay Cuthbert
Vice President

Enclosure

Suite #740, 404 – 6 Avenue S.W., Calgary, AB T2P 0R9 Canada Office: 403.233.9366 Fax: 403.668.5997

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jbr environmental consultants, inc.
www.jbrenv.com
8160 S. Highland Drive • Sandy, Utah 84093 • [P] 801.943.4144 • [F] 801.942.1852

August 28, 2006

U.S. Fish and Wildlife Service
Utah Field Office - Ecological Services
Attn.: Betsy Herrmann
2369 West Orton Circle
West Valley City, UT 84119

Dear Ms. Herrmann:

Earth Energy Resources Inc. is proposing to mine and process tar sand deposits within an area of approximately 6,000 acres, currently under lease from the State of Utah's School and Institutional Trust Lands Administration (SITLA). The project area is located at the southern extent of Seep Ridge in Uintah and Grand Counties, on the east edge of R 23 E (see enclosed map). The initial development area would encompass about 500 acres, with approximately 50 acres of proposed active disturbance at any one time.

We request that your office provide a site specific list of endangered, threatened, and candidate species and any known occurrences for Earth Energy Resources Inc.'s planned tar sands mining operation location delineated above.

The information you provide will be used to assist us in complying with the Endangered Species Act and in preparing a Notice of Intention to Commence Large Mining Operations. We appreciate your time and effort in dealing with this request. If you have any questions, please contact me at (801) 943-4144.

Sincerely,

Linda Matthews

Linda Matthews
JBR Environmental Consultants, Inc.

enclosures – map

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MONTGOMERY
ARCHAEOLOGICAL
CONSULTANTS
Box 219, 322 East 100 South, Moab, Utah 84532 (435) 259-5764 Fax (435) 259-5608

REC'D JUN 11 2007

June 7, 2007

Linda J. Matthews
JBR Environmental Consultants, Inc.
8100 S. Highland Drive
Sandy, UT 84003

Dear Ms. Matthews:

Enclosed please find two copies of the report entitled "Class I Literature Review and Class III Inventory of Earth Energy Resources, Inc.'s PR Spring Oil Sand Project in Uintah and Grand Counties, Utah." The Class I literature search indicated that 17 previous cultural resource inventories were conducted in the EER's. Lease Area resulted in the documentation of one ineligible lithic scatter (42Un1788). The Class III inventory of EER's PR Spring Oil Sand Mine resulted in no previously documented sites. Hence archaeological clearance is recommended for this undertaking.

We appreciate the opportunity in providing consulting services for this project. We have sent a PDF and WORD version documents of the report to you.

Sincerely,

Jacki A. Montgomery

Jacki Montgomery
Project Archaeologist

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06/11/28

JON M. HUNTSMAN, JR.
Governor
GARY R. HERBERT
Lieutenant Governor

State of Utah
DEPARTMENT OF NATURAL RESOURCES
Division of Oil, Gas & Mining

MICHAEL R. STYLER
Executive Director
JOHN R. BAZA
Division Director

Supervisor [signature]

Inspection Report
Minerals Regulatory Program
Report Date November 15, 2006

Mine Name: Leonard Murphy
Operator Name: Earth Energy Resources

Permit number: M0190059
Inspection Date: October 12, 2006
Time: 3:00-3:50 PM

Inspector(s): Paul Baker
Other Participants: None
Mine Status: Inactive at present

Weather: Mostly cloudy, 30's, some snow in protected areas

Elements of Inspection	Evaluated	Comment	Enforcement
1. Permits, Revisions, Transfer, Bonds	☒	☐	☐
2. Public Safety (shafts, adits, trash, signs, highwalls)	☒	☐	☐
3. Protection of Drainages / Erosion Control	☐	☐	☐
4. Deleterious Material	☐	☐	☐
5. Roads (maintenance, surfacing, dust control, safety)	☒	☐	☐
6. Concurrent Reclamation	☐	☐	☐
7. Backfilling/Grading (trenches, pits, roads, highwalls, shafts, drill holes)	☐	☐	☐
8. Water Impoundments	☐	☐	☐
9. Soils	☒	☒	☐
10. Revegetation	☐	☐	☐
11. Air Quality	☐	☐	☐
12. Other	☒	☒	☐

Purpose of Inspection:
This was a routine inspection. I had never been to the site and decided to inspect it since it is in a remote location and I was in the area.

Inspection Summary:
9. Soils
The operator has salvaged and stockpiled soils from some of the disturbed area but not all. Photo 5 shows an area southeast and downhill of the pit. Since vegetation is protruding through the overburden, it is apparent the soil was not removed. There are other similar areas, but there are also places where the operator has stockpiled soil (Photos 6 and 7).

12. Other
There are several pieces of equipment on site, and I don't know what most of them are. In the background on the left side of Photo 3 are three tanks in an unlined bermed area.

Conclusions and Recommendations:
I believe the operator has stockpiled enough soil to reclaim the disturbed area, but if additional area is disturbed, the operator should ensure that soil is salvaged. Soil in the area is well developed with a fair amount of organic matter, and it should not be wasted.

If petroleum products are to be stored in the tanks, the bermed area should be lined.

1594 West North Temple, Suite 1210, PO Box 145801, Salt Lake City, UT 84114-5801
telephone (801) 538-5340 • facsimile (801) 359-3940 • TTY (801) 538-7458 • www.ogm.utah.gov

I used a GPS unit to map the mine area, and a copy of this map is attached. There are two short access roads that should be included as part of the disturbed area. The main part of the mine area is 3.59 acres. With the roads included, the total disturbed is unlikely to exceed four acres.

Inspector's Signature ____________ **Date:** 11/16/06

PBB:pb
cc: Barclay Cuthbert, Earth Energy
Will Stokes, SITLA
Attachment: GPS & Photos

ATTACHMENT
Photographs
M0190059, Leonard Murphy Mine, Earth Energy
Inspection Dated: October 31, 2006;Report Dated: November 15, 2006

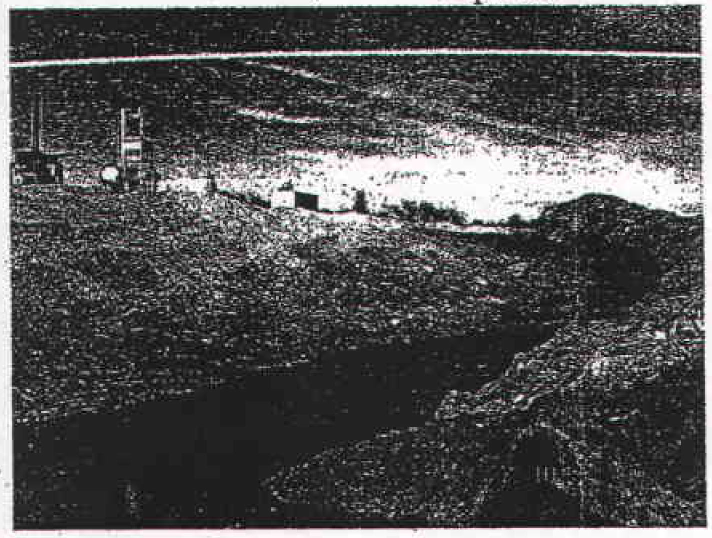

Photo 1. The mine pit on the southeast side of the disturbed area. Some of the processing facilities can be seen on the left.

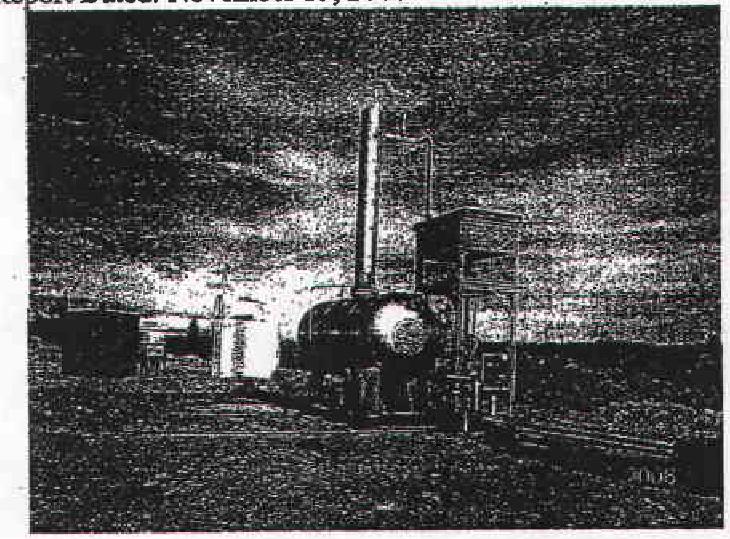

Photo 3.

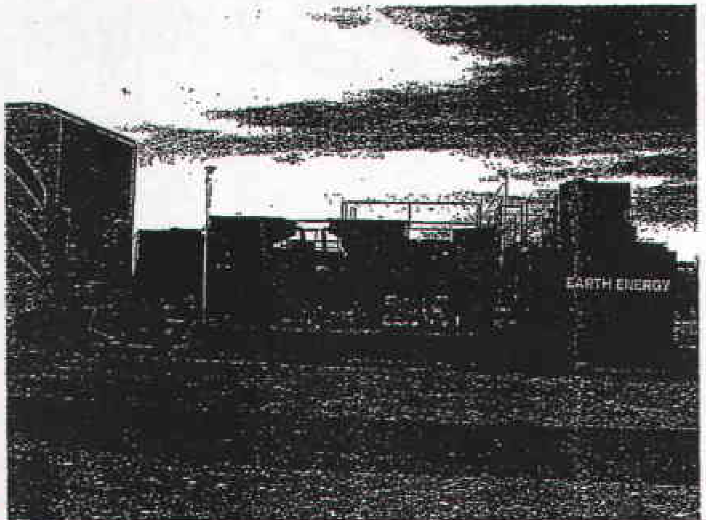

Photo 2. This photo and Photos 3 and 4 show some of the facilities.

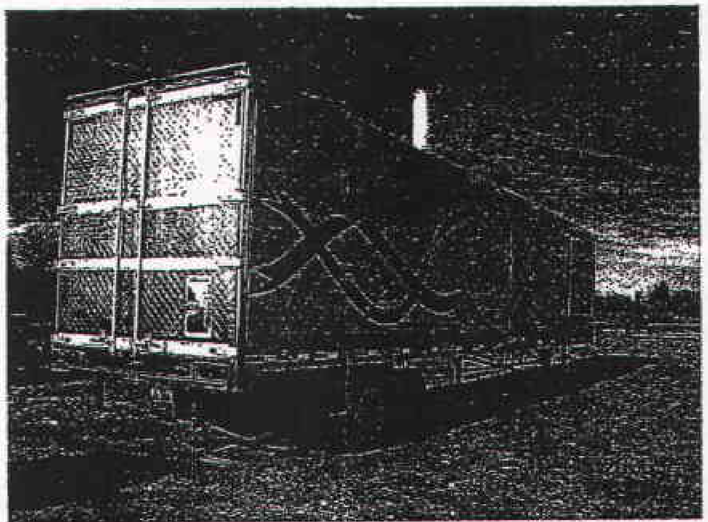

Photo 4.

Photo 5. This shows an area on the outslope of the pit. Since vegetation is protruding from under the overburden, it does not appear soil was salvaged from this area.

Photo 6. This photo and Photo 7 show areas on the northwest side of the disturbed area where it appears soil has been stockpiled or windrowed.

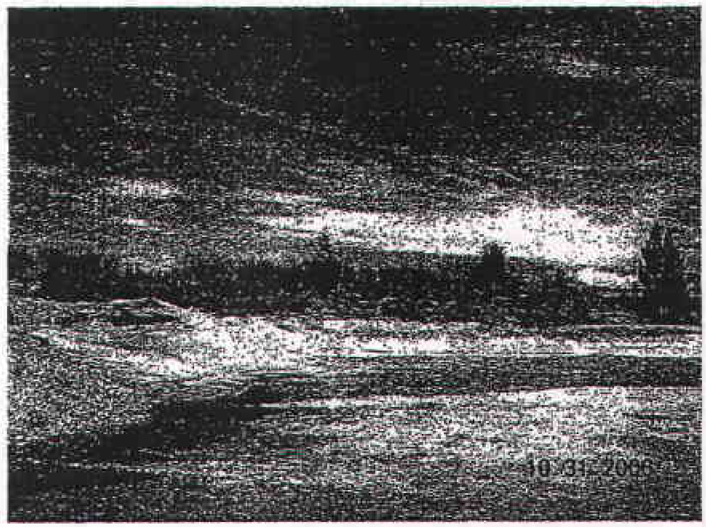

Photo 7.

Mine Number: S0190059
Mine Name: Leonard Murphy 1
Township 15.5 S Range 24 E Section 32 SLBM

Inspection Date Oct. 31, 2006
Map Produced by DKS

Acres Disturbed	3.59
Acres Regraded	0
Acres Seeded	0
Road Acres Disturbed	0
Total Acres Distrubed	3.59
Acres Released	0
Acres Excluded	0
Acres PreExisting	0
Acres Prelaw	0

Legend
All items symbolized in legend may not be appear on map

County Boundary	Township or range Line
Access	Township or range line; location doubtful
Mine	Section line
NonMine	Section line; location doubtful
Reclaimed	Disturbed
Other	Regraded
Interstate	Seeded
US Route	Released
State Route	Excluded
Primary Route	PreExisting
Secondary Route	Prelaw
Main Dirt Road	Bond Area
Unimproved Road	SITLA Mineral Leases
Interchange	BLMSalableMinerals
Trail	CommunityPit
	SITLA Mineral Ownership

DOQ imagery date 2004

UTAH DNR

Dept. of Natural Resources
Division of Oil, Gas, and Mining
Mineral Mines Program

N W E S

0 625
Feet
1:7,500 1 inch equals 625 feet
Verify Scale

Different data sources and input scales may cause misalignment of data layers. This product may not meet DOGM standards for accuracy and content.

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Grand County Conditional Use Permit

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Uintah County Conditional Use Permit

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UINTAH COUNTY PLANNING COMMISSION

****

IN THE MATTER OF:
EARTH ENERGY RESOURCES, INC.
APPLICATION FOR: <u>CUP FOR A TAR SANDS MINING AND PROCESSING FACILITY ON PROPERTY LOCATED AT SECTIONS 35&36 TOWNSHIP 15 South RANGE 23 EAST, Uintah County.</u>

FINDINGS OF FACT, STATEMENT OF LAW AND RECOMMENDATION

****

Facts

1. On May 16, 2007 Earth Energy Resources, Inc. appeared before the Uintah County Planning Commission requesting a Conditional Use Permit (CUP) to allow a tar sands mining and processing facility at Range 23E, Township 15S, Sections 35 & 36 in Uintah
2. Property is zoned MG-1.
3. A tar sands mining and processing facility is a conditional use in the MG-1 Zoning District.
4. The property is about 3,440 acres with about 200 acres being used for this purpose.
5. Meeting was advertised in the Vernal Express and Uintah Basin Standard, posted on the Uintah County website & posted in three (3) public places.
6. The Uintah County Planning Department has not received any comments from the public in regards to this CUP.

Decision and conditions issued

We, the Uintah County Planning Commission on May 16, 2007, do hereby recommend to the Uintah County Commission APPROVAL of this Conditional Use Permit, for Applicant **Earth Energy Resources** to use the property currently known as or described as **Sections 35 & 36, Township 15 South, Range 23 East, Uintah County,** for the following purpose: **to operate a tar sands mining and processing facility.**

Due to the unique characteristics of the use of the property or the potential impact on the county, surrounding neighbors or adjacent land, to mitigate or eliminate the detrimental impacts and for protection of adjacent properties and the public welfare (see Sections 17.76.010, 17.76.040, and 17.76.050 of the Uintah County Planning and Zoning Ordinance), we hereby find it necessary to and do hereby impose the following conditions, which must be complied with to establish and continue the use:

1. All tar and mining agency regulations and applicable laws and reclamation regulations imposed by DOGAM must be followed.

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UINTAH COUNTY PLANNING COMMISSION

****

IN THE MATTER OF:
EARTH ENERGY RESOURCES, INC.
APPLICATION FOR: <u>CUP FOR A TAR SANDS MINING AND PROCESSING FACILITY ON PROPERTY LOCATED AT SECTIONS 35&36 TOWNSHIP 15 South RANGE 23 EAST, Uintah County.</u>

FINDINGS OF FACT, STATEMENT OF LAW AND RECOMMENDATION

****

Applicable Law

<u>17.76.060 Determination.</u>

A. The planning commission may deny or permit a conditional use to be located within any zone in which the particular conditional use is listed. In authorizing any conditional use, the planning commission shall impose such requirements and conditions necessary for the protection of adjacent properties and the public welfare.
B. The Uintah County zoning administrator may permit or deny applications for home occupations in accordance with the regulations contained herein. The zoning administrator may forward any application to the planning commission for a decision.

Decision

On May 16, 2007, in light of the Finding of Fact and Statement of Law, the Uintah County Planning Commission recommended APPROVAL of the CUP, with the above mentioned stipulations, to the Uintah County Commission.

We, the Uintah County Commission on May 21, 2007, do hereby APPROVE this Conditional Use Permit, for Applicant Earth Energy Resources with the above mentioned stipulations.

[signature]
Chair, Uintah County Planning Commission

Michael J. McKee
Chair, Uintah County Commission

Connie Lee Deputy
Attest, Clerk-Auditor, Uintah County

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Division of Water Quality Correspondence

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State of Utah

Department of Environmental Quality

Richard W. Sprott
Executive Director

DIVISION OF WATER QUALITY
Walter L. Baker, P.E.
Director

JON M. HUNTSMAN, JR.
Governor

GARY HERBERT
Lieutenant Governor

March 4, 2008

Mr. Barclay Cuthbert
Earth Energy Resources, Inc.
Suite 740, 404 – 6th Avenue SW
Calgary, Alberta, Canada T2P 0R9

Subject: PR Spring Tar Sands Project, Uintah and Grand Counties, Utah
Ground Water Discharge Permit-By-Rule

Dear Mr. Cuthbert:

The Division of Water Quality (DWQ) has reviewed the information submitted by JBR Environmental Consultants, Inc. on February 22, 2008 requesting ground water discharge permit-by-rule for the proposed Earth Energy Resources, Inc. PR Spring tar sands project. The proposed operation consists of open-pit mining of tar sands, extraction of bitumen, and disposal of tailings and waste rock.

Below are several relevant factors for determining whether the proposed operation will have a *de minimis* effect on ground water quality or beneficial uses of ground water resources.

1. Based on Material Safety Data Sheets and other information that you sent to DWQ in January 2007, the reagent to be used for bitumen extraction is generally non-toxic and volatile, and most of it will be recovered and recycled in the extraction process. (Because the extraction process is proprietary at this time, this reagent will not be identified in public documents.)

2. Bitumen extraction will be done using tanks and equipment at the processing facility located at the mine site, and no impoundments or process water ponds are planned. Most of the water used in the process will be recovered and recycled.

3. Processed tailings will not be free-draining and will have moisture content in the 10 to 20 percent range. The tailings will not contain any added constituents that are not present naturally in the rock, other than trace amounts of the reagent used for bitumen extraction. Analysis of processed tailings using the Synthetic Precipitation Leachate Procedure indicates that leachate derived from the tailings by natural precipitation would have non-detectable levels of volatile and semi-volatile organic compounds. Unprocessed tar sands and processed tailings were analyzed using the Toxicity Characteristic Leaching Procedure (TCLP) with an extraction process that uses a much lower pH than is likely to occur at the mine site. Analytical results indicate that TCLP metals would not be leached from the tailings at detectable levels except for barium, which was detected at levels below the Utah ground water quality standard of 2.0 milligrams per liter (Table 1 of UAC 317-6). Based on these data, the tailings will be disposed by backfilling into the mine pit.

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4. The uppermost geologic formations at the site are the Parachute Creek and Douglas Creek Members of the Green River Formation, which consist of fluvial-deltaic and lacustrine-deltaic deposits of claystone, siltstone, fine-grained sandstone, and limestone. The Parachute Creek Member outcrops over most of the Earth Energy lease and is the 0 to 50-foot thick overburden above the tar sand deposits of the Douglas Creek Member. Shallow ground water at the site is not part of a regional aquifer but occurs in localized laterally discontinuous perched sandstone lenses of the Douglas Creek Member. Exploration drilling did not encounter ground water within 150 feet of the land surface. Based on records from the Division of Oil, Gas, and Mining, the closest major aquifer is the Mesa Verde Formation, which occurs approximately 2000 feet below ground surface in the area of the proposed mine. The topography of the project area is characterized by mesas incised by deep, narrow canyons, and limited shallow ground water discharges as springs in the canyon bottoms. There are no springs in the Earth Energy leased area and the nearest spring is PR Spring located slightly less than a mile east of the project site.

Considering the factors described above, the proposed mining and bitumen extraction operation should have a *de minimis* potential effect on ground water quality and qualifies for permit-by-rule status under UAC R317-6-6.2.A(25). If any of these factors change because of changes in your operation or from additional knowledge of site conditions, this permit-by-rule determination may not apply and you should inform the DWQ of the changes. If future project knowledge or experience indicates that ground water quality is threatened by this operation, the Executive Secretary may require that you apply for a ground water discharge permit in accordance with UAC R317-6-6.2.C.

This operation may require a storm water permit under the Utah Pollutant Discharge Elimination System (UPDES). Please contact Mike George of this office at (801) 538-9325 to determine if a storm water permit is required.

Disposal of domestic wastewater from the operation should be done in a manner approved by the appropriate local health department; Tri-County Health Department for Uintah County or Southeastern Utah Health Department for Grand County.

If you have any questions about this letter, please contact Mark Novak at (801) 538-6518.

Sincerely,

Robert L. Herbert

Rob Herbert, P.G., Manager
Ground Water Protection Section

cc: Robert Bayer, JBR
Paul Baker, DOGM
Carl Adams, DWQ-TMDL
Mike George, DWQ-UPDES Storm Water
Dave Ariotti, Southeastern Utah District Engineer
Scott Hacking, Tri-County District Engineer
Southeastern Utah Health Department
Tri-County Health Department

F:/MNovak/WP/EarthEnResPBR Ltr

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Earth Energy
DWQ
Submittal.

jbr environmental consultants, inc.
www.jbrenv.com
8160 South Highland Drive • Sandy, Utah 84093 [P] 801.943.4144 [F] 801.942.1852

February 21, 2008

Mr. Mark Novak
Utah Division of Water Quality
288 North 1460 West
P.O. Box 144870
Salt Lake City, Utah 84114-4870

RE: PR Spring Mine, Request for Permit-by-Rule Determination

Dear Mr. Novak:

On behalf of Earth Energy Resources, Inc. (Earth Energy), thank you for your involvement in the permitting process for the proposed PR Spring tar sands mining and processing operation. As you are aware, Earth Energy's PR Spring project is located primarily in southern Uintah County, and extends into northern Grand County. The project area lands and minerals are under lease from Utah State Institutional Trust Lands Administration.

This letter transmits a brief report with attachments, intended to provide information to support Earth Energy's request for a determination that the proposed means of ore processing and processed sand disposal be considered permitted by rule under Utah's Ground Water Protection Rules (UAC R317.6-6). In part, this information was compiled to address items discussed in the initial January 10, 2007 meeting at the Division of Water Quality (DWQ) office with you, Tom Rushing, and Jodi Gardberg, and additional comments in your e-mail dated March 30, 2007 (attached).

Please contact either the undersigned or Mr. Barclay Cuthbert with Earth Energy Resources, Inc. (403.233.9366) with any questions you may have. Thank you very much.

Sincerely,

Robert J. Bayer

Robert J. Bayer, PG
Managing Principal

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Enclosure(s)
cc: Barclay Cuthbert/Earth Energy Resources, Inc.

Subject: FW: sampling plan

-----Original Message-----
From: Barclay Cuthbert
[mailto:barclay.cuthbert@earthenergyresources.com]
Sent: Thursday, April 05, 2007 3:46 PM
To: Bob Bayer; Linda Matthews
Subject: FW: sampling plan

Copy of response from Mark Novak.

Regards,

Barclay

Best regards,
Earth Energy Resources Inc.

Barclay Cuthbert
Vice President, Operations
Tel: + 1.403.233.9366
Cell: + 1.403.619.4230
Fax: + 1.403.668.5097
E-mail: barclay.cuthbert@earthenergyresources.com
Suite # 740, 404 - 6 Avenue SW
Calgary, Alberta T2P 0R9

-----Original Message-----
From: Mark Novak [mailto:mnovak@utah.gov]
Sent: March 30, 2007 4:41 PM
To: Barclay Cuthbert
Cc: Jodi Gardberg; Paul Baker
Subject: sampling plan

Using Crown Ridge samples for the testing would be acceptable for the permit application, but you should mention the sample source in the application, and any known differences between it and the PR Spring tar sand. (for example, stratigraphic position) Once the operation is up and running, I would like similar tests run on the PR Spring tailings, and the proposed tailings management plan modified if the results are any different from the Crown Ridge samples.

I am also concerned with salinity, and would like the SPLP leachate analyzed for TDS and major ions (Na, Ca, Mg, K, Cl, SO4 and alkalinity).

I should be in the office all next week if you would like to call (801 538 6518).

Thank you for this information.

Mark

>>> Barclay Cuthbert <barclay.cuthbert@earthenergyresources.com>
>>> 3/30/2007

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10:34 AM >>>
Hi Mark,

I've put together a proposal for the SPLP and Oil & Grease testing required for our permit application and I'd like to discuss this proposal with you.
Once you've had a chance to review the attachment, please let me know of a good time to call and we can discuss.

Hope you have a good weekend.

Regards,

Barclay

Best regards,

Earth Energy Resources Inc.

Barclay Cuthbert

Vice President, Operations

Tel: + 1.403.233.9366

Cell: + 1.403.619.4230

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Suite # 740, 404 - 6 Avenue SW

Calgary, Alberta T2P 0R9

-----Original Message-----
From: Mark Novak [mailto:mnovak@utah.gov]
Sent: January 31, 2007 8:43 AM
To: barclay.cuthbert@earthenergyresources.com
Cc: Jodi Gardberg
Subject: RE: MSDS received

Because the material is an oil, your management plan for the spent tailings should prevent it from being released to surface water. This should include covering the tailings with topsoil for final disposal and establishing a vegetative cover, and preventing runoff from the tailings from discharging into surface water while the tailings are exposed before final burial.
(Berms around the temporary storage area should take care of this.) When you characterize the tailings leachate (from Synthetic Precip. Leaching
Procedure) for the permit application, you should analyze it for the parameter Oil & Grease (EPA Method 1664A).

Thank you for sending in this information, and please contact me if you have any questions about other material needed for the permit application.

Best Wishes,

Mark

IR - 000257

Earth Energy Resources, Inc.
PR Spring Operation, Uintah and Grand Counties, Utah
Ground Water Discharge Permit-by-Rule Demonstration

Introduction

Earth Energy Resources, Inc. (Earth Energy) is in the process of acquiring all required state and federal permits prior to opening and operating a tar sands mine and process plant in northeastern Utah. Known as the PR Spring operation, the mine and plant would initially disturb approximately 200 acres of lands that Earth Energy has leased from Utah State Institutional Trust Lands Administration (SITLA). The project would be located in T15S, R23E, SLB&M, Uintah County, Sections 35 & 36, and T15½S, R24E, Grand County, Sections 31& 32 **(Figure 1)**.

This report provides information to support Earth Energy's request to the Utah Division of Water Quality (DWQ) for a determination that the PR Spring operation be considered as a permitted-by-rule facility under Utah's Ground Water Protection Rules (UAC R317-6). UAC R317-6-6.2.A.1 states that "*facilities with effluent or leachate which has been demonstrated to the satisfaction of the Executive Secretary to conform and will not deviate from the applicable class TDS limits, ground water quality standards, protection levels or other permit limits and which does not contain any contaminant that may present a threat to human health, the environment or its potential beneficial uses of the ground water*" are considered to be permitted by rule. Also permitted by rule (at UAC R317-6-6.2.A.25) are "*facilities and modifications thereto which the Executive Secretary determines after a review of the application will have a de minimis actual or potential effect on ground water quality.*" Earth Energy believes that the proposed means of tar sands processing, processed sand disposal, and other aspects of the PR Spring operation meet these criteria, as described in detail below.

Environmental Setting

Earth Energy's PR Spring project would be located on the Tavaputs Plateau along the southeastern rim of the Uinta Basin. The site is within the Willow Creek sub-basin of the Green River watershed. The proposed disturbances would be located on a relatively flat interfluve between PR Canyon and Main Canyon, extending into the heads of two small ephemeral tributaries to Main Canyon. Average elevation at the project site is approximately 8,100 feet. The small headwater drainages contain very small active-channel cross-sections, and typically show no evidence of live water or riparian vegetation. Precipitation in this area is estimated at about 12 inches annually (Price and Miller 1975), which is generally not sufficient to sustain perennial flow in the smaller watersheds in this region. Instead, much of the area is dissected by numerous ephemeral drainages located in large canyons with steep side slopes.

Thick, cross-bedded sandstone, mapped by Gaultieri (1988) as the Renegade Member of the Wasatch Formation, crops out in the bottom of Main Canyon. These beds are overlain by the Green River Formation, which contains lenticular beds of lacustrine sandstone saturated with bitumen separated by intervals of barren sandstone, siltstone, shale, mudstone and calcareous

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marl. The Parachute Member of the Green River Formation is the surface bedrock formation found throughout much of Earth Energy's lease, and the underlying Douglas Creek member of that formation contains the tar sands deposit that would be mined during this project. Five distinct asphalt impregnated sands, labeled "A", "B", "C", "D" and "E" with "E" the highest strata, occur in the upper portion of the Douglas Creek Member (Byrd, William D. 1970; Clem, K. 1984). The "E" bed is regionally known, but is not present locally. The remaining beds crop out in PR Canyon to the northeast and Main Canyon to the southwest of Earth Energy's proposed operations. All four beds occur in an interval 240 to 290 feet thick (Murphy, Leonard A., 2003 private report). Earth Energy's primary targets at this time are the "C" and "D" beds. The Douglas Creek Member forms the uppermost recognized aquifer in the project area.

BLM wrote the following about the geology and hydrogeology in the general vicinity of the project area (USDI BLM 2007):

> The Douglas Creek Aquifer receives recharge mainly by infiltration of precipitation and surface water in its outcrop area, with little leakage from underlying bedrock aquifers. It discharges locally to springs in the outcrop area and to alluvium along major drainageways such as the Green and White Rivers. In the study area, flow is generally to the north and northwest. The unit is roughly 500 ft thick, although in the center of the Uinta Basin it is as thick as 1,000 ft. Maximum well yields are less than 500 gpm. Water type is typically sodium sulfate to sodium bicarbonate. TDS levels range from 640 to 6,100 mg/L (Holmes and Kimball 1987).

Previous geologic exploration drilling at the site, at maximum depths of approximately 150 feet below ground surface, did not encounter ground water. However, there are several nearby springs and/or seeps that provide evidence of localized, shallow ground water. Most springs in the area, including the nearby PR Spring, are reported to discharge from the Parachute Creek Member of the Green River Formation (Price and Miller 1975), and represent isolated, perched aquifers. PR Spring is located slightly less than one mile east of Earth Energy's proposed operation, and is associated with several water rights for stock watering uses. It issues in the canyon bottom near the head of PR Canyon. Other springs mapped by the USGS and within a similar proximity to the site are located south of the proposed operation in the bottom of Main Canyon and its tributaries. PR Spring issues at an elevation of approximately 8,040 feet; other nearby springs issue at elevations ranging from about 7,700 to 8,160 feet.

While the Green River Formation includes various other water bearing zones (including the Birds Nest zone of the Parachute Creek Aquifer and the Douglas Creek Aquifer), the State Water Plan (Utah Division of Water Resources 1999) does not include any aquifers within this formation as significant enough to be targets for ground water development. Further, information from Green River Formation water wells and springs indicates generally low yields (Price and Miller 1975). Instead, the underlying Wasatch Formation and the Mesa Verde Formation (Group) are the nearest aquifers of a regional extent.

Price and Miller (1975) indicate that the potentiometric surface in the general area is 1,500 feet below ground level (BGL) or greater, with a gradient to the north. The Division of Oil, Gas and Mining's (DOGM) oil and gas well log records (DOGM 2007) were searched for relevant information on stratigraphy and ground water. Two of the well records (Webb (API #43-047-

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30097, drilled in 1970-71), Lindisfarne (API #43-047-35567) drilled in 2006)) and other reports (Howells et al. 1987) describe the Mesa Verde as the nearest fresh water aquifer, under the low-permeability Green River and Wasatch formations. The average distance from ground level to the Mesa Verde was 2,011 feet, based on DOGM records of oil/gas wells within 3.3 miles of the project site and surrounding it in all directions. Table 1 shows the distance from ground level to the top of the Mesa Verde, taken from DOGM well files. Only recorded data is entered (e.g., if surface formation was not described it was left blank, if surface was described as the Green River Formation, zero (0) was entered in column 5).

Table 1. Distance BGL to Aquifer (from DOGM well files)

		Location Relative to Project Site		Distance BGL (in ft)			
Well Name	**T-R-S**	**Direction**	**Distance (mi)**	**Green River Formation**	**Wasatch Formation**	**Mesa Verde Formation**	**Noted Water Occurrence**
Lindisfarne	15-23-26	NNW	1.35	0	1,282	1,966	
Black Horse Canyon	15-24-31	ENE	1.2			1,905	
Webb	15-24-31	E	1.3			1,266	1,266
Divide 32-32	15.5-24-32	ESE	0.7	0		2,148	
UTFEE	15.5-24-32	SE	1.1	0	710	1,768	
UTON	16-24-5	SSE	1.8	0	600	1,800	
Horse Point	16-24-6	SSW	1.2			2,123	
Little Berry	16-23-2	SW	3.3			2,108	
Duncan 3	15-23-28	W	2.8	0	900	2,100	
Duncan 14	15-23-28	WNW	3.1	0		2,465	
Main 1	15-23-28	NW	2.35	0	1,365	2,475	

The nearest water well in the State water rights database (DWR 2007) is a BLM well (water right #49-1597) approximately three miles east in T15S, R24E, SESE Section 32; BLM initially drilled and abandoned a dry well (822 feet deep), then drilled a second well six feet away from the first and finished the well at 98 feet (static water level 60.9 ft; pumping at two gallons per minute (gpm) for one hour caused a 15-foot drop) (DWR 2007). According to the database, no proof of beneficial use was ever submitted for the water right associated with this well, and the right lapsed in 2002. The current physical status of the well is not known; there is no record in the database of the well having been plugged and abandoned.

A water rights application (No. 49-1567) has been filed with the State Engineers Office by a private party on a small spring located within Earth Energy's proposed disturbance area, as well as several other nearby springs; in general, these springs are ones that are not shown on USGS mapping. To date, the State Engineer has not granted this water right, in part because there were official protests filed and in part because the applicant has not submitted requested information to the State Engineer. A May 16, 2007 reconnaissance trip to locate the on-site spring and determine a flow rate found no evidence of ground water discharge at this site. It is not known whether such a spring previously discharged at this location or whether the site location associated with the water right application was reported incorrectly. A very min[illegible] flow too small to be measured, was found approximately 100 vertical feet down from, and ¼ mile west of, the spring identified with the water right. No other water was found in the immediate vicinity during this survey. Further, as noted above, exploration drilling in the vicinity, to depths of 150 feet, did not encounter ground water.

The baseline water quality of ground water underlying the project area is not known. However, the BLM (1984) notes that known springs within the combined Hill Creek and PR Springs Special Tar Sands Area (STSA) typically range from fresh to moderately saline, with total dissolved solids (TDS) ranging from about 300 mg/L to 6,100 mg/L (BLM 1984). Generally, the springs are freshest near the southern extent of the STSA, in the vicinity of the Project Area, with TDS concentrations of less than 500 mg/L (Price and Miller 1975). In 1964, PR Spring was discharging at 5.6 gpm and had a dissolved solids concentration of 380 mg/L (Price and Miller 1975).

More recently BLM has written the following (USDI BLM 2007):

> Dissolved salt in the rivers is a major concern in the Uinta Basin. The salts originate from marine and lacustrine sedimentary rocks and their derived soils that have high salt content. Surface runoff, irrigation return flow, saline groundwater discharges, and evapotranspiration are the major causes of the elevated TDS concentrations in the surface water (Price and Miller 1975). The concentrations of dissolved salt in streams generally are low near headwater areas, but increase dramatically near the lower reaches of the streams. This is magnified during low-flow periods.

In spring 2008, Earth Energy plans to drill a test water well approximately 1¼ mile east of the proposed PR Spring operation, in order to develop a source for its process water requirements. Geologic logging will include observations on specific locations where ground water is encountered, an aquifer pump test will be conducted, and water quality samples of the target aquifer will be collected. These will help to further define the location and the baseline chemistry of the area's ground water.

Surface water quality data for nearby streams is lacking. However, Willow Creek, to which Main Canyon is tributary, is listed as an impaired stream on Utah's 303(d) list. The listed pollutant is total dissolved solids (DWQ 2006).

PR Spring Operation Description

Earth Energy plans to mine tar sands from a 62-acre open pit (**Figure 2**), from which it will also remove overburden and interburden. Under the terms of the SITLA lease, mining may occur up to a maximum depth of 500 feet below ground surface; the current pit design, which will mine the D and C beds, extends to a maximum depth of about 150 feet. Based upon exploration boreholes and a five-acre test pit, overburden varies from 0 to 50-feet thick, and interburden thickness averages 15 feet. The "D" bed averages 21 feet thick, and the "C" bed averages 24 feet thick.

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The mined tar sands would be stockpiled adjacent to the processing facility; up to about 40,000 yd^3 of tar sands (a two-week supply) could be stockpiled at any one time. Overburden and interburden would initially be placed in overburden/interburden disposal sites, which will be constructed as small valley fills. As the tar sands are processed and mining progresses, sand and fines remaining after extraction of the bitumen will be used to backfill the open pit. The waste sand and fines will be alternately placed with the available over/interburden rock to provide stability. At the end of this phase of mining, two external overburden/interburden disposal sites (approximately 25 acres each) will remain, and the open pit will have been backfilled to about 50-percent of capacity.

The processing facility (**Figure 3**) will be adjacent to the open pit, covering approximately 15 acres, and will include a mine office and associated parking area; a maintenance shop, warehouse, power plant, equipment parking and service area; process equipment, sand de-watering equipment, a tank farm, tank truck loading area, and a lined water storage pond that will serve as a reserve process water pond and plant-site runoff collection pond; and stockpiles for processed sand, reject materials (ore loads that contain too much interburden or overburden to be viable for processing), and ore. The mine office will be a modular building placed on a gravel pad. The process equipment will be skid-mounted. The warehouse and maintenance shop will be "Sprung-type" semi-permanent structures placed on concrete pads. The tank farm will be designed, constructed, and operated as required by the Spill Prevention, Control, and Countermeasures (SPCC) regulations at 40 CFR 112. Among other requirements, these regulations set forth requirements for secondary containment of stored oil products (i.e. 110 percent of the capacity of the largest tank). Because the tank truck loading area will involve the transfer of large quantities of hydrocarbons, Earth Energy's SPCC Plan will also address best management practices (BMPs) to prevent or manage releases from this area as well as from the tank farm.

Earth Energy has patented a chemical method for extracting hydrocarbons from tar sands. Known as the Ophus Process, this production method produces clean (chemically inert), "damp-dry" sand tailings that can be backfilled into the quarry. The method relies upon a proprietary cleaning emulsion, whose specifications and Material Safety Data Sheet (MSDS) have been provided to DWQ as confidential information. As indicated in the MSDS, while the cleaning emulsion's biodegradability has not been determined, related chemicals are known to be biodegradable. Further, the emulsion evaporates rapidly when exposed to air and is insoluble in water.

Figure 4 shows the process flow diagram (confidential). The extraction process begins when the mined tar sand is sent through a crusher or de-lumper and reduced to a two-inch-minus aggregate size. From there, the crushed ore is augered to a heated slurry mixer where the cleaning emulsion is introduced along with water and the ore slurried to the consistency of a thick, gritty milkshake. The oil sand slurry is then moved by screw conveyor to the slurry tank where primary separation of the bitumen from the sand occurs. The produced sand with residual bitumen is then pumped through a series of separation towers where the last traces of bitumen are removed. All of the liberated bitumen is captured, polished with cyclones and/or centrifuges and then pumped to a storage tank for heated storage prior to transport. The cleaning chemical is then removed from the bitumen by distillation and recycled to the front of the process.

Although this is a closed system, Earth Energy is coordinating with EPA and the Utah Division of Air Quality in regard to possible air emissions due to fugitive or other losses. The chemical is not changed as a result of processing – it acts as a diluting and a cleaning agent, but is not itself altered by bitumen extraction operations.

Approximately 85 percent of the total water used during the extraction of bitumen from oil sand will be recycled. The chemically cleaned produced sand is de-watered on a shale shaker (or similar device) and the recovered water is pumped to a holding tank for recycle to the front of the process. Additional cleaning agent is added to the re-cycled water to bring it back to full strength. De-watered sand and fines represent the two solid streams of residual waste material that will then be conveyed to a stockpile for loading and backhaul to the mine pit. The first stream, coarse solids, is primarily quartz sand which has particle sizes large enough to separate from the hydrocarbon phase and gravimetrically separate from the liquids. This phase is collected at the bottom of the separation towers and dewatered. The second stream is the fines (including clays), which typically remain entrained in the hydrocarbon phase during the initial bitumen separation. After the bitumen is extracted from the oil sands, a combination of hydrocarbon phase, water, and clays and fines are routed to the separation/polishing components of the Ophus Process where they are separated. The dewatered sands and fines are placed in a temporary storage pile, from which they are back-hauled to the pit backfill every 24 hours. The dewatered residual solids in the storage pile will contain approximately 15 to 20 percent moisture and when mixed will have a plastic consistency that will not release free water while in the stockpile. This material will be near optimum moisture for compaction when it is returned to the pit.

The final grading plan for the plant site will ensure that all plant site run off, including any free water from the residual solids storage pile (after a precipitation event, for example) will flow to the reserve water pond. The water in the reserve pond will be used during outages of the main water supply system, and may also be used for dust suppression on haul roads and in the open pit.

Water is expected to be consumed at a rate of approximately 1.5-2 barrels for each barrel of produced bitumen. The 2,000 barrel/day operation would use approximately 4,000 barrels of water, or 116 gpm based upon 24-hour processing. All of the water that is not recycled would either evaporate or be returned to the open pit as moisture within the processed sand, which would be mixed with returned overburden and interburden as pit backfill. The backfill would be unsaturated and non-free-draining.

In Utah, discharge of process waters, wastewaters, and storm water runoff from industrial facilities to surface water is typically regulated by DWQ through the Utah Pollutant Discharge Elimination System (UPDES) program, except where Tribal Land is involved, in which case EPA has regulatory authority over such discharges. Earth Energy's PR Spring operation will be located partially on Tribal Land and partially on non-tribal land, thus both EPA and DWQ have jurisdiction over any such discharges to surface water. As there will be no discharge of process water or wastewater to surface waters, a permit for these types of discharges will not be required from either agency. The need to obtain a permit for storm water discharges is currently being investigated with both EPA and DWQ. However, regardless of whether a permit is required by either or both agencies, storm water generated on-site will be managed so as to prevent its release to surface water (through BMPs such as grading, impoundment, and re-use).

Demonstration of Permit-by-Rule Conformance

Earth Energy believes that all aspects of the PR Spring operation will conform to the requirements stated at UAC R317-6-6.2.A.1 and A.25 (quoted above), thus allowing it to be considered as permitted by rule. First, the facility design and the nature of the operation minimize the potential for contaminant release. Second, the characteristics of residual water associated with the tar sands process do not suggest an environmental threat. Last, the hydrogeologic setting of the area in combination with various aspects of the project design limits the vulnerability of the aquifer to direct or leached contamination. In sum, Earth Energy's PR Spring operation is expected to have no more than a *de minimis* effect on ground water or surface water. These subjects are discussed in detail below.

Potential for Contaminant Release

As described above, the 15-acre process facility would include a fuel farm with full secondary containment capacity, a lined water pond, and self-contained process equipment. All of these facilities are designed to prevent release of fuels, process water, or process chemical. Any inadvertent release due to an accident or upset condition would be properly contained and mitigated. Temporary stockpiles of raw or processed tar sands would be protected from storm water run-on: the site is located atop a flat ridge with little or no up-gradient watershed, and berms would be used to control what runoff is produced from local precipitation. Further, as noted above, the process chemical itself is not water soluble and does not pose a threat other than that due to its flammability. There would be no effluent released during the operations; water would be used and recycled in a closed-loop fashion, with only a small portion exposed and lost to the environment as unrecoverable entrained moisture in the pore spaces of the produced sand and fines.

The overburden/interburden disposal sites would contain excavated non-oil-bearing sedimentary rock that would be chemically inert. The western-most of these disposal sites would be located on the area for which a water right (discussed above) has been filed on a small spring. Although there is no sign that such a spring exists at this location, the disposal site has been designed with a drain system to accommodate any flow from such a spring, should one be located within its footprint. Any such outflow would be routed down-slope along the eastern limit of the fill to a discharge point below the toe of the disposal site.

In sum, all of the above-described aspects of the PR Spring operation represent a negligible potential for contaminant release.

The processed tar sands that would be disposed back into the open pit represent the material with the characteristics most likely to contaminate water that contacts the material. Petroleum compounds associated with bitumen residual, entrained process water, or remaining process chemical represent, in theory, potential sources of contamination. To further investigate this

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potential, lab analyses -- using Toxicity Characteristic Leaching Procedure (TCLP Method 1311) and Synthetic Precipitate Leachate Procedure (SPLP Method 8270C/3510C and GC/MS 8260B), as well as leaching procedures using other solvents (EPA Method 8015B/3545), were run on unprocessed tar sands, processed sands and processed fines. Results of those tests are described below.

Characteristics of Residual

After processing, the tar sands will be nearly dry (10 to 20-percent moisture remaining from entrained process water); they will also contain some residual hydrocarbon due to a less-than-100-percent processing efficiency, and some residual process chemical. Processing produces two streams of residual material: 1) eighty percent in the sand size-class (d_{50} = 117 μm), and 2) twenty percent fines (d_{50} = 18 μm)[1]. This material would be placed back into the open pit and layered with removed overburden and interburden as a disposal/reclamation practice. Once the backfill is complete, the area would be topsoiled and revegetated. Any residual extraction fluid would be expected to evaporate quickly, due to its high volatility.

To investigate the chemical characteristics and leaching potential of the processed tar sands, two sets of samples were collected and analyzed. In 2005, samples of unprocessed tar sand were obtained from the Leonard Murphy #1 pit at the PR Spring site. The Leonard Murphy #1 pit is a small (approximately five acres) test pit located within the footprint of the proposed 62-acre quarry. One of the tar sands samples was analyzed in its raw state, and one was processed through a shop-scale demonstration plant prior to laboratory analysis. In 2007, additional tar sands samples were obtained from Asphalt Ridge, located approximately 40 miles north of the PR Spring site. One of the tar sands samples was analyzed in its raw state, and one was processed at Earth Energy's pilot-scale plant in Grande Prairie, Alberta prior to analysis; the produced sands and fines were analyzed separately because they are generated as two separate waste streams, as described above. For both the 2005 and the 2007 sampling events, the tar sands were processed using the same Ophus Process that was described above and proposed for the upcoming PR Spring operation. The Asphalt Ridge samples are assumed to be a valid stand-in for the PR Spring operation because of their similarity geologically and analytically. Results from both sets of analyses are provided in Tables 2 and 3 and the discussion that follows. The full laboratory analysis reports for the 2007 samples are attached.

Table 2 Leonard Murphy #1 Tar Sands Analytical Summary

ANALYTICAL PARAMETER (UNITS)	UNPROCESSED TAR SAND	PROCESSED SAND
Total Petroleum Hydrocarbon – Diesel Range Organics		
TPH-DRO (mg/kg)	19,000	2,700
TCLP Volatiles [1]		
Benzene (mg/L)	NA	<0.042
Ethylbenzene (mg/L)	NA	<0.042
Toluene (mg/L)	NA	<0.042
Xylenes, total (mg/L)	NA	<0.042

[1] Note that the unmilled PR Spring ore has a d_{50} of 173 μm.

ANALYTICAL PARAMETER (UNITS)	UNPROCESSED TAR SAND	PROCESSED SAND
TCLP Metals		
Arsenic (mg/L)	<0.10	<0.10
Barium (mg/L)	0.47	1.6
Cadmium (mg/L)	<0.030	<0.030
Chromium (mg/L)	<0.050	<0.050
Lead (mg/L)	<0.10	<0.10
Mercury (mg/L)	<0.0010	<0.0060
Selenium (mg/L)	<0.10	<0.10
Silver (mg/L)	<0.10	<0.10
TRPH		
TRPH (mg/L)	3.3	<3.0

(Source: American West Analytical Laboratories)
[1]Sample was received with headspace, which could compromise results

Table 3 Asphalt Ridge Tar Sands Analytical Summary

ANALYTICAL PARAMETER (UNITS)	UNPROCESSED TAR SAND	PROCESSED SAND	PROCESSED FINES
Total Petroleum Hydrocarbon – Diesel Range Organics			
TPH-DRO (mg/kg)	12,000	930	3,400
SPLP Semi-volatiles[1]			
3&4-Methyphenol (mg/L)	<0.025	<0.025	<0.025
2-Methylphenol (mg/L)	<0.025	<0.025	<0.025
2,4-Dinitrotoluene (mg/L)	<0.025	<0.025	<0.025
Hexachlorobenzene (mg/L)	<0.025	<0.025	<0.025
Hexachlorobutadiene (mg/L)	<0.025	<0.025	<0.025
Hexachloroethane (mg/L)	<0.025	<0.025	<0.025
Nitrobenzene (mg/L)	<0.025	<0.025	<0.025
Pentachlorophenol (mg/L)	<0.025	<0.025	<0.025
Pyridine (mg/L)	<0.025	<0.025	<0.025
2,4,5-Trichlorophenol (mg/L)	<0.025	<0.025	<0.025
2,4,6-Trichlorophenol (mg/L)	<0.025	<0.025	<0.025
SPLP Volatiles[1]			
Benzene (mg/L)	<0.040	<0.040	<0.040
Carbon tetrachloride (mg/L)	<0.040	<0.040	<0.040
Chlorobenzene (mg/L)	<0.040	<0.040	<0.040
Chloroform (mg/L)	<0.040	<0.040	<0.040
1,4-Dichlorobenzene (mg/L)	<0.040	<0.040	<0.040
1,2-Dichloroethane (mg/L)	<0.040	<0.040	<0.040
1,1-Dichloroethane (mg/L)	<0.040	<0.040	<0.040
2-Butanone (mg/L)	<0.020	<0.020	<0.020
Tetrachloroethene (mg/L)	<0.040	<0.040	<0.040
Trichloroethene (mg/L)	<0.040	<0.040	<0.040
Vinyl chloride (mg/L)	<0.020	<0.020	<0.020
TCLP Metals			
Calcium (mg/L)	2.1	0.71	3.1
Magnesium (mg/L)	<0.50	<0.50	0.77
Potassium (mg/L)	<0.50	<0.50	1.2
Sodium (mg/L)	3.8	9.9	29
Inorganic Analysis			
Alkalinity (as $CaCO_3$) (mg/kg)	<20	63	75
Bicarbonate (as $CaCO_3$)	<20	63	66

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ANALYTICAL PARAMETER (UNITS)	UNPROCESSED TAR SAND	PROCESSED SAND	PROCESSED FINES
(mg/kg)			
Carbonate (as $CaCO_3$) (mg/kg)	<10	<14	<12
Chloride (mg/kg)	<5.0	19	21
Sulfate (mg/kg)	<5.0	60	61
Total Dissolved Solids (mg/kg)	24	300	6,100
Other Hydrocarbons			
Oil & Grease (mg/kg)	140,000	3,000	30,000
TRPH (mg/kg)	64,000	1,100	9,500

(Source: American West Analytical Laboratories)
[1] Holding times were exceeded

Volatile and Semi-Volatile Organics

All sample results – before and after processing – show that both volatile and semi-volatile organics were below detection in the leachate, confirming that the organics present are among the least mobile. However, it may be relevant to note that the analyses for these parameters were compromised to an unknown extent: the 2005 samples were received with headspace in the vials, which does not meet sampling protocol, and the 2007 samples were not analyzed by the lab within the allowable holding times. In addition to these sampling and lab errors, reporting limits for volatiles and semi-volatiles were generally above the applicable ground water standard for these analytes. Thus, it is possible that greater concentrations than those measured by the lab were actually present in the samples. Tar sands are comprised of bitumen, which is the non-volatile end member of the petroleum maturation process. By definition, then, bitumen contains little or no volatile or semi-volatile constituents. Therefore, it is believed that the results still indicate a *de minimis* effect on ground water from volatile or semi-volatile components, particularly given the hydrogeologic setting as described below.

Non-volatile Hydrocarbons

As expected, all sample results show that TRPH, TPH-DRO, and oil and grease were very high in the unprocessed ore and significantly reduced by processing. In spite of these reductions, some levels remain relatively high, particularly in the processed fines. In fact, the lab analytical reports note that the results for oil and grease are outside the method limits for the unprocessed ore and the processed fines, as well as for TRPH for the processed fines. Note that both of these analyses used EPA Method 1664a, which uses n-Hexane as the solvent; while this may be useful in characterizing the processed tar sand material, it does not characterize the likely leachate from precipitation. The absence of volatile or semi-volatile constituents in the processed material indicates that the organic compounds in the residual material are likely to be no more mobile than the *in situ* tar sands themselves.

One way of considering the environmental effects of the residual material is to compare it with the Utah's Department of Environmental Quality, Division of Environmental Response and Remediation's clean-up standards for petroleum-contaminated soils at underground storage tank sites. The initial screening and Tier 1 risk-based screening levels for oil and grease or TRPH are 1,000 mg/kg and 10,000 mg/kg, respectively. Of the total petroleum analyses preformed on the Asphalt Ridge samples, only the oil and grease analysis for the processed fines sample exceeded the Tier 1 screening level. However, when the processed fines are mixed with the processed

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sands in their produced ratio of 1:4, the combined result would be 8,400 mg/kg, which complies with the applicable Tier 1 screening level. Table 4 shows the effect of recombining the processed sands and fines for the three types of total petroleum analyses performed on the Asphalt Ridge samples.

Table 4 Comparison of Total Petroleum Analyses with Tier 1 Screening Levels

Analysis	Processed Sand	Processed Fines	((b*.708)+(c*.177))/(.708+.177)	Tier 1 Screening Criteria
TPH-DRO	930	3,400	1,424	5,000
Oil & Grease	3,000	30,000	8,400	10,000
TRPH	1,100	9,500	2,780	10,000
All analyses are in mg/kg				

Metals and Other Inorganics

The 2005 samples were analyzed for TCLP trace metals, and non-detects were reported for all of the analyzed metal constituents except barium. At DWQ's request, the 2007 samples were analyzed for TCLP calcium, magnesium, potassium, and sodium as a means of determining the potential of the leachate to cause salinity in any ground water it might enter. The results were detectable, but levels of the constituents were unremarkable. In regard to ground water quality standards, for those parameters for which TCLP metals were analyzed in 2005, the following is noted: barium, chromium, lead, and silver concentrations met ground water quality standards. The detection limits for the TCLP extract from analysis of arsenic, cadmium, mercury, and selenium were greater than the ground water quality standards for these parameters; therefore, comparison of these analyses with ground water quality standards is not possible.

It is believed that the results indicate a *de minimis* effect on ground water from the analyzed metals, particularly given the hydrogeologic setting as described below.

Total Dissolved Solids

Because the project is located within the Colorado River Basin, salinity (as measured by total dissolved solids) is a concern for any potential discharges to surface waters or ground water. Further, ground water in the State is classified according to its TDS, which, in-turn, drives protection levels established in a ground water permit. The TDS concentration of ground water in the general project vicinity varies by an order of magnitude (from 300 to 6,000 mg/L as described above), but site-specific TDS data for ground water underlying the project area are not available. The TDS analyses in Table 3 are reported in mg/kg and result from a non-standard analytical method; therefore these results are not considered relevant for estimation of the TDS of leachate from the process residuals. The expected TDS of leachate that might develop from the processed oil sands is not known, however, the Orphus process affects organic compounds and does not possess the acid or caustic qualities necessary to dissolve inorganic compounds. In addition containment of the residual material in the open pit will generally prevent the release of any fluids from the waste material.

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Extraction Fluid Residual

In addition to the residual product characterized in the above tables, there would likely be some residual extraction fluid in the processed residual. The previously provided MSDS for the proprietary extraction fluid supports the contention that, in the unlikely event that leaching by rain water mobilizes residual extraction fluid, the fluid poses virtually no ecological or human health risk. Given the nature of this emulsion and the concentration in which it will occur in the produced sands and fines, no impact to water quality would be expected as a result of its use and the subsequent placement of dried produced sands and fines at the proposed disposal site.

Hydrogeologic Setting

Another factor in assessing risk to ground water is the vulnerability of the aquifer to direct or leached contamination from the storage site. The lack of water wells in the area complicates this task, but also suggests that no productive aquifer has been located close enough to the ground surface to provide an economical water source. As discussed above, the relevant major, regional aquifer in this area is likely to be associated with the Mesa Verde Formation (Group). The vertical distance between the placed processed sands and this aquifer is documented in oil and gas well logs to be in the range of 1,500 to 2,000 feet, which would provide a sufficient interval of protection from any leachate.

At the same time, there is evidence of shallower, localized ground water in the area (see the Environmental Setting section, above). While the presence of such ground water directly underlying the storage site is thought to be unlikely (no springs have been noted and exploration drilling did not encounter ground water between the surface and 150 feet), it is not possible to preclude its presence.

To analyze the potential for precipitation falling on the disposed processed residual material to migrate through the depository to native materials at the bottom of the pit excavation, the following factors need to be considered. The processed sand will be dry (10-20 percent moisture content), and because of the low rainfall in the area, breakthrough of infiltrating precipitation to the base of the pit waste deposits is not anticipated to occur. In order for breakthrough to occur, the dried sand and clay fines would have to exceed their field capacity. The addition of the intervening layers of waste rock, which is comprised primarily of shale, will help to further reduce infiltration as time goes on.

State and federal publications (Price and Miller 1975; Howells, Longson & Hunt 1987) describe the Green River, Mesa Verde and Wasatch formations as intermixed strata of sandstone, shale, siltstone, and mudstone, with permeabilities ranging from very low to high. This profile is in keeping with the documented springs in the area, localized/perched aquifers, fresh to briny ground water quality, and lack of ground water developments. While none of this precludes the possibility of shallower localized ground water in the area, it reduces the likelihood that leachate from the processed sands could reach and contaminate an aquifer of economic significance. It should also be noted that the maximum surface area of exposed residual material at any one time will be approximately 25 acres, since areas would be reclaimed (topsoil and vegetation) as soon as they are "filled."

Nevertheless, to err on the side of caution, Earth Energy will implement several measures during the initial operations. First, the additional exploration drilling scheduled for the spring of 2008, within a wider area of the proposed pit (and storage site for processed sands), will provide more information on subsurface conditions and encountered water, if any. Should evidence of shallow ground water be discovered, Earth Energy will coordinate with DWQ to further investigate this issue. When pit excavations begin, visual monitoring for the presence of intercepted ground water will be performed routinely. While precipitation will also be contributing water to the pit, careful observation, along with sampling, should allow the two sources to be distinguished from each other. Again, if it appears that ground water has been intercepted, Earth Energy will coordinate with DWQ to further investigate this issue.

Summary

The above information supports Earth Energy's request that DWQ find the PR Spring operation to be permitted by rule as allowed by the Ground Water Protection rules. The operation is not expected to generate contaminants in quantities that would present a threat to human health or the environment, and the hydrogeologic setting of the operation greatly reduces the potential for any water associated with the operation to commingle with ground water. Chemical analyses of leachate from processed materials revealed no problematic results, except where leaching was performed using solvents that would not accurately characterize leachate from precipitation. Further, the operation will manage process water and storm water so as to avoid discharge of either to surface waters. We believe this demonstrates a *de minimis* impact from the proposed operation.

LICENSED PROFESSIONAL GEOLOGIST
ROBERT J. BAYER
No. 5263658-2250
STATE OF UTAH

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www.earthenergyresources.com

To: Mark Novak
State of Utah, Division of Water Quality
Via e-mail: mnovak@utah.gov

From: Barclay Cuthbert

Date: 30 March 2007

Subject: Testing of processed and unprocessed tar sand

Pages: 2

Mark,

In the time since our correspondence concerning testing methods for the chemical we use in our bitumen extraction process, we have completed modifications to our shop demonstration unit in Grande Prairie, Canada. We have commenced run testing with our shop unit and are in position to conduct SPLP testing on both raw tar sand and the solids generated from the process.

The tar sand that we are using for our tests was obtained from the pit at the Crown Asphalt Ridge facility in Vernal. This tar sand is similar in composition to the ore at our leased acreage in PR Spring; we chose to use this sand for our tests because of its availability in the existing pit and the comparatively easier logistics of moving equipment into the pit near Vernal and subsequently trucking the tar sand to Canada.

For our testing program for the Disision of Water Quality, I propose that we conduct the SPLP (metals) testing on solids samples from two different runs our our equipment. Testing will include:

- Both SPLP (metals) and Oil & Grease (EPA Method 1664A) on each of the samples

Suite #740, 404 – 6 Avenue S.W., Calgary, AB T2P 0R9 Canada Office 403.233.9366 Fax 403.668.5097

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- Tests on the raw ore sample (no processing) and on the solids produced from the extraction process, which are recovered separately as sands and fines.
- Representative samples of the sands and fines produced over the course of each run – typically about one hour in duration, processing about one and a half tons of tar sand
- The SPLP and Oil & Grease testing will be conducted by American West Analytical Laboratories and I have discussed proper sample handling and shipping procedures with the laboratory.

I would like to review this proposal with you and ensure that it meets the requirements for our permit application; once you have had a chance to review this information, please let me know of a convenient time to call you.

Best regards,

Barclay

Barclay

Suite #740, 404 – 6 Avenue S.W., Calgary, AB T2P 0R9 Canada Office 403.233.9366 Fax 403.668.5097

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Miscellaneous Correspondence

State of Utah

Department of Natural Resources

MICHAEL R. STYLER
Executive Director

Division of Wildlife Resources

JAMES F. KARPOWITZ
Division Director

JON M. HUNTSMAN, JR.
Governor

GARY R. HERBERT
Lieutenant Governor

October 16, 2006

Linda Matthews
JBR Environmental Consultants, Inc.
8160 South Highland Drive
Sandy, Utah 84093

Dear Linda Matthews:

I am writing in response to your email dated October 10, 2006 regarding information on species of special concern proximal to the Earth Energy Resources' project area for development of tar sand deposits located in Sections 26, 35, and 36 of T 15S, R 23E, Sections 31 and 32 of T 15 ½ S, R 24E, and Sections 5 and 6 of T 16S, R 24E, SLB&M (Uintah and Grand Counties).

The Utah Division of Wildlife Resources (UDWR) has records of occurrence for spotted owl and greater sage-grouse within the project area noted above. The aforementioned species are included on the *Utah Sensitive Species List*.

The information provided in this letter is based on data existing in the Utah Division of Wildlife Resources' central database at the time of the request. It should not be regarded as a final statement on the occurrence of any species on or near the designated site, nor should it be considered a substitute for on-the-ground biological surveys. Moreover, because the Utah Division of Wildlife Resources' central database is continually updated, and because data requests are evaluated for the specific type of proposed action, any given response is only appropriate for its respective request.

In addition to the information you requested, other significant wildlife values might also be present on the designated site. Please contact UDWR's acting habitat manager for the northeastern region, Miles Hanberg, at (435) 781-6707 if you have any questions.

Please contact our office at (801) 538-4759 if you require further assistance.

Sincerely,

Sarah Lindsey

Sarah Lindsey
Information Manager
Utah Natural Heritage Program

cc: Miles Hanberg, NER

1594 West North Temple, Suite 2110, PO Box 146301, Salt Lake City, UT 84114-6301
telephone (801) 538-4700 • facsimile (801) 538-4709 • TTY (801) 538-7458 • *www.wildlife.utah.gov*

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Water Rights Information

State of Utah
DEPARTMENT OF NATURAL RESOURCES
Division of Water Rights

JON M. HUNTSMAN, JR.
Governor
GARY R. HERBERT
Lieutenant Governor

MICHAEL R. STYLER
Executive Director

JERRY D. OLDS
State Engineer/Division Director

EARTH ENERGY RESOURCES, INC. - USER
SUITE 740, 404 - 6TH AVENUE SW
CALGARY, ALBERTA, CANADA T2P 0R9

November 29, 2007

Dear Applicant:

RE: 49-2274 (a33805)

This letter is in response to your request to drill a well BEFORE the underlying application has been formally Approved by the State Engineer. This well is located at:

North 750 feet, East 500 feet, from the SW Corner, Sec 31, Town 15S, Range 24E, SLB&M.

PERMISSION IS HEREBY GRANTED to proceed with the drilling of this well. The purpose of this well is to determine the quality and availability of an adequate water supply to support the beneficial uses requested in **49-2274 (a33805)**. While this letter grants you permission to proceed with the construction of the well, **IT DOES NOT GRANT ANY PERMISSION OR APPROVAL TO DIVERT OR USE THE WATER FOR ANY PURPOSE WHATSOEVER**, other than the minimal amount required for quality/quantity testing, UNTIL THE UNDERLYING APPLICATION HAS BEEN FORMALLY APPROVED BY THE STATE ENGINEER.

If the well will be deeper than 30 feet, you must contract with a licensed Utah water well driller, and the well must be constructed in accordance with the State of Utah Administrative Rules for Water Well Drillers.

Following completion and testing, the well casing must be sealed with a tamper-resistant, water-tight cap. This well must remain sealed and, again, NO water is to be diverted or used for any beneficial purpose UNTIL application **49-2274 (a33805)**. has been Approved by the State Engineer. If in the event that this application is Rejected or otherwise denied, then the well must be properly abandoned by a licensed Utah water well driller.

Enclosed you will find two postage-paid forms. One is the Driller (START) Card form, which you MUST give to the licensed driller with whom you contract to drill the well. The other is the Applicant Card form. It is YOUR RESPONSIBILITY to sign and return this form to this office immediately upon well completion. **Your submittal of the APPLICANT Card form will be notice to our office that the work has been completed and will begin the 30-day period in which the driller is to submit a report as required herein.** The driller cannot legally commence drilling of the well until you provide him with the Driller (START) Card form, which will then be submitted to our office for verification. You should review the contents of this letter with the driller to be certain that the instructions and conditions are thoroughly understood by all parties.

Please note that this permission to proceed with the drilling of this well expires May 29, 2008.

Sincerely,

Robert Leake, P.E.
Regional Engineer

1594 West North Temple, Suite 220, PO Box 146300, Salt Lake City, UT 84114-6300
telephone (801) 538-7240 • facsimile (801) 538-7467 • *www.waterrights.utah.gov*

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AGREEMENT TO ALLOCATE A PORTION OF WATER RIGHT NUMBER 41-3523 FROM THE UINTAH WATER CONSERVANCY DISTRICT TO EARTH ENERGY RESOURCES, INC.

This Agreement is made this 26th day of July, 2006 by and between the Uintah Water Conservancy District ("District"), and Earth Energy Resources, Inc. ("Earth").

WHEREAS, on March 12, 1996, the United States, Department of Interior, Bureau of Reclamation, assigned Water Right No. 41-3479 to the Utah Board of Water Resources, and on March 9, 2000, the Utah Board of Water Resources assigned 43.400 acre feet of said water right to the Uintah Water Conservancy District. The quantity of said undeveloped water right is up to 43.400 acre feet annually diverted from the Colorado River System subject to the terms of that assignment (copy of the assignment is attached hereto), and

WHEREAS, the 43.400 acre feet of water has been segregated from the original water right and now carries water right number 41-3523.

WHEREAS, the District finds that it is in the best interest of certain water users that portions of that Water Right No. 41-3523 be developed, diverted, and perfected by contracting with them for a portions of said water right, and

WHEREAS, Earth has applied to the District for and has demonstrated an imminent need for water from the Colorado River System and the ability to put such water to beneficial use and has expressed the desire for to have assigned to them 360 acre feet of water they have applied for from the Uintah Water Conservancy District subject to the conditions expressed herein, and

WHEREAS, it is the desire of the parties that Earth obtain a water right from the District upon fulfilling all of the requirements imposed by the law and required by the assignment of the water right from the Utah Board of Water Resources to the District, and,

WHEREAS, the parties have agreed to contract to allow Earth to proceed to help the District to secure a Certificate of Appropriation from the Utah State Engineer for certain water and once that Certificate is obtained and other requirements met that the District will assign the water right to Earth.

NOW THEREFORE, by execution of this Agreement, and in consideration of the mutual covenants and agreements expressed herein, the District and Earth enter into this agreement as follows:

1. Authorization to Proceed. The District hereby authorizes Earth, to prepare for the District, at Earth's expense, change applications and such other documents as are reasonably necessary to obtain a certificate of appropriation for a portion of the

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District's water right amounting to three hundred sixty (360) acre-feet of water in the Colorado River System. represented by Water Right No. 41-3523.

2. Performance of Work and Payment of all Expenses. Earth shall prepare for approval and signature of the District a change application or a temporary application for water in accordance with state law for the use of said water. Said Change Application shall be filed in the name of the District and Earth shall bear any and all costs associated with the filing of the change application and any and all costs relating to or associated with the use and development of the water described herein. including. but not limited to. any federal depletion charge associated with its use. development, or storage.

3. Assignment of Water Right. Upon Earth processing the matter and obtaining a Certificate of Appropriation for the District for the water covered by this Agreement. the District agrees to assign the water right to Earth. The water right described herein is subject to the condition that Earth files Proof of Appropriation with the State Engineer by August 31. 2008.

4. Payment of Application fees. The District reserves the right to refuse to assign the water right if agreed upon application fees of $15 per Acre Foot or $5,400 to the District is not paid in a timely manner.

5. Default. In the event of default in performing the obligations under this agreement by either party the defaulting party agrees to pay all costs of enforcement including a reasonable attorneys' fee.

6. Notices. Any notices regarding this agreement are to be forwarded to the following:

Manager
Uintah Water Conservancy District
78 W 3325 N
Vernal, UT 84078

Page van Loben Sels
Earth Energy Resources. Inc.
One Beechwood Dr.
Oakland. CA 94618

IN WITNESS WHEREOF, the Uintah Water Conservancy District. has caused its presents to be signed by the President of said District by authority of a resolution of said District.

UINTAH WATER CONSERVANCY DIST:

Herb Snyder. President

EARTH ENERGY RESOURCES, INC.:

By:

Page van Loben Sels. President

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EARTH

www.earthenergyresources.com

October 13, 2006

UINTAH WATER CONSERVANCY DISTRICT
78 West 3325 North
Vernal, Utah 84078
Telephone: (435) 789-1651
Via facsimile: (435) 789-1670

For the attention of: Herb Snyder, President

REFERENCE: Change of address request for Earth Energy Resources, Inc.

Dear Mr. Snyder:

With reference to the Agreement to Allocate A Portion of Water Right Number 41-3523 from the Uintah Water Conservancy District to Earth Energy Resources, Inc., we hereby request that the contact and address for Earth Energy Resources, Inc. be changed to:

Barclay Cuthbert
Earth Energy Resources, Inc.
Suite 740, 404 – 6th Avenue SW
Calgary, Alberta, Canada T2P 0R9
Telephone: (403) 233-9366
Facsimile: (403) 668-5097
E-mail: barclay.cuthbert@earthenergyresources.com

If you require anything further in relation to this matter, please contact me at your convenience.

Yours truly,
Earth Energy Resources, Inc.

Barclay Cuthbert

Barclay Cuthbert
Vice President

CLEAN EFFICIENT PROSPEROUS

Suite #740, 404 – 6 Avenue S.W., Calgary, AB T2P 0R9 Canada Office: 403.233.9366 Fax: 403.668.5097

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Air Quality Correspondence

RECEIVED MAR 15 2010
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

Ref: 8ENF-AT

MAR 10 2010

Barclay Cuthbert
Vice President
Earth Energy Resources
Suite #740
404 – 6 Avenue S.W.
Calgary, AB T2P 0R9 Canada

Subject: Subpart Ja Applicability Determination Request – Earth Energy Resources, Inc., Oil Sand Mining and Processing – PR Spring Mine

Dear Mr. Cuthbert:

I am responding to your May 29, 2009, letter requesting an applicability determination for the Earth Energy Resources, Inc. (Earth Energy) PR Spring Mine with regards to New Source Performance Standard (NSPS) Subpart Ja.[1] Earth Energy proposes to operate an oil sand mine and processing facility (i.e., mill) in eastern Utah. The operation will include mining of the naturally occurring oil sands and extraction of the bitumen from these sands. As discussed below, EPA does not believe that the Earth Energy PR Spring Mine is subject to NSPS Subpart Ja.

Your May 29, 2009, letter explains that the Earth Energy PR Spring Mine extraction process will be as follows: (1) mined and conditioned oil sand ore is sent through a crusher/delumper and reduced to 2 inch-minus aggregate size; (2) crushed ore is augured or conveyed to a heated slurry mixer where the cleaning emulsion is introduced and the ore slurried to the consistency of a thick gritty milkshake; (3) oil sand slurry is then moved by screw conveyor to the slurry tank where primary separation of the bitumen from the sand occurs; (4) produced sand with residual bitumen is pumped through a series of separation towers where the last traces of bitumen are removed; (5) all the liberated bitumen is captured, polished with cyclones and/or centrifuges, and pumped to a storage tank; (6) the cleaning chemical is then

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[1] Subpart Ja, 40 C.F.R. §§60.100a et seq., is entitled "Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After May 14, 2007."

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removed from the bitumen by distillation and recycled to the front of the process[2]; and (7) produced bitumen is pumped to a product (sales) tank for heated storage prior to transport.[3]

NSPS Subpart Ja applies to certain affected facilities in petroleum refineries. The definition of "petroleum refinery in 40 C.F.R. 60.101a reads: "Petroleum refinery means any facility engaged in producing gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricants, asphalt (bitumen) or other products through distillation of petroleum or through redistillation, cracking, or reforming of unfinished petroleum derivatives." Even though the Earth Energy PR Spring Mine will be producing bitumen, the operation will not be producing the bitumen "through distillation of petroleum or through redistillation, cracking, or reforming of unfinished petroleum derivatives." Although distillation will be occurring at the Earth Energy PR Spring Mine, it will be for the purpose of recovering the cleaning chemical from the bitumen and not to upgrade the bitumen to a refined product. Additionally, the produced bitumen will be sent off-site to a petroleum refinery for further processing. Therefore, EPA does not believe the Earth Energy PR Spring Mine would be considered a "petroleum refinery" and subject to NSPS Subpart Ja.

The above discussion is consistent with EPA's December 22, 2008 proposed revision to the definition of "petroleum refinery" in NSPS Subpart Ja (73 FR 78522). In the December 22, 2008 proposal notice (at 78526), EPA indicated that "Facilities that only produce oil shale or tar sands-derived crude oil for further processing using only solvent extraction and/or distillation to recover diluent that is then sent to a petroleum refinery are not themselves petroleum refineries. This is because they are only producing feed to a petroleum refinery as a product and not refined products. Facilities that produce oil shale or tar sands-derived crude oil and then upgrade these materials and produce refined products would be a petroleum refinery." The revised definition of "petroleum refinery" proposed on December 22, 2008, reads:

> Petroleum refinery means any facility engaged in producing gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricants, asphalt (bitumen) or other products through distillation of petroleum or through redistillation, cracking, or reforming of unfinished petroleum derivatives. A facility that produces only oil shale or tar sands-derived crude oil for further processing at a petroleum refinery using only solvent extraction and/or distillation to recover diluent is not a petroleum refinery.

---

[2] Electronic communication (email) on November 2, 2009, from Mr. Erin Hallenburg, JBR Environmental, to Carol Smith, EPA, indicates that "any light ends from the bitumen that may accumulate in the TAI [cleaning chemical] would be recovered through a second stage distillation process. This process would distill any light boiling fractions from the TAI and these recovered fractions would be blended into our sales bitumen tank."

[3] In the email referenced in footnote 2, Mr. Hallenberg also indicated that "no further processing is performed on site. The final product, bitumen, will be headed to an oil refinery for further processing."

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If you have any questions or concerns regarding this letter, please contact Laurie Ostrand of my staff at (303) 312-6437 or by email at ostrand.laurie@epa.gov.

Sincerely,

Cynthia J. Reynolds

Cynthia J. Reynolds, Director
Technical Enforcement Program

cc: Donald Law, EPA Region 8

Mr. Erin Hallenburg, QEP, P.E.
JBR Environmental Consultants, Inc.
8160 S. Highland Dr.
Sandy, UT 84093

EARTH ENERGY RESOURCES

www.earthenergyresources.com

May 29. 2009

Ms. Cynthia Reynolds
USEPA REGION 8
1595 Wynkoop St., 8ENF-AT
Denver. CO 80202

Re: Subpart Ja Applicability Determination Request – Earth Energy Resources, Inc., Oil Sand Mining and Processing – PR Spring Mine

Earth Energy Resources, Inc. (Earth Energy) is requesting an applicability determination for the Earth Energy PR Spring Mine with regards to CFR 40 Part 60 Subpart Ja - Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced after May 14, 2007.

Earth Energy has proposed to operate an oil sand mine and processing facility (i.e. mill) in eastern Utah. The operation will include mining of the naturally occurring oil sands and extraction of the bitumen from these sands. Earth Energy originally submitted a Notice of Intent (NOI) to the Utah Division of Air Quality (UDAQ) for a Permit to Construct (PTC) in October of 2007. After several months, the UDAQ informed Earth Energy in January of 2008 that the facility location was on Indian Jurisdictional lands and thus the EPA would be the permitting authority. There have been extensive conversations with the EPA, and several consultant-based determinations submitted, as well as a face-to-face meeting (July 15, 2008) at the EPA Region 8 offices, initiated by Earth Energy.

At the July meeting in Denver, Earth Energy and their consultant representatives were told that a determination would be made in regard to Subpart Ja and other issues in October 2008. Earth Energy and their consultants pressed for an answer from EPA in October 2008. As a result, Earth Energy was informed by the EPA Region 8 that a "determination request" in regards to the applicability of Subpart Ja would be need to be submitted to the EPA's Compliance Division. The following information is being provided to EPA Compliance Division, in response to this request for a compliance determination on the applicability for 40 CFR Part 60 Subpart Ja.

Process Description

The extraction process begins when the mined and conditioned oil sand ore is sent through a crusher/ delumper and reduced to a 2 inch-minus aggregate size. From there, the crushed ore is augured or conveyed to a heated slurry mixer where the cleaning emulsion is introduced and the ore slurried to the consistency of a thick gritty milkshake. The oil sand slurry is then moved by screw conveyor to

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the slurry tank where primary separation of the bitumen from the sand occurs. The produced sand with residual bitumen is then pumped through a series of separation towers where the last traces of bitumen are removed. All of the liberated bitumen is captured, polished with cyclones and or centrifuges, and pumped to a storage tank. The cleaning chemical is then removed from the bitumen by distillation and recycled to the front of the process. Produced bitumen is pumped to a product (sales) tank for heated storage prior to transport.

The clean produced sand is de-watered on a shale shaker (or similar device) and the recovered water is pumped to a holding tank for recycle to the front of the process. Additional cleaning agent is added to the re-cycled water to bring it back to full strength. De-watered sand and clay fines are then conveyed to a stockpile for loading and backhaul to the mine pit. At this point, the discharged sand and clay fines contain between 10 and 20% water.

When the cleaning emulsion contacts the bitumen in the oil sand, the [redacted] and emulsifier partition into the hydrocarbon phase to promote the stripping and extraction of the bitumen from the solids matrix of the ore. Once the hydrocarbon phase is separated from the water phase and solids (both coarse sand and clays and fines), it is distilled to recover the [redacted]. The [redacted] is re-used in the process, while the emulsifier remains in the bitumen, which exits the process as the residual from the distillation step.

The composition of the cleaning emulsion is:

Component	Weight percent
[redacted]	35.82%
Water	63.97%
Emulsifier	0.21%
Anti-foam	0.00%
Total	100.00%

The emulsifier is an alkylbenzenesulphonate, branched and straight chain and the anti-foam is a silicone based antifoam (such as those used in Jacuzzi spas).

Earth Energy has examined the applicability requirements and associated definitions in Subpart Ja and provided comments about the facility in italics.

60.100a Applicability, designation of affected facility, and reconstruction.

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(a) The provisions of this subpart apply to the following affected facilities in petroleum refineries: fluid catalytic cracking units (FCCU), fluid coking units (FCU), delayed coking units, fuel gas combustion devices, including flares and process heaters, and sulfur recovery plants. The sulfur recovery plant need not be physically located within the boundaries of a petroleum refinery to be an affected facility, provided it processes gases produced within a petroleum refinery.

The PR Springs Mine does not have FCCU or FCU, or a delayed coking unit. In addition, the processes at the facility including process heaters are not fueled by gases produced at the plant and the plant will not be involved in sulfur recovery. As such, there are no sources at the PR Spring Mine to which Ja is applicable.

§ 60.101a Definitions

Petroleum refinery means any facility engaged in producing gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricants, asphalt (bitumen) or other products through distillation of petroleum or through redistillation, cracking, or reforming of unfinished petroleum derivatives.

The process does not produce gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricants, or other products through distillation or redistillation of petroleum. The only distillation process involved is recovery of the [redacted] which does not result in a petroleum product.

There have been concerns raised about data that suggested that 3% of the bitumen light ends might be fractionated off during the solvent distillation. Earth Energy performed an assay on a sample of bitumen from the PR Spring mine site. The initial boiling point of the bitumen is 213°C/415°F [ASTM D2892/D5236], which is well above the distillation temperature used to recover the [redacted]. The data from the assay show good agreement with physical properties of PR Spring bitumen measured by the Utah Heavy Oil Center, University of Utah, where volatiles distilling below 204°C/399°F is less than 0.4%.

Fuel gas means any gas which is generated at a petroleum refinery and which is combusted. Fuel gas includes natural gas when the natural gas is combined and combusted in any proportion with a gas generated at a refinery. Fuel gas does not include gases generated by catalytic cracking unit catalyst regenerators and fluid coking burners, but does include gases from flexicoking unit gasifiers. Fuel gas does not include vapors that are collected and combusted to comply with the wastewater provisions in §60.692, 40 CFR 61.343 through 61.348, 40 CFR 63.647, or the marine tank vessel loading provisions in 40 CFR 63.562 or 40 CFR 63.651.

The process does not involve the use of gas produced at the facility to operate any equipment.

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Earth Energy has been working with the EPA for over 2 1/2 years to determine the permitting requirements for this facility. Based on previous communications with the EPA, the Subpart Ja applicability determination can only be performed by EPA and requires a formal request. It was our impression that EPA Region 8 Task Force was in the process of making the determination after our July 15, 2008 meeting and would decide by October, 2008. Since all future permitting and project feasibility is dependant on this determination, we respectfully request the EPA Compliance Division to inform us of the requirements for the PR Spring oil sand mine and processing facility in the very near future. Additional information on the process, permitting and/or timeline can be found either in your files, by contacting JBR Environmental (801-943-4144) or by contacting me directly.

Yours truly,
Earth Energy Resources, Inc.

Barclay Cuthbert

Barclay Cuthbert
Vice President

Enclosures (2)

cc: Tim Wall, Earth Energy Resources, Inc.
File

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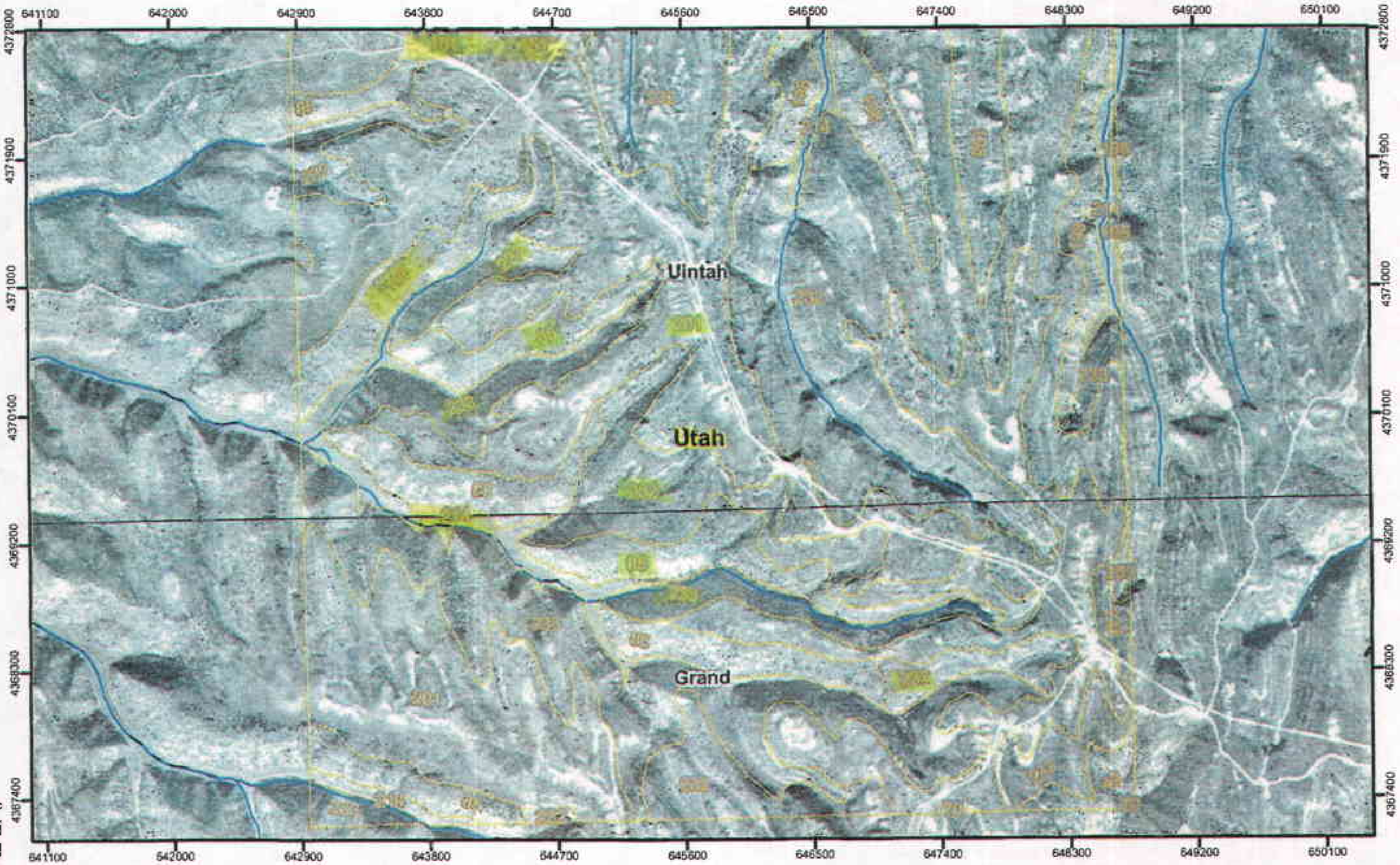
Appendix C
Soils Descriptions & Vegetation Data

SOIL SURVEY OF GRAND COUNTY, UTAH - CENTRAL PART; UINTAH AREA, UTAH - PARTS OF DAGGETT, GRAND AND UINTAH COUNTIES

EER Soils for Entire Permit Area 05.18.07



SOIL SURVEY OF GRAND COUNTY, UTAH - CENTRAL PART; UINTAH AREA, UTAH - PARTS OF DAGGETT, GRAND AND UINTAH COUNTIES

EER Soils for Entire Permit Area 05.18.07

MAP LEGEND

- Soil Map Units
- Cities
- Detailed Counties
- Detailed States
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans
- Escarpment, bedrock
- Escarpment, non-bedrock
- Gulley
- Levee
- Slope
- Blowout
- Borrow Pit
- Clay Spot
- Depression, closed
- Eroded Spot
- Gravel Pit
- Gravelly Spot
- Gulley
- Lava Flow
- Landfill
- Marsh or Swamp
- Miscellaneous Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Slide or Slip
- Sinkhole
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Perennial Water
- Wet Spot

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 12

Soil Survey Area: Grand County, Utah - Central Part
Spatial Version of Data: 1
Soil Map Compilation Scale: 1:24000

Soil Survey Area: Uintah Area, Utah - Parts of Daggett, Grand and Uintah Counties
Spatial Version of Data: 4
Soil Map Compilation Scale: 1:24000

Map comprised of aerial images photographed on these dates:
7/3/1997

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend Summary

Grand County, Utah - Central Part

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
49	Reva-Falcon families-Rock outcrop complex	49.5	0.6
70	Sula-Razorba families complex	4.1	0.1

Uintah Area, Utah - Parts of Daggett, Grand and Uintah Counties

	Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
FOUND IN STUDY AREA LOW	85	Gompers-Rock outcrop complex, 50 to 80 percent slopes	680.7	8.4
	151	Moonset-Whetrock association, 8 to 50 percent slopes	10.2	0.1
	198	Saddlehorse-Rock outcrop-Pathead association, 50 to 80 percent slopes	640.1	7.9
FOUND IN STUDY AREA HIGH	201	Seeprid-Utso complex, 4 to 25 percent slopes	2,859.1	35.2
	214	Soward sandy loam, 3 to 15 percent slopes	239.3	2.9
FOUND IN STUDY AREA MID	232	Tosca gravelly sandy loam, 25 to 40 percent slopes	2,394.0	29.5
	233	Tosca gravelly sandy loam, 40 to 80 percent slopes	1,234.6	15.2

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Map Unit Description (Brief, Generated)

Uintah Area, Utah - Parts of Daggett, Grand and Uintah Counties

Map unit: 85 - Gompers-Rock outcrop complex, 50 to 80 percent slopes

Component: Gompers (55%)

The Gompers component makes up 55 percent of the map unit. Slopes are 50 to 80 percent. This component is on hills. The parent material consists of colluvium over residuum derived from shale. Depth to a root restrictive layer, bedrock, lithic, is 8 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R034XY342UT Upland Very Steep Shallow Loam (pinyon-Utah Juniper) ecological site. Nonirrigated land capability classification is 7e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 23 percent. The soil has a slightly sodic horizon within 30 inches of the soil surface.

Component: Rock outcrop (40%)

Generated brief soil descriptions are created for major soil components. The Rock outcrop is a miscellaneous area.

Map unit: 151 - Moonset-Whetrock association, 8 to 50 percent slopes

Component: Moonset (45%)

The Moonset component makes up 45 percent of the map unit. Slopes are 8 to 50 percent. This component is on hills. The parent material consists of slope alluvium and colluvium derived from sandstone and shale. Depth to a root restrictive layer, bedrock, lithic, is 10 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R034XY322UT Upland Shallow Loam (pinyon-Utah Juniper) ecological site. Nonirrigated land capability classification is 7e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent.

Component: Whetrock (45%)

The Whetrock component makes up 45 percent of the map unit. Slopes are 8 to 50 percent. This component is on hills. The parent material consists of slope alluvium and colluvium over residuum derived from sandstone and shale. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R034XY330UT Upland Stony Loam (pinyon-Utah Juniper) ecological site. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 23 percent. The soil has a slightly sodic horizon within 30 inches of the soil surface.

Map unit: 198 - Saddlehorse-Rock outcrop-Pathead association, 50 to 80 percent slopes

Component: Saddlehorse (35%)

The Saddlehorse component makes up 35 percent of the map unit. Slopes are 50 to 80 percent. This component is on mountain slopes. The parent material consists of colluvium over residuum derived from sandstone and shale. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R048AY475UT Mountain Very Steep Stony Loam (douglas Fir) ecological site. Nonirrigated land capability classification is 7e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 23 percent. The soil has a slightly sodic horizon within 30 inches of the soil surface.

Component: Rock outcrop (30%)

Generated brief soil descriptions are created for major soil components. The Rock outcrop is a miscellaneous area.

Map Unit Description (Brief, Generated)

Uintah Area, Utah - Parts of Daggett, Grand and Uintah Counties

Map unit: 198 - Saddlehorse-Rock outcrop-Pathead association, 50 to 80 percent slopes

Component: Pathead (20%)

The Pathead component makes up 20 percent of the map unit. Slopes are 50 to 80 percent. This component is on mountain slopes. The parent material consists of colluvium derived from sandstone and shale. Depth to a root restrictive layer, bedrock, lithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R048AY475UT Mountain Very Steep Stony Loam (douglas Fir) ecological site. Nonirrigated land capability classification is 7e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Map unit: 201 - Seeprid-Utso complex, 4 to 25 percent slopes

Component: Seeprid (45%)

The Seeprid component makes up 45 percent of the map unit. Slopes are 4 to 25 percent. This component is on hills. The parent material consists of eolian deposits over residuum derived from sandstone and shale. Depth to a root restrictive layer, bedrock, lithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 6 percent. This component is in the R048AY451UT Mountain Stony Loam (browse) ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 40 percent.

Component: Utso (40%)

The Utso component makes up 40 percent of the map unit. Slopes are 4 to 25 percent. This component is on mountains. The parent material consists of eolian deposits and slope alluvium over residuum derived from shale and sandstone. Depth to a root restrictive layer, bedrock, lithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 4 percent. This component is in the R048AY448UT Mountain Stony Loam (mountain Big Sagebrush) ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 8 percent.

Map unit: 214 - Soward sandy loam, 3 to 15 percent slopes

Component: Soward (85%)

The Soward component makes up 85 percent of the map unit. Slopes are 3 to 15 percent. This component is on drainageways. The parent material consists of alluvium derived from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is rarely flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 4 percent. This component is in the R048AY410UT Mountain Loamy Bottom (basin Wildrye) ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 7 percent.

Map unit: 232 - Tosca gravelly sandy loam, 25 to 40 percent slopes

Component: Tosca (90%)

The Tosca component makes up 90 percent of the map unit. Slopes are 25 to 40 percent. This component is on mountains. The parent material consists of slope alluvium derived from sandstone and shale. Depth to a root restrictive layer, bedrock, lithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 85 percent. This component is in the R048AY451UT Mountain Stony Loam (browse) ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 30 percent.

VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 1 — Date: 08/16/07

Location: SO. 15° Slope, Mixed Tall Shrub Community — Observers: JS, MS

Shrubs & Trees	Percent
Mountain mahogany	20%
Douglas rabbitbrush	3%
Wyoming big sage	2%
Total	
Forbs	**Percent**
Snowberry	5%
Pussy toes	Trace
Total	
Grasses	**Percent**
Western wheatgrass	6%
Bottlebrush squirreltail	2%
Indian ricegrass	2%
Total	
Other	**Percent**
Litter	10%
Rock	10%
Bare Ground	35%
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 2

Date: 08/16/07

Location: SW. 10° Slope
Mixed Tall Shrub Community

Observers: JS, MS

Shrubs & Trees	Percent
Wyoming big sage	25%
Snowberry	5%
Gambel aak	5%
Serviceberry	2%
Total	
Forbs	**Percent**
Globe Mallow	1%
Total	
Grasses	**Percent**
Undifferentiated bunchgrasses	17%
Total	
Other	**Percent**
Litter	25%
Rock	10%
Bare Ground	10%
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 3 Date: 08/16/07

Location: NW 15° Slope Observers: JS, MS
Sagebrush-Grass Community

Shrubs & Trees		Percent
Wyoming big sagebrush		25%
Snowberry		3%
Douglas rabbitbrush		2%
	Total	
Forbs		**Percent**
Lupine		1%
Dandilion		Trace
	Total	
Grasses		**Percent**
Undifferentiated bunchgrasses		55%
Bluegrass	20%	
Western wheatgrass	20%	
Needle-and-thread grass	15%	
	Total	
Other		**Percent**
Litter		9%
Rock		
Bare Ground		5%
	Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 4

Date: 08/16/07

Location: SW 2% Slope
Mixed Tall Shrub Community

Observers: JS, MS

Shrubs & Trees	Percent
Mountain mahogany	20%
Snowberry	5%
Utah juniper	20%
Gambel oak	2%
Total	
Forbs	**Percent**
Total	
Grasses	**Percent**
Western wheatgrass	5%
Bluegrasses	8%
Needle-and-thread Grass	7%
Total	
Other	**Percent**
Litter	13%
Rock	10%
Bare Ground	10%
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 5 Date: 08/16/07

Location: SW 1% Slope Observers: JS, MS
Sage Brush-Grass Community

Shrubs & Trees	Percent
Snakeweed	5%
Total	
Forbs	**Percent**
Pussy toes	2%
Marsh sowthistle	5%
Unknown Forb	1%
Arenaria	2%
Total	
Grasses	**Percent**
Western wheatgrass	20%
Total	
Other	**Percent**
Litter	5%
Rock	30%
Bare Ground	30%
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 6

Date: 08/16/07

Location: WSW 7% Slope
Sagebrush-grass Community

Observers: JS, MS

Shrubs & Trees	Percent
Wyoming big sagebrush	30%
Douglas rabbitbrush	
Total	
Forbs	**Percent**
Agoseris Glauca	Trace
Total	
Grasses	**Percent**
Undifferentiated bucnhgrasses	25%
Total	
Other	**Percent**
Litter	35%
Rock	5%
Bare ground	
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 7

Date: 08/16/07

Location:

Observers: JS, MS

Shrubs & Trees	Percent
Gambel oak	90%
Serviceberry	5%
Total	
Forbs	**Percent**
Total	
Grasses	**Percent**
Bluegrasses	1%
Total	
Other	**Percent**
Litter	4%
Rock	
Bare Ground	
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 8 Date: 08/16/07

Location: W 3% Slope Observers: JS, MS
Sagebrush-grass Community

Shrubs & Trees	Percent
Sagebrush	20%
Snowberry	Trace
Total	
Forbs	**Percent**
Pussy toes	15%
Total	
Grasses	**Percent**
Koeleria sp.	5%
Needle-and-thread grass	10%
Total	
Other	**Percent**
Litter	10%
Rock	
Bare Ground	40%
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 9

Date: 08/16/07

Location: NW 5% Slope

Observers: JS, MS

Shrubs & Trees	Percent
Wyoming big sagebrush	80%
Snowberry	8%
Total	
Forbs	**Percent**
Hedesarum Boreale	Trace
Total	
Grasses	**Percent**
Bottlebrush squirreltail	3%
Total	
Other	**Percent**
Litter	9%
Rock	
Bare Ground	
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 10

Date: 08/16/07

Location: NNW 3% Slope
Mixed Tall Shrub Community

Observers: JS, MS

Shrubs & Trees	Percent
Serviceberry	30%
Coyote willow	50%
Gambel oak	5%
Mountain mahogany	5%
Total	
Forbs	**Percent**
Total	
Grasses	**Percent**
Total	
Other	**Percent**
Litter	10%
Rock	
Bare Ground	
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 11 Date: 08/16/07

Location: SW 2% Slope Observers: JS, MS
Sage Brush-grass grading to P/J/Doug Fir Community

Shrubs & Trees	Percent
Wyoming big sagebrush	5%
Total	
Forbs	**Percent**
Water leaf	1%
Arenaria sp.	1%
Total	
Grasses	**Percent**
Bottlebrush squirreltail	5%
Bluegrasses	3%
Total	
Other	**Percent**
Litter	15%
Rock	35%
Bare Ground	35%
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 12

Date: 08/16/07

Location: W 2% Slope
P/J/Doug Fir Community

Observers: JS, MS

Shrubs & Trees	Percent
Pinyon pine	100%
Total	
Forbs	**Percent**
Total	
Grasses	**Percent**
Total	
Other	**Percent**
Litter	
Rock	
Bare Ground	
Total Cover (should equal 100%)	100%

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VEGETATION SURVEY FORM

Property: Earth Energy Resources

Quadrat #: 13 Date: 08/16/07

Location: NW 3% Slope Observers: JS, MS

P/J/Doug Fir grading to sagebrush-grass Community

Shrubs & Trees	Percent
Wyoming big sagebrush	25%
Bitterbrush	30%
Pinyon pine	15%
Total	
Forbs	**Percent**
Pussy toes	3%
Figwort	3%
Total	
Grasses	**Percent**
Western wheatgrass	4%
Bluegrasses	5%
Stipa Comata	5%
Total	
Other	**Percent**
Litter	7%
Rock	
Bare Ground	3%
Total Cover (should equal 100%)	100%

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Appendix D
Equipment List & Process Flow Sheet

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Earth Energy Resources Inc. - PR Spring Oil Sand Mine

List of Equipment for Utah DAQ Emissions Inventory - Rev.6

Mining Equipment

Item No.	Quantity	Description	Power (hp / kW)		Service Factor[1]	Total Power[2] (hp / kW)	
1	1	Wirtgen 2200SM Surface Miner	900	672	0.50	450	336
2	2	Mine truck (20 ton cap)	260	194	0.70	364	272
3	1	Tracked Excavator (Cat 345 or equiv.)	290	216	0.50	145	108
4	2	Dozer (Cat D8R c/w ripper))	305	228	0.50	305	228
5	1	Grader (Cat 14H or equiv.)	215	160	0.30	65	48
6	1	Wheel Loader (Cat 950G or equiv.)	180	134	1.00	180	134
7	2	Cat 325-mounted Rock Drill (diesel air comp.)	168	125	0.50	168	125
8	1	Water Truck (100 bbl)	250	186	0.30	75	56
9	1	Equip. Service truck (5 ton)	150	112	0.40	60	45
10	4	Pick-up trucks	150	112	0.40	240	179
11	1	Crew van	200	149	0.25	50	37
12	1	Plant Generator (natural gas, 0.5 MW)	670	500	1.00	670	500
13	1	Plant Generator (diesel back-up, 0.25 MW)	335	250	0.05	17	13
14	1	Camp Generator (diesel, 0.25 MW)	335	250	1.00	335	250
15	4	Light Towers (diesel, 100 kW)	134	100	0.20	107	80
16	1	Electric Welder (diesel, 45 kW)	60	45	0.10	6	5
17	1	Submersible Water Pump (diesel/electric)	120	90	0.90	108	81
18	1	Water Pipeline Delivery Pump (diesel)	50	37	0.90	45	33
19	3	Water Pumps (3 inch, gas)	5	4	0.10	2	1

Process Equipment (single train operation to start)

Item No.	Quantity	Description	Energy (MMBtu / kWh)		Service Factor	Total Energy (MMBtu / kWh)	
1	1	Process Heater (gas fired, 10MM Btu)	10	2930	0.95	9.5	2784
2	1	Process Water Heater (gas fired, 10MM Btu)	10	2930	0.95	9.5	2784
3	1	TAI Distillation boiler (gas fired, 10MM Btu)	10	2930	0.95	9.5	2784

NOTES:

1. Service Factor is defined as operating fraction of a 24 hr day
2. Total power expended by piece of equipment in a 24 hr day

Compiled by: TJW
Date: Sept 6/07

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Earth Energy Resources Inc.
PR Spring Oil Sand Mine
List of tankage and buildings located within the processing site
Date prepared: 17 May 2007

Tankage

Item Number	Description	Required Capacity (bbl)	Tank Size (bbl)	Tanks Required	Notes
1	Bitumen (sales oil) storage	2,000	500	4	2 days storage @ 1,000 bbl/day
2	Hydrocarbon storage (distillation feed tanks)	1,000	500	2	0.75 day storage @1,000 bbl/day
3	Process water	4,000	1,000	4	Water to oil sand ratio of 5:1, 2 hour recycle time
4	Chemical active ingredient	1,000	400	3	Estimated usage 300 bbl/day
5	Cleaning emulsion storage	1,000	400	3	Estimated usage 1,000 bbl/day
6	Fuel (diesel)	400	400	1	Based on fuel delivered in 100 bbl loads
7	Make up water (pond)	10,000	10,000	1	Water from well stored on site in pond

Buildings

Item Number	Description	Size (ft^2)		Number	Notes:
1	Process trains	-		2	Process trains not enclosed, skid mounted
2	Distillation unit	-		1	Skid mounted
3	Sand dewatering equipment	-		1	Skid mounted
4	Power plant	2,500		1	1 gas generator, 1 diesel backup, 1 boiler
5	Maintenance structure	10,000		1	Sprung structure on concrete pad
6	Warehouse	10,000		1	Sprung structure on concrete pad
7	Plant office & buildings	2,500		1	Portable housing (3-5 units, on gravel pad)
8	Truck loading area (bermed & lined)	7,500		1	50' x 150' contained with sufficient leak containment
	Camp	10,000		1	Remote camp for mine & process plant personnel (20)

Appendix E
Surety Calculation

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Earth Energy Resources Bond Summary Worksheet

Please see attached sheets ("Equipment", "Rates", and "Building Calcs") for backup information

CRG = Cost Reference Guide, 2008 — Means 2008 = 629 RS Means Heavy Construction Cost Data, 2008

1	**Clean up and Removal of Structures (Removing crushers, conveyors, etc.)**	
	This entails removing the equipment listed below by dismantling, loading on dump trucks and flat-bed trailers with a crane and four laborers, and hauling to the Uintah County Landfill for disposal. Costs for the crane, laborers, hauling by truck, dump fees, and use of a water truck to suppress dust during demo activities are included below each category.	
	Dump fees are $30/load for a 10-12 yard dump truck, $50/ton for a 30-50 yard dump truck, $15/ton for loads on flatbeds, $20/ton for petroleum contaminated soils. No liquid wastes are accepted, according to Greg Jensen, Uintah County Landfill, April 2008.	
	The Landfill is 88 miles from the mine site.	
	Items to be Removed	
	Tanks	22 tanks (7 400 bbl, 15 1,000 bbl, total volume 98,960 cu. ft., will be cut into pieces, lifted onto a trailer, and hauled to the Uintah County Landfill.
	Maintenance Shop and Warehouse	These are "Sprung" aluminum structures. Easily dismantled using hand power tools and crane. Removal of both 10,000 ft2 buildings will require 5 days and will fill 4 trailer loads. Weight is 35,525 pounds each, (personal communication, April 1, 2008, Jared Heaton of Sprung Instant Structures, website at: http://www.sprung.com/en/index.php.) The mine office is a portable structure and will be removed from the site.
	Mine Office	The mine office will be removed by ATCO and all costs will be born by them. They will do any and all prep work related to this task and bear those costs as well. Prep work will generally just entail disconnecting hoses. The building will not be gutted as it may be used elsewhere by others off site. No costs are included here for the office building because non will be incurred by Earth Energy.
	Power plant	Size is approximately 2,500 ft^2, weighs 20 tons, and consists of 1 gas generator, 1 diesel back-up, 1 boiler. Removal using a crane, loader, and laborers will take one day and 2 trailers.
	Process train	One process train. Each includes piping, hoses, etc. and is skid-mounted. Each is approximately 480 ft. long by 75 ft. wide by 20 ft. high. The train would be drained of all process materials, disconnected to individual skids and hauled away. Once cut up, the volume would be roughly 2,000 CY.
	Distillation unit	The distillation unit weighs approximately 20 tons and will require a crane to load on a trailer. It will fill 90% of one trailer load to remove.
	Sand dewater unit	The sand dewater unit weighs approximately 20 tons and will require a crane to load on a trailer. It will fill 90% of one trailer load to remove.
	Sand remaining in process unit	Assume a 2 day retention time in the process unit. Total sand processed is 3,944,228 CY.With a bulk factor of 1.3, this produces 5,127,496 CY. 5,127,496 CY /((6 yr)(350 day/yr)) = 2450 CY/ day or 4900 CY to be removed to the mine waste area. Liquids in the process train will be minimal and the costs of hauling that material off site are within the costs associated with draining tanks.
	Water Storage Pond Liner	The 60-mil liner will be removed with the crane and 4 laborers, and placed on a partially loaded trailer load. Because it will be part of another load, no transport fees are included.
	Items to be Buried in Place	
	Gravel from Parking Area next to maintenance shop	The gravel parking area is approximately 2.6 acres in size, covered with 4 inches of gravel, making 1,396 CY to be disposed. Gravel will be pushed to the cleaned-out water storage pond location to partially fill this void.
	Rip and Bury Sprung Structure Foundations	Concrete foundations of Sprung Structures will be ripped with a dozer and buried in place.
	Reserve Ore, Sand and fine tails, and Reject Materials	Reserve ore, sand and fine tails, and reject ore stockpiles (approximately 60,000 CY, total) from the plant area will be loaded into trucks and hauled to the pit area (prior to final grading and reclaiming) where an opening will be made to place the ore. The excavated overburden will be used to cover these materials.

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Crane					Subtotal		
(assume 4 hours to load one truck)							
	total hours	equip	labor				
item	hours	$/hr	$/hr				
item							
tanks (22)	12.00	$141.72	$61.75		$2,441.64		
maint/whse	16.00	$141.72	$61.75		$3,255.52		
power plant	2.40	$141.72	$61.75		$488.33		
process train	228.00	$141.72	$61.75		$46,391.16		
distillation unit	4.00	$141.72	$61.75		$813.88		
sand dewater unit	3.60	$141.72	$61.75		$732.49		
water storage pond liner	8.00	$141.72	$61.75		$1,627.76		
tank farm liner	40.00	$171.82	$61.75		$9,342.80		
						Subcategory total	$65,094
	See Rates sheet: Crane, 65 ton. From Cost Reference Guide (CRG) and Means 2008 data.						
Laborers			4 laborer hrs		Subtotal		
			for ea crane				
			hour*				
assumes 4 laborers per crane hour			labor				
item	total hours		$/hr				
tanks (22)	48.00		$47.05		$2,258.40		
maint/whse	64.00		$47.05		$3,011.20		
power plant	9.60		$47.05		$451.68		
process train	912.00		$47.05		$42,909.60		
distillation unit	16.00		$47.05		$752.80		
sand dewater unit	14.40		$47.05		$677.52		
water storage pond liner	32.00		$47.05		$1,505.60		
tank farm liner	160.00		$47.05		$7,528.00		
						Subcategory total	$59,095
	See Rates sheet: Laborers. From Means 2008 data.						
	*Basis for relationship is best professional judgement and past experience.						
Trucking to dump	(Assumes 35 ton load/truck)				Subtotal		
item	tons	no. of trucks	# miles (round trip)	$/mile			
tanks (22)	107	3.0	176	2.04	$1,077.12		
maint/whse	35	4.0	176	2.04	$1,436.16		
power plant	20	0.6	176	2.04	$215.42		
process train	1,995	57.0	176	2.04	$20,465.28		
distillation unit	30	1.0	176	2.04	$359.04		
sand dewater unit	30	0.9	176	2.04	$323.14		
						Subcategory total	$23,876
	$/mile from Means 2008 Heavy Construction Cost Data 31 23-23.18- 4700						
Dump Fees					Subtotal		
item	tons			$/ton			
tanks (22)	107			15.00	$1,605.00		
maint/whse	35			15.00	$525.00		
power plant	20			15.00	$300.00		
process train	1,995			15.00	$29,925.00		
distillation unit	30			15.00	$450.00		
sand dewater unit	30			15.00	$450.00		
						Subcategory total	$33,255
	Per Greg Jensen, Uintah County Landfill, April, 2008						

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	Push gravel from parking area to storage pond					Subtotal		
		Production		equip	labor			
	Quantity (CY)	(lcy/hr)	total hours	$/hr	$/hr			
	1,396.00	62.25	22.43	$108.89	61.75	$3,827.46		
							Subcategory total	$3,827
		See Equipment: Scrapers; and Rates Sheet: Cat 631 Scraper						
	Move ore-related piles to pit backfill					Subtotal		
		Production		equip	labor			
	Material/quantity	(lcy/hr)	total hours	$/hr	$/hr			
	Reserve Ore - 40,000	255	156.86	$171.82	60.10	$36,378.97		
	Sand-Fine Tails - 10,000	255	39.22	$171.82	60.10	$9,095.90		
	Reject Pile - 10,000	255	39.22	$171.82	60.10	$9,095.90		
	Sand in Process - 4900	255	19.22	$171.82	60.10	$4,457.50	Subcategory total	$59,028
		See Equipment: Dozer, Regrading Dumps; and Rates Sheet: D8 Dozer						
	Rip Concrete foundations* - maintenance/warehouse buildings (20,000 sq ft)					Subtotal		
		Production	total hours	equip	labor			
	area (acres)	(ac/hr)	hours	$/hr	$/hr			
	0.5	0.60	3.33	$108.89	61.75	$568.23		
							Subcategory total	$568
		See Equipment: Dozer, Ripping & pulling; and Rates Sheet: D8 Dozer						
		*Assumption is that concrete is 6 inches thick with standard rebar.						
						1 TOTAL		$244,744
2	Backfilling, grading, and contouring							
	The mine pit will be backfilled to 50-60% of the original volume as part of the mining process using produced sand and cast-back overburden and interburden. The final cut during mining will create a 3:1 slope to blend with surroundings (see cross-sections), thus no backfilling will be required in any area during reclamation.							
	The rough backfilled North and West pit surfaces (93 ac), perimeter road and haul roads segments not integral to oversburden/interburden storage areas (17 ac), and overburden/interburden storage areas (70 ac) will all be finish-graded (minor cut and fill) with a Cat 14 grader to assure the land blends with surroundings. A water truck will be available to suppress dust.							
	Grading/Contouring							
		production		equip	labor	Subtotal		
	area (ac)	ac/hr	total hrs	$/hr	$/hr			
	180.00	3.15	57.14	$68.85	$60.10	$7,368.20		
		See Equipment: Grading; and Rates sheet: Cat 14 Grader						
	Water Truck					Subtotal		
		total	equip	labor				
		hours	$/hr	$/hr				
		57.14	138.91	$60.10		$11,371.43		
		See Rates Sheet: 100,000 gal Water Truck						
						2 TOTAL		$18,740

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3	Soil Material redistribution and stabilization						

Approximately 132,250 cubic yards of topsoil and vegetative debris will be redistributed to about a five-inch depth with a scraper and dozer assist, over approximately 195 acres of the mine. Average haul is 600 ft. The 18 acres of topsoil storage areas will not be topsoiled because they will not be stripped of topsoil.

Topsoil Replacement	production	Total	equip	labor	Subtotal		
Total CY	cy/hr	hours	$/hr	$/hr			
132250	255	518.63	171.82	60.1	$120,280.67		
	Assumes a self-propelled scraper with 1/4 dozer assist. From Means 2008 31 23-16.50-2000						
					3 TOTAL		$120,281

4	Revegetation (preparation, seeding, mulching)						

Soil stabilization in preparation for seeding is addressed in No. 3 above. No mulch or fertilizer will be used. All 213 acres affected at the mine area will be seeded with a D6 tractor-pulled broadcast seeder. Seed price quote is from Granite Seed; Lehi, Utah; March, 2008.

Revegetation - 213 ac					Subtotal		
	area (ac)	production	equip	labor			
		ac/hr	$/hr	$/hr			
seed application	213.00	0.75	$61.12	$60.10	$25,819.86		
		cost per acre					
seed cost ($/ac)	213.00	697.50			$148,567.50		
	See Equipment: Dozing, Seeding; and Rates Sheet: D6 Dozer						
					4 TOTAL		$174,387

5	Safety gates, berms, barriers, signs, etc.						

A highwall safety berm, extending up to 2,000 linear feet, 4 feet high and 12 feet wide, may be in place on the side of the backfilled pit when reclamation commences. It will be blended into the regraded pit with a D8 dozer.

Approximately 4,000 feet of fence with a wooden top rail (as per DWR request) will be in place between the mine and Seep Ridge Road, as well as two metal safety gates, and safety signs. These will be removed once reclamation is completed and vegetation is growing.

Safety fences					Subtotal		
	# feet removed	$/lin feet					
	4,000.00	$2.69			$10,760.00		
	From Means 2008 02 41 13.60 1650						
Highwall safety berm							
		production	equip	labor	Subtotal		
	CY material	CY/hr	$/hr	$/hr			
	1,778	62.5	61.12	60.10	$3,448.47		
	From Equipment: Dozing, Regrading Dumps; and Rates Sheet: D8 Dozer						
					5 TOTAL		$14,208

6	Demolition, removal and disposal of facilities/structures, regrading/ripping of facilities areas						
	Buildings to be demolished			volume	demolition		Subtotal
		area (sq ft)	height (ft)	(cu ft)	$/cu ft^		
	warehouse	10,000.00	20.00	200,000.00			
	maint. Shop	10,000.00	20.00	200,000.00			
		Total Volume (cu ft)		400,000.00	0.31		$124,000.00
		Demolition $/ cu ft from Means 2008 02 41-16.13-0100					

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	Removal and disposal is included in item #1 above; none of these structures will be buried.							
	Ripping concrete in place, burial, and ripping remaining facilities area						Subtotal	
			production		equip	labor		
		Acres	ac/hr	total hrs	$/hr	$/hr		
		13.00	0.60	22	108.89	61.75	$3,697.20	
		See Equipment: Dozing, Ripping; and Rates Sheet: D8 Dozer						
						6 TOTAL		$127,697
7	Regrading, ripping of waste dump tops and slopes							
	Grading of overburden/interburden storage areas will entail reworking approximately 132,259 cubic yards of material to bring these areas to a 3:1 slope. These areas will not need to be ripped as they will not be compacted. A trackhoe, backhoe, and dozer will be utilized.							
	Regrading of waste dumps						Subtotal	
			production		equip	labor		
		Cubic Yards	ac/hr	total hrs	$/hr	$/hr		
		132,259	62.25	2,124.64	108.89	61.75	$362,548.57	
		See Equipment: Dozing, Regrading Dumps; and Rates Sheet: D8 Dozer						
						7 TOTAL		$362,549
8	Regrading/ripping soil stockpiles, pads and other compacted areas							
	Soil stockpile areas (18 acres) will not need to be regraded as the underlying surface has not been disturbed, but will be ripped; the 15-acre plant site will also be ripped. These total 33 acres will be ripped to relieve compaction using a Cat 14 grader. Regrading of surfaces is included in Bullet 2 above.							
	Ripping topsoil stockpile areas							
			production		equip	labor	Subtotal	
		Acres	ac/hr	total hrs	$/hr	$/hr		
		33.00	3.15	10.48	108.89	61.75	$1,788.31	
		See Equipment: Grading; and Rates Sheet: Cat 14 Grader						
						8 TOTAL		$1,788
9	Ripping roads							
	Non-integral to overburden/interburden storage areas							
	Ripping roads							
		area (ac)	production		equip	labor	Subtotal	
			ac/hr	total hrs	$/hr	$/hr		
		17.00	0.60	28.33	$108.89	$61.75	$4,834.23	
		See Equipment: Dozing, Ripping; and Rates sheet, D8 Dozer						
						9 TOTAL		$4,834
10	Drainage Reconstruction							
	The headwaters of two ephemeral drainages affected by mining will be filled with overburden/interburden storage areas. Rip-rapped and energy dissipators will be constructed during mining to protect these areas from erosion (See Erosion and Sediment Control Plan). These are permanent structures. No drainage reconstruction will be required during reclamation.							

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11	**Mulching, fertilizing and seeding the affected areas**							
	No mulch or fertilizer will be used in reclamation efforts. All 213 affected acres will be seeded. See No. 4, above.							
12	**General site clean up and removal of trash and debris**							
	Trash removal will occur after all buildings and facilities are removed; it will involve collection of all refuse, litter, stray metal, pipe, wood, insulation, and other debris. The 213-acre area will be inspected by 3 laborers with a pick up truck. All trash will be collected, loaded onto haul trucks, and transported to the Uintah County Landfill for proper disposal. Trash volumes and weight are expected to make up only a small part of another existing load, thus no cost for transport or disposal is included here.							
	Trash removal						**Subtotal**	
		# acres	**pick up 1.6ac/hr**	**labor $/hr**	**no. of laborers**			
		213.00	1.60	$47.05	3		$18,790.59	
		See Rates sheet, Laborer						
						12 TOTAL		**$18,791**
13	**Removal/disposal of hazardous materials**							
	Any fuels remaining on site would be used to fuel equipment used in reclamation work. Most fuel, oil, lubricants will be removed by Tri-State Recycling at no cost, based on quote from Tri-State, March 2008.							
	A charge to remove partial containers and small amounts of hydrocarbon wastes will be charged.							
	One trip will be required. No Hazardous materials are stored on site.							
	Removal of hydrocarbons						**Subtotal**	
		cost/mile	**miles, round trip**					
		$1.56	176				$274.56	
		Based on quote from Charles Martin, Tri- State Recycling, April 2008						
						13 TOTAL		**$275**
14	**Equipment Mobilization**							
	This bullet includes removal (demobilization only) of abandoned mining equipment from the site.							
			mob	**demob**	**Means 2008 reference number**			
	Reclamation Equipment	D8 dozer	$355.00	$355.00		01 54-36.50-0100		
		950 Loader	$355.00	$355.00		01 54-36.50-0100		
		track hoe	$217.00	$217.00		01 54-36.50 -0020		
		Cat 14 grader	$355.00	$355.00		01 54-36.50-0100		
		crane	$405.00	$405.00		01 54-36.50- 2100		
		631 scraper	$530.00	$530.00		01 54-36.50 -0700		
		Water truck	$355.00	$355.00		01 54-36.50-0100		
		D6 Dozer	$355.00	$355.00		01 54-36.50-0100		
		Seeder, Manure Spreader		(piggyback with other equipment - no addt'l cost)				
		Semi and Low-boy trailer		(used to mobilize other equipment - no addt'l cost)				
	Mining Equipment	Surface Miner		405.00		01 54-36.50- 2100		
		Rock Drill		405.00		01 54-36.50- 2100		
		D8 dozer		$355.00		01 54-36.50-0100		
		950 Loader		$355.00		01 54-36.50-0100		
		track hoe		$217.00		01 54-36.50 -0020		
		Cat14 grader		$355.00		01 54-36.50-0100		
		Water truck		$355.00		01 54-36.50-0100		
		35 Ton haul trucks(4)		1,420.00		01 54-36.50-0100		
		Total	**$2,927.00**	**$6,794.00**				
						14 TOTAL		**$9,721**

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15	**RECLAMATION BASE COST**							**$1,098,014**
15.1	**Supervision during Reclamation (10% of Reclamation Base Cost)**							**$109,801**
15.2	**Revegetation Monitoring & Weed Control**							
	Assume two trips per year, 3 years, 10 hours per trip							
	labor $/hr	truck/hr	hours	gas $100/trip		subtotal		
	75.00	30.00	60.00	600.00		6,900.00		
	Administrative costs equal to 15 percent of subtotal					1,035.00		
	Weed control costs equal to 25 percent of revegetation costs (in category 4)					37,141.88		
	Second seeding costs equal to 50 percent of revegetation costs (in category 4)					74,283.75		
		Total				**119,360.63**		
		Based on average consultant rates for technicians, and rental vehicle rates for SLC area, 2008						
						15.2 TOTAL		**$119,361**
16	**SUBTOTAL (2)**							**$1,327,176**
16.1	Contingency (5%)							**$66,359**
17	**SUBTOTAL (3)**							**$1,393,535**
17.1	Escalation (for 5 years at 3.8% per year)							**$285,675**
18	**GRAND TOTAL**							**$1,679,210**
	GRAND TOTAL ROUNDED							**$1,679,200**

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Tank Calculations

Tank Calculations to determine Dump Fee Costs							
400 bbl tanks	diameter(ft)	height (ft)	thickness(ft)	density(lb/cf)	# units	total lbs	total tons
1000 bbl tanks	12	20	0.0208	485	7	53243	27
	21	16	0.0208	485	15	159730	80
					Total tons for tanks		107

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EQUIPMENT INFORMATION

DOZING		CPH pg.			CPH pg.			CPH pg.
Ripping & pulling dimpler			**Seeding**			**Mulching**		
D-8			**D-6**			**D-6**		
Ripper width(ft)	8.0	1--57	Seeder width (ft)	10.0	MS	Mulcher width (ft)	8	MS
Ripper penetration(ft)	2	1--57						
speed (mi/hr)	1.0	1--60	speed (mi/hr)	1.0	1--60	speed (mi/hr)	1.0	1--60
Maximum Production(ac/hr)	0.97		Maximum Production(ac/hr)	1.21		Maximum Production(ac/hr)	0.97	
Correction Factors			Correction Factors			Correction Factors		
Operator	0.75	1--46	Operator	0.75	1--46	Operator	0.75	1--46
efficiency (50 min/hr)	0.83	1--46	efficiency (50 min/hr)	0.83	1--46	efficiency (50 min/hr)	0.83	1--46
Corrected Production	0.60		Corrected Production	0.75		Corrected Production	0.60	
(ac/hr)			(ac/hr)			(ac/hr)		

DOZING Regrading dumps and		CPH pg.	GRADING		CPH pg.
Pushing into Storage pond			**Grading**		
D-8			**Cat 14**		
500 ft ave push			grader blade width (ft)	13.9	2--17
			speed (mi/hr)	3.0	2--16
Maximum Production(lcy/hr)	100.00		Maximum Production(ac/hr)	5.05	
Correction Factors			Correction Factors		
Operator	0.75	1--46	Operator	0.75	1--46
efficiency (50 min/hr)	0.83	1--46	efficiency (50 min/hr)	0.83	1--46
Corrected Production	62.25		Corrected Production	3.15	
(lcy/hr)			(ac/hr)		

SCRAPERS	CPH pg.	
Top Soil Replacement		
Stockpile move to pit		
Cat 631		
Capacity (cu yd)	8--2	29
Average Haul Distance		600
Cycle Time		
Loading time (min)	8--11	0.9
Spreading time (min)	8--11	0.7
Loaded Haul time (min)0% grade	8--37	1.0
Empty Haul time (min)0% grade	8--37	0.8
Cycle Time (min		3.4
Cycles per Hour		17.6
Max Production Rate (lcy/hr)		512
Correction Factors		
Operator	1--46	0.75
Job Efficiency(50 min/hr)	1--46	0.83
Load Factor		0.8
Total Correction Factor		0.50
Corrected production rate(cy/hr)		255

All cycle times and Correction factors are from Caterpillar Performance Handbook (CPH) Edition 38, January 2008

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RATES and SEED MIX

EQUIPMENT COSTS				
Hourly Rates	**Equipment Hourly Rates**	**CRG* Page No.**	**Labor Hourly Rates**	**Labor Type****
Semi-Truck & Low-boy trailer	(use rig that brings equip. in for equipment removal (Bullet # 1))			
D8 Dozer	108.89	9--53	61.75	Equip Oper - Heavy
950 Loader	55.82	9--33	61.75	Equip Oper - Heavy
Cat 330 Track hoe	93.70	10--18	60.10	Equip Oper - Medium
Cat 14 Grader	68.85	9--5	60.10	Equip Oper - Medium
Crane 65-Ton	141.72	13--11	61.75	Equip Oper - Heavy
Cat 631 Scraper	171.82	9--50	60.10	Equip Oper - Medium
10,000 gal Water truck	138.91	20--11	60.10	Equip Oper - Medium
D6 Dozer	61.12	9--53	60.10	Equip Oper - Medium
Laborer			47.05	Common bldg. Laborers

*Equipment Hourly Rates include overhead and profit from Cost Reference Guide (CRG) 2008
**Labor Hourly Rates include overhead and profit from inside back cover Means Heavy Construction Cost Data 2008

SEED MIX				
Species	**Seeds/lb**	**PLS seeds/ac**	**Cost for PLS pound**	**Total Cost**
Forbs-				
Blue flax (*Linum lewisii*)	293,000	0.5	$12.50	$6.25
Rocky Mountain penstemon var. Bandera (*Penstemon strictus*)	592,000	0.25	$40.00	$10.00
Small burnet (*Sanguisorba minor*)	55,000	1	$4.00	$4.00
Lupine (*Lupinus caudatus or L. alpestris*)	27,600	1	$70.00	$70.00
Total forbs in seed mix		**2.75**		
Grasses -				
Muttongrass (*Poa fendleriana*)	890,000	2	$65.00	$130.00
Canby bluegrass (*P. canbyi*)	926,000	1	$14.00	$14.00
Indian ricegrass (*Achnaetherum hymenoides*)	150,000	2	$31.50	$63.00
Great basin wildrye var. Magnar (*Leymus cinereus*)	130,000	2	$9.00	$18.00
Bluebunch wheatgrass (*Pseudoroegneria spicata ssp. spicata*)	140,000	3	$48.00	$144.00
Western wheatgrass (*Pascopyrum smithii*)	110,000	3	$5.25	$15.75
Total grasses in seed mix		**13**		
Shrubs -				
Sagebrush – Wyoming or Mountain (Artemisia tridentata wyomingensis or vaseyana)	2,500,000	0.25	$50.00	$12.50
Bitterbrush var. Lassen (*Purshia tridentata*)	15,000	2	$35.00	$70.00
Serviceberry (*Amelanchier alnifolia*)	25,800	1	$65.00	$65.00
Snowberry (*Symphoricarpos albus*)	75,000	1	$75.00	$75.00
Total shrubs in seed mix		**4.25**		
TOTAL COST FOR SEEDS		**20**		**$697.50**

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Appendix F
Site Photos

Looking up at north-facing sideslope in upper drainage, proposed pit area

Typical upper drainage slope, looking to northwest (southwest-facing slope)

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Slope view mid-drainage, looking up toward Seep Ridge Road

View upslope, just outside (southwest of) current 5-acre activity area; within proposed pit

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Appendix G
Storm Water Pollution Prevention Plan

STORM WATER
POLLUTION PREVENTION PLAN
PR Spring Mine
Earth Energy Resources Inc.

Prepared for:

Earth Energy Resources, Inc.
Suite #740 404 – 6th Avenue SW
Calgary, Alberta T2P 0R9

Prepared by:

jbr environmental consultants, inc.

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March 25, 2009

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PR Spring Mine

1.0 INTRODUCTION

In 1972, Congress passed the Federal Water Pollution Control Act, also known as the Clean Water Act (CWA), to restore and maintain the quality of the nation's waterways. The ultimate goal was to make sure rivers and streams were fishable, swimmable, and drinkable to their highest natural level. In 1987, the Water Quality Act added provisions to the CWA that allowed the Environmental Protection Agency (EPA) to govern storm water discharges from industrial activities through its National Pollution Discharge Elimination System (NPDES) permit program. EPA published the final notice for Phase I of the Multi-Sector General Storm Water Permit program in 1995 (Federal Register Volume 60 No. 189, September 20, 1995, page 50804). Subsequent to that date, states for which EPA had granted NPDES permitting authority adopted their own version of the storm water regulations. One of those states was Utah, with the exception of lands within the state designated as tribal lands or "Indian County", where EPA retains permitting authority. Utah's Division of Water Quality (DWQ) has developed the *General Multi-Sector Permit for Storm Water Discharges Associated With Industrial Activity* (General Permit) to closely follow the EPA program, and issues coverage under the General Permit (No. UTR000000) to applicable industrial facilities.

The General Permit includes provisions for the development of a Storm Water Pollution Prevention Plan (SWP3) by each industrial facility discharging storm water, including oil and gas extraction facilities. Oil sand mining, tar sands mining, and extracting oil from oil sands and oil shale, all fall under Major Group 13: Oil and Gas Extraction, in the Standard Industrial Code, which is used to categorize and set storm water regulatory standards for various classes of industries. The purpose of a SWP3 is to identify and prescribe storm water pollution prevention measures and best management practices (BMPs). Properly constructed and implemented, the BMPs minimize or eliminate the transport of any pollutants generated by the facility to any surface water bodies. Revisions to the SWP3 and the BMPs are made at prescribed intervals; when operational changes occur; or as site conditions warrant.

1.1 INDUSTRIAL ACTIVITY DESCRIPTION

Earth Energy Resources Inc. (Earth Energy) operates a tar sand mine and processing plant near PR Spring. The company mines tar sand deposits and extracts bitumen using a patented chemical method known as the Ophus Process, which produces clean (inert), "damp-dry" sand tailings that are backfilled into the quarry.

Although there are no treatment ponds located on the site, a retention pond is located at the lowest point of the plant site and it collects all plant site runoff and runoff-transported sediments. It is also used to store reserve make-up water (approximately 10,000 barrels, which equates to a 2.5-day supply). This pond is lined in order to preserve the availability of make-up water. Lining is not needed to prevent water quality impacts. Any sediments that collect in this pond are removed as needed to maintain design capacity.

The plant site and open-pit portions of this facility have zero discharge of storm water and/or snowmelt from the facility to off-site drainage ways or water bodies. All precipitation collected within the working mine pits and process areas is collected and used in tar sands processing or for dust suppression on mine and plant roads. On occasion, the outslopes of overburden/interburden storage piles may shed precipitation, however this runoff (and pollutants it may convey) is minimized through design features described later in this document.

Roughly half of the land on which the facility rests is designated as "Indian Country" and falls under EPA jurisdiction. EPA does not require an NPDES storm water permit for this industrial sector (Oil and Gas Extraction Facilities) unless a facility had demonstrable previous releases. Earth Energy has not had such a release and thus EPA does not require a permit. However, the other half of the facility is not on Indian Country lands, so the DWQ has primacy. In contrast to EPA, the DWQ requires a Utah Pollution Discharge Elimination System (UPDES) storm water permit for oil and gas extraction facilities and has developed industry-specific requirements (General Permit Appendix II, Sector I) for such facilities. This SWP3 explains storm water management for the entire facility, regardless of regulatory oversight. Copies of the General Permit and General Permit Appendix II, Sector I are located in **Appendix A** of this SWP3. A copy of the Notice of Intent requesting coverage is also included in **Appendix A**.

The purpose of this SWP3 is to identify potential pollutant sources and prescribe storm water pollution prevention measures and BMPs. As constructed and implemented, the BMPs minimize or eliminate the transport of any pollutants generated by the facility to any surface water bodies. Revisions to the SWP3 and the BMPs are made at prescribed intervals; when operational changes occur; or as site conditions warrant.

Figure 1 is a location map. Figures 2 and 3 are site maps for the mine and the processing facility, respectively.

2.0 FACILITY DESCRIPTION

2.1 GENERAL FACILITY DESCRIPTION

The Earth Energy mine is located in Sections 26, 27, 28, 33, 34, 35, and 36 of Township 15 South, Range 23 East in Uintah County, Utah; and Sections 31 and 32 of Township 15.5 South, Range 24 East in Grand County, Utah,. The plant site is located in Section 35 of Township 15 South, Range 23 East. The Universal Transverse Mercator (UTM) Coordinates for the center of the mine, UTM Datum NAD27, are 4369592 km Northing, 645187 km Easting, Zone 12. Location and site maps are located in **Appendix B**.

The office address for Earth Energy is: Earth Energy Resources, Inc., Suite 740, 404-6th Avenue SW, Calgary, Alberta, T2P 0R9, Canada.

Mining is conducted using a self-contained mobile surface mining machine (e.g. Wirtgen 2200SM Surface Miner). Overburden and interburden are removed by conventional drill/blast/muck or rip/muck methods and initially stored in a waste dump southwest of the open pit. Eventually, interburden is mixed with sand/clay fines tailings and placed back into mined-out portions of the pit.

A reserve ore pile between 30,000 to 40,000 cubic yards in size is maintained on site. Approximately 920,000–1,200,000 tons of tar sand ore is mined per year and 1,000,000–1,400,000 tons of overburden/interburden is mined per year.

The process train is designed to accommodate 3,000–3,500 tons of ore per day, producing approximately 2,000 bbl/day of bitumen. Approximately 1.5–2 barrels of water is consumed for each barrel of produced bitumen. Thus, approximately 4,000 barrels of water, or 116 gallons per minute (gpm), is used every 24-hour period for processing.

While a portion of the process water is recycled and stored in a tank for re-use, the majority of the water consumed in the process is simply returned to the environment as un-recoverable entrained moisture in the pore spaces of the sand and clay fines tailings. Some evaporates off. When returned to the open pit as part of on-going reclamation, the produced sand/fines still contain 10 to 20 percent entrained water and less than 4,000 ppm residual hydrocarbons (principally near-inert asphaltenes). Approximately 4.8 million cubic yards of overburden, interburden, and tailings (sand and fines) will eventually be placed back into the open pit as mining progresses.

2.2 SITE DESCRIPTION

The property sits atop a plateau at approximately 8,000 feet elevation. The 62-acre initial mine pit is delineated on Figure 2. It is designed with a perimeter highwall which, during operations, is higher than the highest elevation of the pit floor. All precipitation falling within the mine pit boundaries collects in the bottom of the pit, none runs off.

The processing facility is located adjacent to Uintah County Road 2810 in the area shown on Figure 3. It covers approximately 15 acres, and includes a mine office and associated parking area; a maintenance shop, warehouse, power plant, equipment parking and service area; process equipment, sand de-watering equipment, a tank farm, tank truck loading area, and water retention pond; and stockpiles of processed sand, reject materials, and ore.

The tank farm is constructed with an impermeable barrier to prevent any liquid emissions from leaving those areas of the process site. It is constructed with secondary containment sufficient to meet applicable Spill Prevention Control and Countermeasure (SPCC) Plan regulations for tank farm construction (total volume of the bermed area greater than 110% volume of the largest tank contained in the farm, for example). Although SPCC Plans by regulation are required to address only hydrocarbon materials, the Earth Energy SPCC Plan is a comprehensive liquids management plan.

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3.0 POLLUTION PREVENTION TEAM

A key to implementing this SWP3 is the identification of a Pollution Prevention Team. The team is responsible for developing, implementing, maintaining, and revising the SWP3 for Earth Energy, and is comprised primarily of Earth Energy personnel with training in storm water regulations and controls, and who have control over the facility and facility personnel. These individuals are empowered with the ability to commit company resources and to implement action items identified in and required by the SWP3. The titles and specific assignments of the main team members are listed below. Additional team members are assigned on an as-needed basis.

STORM WATER POLLUTION PREVENTION TEAM

TEAM MEMBER	TITLE	RESPONSIBILITY
Earth Energy Staff Member	Vice President, Operations	Responsible party Signatory for certifications Technical support SWP3 revisions Oversight on regulatory submittal Annual site compliance evaluation Inspection oversight On-site spill response Employee training
Earth Energy Staff Member	Site Operations Manager	Inspections Record keeping On-site spill response BMP implementation scheduling Maintenance oversight Maintenance of BMPs Contractor supervision Employee training
JBR Environmental Consultants, Inc.	Environmental Consultant	Annual site compliance evaluation SWP3 revisions Preparation of regulatory submittals Technical support

4.0 DESCRIPTION OF POTENTIAL POLLUTANT SOURCES

This section outlines the means by which various pollutants have the potential to enter storm water runoff. It also describes the activities by which those pollutants may be generated, the materials that may be the source of the pollutants, their locations at the facility (bitumen extraction facility or mine pit), and an assessment of the risk associated with various site activities. Storm water management methods are generally described in this section as well, with the detailed descriptions of storm water BMPs given in Section 5.0.

4.1 Facility Drainage

The plant site is constructed to be self-contained with the use of perimeter berms or ditches where needed. All ditches are designed to pass the 10-year, 6-hour precipitation event. They are triangular in cross section with side slopes approximately 2H:1V; depth including freeboard is less than 2 feet or equivalent in cross section. Berms are generally 2 feet high, with a two-foot top width and 2H:1V side slopes. All precipitation falling on the plant site is collected in these ditches and flows to the water retention pond located at the low point of the plant site.

The plant site has little to no up-gradient, off-site runoff flowing onto the site, so the retention pond collects only runoff generated from precipitation falling upon the plant site itself. It is also used to store fresh make-up water. Any sediments collected in the pond are removed as needed in order to maintain its design capacity. It is designed to contain the runoff from the 10-year, 24-hour precipitation event as well as sediment storage and make-up water.

Water falling within the mine pit boundaries collects in sumps located in the bottom of the pit, thereby preventing runoff from leaving the mine site. The accumulated precipitation is removed from the pit along with the solid materials, and is processed along with the bitumen bearing sands. As needed, and if available, collected precipitation can also be pumped from the mine and used for dust suppression on mine and plant roads. The active mining area will remain a pit at all times. No pit configurations are planned where storm water will be allowed to egress the active mine workings. Further, the highwall safety berms prevent runoff from outside the pit perimeter from entering the pit.

The outslopes of overburden/interburden storage piles receive only minor amounts of precipitation and runoff. In the event that they do shed precipitation after particularly heavy rainfall, this runoff (and pollutants it may convey) is minimized due to the mixed nature of the overburden/interburden itself, and the construction of bermed storage cells that encapsulate fines, as explained in Section 5.9.2. Runoff generated from these outslopes is controlled along the sides of the dumps by placing armoring between the edge of the dump and the native slope (essentially forming a triangular channel-type feature). Runoff from the face of the dump is captured at the toe of the slope, where the coarsest materials typically settle as the dump expands. The concentration of coarse materials at the toe of the fills provides a natural energy dissipater for storm runoff from the faces of the dumps. In addition, a rip-rapped energy dissipater is constructed at the toe of the slope.

4.2 Inventory of Exposed Materials

Listed below are significant materials at the Earth Energy site that have the potential to be exposed to storm water. These materials are described in regard to the location and method of storage. Current material management practices and relevant storm water controls are also briefly described.

4.2.1 At the Mine Pit

The pit is self-contained. Materials stored within this area that could cause pollution if allowed to leave this area include:

Mobile equipment includes the Wirtgen miner, a loader, track hoe, scrapers, dozers, water trucks, and haul trucks. This equipment, except for the water truck, is used to remove overburden, mine the tar sand, transport it to the plant site, and bring the processed material (tailings) back to the mine pit for disposal. The water truck is used to water the unpaved roads and the entrance road to reduce fugitive dust emissions.

4.2.2 At the tar sands processing facility (Plant Site)

The entire plant site is fully contained using a system of berms and ditches. Materials stored within this area that could cause pollution if allowed to leave this area include:

Temporary ore piles, tailings piles, and storage piles are not covered and thus are exposed to rainwater and snowmelt. The runoff from temporary ore and tailings storage piles at the processing plant is captured by ditches and routed to the plant site retention pond. Precipitation encountering storage piles and slopes within the mine pit collects in low-lying areas within the pit and either infiltrates into the ground or evaporates, or is pumped out of the pit and used at the plant site.

Hydrocarbons include diesel fuel, solvent and various oils and lubricants. The tank farm area contains the following tanks:

- (7) 400 bbl tanks
- (15) 1,000 bbl tanks

All of the tanks are within the SPCC containment area, which is lined and designed to contain greater than 110 percent of the volume of the largest container. None of the tanks are open to the elements. Other oils, lubricants, miscellaneous chemicals are stored in the enclosed warehouse or maintenance building, located within the bermed, ditched area of the plant site. In the event of a spill, personnel follow the spill reporting guidelines located in Section 5.7. Any contaminated soil is removed and disposed of in accordance with state and federal regulations.

Process equipment includes conveyor systems, crushers, power plant (1 diesel generator, 1 gas generator, 1 boiler), and fully enclosed extraction processing equipment (e.g. process train, distillation unit, sand de-watering unit, conveyors, heated slurry mixers, slurry tanks, separation towers, cyclones, centrifuges, shakers, pumps, and other process steps). Process equipment is located within the 15-acre plant site with connecting piping between individual pieces of equipment. Process water is recycled and stored in a 4,000 barrel heated tank. Storm water coming into contact with this equipment is diverted to the retention pond on the west side of the facility, where it evaporates, is used in the extraction process, or is used for dust suppression on mine and plant roads. In order to maintain its design capacity, sediments collected in the pond are removed as needed to mined-out portions of the pit floor. All process equipment is within the plant site and containment area. No processing equipment is located in the mine pit.

Vehicle fueling occurs only in the SPCC containment area. Extreme care is taken to avoid fuel spills, however, in the event of a spill, trained staff is equipped to take all necessary actions to contain and clean up the spill quickly and safely.

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The Bone yard is in the plant site area and is used to store obsolete or unused equipment. Storm water that contacts materials stored here drains to the retention pond in the plant site area.

4.2.3 Transport and storage of process solvents and surfactants

Ore is conveyed from the mine to the adjacent plant site in haul trucks, where ore is crushed and loaded into enclosed processing equipment to extract oil from the tar sands. Processing (extracting) equipment is located within the plant site, which is fully bermed and contained.

Tailings are temporarily stored near the extraction facility before they are loaded and transported back to the mine pit for permanent disposal as pit backfill in mined areas or in the overburden/interburden storage areas within bermed storage cells constructed of compacted, coarse overburden materials as described in section 5.9.2.

4.2.4 Unpaved roads and parking areas

Roads and parking areas are located throughout mine site. These roads could contribute sediment to storm water runoff if not properly maintained. Watering and grading of the unpaved roads and high traffic areas minimizes this potential. Roads are bermed and designed to drain either to the pit or to the plant site. Storm water that drains into the pit either evaporates or infiltrates into the ground. Storm water and snowmelt that runs off the roads and parking areas in the plant site drains to the retention pond where it is re-used in the plant site or re-used to water roads.

4.2.5 Ore Storage Areas

Ore is stored either within the pit or within the plant site, both of which are fully contained.

4.2.6 Overburden Storage Areas

As described in more detail under Section 4.1 above, overburden storage areas are outside of the pit and plant site containment areas, so it is possible that sediments could be released onto undisturbed lands or waters of the state. Sediment release is controlled and minimized through the natural sorting of the overburden materials that takes place as overburden is placed on the dump, creating a rough surface that captures sediment, as well as other measures as described in Section 5.9.2. The use of armoring and rip-rap around the sides and base of the dumps also ensures sediment capture, minimizing the volume of runoff and/or sediments that could reach waters of the state.

4.2.7 Topsoil Storage Areas

There are up to 18 acres devoted to topsoil storage in three areas around the pit. These storage areas are located on flat to gently sloping ground along the margins of the mining and processing areas. Erosion of the topsoil piles themselves is minimized by seeding with a fast growing cover grass, such as slender wheatgrass and/or Sandberg bluegrass at 10 PLS (pure live seed) pounds per acre. Topsoil piles are also bermed at the outer edges, using the salvaged and compacted woody vegetation that is removed prior to topsoil salvage activities. These berms are trapezoidal in cross section: two feet high, with a two-foot wide top width and approximately 1.5H:1V sideslopes.

4.3 SIGNIFICANT SPILLS AND LEAKS

No significant/reportable spills or leaks have occurred at the Earth Energy facility in the last three-year period (since before 2006).

4.4 SAMPLING DATA

Storm water sampling data has not been collected at the Earth Energy facility, nor is any required under the terms of the General Permit and the relevant Sector I requirements. Only visual inspection of samples is required (see Section 8.1).

4.5 RISK IDENTIFICATION AND SUMMARY OF POTENTIAL POLLUTANT SOURCES

This section further describes the materials listed above, and activities occurring that could result in pollution to storm waters. They include loading and unloading operations; outdoor storage activities; outdoor drilling, mining, and processing activities; dust and particulate generating activities; on-site waste disposal practices and cleaning activities; and miscellaneous activities that could result in storm water pollution. The sources and/or activities are evaluated according to their risk of storm water contamination.

4.5.1 Loading and Unloading Operations

Materials subject to loading and unloading operations include tar sand ore, bitumen, process solvent, tailings, diesel fuel, gasoline, and oil.

Since ore loading occurs within the pit, any contact runoff collecting in low-lying areas either soaks into the ground or evaporates; any transported sediment remains in the pit. The risk of storm water runoff contamination off-site from the loading of tar sand ore is extremely low.

Processed bitumen is highly viscous and insoluble, particularly at ambient temperatures. These characteristics are largely responsible for the facility's *de minimus* impact status in regards to groundwater discharge permitting requirements. If exposed to precipitation or spilled, bitumen is unlikely to mobilize, and thus poses no threat to water resources off site. Further, as noted elsewhere, the process plant site is fully contained by berms and ditches and does not generate off-site runoff.

The process chemical, in its neat form (without additives), is transferred from the distillation unit into storage tanks noted on Figure 3, and from the storage tanks to the blending area using appropriate pumps. There are no other waste streams that might get into the solids or tailings. The chemical is stable, colorless, evaporates rapidly when exposed to air, and has negligible solubility in water. It is removed from the bitumen by distillation and recycled to the front of the process.

The cleaning emulsion's biodegradability has not been determined, but related chemicals are known to be biodegradable. In the event of a spill, the process chemical, in its neat

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and/or emulsified forms, is contained by the engineered spill controls and all appropriate responses are made, as per the facility SPCC Plan.

The tailings have been deemed to have a *de minimis* effect on ground water quality by the DWQ, based on the low residual bitumen and process chemical in the tailings material, the design of the pit backfill, and the geologic setting. Storm water that has been in contact with the tailings is contained in either the mine pit or the lined retention pond for the plant site.

The transfer of diesel fuel between the storage tanks and equipment, and the transfer of various oils (motor, hydraulic, etc.) does not affect storm water runoff under normal circumstances. If a spill occurs, the proper notifications are made and the spill is cleaned up immediately. In addition, all fuel and oil transfers occur within the spill containment area of the plant site.

Since all storm water and snowmelt runoff remain in the pit or are collected in the lined retention pond, the risk of storm water contamination off-site from the transfer and storage of diesel fuel and oils is extremely low.

4.5.2 Outdoor Storage Activities

Outdoor storage activities include storage of tar sand ore piles, obsolete or unused equipment, and storage tanks described in Section 4.2. To reduce the risk of contamination, materials and equipment are inspected regularly, maintained in good condition, and stored in locations that reduce the potential of a collision with mobile equipment. Storage tanks are maintained in good condition and are inspected regularly for leaks. Ore piles are kept within the bermed, self-contained plant site or within the recessed pit. Tanks are located within the SPCC containment area of the plant site. The SPCC containment area is designed to contain 110% of the capacity of the largest (highest volume) tank. Obsolete equipment is kept within the plant site, which is bermed and/or ditched to prevent off-site runoff.

The risk of storm water contamination is thus extremely low.

4.5.3 Outdoor Drilling, Mining, and Processing Activities

Drilling, mining, and processing activities include the mining of tar sand, which includes occasional blasting; the conveying, crushing, and stockpiling of the tar sand ore; and processing of ore using the Ophus process.

Overburden and or interburden are typically removed by conventional drill/blast/muck or rip/muck methods. Where blasting is required to facilitate material removal, each blast is designed to create a controlled blast, with adequate stemming to eliminate fly-rock and minimize vibration and dust, while generating aggregate size conducive for removal from the mine area. Blasting is conducted in accordance with local, state, and federal rules.

Ore is loaded and conveyed from the mine to the plant site in haul trucks, where it is crushed and loaded into enclosed processing equipment to extract oil from the tar sands.

Roads are bermed and designed to drain to contained areas. Processing (extracting) equipment is located within the plant site, which is fully bermed and contained.

Tailings are temporarily stored near the plant site before they are loaded and transported back to the mine pit for permanent disposal as pit backfill in mined areas or in the overburden/interburden storage areas within bermed storage cells constructed of compacted, coarse overburden materials, as described in Section 5.9.2. As noted above, roads are bermed and designed to drain to contained areas.

The pit is recessed; all water incident to it is captured in the pit. The maximum depth of the North Pit is approximately 140 feet. Exploratory drill hole data did not encounter any groundwater. It is highly unlikely that mining activities or precipitation gathered there will affect groundwater, and the risk of contamination to storm water runoff due to these activities is extremely low.

4.5.4 Dust/Particulate Generating Activities

The activities included in Section 4.5.3 and vehicle traffic on unpaved roads and parking areas generate dust. Crushing of the ore generates dust. Dust generated from these activities could potentially settle off-site and be carried by storm water or snowmelt. To reduce dust generation, water sprays are used routinely on crushers, roads, mining areas, and parking areas; this is also necessary as part of the facility's air quality permit compliance.

Thus, the risk of contamination to storm water runoff due to these activities is extremely low.

4.5.5 On-site Waste Disposal and Cleaning Practices

Solid waste (*i.e.*, paper trash and food wastes/wrappers) is disposed of in trashcans, located inside the office trailer and in the mine pit. Windblown debris is picked up routinely and placed in trashcans. Trash is regularly taken to a licensed landfill for proper disposal. The risk of storm water contamination from trash and windblown debris is very low.

4.5.6 Miscellaneous Liquid Sources/Activities

The risk of storm water contamination from the transfer and storage of diesel fuel and processing chemicals, and other materials was described in Sections 4.5.1 and 4.5.2. The process water stream is not exposed to precipitation. Water sprayed on the roads soaks into the ground a short distance and then evaporates. No other water or liquids are used at the facility.

The risk of storm water and snowmelt contamination off-site is extremely low.

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4.6 ON-SITE CONTRACTORS

4.6.1 On-site Contractors Not Under Earth Energy's Control

From time to time there are outside contractors that arrive with tanker trucks transport processed oil to off-site markets. They do not process any materials and are on site only for the 15-30 minutes it takes to arrive on site, load the truck, report at the office, and drive away. In the unlikely event that a leak, spill, or tip-over occurs to an outside contractor's vehicle, the plant site area is self-contained with berms that prevent release of fuels, waters, or sediments. A spill kit is maintained on site and clean-up begins immediately.

4.6.2 Service Contractors

Generally, fuel trucks make deliveries every few weeks. Transfer of fuel takes place within the SPCC containment area, away from surface water collection areas.

Process chemicals are delivered approximately every month to the concrete-surfaced process equipment area within the self-contained plant site area.

Propane is delivered to the office, maintenance shop, and warehouse, and crusher which are all within the self-contained plant site area, approximately once a month.

4.6.3 On-site Contractor Performing a Service for a Third Party

There are no on-site contractors that perform services for third parties.

5.0 MEASURES AND CONTROLS

This section describes various BMPs implemented at Earth Energy that minimize the contribution of storm water pollutants from Earth Energy's industrial activities. Some of these BMPs were briefly described in Section 4.0; others are introduced and fully described below. Unless otherwise noted, all of these practices were implemented at the time operations began.

5.1 GOOD HOUSEKEEPING

Good housekeeping BMPs generally refer to ongoing or regular practices to ensure that areas of the facility with a potential to contribute pollutants to storm water are kept clean and orderly. At the Earth Energy plant site, the following good housekeeping practices are in place:

Litter is controlled through employee awareness, trash receptacle placement, and frequent cleanup. New employees are instructed in litter control as part of their initial training. Wind blown litter and other debris at the facility is routinely removed.

Major repairs to and servicing of vehicles are conducted in the maintenance building, which has a concrete floor and is located within the bermed area. Only necessary servicing of process and mobile equipment, such as replacing a belt, is conducted in the pit.

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Equipment is inspected regularly for leaks. Any fluids leaking from equipment located at the Earth Energy facility are collected along with any contaminated soil, and are either processed with the ore, or disposed of in accordance with applicable state and federal regulations. All spills are cleaned up immediately and reported as outlined in Section 5.3.

During fueling of vehicles and mobile equipment, a person remains with the vehicle or equipment so fuel transfer can be stopped quickly in case of an emergency. Absorbents or other clean up materials are available to ensure that any spills are quickly cleaned up.

5.2 PREVENTIVE MAINTENANCE

Vehicles, equipment, and machinery are maintained in good working condition to minimize the likelihood of discharging fluids. They are serviced on a regular schedule as appropriate. The maintenance intervals, inspections, and work performed are specific to that piece of equipment.

Roads are maintained with an adequate crown to shed water. Berms and ditches are maintained in good condition to reduce erosion and to minimize the amount of sediment transported by storm water.

5.3 SPILL PREVENTION AND RESPONSE PROCEDURES

The use of equipment and the filling of tanks and drums on site represent the largest potential source for liquid spills at the facility. Materials and equipment that are used to contain and clean up a spill includes bulldozers, loaders, absorbent materials, and catch basins and drip pans for leaks. Each person operating equipment or responsible for transferring diesel fuel or oil from one container to another is trained on spill prevention and response.

In the event of a spill or leak, the following actions are taken, as further detailed in the SPCC Plan:

- The person who discovers the spill stops the spill or leak at the source, if it is safe to do so, and contain the spread or migration of the spill by using spill response equipment or by building dirt containment berms.
- The person then notifies their immediate supervisor.
- The Site Operations Manager reports the spill in accordance with the internal reporting procedure outlined in Section 5.7.
- When spills of any size occur, quick containment procedures are implemented followed up with appropriate and timely cleanup and notification procedures. As per R317-6-6.15(B)(1), and UC 19.5.114, spills of 25 gallons or more of hydrocarbons, or spills of any substance that could pollute waters of the state are reported to the DWQ immediately.

5.4 INSPECTIONS

All tanks, valves, piping, and other material and chemical storage and conveyance facilities are inspected at least weekly, as required by the SPCC Plan, for leaks, malfunctions, damage, or maintenance.

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Earth Energy performs visual inspections of all BMPs every calendar quarter to assure they are operating as intended. Sediment control devices are inspected once per week.

During these inspections, material handling and storage areas are checked for signs of erosion and sedimentation. Process, mobile, and obsolete or unused equipment is inspected to ensure that these items are in reasonable condition and are not leaking any fluids. Maintenance areas are inspected to ensure that fluids are properly stored within the maintenance shops. Any facilities, equipment, or structures requiring maintenance are recorded on an inspection form, which is completed and signed by the inspector at the time of inspection. A blank Quarterly Visual Inspection form is located in **Appendix C**.

Any evidence of excessive erosion or sedimentation identified on the inspection form is scheduled for repair. Any new problem areas or potential pollutant sources that have not been addressed by the SWP3 are identified. Deficiencies noted during an inspection are corrected as soon as possible after the inspection, and the SWP3 is revised, as needed. A description of these revisions to the SWP3 and the corrective actions taken is documented on the inspection form and retained as part of this plan. Completed Quarterly Visual Inspection forms are maintained with this SWP3 in **Appendix D** for a minimum of three years from the date of the inspection.

5.5 EMPLOYEE TRAINING

Employees who are responsible for implementing activities identified in this SWP3, are responsible for aspects of storm water management or control, or whose activities could result in increased storm water pollution receives storm water training. Training occurs on an annual basis with each session occurring no later than 12 months after the previous year's training. These training sessions consist of:

- A description of the SWP3 and its goals;
- Employee responsibilities under the SWP3;
- Education on storm water pollution prevention including:
  - spill prevention and response
  - fueling practices
  - good housekeeping
  - truck wash out procedures and equipment wash down procedures
  - identification of potential storm water pollution-related issues
  - material management practices;
- BMPs used or considered for use at the mine;
- Spill prevention and response;
- Question and answer period; and
- Other topics considered pertinent during each session.

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The training program is reviewed annually and modified as necessary to meet facility conditions. Training records are retained as indicated in Section 5.6.

5.6 Record Keeping Requirements

Many types of records and reports are required by the storm water permit and the SWP3. The required records and their storage locations are listed in the following table. All records associated with the storm water permit and the SWP3 are retained for at least 3 years from the date that the report or record was generated. Employee training records are maintained for the length of employment. A copy of this SWP3 is maintained on site at the Earth Energy facility and will be made available upon request.

RECORDS/REPORTS and STORAGE LOCATION

RECORD or REPORT	STORAGE LOCATION
Blank and Completed Quarterly Visual Inspection Forms	Appendices C & D in SWP3
Blank and Completed Annual Site Compliance Evaluations	Appendices E & F in SWP3
Blank and Completed Quarterly Visual Monitoring Forms	Appendices G & H in SWP3
Completed Spill and Spill Cleanup Reports/Summaries	Appendix I in SWP3
Spill Prevention, Control and Countermeasure Plan	Appendix J
Employee Training Records	Human Resources

5.7 Internal Reporting Procedures

If a spill or storm water contamination occurs, the person who discovers the spill reports the incident to their immediate supervisor, who then reports the spill to either the Site Operations Manager or another person in the line of authority, if the Site Operations Manager cannot be reached. The Vice President of Operations reports the spill or storm water contamination to the appropriate regulatory agencies as required.

5.8 Non-Storm Water Discharges

There are no non-storm water discharges from the site; an appropriately certified non-storm water evaluation is included in Appendix D along with the first quarterly inspection record. The SPCC containment area, the retention pond in the plant site area, and the pit itself provide spill containment for non-storm water-related liquids. In the event of a spill, the spilled substance collected in the retention pond or pit is removed and disposed in an appropriate manner in accordance with regulations and the SPCC Plan.

Water is used on site for dust suppression on roads and tailings stockpiles, and in the processing of the tar sands. The source of this water is both rainfall collecting in the plant site retention pond, and a well associated with water right number 41-352, allocated to Earth Energy from the

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Uintah County Water Conservancy District. This well water is piped to the Earth Energy plant site (Figure 3). All well water and intercepted rainwater is stored on site in the lined retention pond at the plant site; water is also stored in tanks, which are outfitted with manifolds and valves to allow measured flow for dust control and/or processing uses.

The amount of water used for dust suppression is not enough to infiltrate and intercept groundwater, nor is it enough to produce runoff. Water used for processing is recycled or is entrained moisture in the tailings, as described in Section 2.1. The effect of this water on ground water resources was determined to be *de minimis*, as described in Section 4.5.1. Thus, there is very little opportunity for non-storm water pollution to affect ground or surface waters of the state.

5.9 SEDIMENT AND EROSION CONTROL

5.9.1 Site description

The Earth Energy mine site, at its full development, will affect approximately 213 acres of land. The mine excavates and processes tar sand ore from a mine pit and then processes it in an extraction facility in the plant site. These activities all take place within the 213-acre area. The runoff coefficient for the plant site and the open pit area is estimated at 0.85 and the runoff coefficient for the overburden/interburden storage areas is estimated at 0.25. Drainage patterns around the site and within the mine area are shown on Figure 2, Mine Map. If storm water were to discharge from the site, the receiving water would be an intermittent drainage in Main Canyon, which drains to the White River near Ouray, Utah.

Sedimentation and erosion issues are controlled using several practices and control measures. Sediment control devices, such as silt fences, are inspected once per week. These control measures and features are outlined below.

5.9.2 Control measures

Vegetation is left in place as much as possible. Inactive and undisturbed areas of the property are covered with a variety of grasses, forbs, and shrubs. This vegetation enhances infiltration and impedes storm water and snowmelt runoff, which minimizes the potential to erode the underlying soil. In addition, vegetation filters out sediment that may be transported in the runoff so that the sediment remains on site.

Roads either drain toward the pit or toward the plant site. As needed, certain haul roads are ditched, and when the grade increases to above two percent, water turn-outs are constructed to prevent erosion of the road base.

All topsoil piles are bermed to catch eroded material and prevent run-on and run-off of storm water.

The plant site is constructed to be a self-contained area using perimeter berms or ditches as needed to direct runoff. Ditches are designed to pass the 10-year, 6-hour precipitation event. All precipitation incident to the plant site is collected in the water retention pond.

located at the low point of the site (Figure 3). This pond is cleaned of sediments as needed.

5.9.3 Mine and Overburden/Interburden storage areas

Two overburden/interburden storage areas (waste piles) are being constructed. To prevent erosion of fine material on the outslopes of these piles during mining, initially produced sand tailings is impounded within bermed storage cells constructed of compacted, coarse overburden materials in the upper reaches (flattest) areas of the overburden/interburden storage areas. Eventually, each 15-20 foot tall cell will be filled with commingled clean sand/clay fine tailings. When the first cells are filled to capacity, successive tiered levels will be constructed until the mine pit has sufficiently advanced to permit direct replacement of the tailings back into the mine. To control erosion, the top surfaces of these storage areas will be maintained with a very slight grade away from the outslope to minimize runoff away from the mine. During mining, coarser materials typically end up near the toe of expanding fills, providing a natural energy dissipater for storm runoff from the faces of the dumps catching any fines between the coarse rock.

Tailings placed in the upper reaches of the overburden/interburden storage areas will ultimately become fully encapsulated within the finished and reclaimed overburden/interburden storage areas. Upon reclamation, runoff generated from the outslopes of the overburden/interburden storage areas will be controlled by facing the steepest sections of the finished slopes with coarse overburden material and dedicated armoring placed within the contact between the pile and the native slope (essentially forming a triangular channel-type feature).

5.9.4 Off-site Vehicle Sediment Tracking

To minimize off-site vehicle sediment tracking, mining equipment is dedicated to the site and remains on site. Travel ways within the plant site are graveled or compacted to minimize sediment production. The plant site is serviced by a dirt county access road. There is no net change in the amount of sediment entering or leaving the plant area. The possibility that a measurable sediment volume would get tracked off site is too low to warrant additional controls.

5.10 RUNOFF MANAGEMENT

Most storm water and snowmelt is captured in the pit or the plant site. Roads are sloped or crowned so that water drains off the roads instead of running down the road and causing ruts to develop. The roads are also periodically bladed to minimize the development of ruts. Berms and conveyance ditches divert water to the pit, where water either evaporates or infiltrates, or to the plant site and the lined retention pond, where water evaporates or is re-used, as described in the preceding sections.

The only water that could leave the site comes from the overburden storage sites. As noted in Section 4.1 and 5.9.2, sediment release is controlled and minimized through the construction of "storage cells" and the natural sorting of the overburden materials that takes place as overburden is placed on the dump. The use of armoring and rip-rap around the sides and base of the dumps also capture sediment, minimizing the volume of runoff and/or sediments that reaches waters of the state.

No additional management practices are necessary or recommended.

5.11 REPORTABLE QUANTITY (RQ) RELEASE

A SPCC Plan is in place. The SPCC Plan addresses response to releases as well as procedures for developing corrective measures following a release. Earth Energy complies with all federal, state, and local regulations for spill prevention and control, and the Special Conditions in Part II B of that permit.

Based on the size and content of the spill, the following agencies are contacted:

Type of Incident	Division	Office Hours Phone	After Hours Phone
Release affecting waters of the state*	Water Quality	801-536-6146	801-536-4123
Petroleum products not affecting water	Environmental Response & Remediation	801-536-4100	
Hazardous Waste spills	Solid & Hazardous Waste	801-538-6170	
CERCLA/EPCRA Hazardous Substances*	Environmental Response & Remediation	801-536-4100	

*** May also require notification of the National Response Center (1-800-424-8802)**

Table from Utah Department of Environmental Quality, Division of Environmental Response and Remediation web page. Accessed March 2009 at http://www.superfund.utah.gov/spills.htm.

5.12 VEHICLE AND EQUIPMENT STORAGE AREAS

The facility operates 24 hours per day, approximately 350 days per year, not including unscheduled shutdowns/outages. Parking areas are graveled. Process equipment is skid-mounted and located on a gravel pad. The warehouse and maintenance shop are 'Sprung-type" semi-permanent structures on concrete pads and are used for vehicle and equipment maintenance tasks. The warehouse and equipment maintenance buildings have concrete floors and containment system to capture any spills. Any spilled liquids are collected and disposed of in accordance with federal, state, and local regulations and as described in the facility SPCC Plan.

5.13 VEHICLE AND EQUIPMENT CLEANING AND MAINTENANCE AREAS

Most vehicle and equipment maintenance is performed on site. Maintenance is performed in the maintenance building as much as possible; the building has a concrete floor and containment for any spills or leaks. Equipment cleaning occurs in an on-site area with appropriate containment. All wash water goes to the storm water retention pond and is used on site (e.g. dust control).

5.14 MATERIALS AND CHEMICAL STORAGE AREAS

The major material and chemical storage area on site is the tank farm which has secondary containment and is covered by the site SPCC Plan. Chemicals and materials stored in smaller quantities are stored in the maintenance or warehouse building, and are properly labeled as to their contents and hazard. Leaking or damaged containers are replaced or repaired and any spilled material is collected and disposed in accordance with all federal, state, and local regulations.

5.15 CHEMICAL MIXING AREAS

Any chemical mixing occurs within the enclosed extraction facility, which is fully contained and controlled. The SPCC Plan fully describes the methods and procedures that are used to respond to any spill, and the steps that are taken to ensure that there are no recurrences. Any small quantity use or mixing of chemicals occurs in an area with secondary containment and full controls, such as the testing laboratory and maintenance building. Chemical transfer areas, such as the product terminal and loading/unloading facilities, are within the plant area and so are within a self-contained area. These areas are inspected on a weekly basis. See Section 5.7 above for specifics of the monitoring and inspection procedures.

6.0 COMPREHENSIVE SITE COMPLIANCE EVALUATION

Some or all of the members of the Pollution Prevention Team complete an Annual Site Compliance Evaluation. A blank Annual Site Compliance Evaluation form is located in **Appendix E**. Completed forms are maintained in **Appendix F** in order to provide a record of the evaluations. The Annual Site Compliance Evaluation is conducted to: 1) confirm the accuracy of the description of potential pollution sources contained in the plan, 2) determine the effectiveness of the plan, and 3) assess compliance with the terms and conditions of the storm water permit.

Areas that are evaluated are those that contribute, or may contribute, to storm water contamination and include, but are not limited to: process equipment areas, material storage and handling areas, storage tanks and oil drums, the warehouse and maintenance buildings, outslopes of overburden waste piles, road ditches, and the sediment retention pond. Measures to reduce pollutant loadings are evaluated to determine whether they are adequate and properly implemented or whether additional controls are needed. Storm water management measures and sediment and erosion control measures are observed to ensure that they are operating correctly. An inspection of spill control equipment, containment systems, and other equipment or structures is also made.

If an area of noncompliance is discovered during this inspection, the following steps are implemented:

- Evaluate source of noncompliance;
- Take corrective action within required time frame as outlined in the General Permit;
- Document the entire event as part of the annual inspection report;

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- Revise the SWP3 as needed; and,
- File a report with the agency, if required.

Based on the results of the evaluation, the description of potential pollutant sources and pollution prevention measures and controls identified in this SWP3 are revised as appropriate within two weeks of the evaluation. Any revisions to the SWP3 are implemented by the facility within 12 weeks of the evaluation.

An annual inspection report is prepared that summarizes:

- The scope of the evaluation
- Personnel making the evaluation
- Date(s) of the evaluation
- Major observations relating to the implementation of the SWP3
- Actions taken to revise the plan.

The report identifies any incidents of noncompliance or certifies that the facility is in compliance with the SWP3 and the General Multi-Sector Permit for Storm Water Discharges. The evaluation reports are retained with this SWP3 for a period of three years from the date of the evaluation. The company owner or a duly authorized representative of the owner signs the reports. Designations as duly authorized representatives under this SWP3 are made in writing to the *Executive Secretary* of the Utah Water Quality Board.

7.0 NUMERIC EFFLUENT LIMITATIONS

There are no numeric effluent limitations or additional requirements for storm water discharges associated with industrial activity from oil and gas extraction facilities (Appendix II, Sector I) that apply to this facility.

8.0 MONITORING AND REPORTING REQUIREMENTS

Under the terms of the General Permit and the relevant Sector 1 requirements, an analytical water monitoring program is not required. The required visual monitoring is described below.

8.1 QUARTERLY VISUAL MONITORING REQUIREMENTS

In the two locations (at the toes of the two overburden/interburden storage areas, downstream of the sediment traps/energy dissipaters) where occasional storm water discharge may occur, visual monitoring occurs once per quarter every year. Guidelines for visual monitoring are listed below.

8.1.1 Visual Monitoring Periods

A visual examination of storm water discharges is performed and documented on a quarterly basis (January-March, April-June, July-September, and October-December) during daylight hours unless rainfall or snowmelt is insufficient to produce a runoff event. All observations are recorded on a Quarterly Visual Monitoring Report Form (a blank form is contained in **Appendix G**). If a sample is not taken due to insufficient rainfall or snowmelt runoff, a report form is still completed by filling in the heading and checking the box that indicates no sample was taken due to insufficient rainfall or snowmelt. Completed forms are maintained in **Appendix H.**

8.1.2 Sample and Data Collection

A minimum of one grab sample per discharge or runoff area is taken during the first 30 minutes when the runoff or snowmelt begins discharging. The sample is examined in a well-lit area. All observations are recorded on the Quarterly Visual Monitoring Report Form. Each sample is collected from the discharge resulting from a storm event that is greater than 0.1 inches in magnitude and that occurs at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event.

8.1.3 Visual Discharge Examination Reports

Visual examination reports are maintained on-site in the SWP3. Each report includes the examination date and time, examination personnel, the nature of the discharge (i.e., runoff or snow melt), visual quality of the storm water discharge as noted in 8.1.2 above, and probable sources of any observed storm water contamination. All observations are recorded on a Quarterly Visual Monitoring Report form. A blank form is contained in **Appendix G**, and completed forms are maintained in **Appendix H.**

8.1.4 Adverse Conditions, Inactive and Unstaffed Sites

If a sample cannot be collected within a specific quarter due to adverse weather conditions, the reason is documented on the report form and placed in **Appendix H** with the other completed forms. Adverse weather conditions that may prohibit the collection of samples include dangerous weather conditions (high winds, electrical storms, etc.) or otherwise make the collection of a sample impracticable (drought, extended frozen conditions, etc.).

9.0 SWP3 MODIFICATION

This SWP3 is amended whenever:

1. There is a significant change in the acreage disturbed; or a significant change to the design, construction, operation, or maintenance of on-site facilities that could have a significant effect on the quantity or location of discharge of pollutants to the waters of the state and which has not otherwise been addressed in the plan;

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2. Inspections or investigations by site operators; or local, state, or federal officials indicate that the SWP3 is not effective in eliminating or significantly minimizing pollutants from sources identified in this plan, or the SWP3 is otherwise not achieving the general objectives of controlling pollutants in storm water discharges associated with the mine.

This SWP3 is also modified within 14 calendar days of knowledge of a release in excess of reportable quantities of hazardous substances or oil into the storm water discharge(s) from the site. The modification process includes:

- A description of the release
- The circumstances leading to the release, and the date of the release
- A SWP3 review to identify measures to prevent the reoccurrence of such releases and to respond to such releases.

The SWP3 is modified where appropriate following this review.

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10.0 CERTIFICATION

In accordance with Section VI.G of the General Permit, the company owner, or a duly authorized representative of the owner, has provided the following certification:

> I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information contained in the plan. Based on my inquiry of the person, or persons, who manage the system, or those persons directly responsible for gathering the information, the information contained in this document is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for providing false information, including the possibility of fine and imprisonment for knowing violations.

______________________________ ______________________________

Printed Name Signature

______________________________ ______________________________

Title Date

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Appendix A

UPDES General Multi-Sector Industrial Storm Water Permit

Appendix II Sector I,

and

Notice of Intent

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The UPDES General Permit and Notice of Intent is pending and this page will be replaced when the UPDES NOI accepted by DWQ.

Appendix B

Figures

(Location and Site Maps)

Figure 1 Location Map

Figure 2 Mine Site Map

Figure 3 Processing Plant Map

Appendix C

Blank Quarterly Visual Inspection Form

Quarterly Visual Inspection Form

Earth Energy Resources, Inc.
Suite #740 404–6th Ave. SW
Calgary, Alberta T2P 0R9

INSPECTORS NAME:	
INSPECTION DATE:	INSPECTION TIME:

Directions: Perform a walk-through of the facility when rain is not falling and check YES or NO for each item. Record any corrective actions that are needed. Review the SWP3 and complete Section 4. Describe the corrective actions that were taken in Section 5.

1. Housekeeping	**YES**	**NO**	**Corrective Actions/Maintenance Required**
• Litter is picked up?			
• Trash receptacles not overflowing?			
2. Materials and Equipment	**YES**	**NO**	**Corrective Actions/Maintenance Required**
• Tailings storage piles located within mine pit?			
• Process, mobile, and obsolete equipment positioned within mine pit?			
• Any signs of leakage from process, mobile, and obsolete equipment?			
• Preventive maintenance has been performed on mobile equipment?			
• Storage tanks and oil drums not leaking?			
• Secondary containment areas for tanks and drums in good condition?			
3. General	**YES**	**NO**	**Corrective Actions/Maintenance Required**
• Any evidence of erosion on slopes or berm along east side?			
• Unpaved roads & parking areas in good condition (*i.e.*, no erosion or ruts)?			
• Any new problem areas or potential pollutant sources?			

4. SWP3 Review

If deficiencies were noted above, are changes to the SWP3 required? YES NO

If yes, describe the revisions that were made:________________________________

5. Corrective Actions Taken

For the Corrective Actions/Maintenance Required that were identified above, enter the action that was taken and the date: ________________________________

Appendix D

Completed Quarterly Visual Inspections Forms

Appendix E

Blank Annual Site Compliance Evaluations

Annual Site Compliance Evaluation Report

Earth Energy Resources, Inc.
Suite #740 404–6th Ave. SW
Calgary, Alberta T2P 0R9

INSPECTORS NAME:	
INSPECTION DATE:	INSPECTION TIME:

1. Perform a walk-through of the facility. Inspect the following areas and answer the questions.

_____ Ore storage piles
_____ Diesel storage tanks
_____ Process equipment (power plant, sand de-watering equipment, retorts, crushers, hoppers, screens, etc.)
_____ Mobile equipment
_____ Obsolete equipment
_____ Oil storage drums
_____ Secondary containment areas for drums and tanks
_____ Unpaved roads and parking areas
_____ Water truck fill station
_____ Berm along east side
_____ Spill response equipment

• Were any substantial erosion problems on the roads or berm on east side identified during the walk-through? If yes, explain:________	**YES**	**NO**
• Any new storm water contaminants or pollutant sources identified during the walk-through? If yes, explain:________	**YES**	**NO**
• Secondary containment areas for tanks and oil drums in good condition? If no, explain:________	**YES**	**NO**
• Additional measures required to reduce pollutant loadings? If yes, explain:________	**YES**	**NO**
• Spill response equipment in place? If no explain:________	**YES**	**NO**

2. Review the SWP3 and the Storm Water Permit.

• Have the BMPs in the SWP3 been effective at minimizing storm water runoff and contamination? If no, explain:________	**YES**	**NO**
• Were any deficiencies in the SWP3 identified? If yes, explain:________	**YES**	**NO**
• Any components of the SWP3 no longer apply or are incorrect? If yes, explain:________	**YES**	**NO**

• Are the descriptions of the potential pollutant sources accurate (Section 4.2)? If no, explain:____	**YES**	**NO**
• Does the facility comply with the requirements in the Storm Water Permit? If no, explain:____	**YES**	**NO**

3. Actions Required: If an explanation is required for any of the above questions, is reporting to a regulatory agency required or revisions to the SWP3 needed?	**YES**	**NO**

If yes, describe the actions taken:____

4. Certification:

If the evaluation does not identify any incidents of noncompliance, a responsible corporate officer* must sign the following certification:

> I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature	Printed Name
Title	Date

* A responsible corporate officer is the president, secretary, treasurer, or vice-president of the corporation or a person who is a duly authorized representative of that person.

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Appendix F

Completed Annual Site Compliance Evaluations

Appendix G

Blank Quarterly Visual Monitoring Forms

Quarterly Visual Monitoring Report Form

Earth Energy Resources, Inc.
Suite #740 404–6th Ave. SW
Calgary, Alberta T2P 0R9

INSPECTORS NAME:	INSPECTION DATE:	INSPECTION TIME:

MONITORING PERIOD: FROM: MONTH____ DAY______ YEAR_______ TO: MONTH______ DAY______ YEAR_______
DURATION OF STORM EVENT:_______ HOURS **RAIN FALL MEASUREMENT:**_____INCHES
TIME ELAPSED BETWEEN RECORDED AND PREVIOUS STORM EVENT:__________DAYS
TYPE OF EVENT: ______ STORM WATER RUNOFF ______ SNOWMELT

IF NO SAMPLE WAS TAKEN DURING THIS MONITORING PERIOD, CHECK THE APPROPRIATE BOX:

☐ NO DISCHARGE OR RUNOFF DUE TO INSUFFICIENT RAINFALL OR SNOWMELT

☐ ADVERSE WEATHER CONDITION, LIST CONDITION:

____

PART 1: Sample and Data Collection

1. Collect one or more storm water runoff samples during a storm event that is greater than 0.1 inches and that occurs at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event or when runoff from snowmelt occurs.
2. Collect samples within the first 30 minutes (or as soon thereafter as practical, but not more than 1 hour) of when the runoff or snowmelt begins discharging.
3. Examine the sample in a well-lit area and fill in each column for each sample taken.

NOTE: No laboratory tests are required to be performed on the samples.

SAMPLE #	SAMPLE LOCATION	COLOR & INTENSITY	CLARITY	ODOR	SOLIDS	OTHER POLLUTANT INDICATORS	COMMENTS and PROBABLE SOURCES of CONTAMINANTS

COLOR:	COLOR INTENSITY:	CLARITY:	ODOR:	SOLIDS:	OTHER POLLUTANT INDICATORS:
DG = Dark Gray LG = Light Gray LB = Light Brown MB = Medium Brown BL =Black G =Green T = Tan Y=Yellow DCB = Dark Chocolate Brown Other = Write in color	VI = Very Intense P = Prominent MP = Moderately Perceptible HP = Hardly Perceptible	TO = Totally Opaque (cannot see through) ST = Slightly translucent NT = Nearly translucent TL = Translucent TP = Transparent	D = Diesel P = Petroleum M = Musty NO = No odor G = Gasoline SO = Solvent SE = Sewage NX=Noxious SU = Sulfur (Rotten Egg) Other = write in odor and explain in Comments column	NS = No solids FS = Floating solids SS = Suspended and settled solids Provide description of solids in Comments column	F = Foam OS = Oil sheen Other = write in any other indicators and explain in the Comments column

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IR - 000367

PART [illegible] Site Walk-through and SWP3 Review

1. Perform a walk-through of the facility during the storm water or snowmelt runoff event.
2. Check YES or NO for each item.
3. Record any corrective action or maintenance that is needed.
4. Review the SWP3 and complete Section 2.
5. Describe the corrective actions that were taken in Section 3.

1. General	**YES**	**NO**	**Corrective Actions/Maintenance Required**
• Any evidence of erosion on slopes or berm on east side?			
• Is runoff leaving the property anywhere?			
• Any erosion or ruts along unpaved roads and parking areas?			
• Any oil sheen or foam on rainwater or snowmelt that are in puddles?			
• Any new problem areas or potential pollutant sources?			

2. SWP3 Review

If deficiencies were noted above, are changes to the SWP3 required? YES NO

If yes, describe the revisions that were made:____________________

3. Corrective Actions Taken

For the Corrective Actions/Maintenance Required that were identified above, enter the action that was taken and the date:

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Appendix H

Completed Visual Monitoring Forms

Appendix I

Spill and Spill Cleanup Reports and Summaries

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Appendix J

Spill Prevention, Control, and Countermeasure (SPCC) Plan

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The SPCC Plan is being written and will be inserted when available.

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Rt. #1

EARTH ENERGY RESOURCES

Document Date 2/8/2011

DWQ-2011-002290

www.earthenergyresources.com

February 08, 2011

Mr. Rob Herbert,
Utah Division of Water Quality
288 North 1460 West
P.O. Box 144870
Salt Lake City, Utah 84114-4870

Subject: PR Spring Tar Sands Project, Uintah and Grand Counties, Utah
Ground Water Discharge Permit-by-Rule

Dear Mr. Herbert:

I write to identify some changes in our PR Spring Tar Sands Project ("Project"), which have been made since the March 4, 2008 letter informing Earth Energy Resources, Inc. ("Earth Energy") of the Project's Ground Water Discharge Permit-By-Rule status from the Utah Department of Environmental Quality, Division of Water Quality ("DWQ"). The letter, a copy of which is attached, enumerated four factors used in determining that the Project "will have a *de minimis* effect on ground water quality or beneficial uses of ground water resources."

> First, based on Material Safety Data Sheets, (which are attached), the reagent used in the extraction process is non-toxic, volatile, and most of it will be recovered and recycled in the extraction process.
>
> Second, extraction will occur using tanks and equipment at a processing facility at the mine site, no impoundments or process water ponds are planned, and most of the water used in the process will be recovered and recycled.
>
> Third, the process tailings will not be free draining, with moisture content in the 10-20% range, and "will not contain any added constituents that are not present naturally in the rock, other than trace amounts of the reagent used for bitumen extraction."
>
> Fourth, the letter addressed the hydrologic setting of the Project.

The letter also states that "[i]f any of these factors change because of changes in your operation or from additional knowledge of site conditions, this permit-by-rule determination may not apply and you should inform DWQ of the changes."

Since the PR Spring Mine, Request for Permit-by-Rule Determination ("Request") was submitted on February 21, 2008 by JBR Environmental Consultants, Inc. on behalf of Earth

Energy, Earth Energy has continued to refine the process for extracting bitumen from tar sand to improve recovery and reduce the potential for impacts to the environment.

First, we have removed the stabilizer component from the cleaning emulsion used for bitumen extraction. Page 5 of the Request provides details of the mixing of the cleaning emulsion and the tar sands. In our development of this "Ophus Process," we have determined that the emulsion can be formed concurrently with introduction to the tar sands, so pre-mixing and stabilization of the emulsion is no longer required. The stabilizer, known as Witconate, is an alkyl aryl sulphonate and is oil soluble, so when the cleaning emulsion was mixed with tar sand, the stabilizer dissolved into the oil phase and was not present in the tailings. The use of a stabilizer was not among the factors that DWQ used in determining that the Project will have a *de minimis* effect on ground water quality, and its omission from the cleaning emulsion removes a chemical from the process stream.

Second, we have identified de-watering equipment that we plan to use on the Project. Page 6 of the Request includes details of methods to de-water sand and fines remaining after bitumen is removed from the tar sands, and we identified a "shale shaker (or similar device)." With a global supplier of mine processing equipment, we have identified equipment that will economically recover water from the sand and fines. For the sand, we now expect to use a horizontal belt filter, and for the fines we expect to use a disk filter. With these components, the aggregate water content of the blended tails should be less than 15% by weight – maximizing our recovery of available water while providing a material at near optimum moisture content for compaction. The shale shaker that we initially contemplated using was not among the four factors that DWQ used to determine that the Project will have a *de minimis* effect on ground water quality.

Third, working with the Utah Department of Natural Resources Division of Oil, Gas and Mining ("DOGM"), we have finalized the size of the overburden/interburden storage areas and provided more detail on the sequencing of mining and backfilling. Page 5 of the Request stated that the overburden/interburden storage areas would be approximately 25 acres each. Our final approved site design includes two overburden/interburden storage areas of 36 and 34 acres. The sizes of these storage areas were not among the four factors, on which DWQ relied in determining that the Project will have a *de minimis* effect on ground water quality.

Fourth, working with DOGM, we have determined it is necessary to dispose of some processed sands and fines in the overburden/interburden storage areas. On page 6 of the Request, we stated that the processed sands and fines remaining after bitumen extraction would be used to backfill the open pit. During initial operations, the pit opening will not be sufficiently large to accept processed sands and fines, so some of these tailings will be placed in the overburden/interburden storage areas. Earth Energy has worked closely with JBR Environmental Consultants and DOGM to ensure that the final design will isolate and encapsulate the tailings within the coarser overburden and interburden, so that they will not migrate and will not impact surface or ground water below the storage areas. The disposal of these tailings was not among the four factors that DWQ used to determine that the Project will have a *de minimis* impact on ground water quality.

None of these process improvements affect the factors used in determining the Projects permit-by-rule status, and, for that reason, had not been reported to DWQ. However, in a challenge to the DOGM's approval of Earth Energy's Notice of Intent to Commence Large Mining Operations ("NOI"), by Living Rivers and its counsel, Western Resources Advocates, these improvements have been raised in an attempt to show that DOGM should not have relied on DWQ's determination in approving the NOI.

Living Rivers and its counsel also focus on the portion of the Request which states: "There are no springs in the Earth Energy leased area." Our understanding of this statement was that there are no springs within the approximately 200-acre Project area, which is accurate. Earth Energy's lease encompasses a much broader area: 5,930 acres, and there are two USGS mapped springs in that much larger area, as described on page 2 of the Request. A map submitted and approved by DOGM, which shows water features in the vicinity, is attached.

Please review this information in conjunction with the original Request and confirm that the Ground Water Discharge Permit-By-Rule status granted on March 4, 2008 remains valid and in effect. If you have any questions or require further information, please contact either the undersigned or Mr. Robert Bayer of JBR Environmental Consultants, Inc. (801.943.4144).

Yours truly,
Earth Energy Resources, Inc.

Barclay Cuthbert

Barclay Cuthbert
Vice President

Enclosure(s)

cc: Robert J. Bayer, JBR Environmental Consultants, Inc.
Dana Dean, Utah Division of Oil, Gas and Mining
Paul Baker, Utah Division of Oil, Gas and Mining
A. John Davis, Holme Roberts & Owen LLP

State of Utah

Department of Environmental Quality

Richard W. Sprott
Executive Director

DIVISION OF WATER QUALITY
Walter L. Baker, P.E.
Director

JON M. HU...SMAN, JR.
Governor

GARY HERBERT
Lieutenant Governor

March 4, 2008

Mr. Barclay Cuthbert
Earth Energy Resources, Inc.
Suite 740, 404 – 6th Avenue SW
Calgary, Alberta, Canada T2P 0R9

Subject: PR Spring Tar Sands Project, Uintah and Grand Counties, Utah
Ground Water Discharge Permit-By-Rule

Dear Mr. Cuthbert:

The Division of Water Quality (DWQ) has reviewed the information submitted by JBR Environmental Consultants, Inc. on February 22, 2008 requesting ground water discharge permit-by-rule for the proposed Earth Energy Resources, Inc. PR Spring tar sands project. The proposed operation consists of open-pit mining of tar sands, extraction of bitumen, and disposal of tailings and waste rock.

Below are several relevant factors for determining whether the proposed operation will have a *de minimis* effect on ground water quality or beneficial uses of ground water resources.

1. Based on Material Safety Data Sheets and other information that you sent to DWQ in January 2007, the reagent to be used for bitumen extraction is generally non-toxic and volatile, and most of it will be recovered and recycled in the extraction process. (Because the extraction process is proprietary at this time, this reagent will not be identified in public documents.)

2. Bitumen extraction will be done using tanks and equipment at the processing facility located at the mine site, and no impoundments or process water ponds are planned. Most of the water used in the process will be recovered and recycled.

3. Processed tailings will not be free-draining and will have moisture content in the 10 to 20 percent range. The tailings will not contain any added constituents that are not present naturally in the rock, other than trace amounts of the reagent used for bitumen extraction. Analysis of processed tailings using the Synthetic Precipitation Leachate Procedure indicates that leachate derived from the tailings by natural precipitation would have non-detectable levels of volatile and semi-volatile organic compounds. Unprocessed tar sands and processed tailings were analyzed using the Toxicity Characteristic Leaching Procedure (TCLP) with an extraction process that uses a much lower pH than is likely to occur at the mine site. Analytical results indicate that TCLP metals would not be leached from the tailings at detectable levels except for barium, which was detected at levels below the Utah ground water quality standard of 2.0 milligrams per liter (Table 1 of UAC 317-6). Based on these data, the tailings will be disposed by backfilling into the mine pit.

288 North 1460 West • PO Box 144870 • Salt Lake City, UT 84114-4870 • phone (801) 538-6146 • fax (801) 538-6016
T.D.D. (801) 536-4414 • *www.deq.utah.gov*

4. The uppermost geologic formations at the site are the Parachute Creek and Douglas Creek Members of the Green River Formation, which consist of fluvial-deltaic and lacustrine-deltaic deposits of claystone, siltstone, fine-grained sandstone, and limestone. The Parachute Creek Member outcrops over most of the Earth Energy lease and is the 0 to 50-foot thick overburden above the tar sand deposits of the Douglas Creek Member. Shallow ground water at the site is not part of a regional aquifer but occurs in localized laterally discontinuous perched sandstone lenses of the Douglas Creek Member. Exploration drilling did not encounter ground water within 150 feet of the land surface. Based on records from the Division of Oil, Gas, and Mining, the closest major aquifer is the Mesa Verde Formation, which occurs approximately 2000 feet below ground surface in the area of the proposed mine. The topography of the project area is characterized by mesas incised by deep, narrow canyons, and limited shallow ground water discharges as springs in the canyon bottoms. There are no springs in the Earth Energy leased area and the nearest spring is PR Spring located slightly less than a mile east of the project site.

Considering the factors described above, the proposed mining and bitumen extraction operation should have a *de minimis* potential effect on ground water quality and qualifies for permit-by-rule status under UAC R317-6-6.2.A(25). If any of these factors change because of changes in your operation or from additional knowledge of site conditions, this permit-by-rule determination may not apply and you should inform the DWQ of the changes. If future project knowledge or experience indicates that ground water quality is threatened by this operation, the Executive Secretary may require that you apply for a ground water discharge permit in accordance with UAC R317-6-6.2.C.

This operation may require a storm water permit under the Utah Pollutant Discharge Elimination System (UPDES). Please contact Mike George of this office at (801) 538-9325 to determine if a storm water permit is required.

Disposal of domestic wastewater from the operation should be done in a manner approved by the appropriate local health department; Tri-County Health Department for Uintah County or Southeastern Utah Health Department for Grand County.

If you have any questions about this letter, please contact Mark Novak at (801) 538-6518.

Sincerely,

Robert L Herbert

Rob Herbert, P.G., Manager
Ground Water Protection Section

cc: Robert Bayer, JBR
Paul Baker, DOGM
Carl Adams, DWQ-TMDL
Mike George, DWQ-UPDES Storm Water
Dave Ariotti, Southeastern Utah District Engineer
Scott Hacking, Tri-County District Engineer
Southeastern Utah Health Department
Tri-County Health Department

F:/MNovak/WP/EarthEnResPBR.Ltr

Frutech

P.O. Box 2219
Covina, CA. 91722-8219
Phone (818) 966-8361 Fax (818) 332-7921

MATERIAL SAFETY DATA SHEET

Emergency Response 800 424 9300

I.- PRODUCT IDENTIFICATION

Manufacturer :	Frutech International Corporation 3/8-Mile East Expressway 83 Mission, TX. 78572
Trade Name :	Orange Terpenes
Formula :	N/A
Chemical and Common Name :	Orange Terpenes.
CAS Number :	8028-48-6

II.- TYPICAL PHYSICAL AND CHEMICAL CHARACTERISTICS

Appearance and Odor :	Colorless liquid with mildly Citrus odor.
Boiling Point (@ 760 mm Hg) :	176.7C (350°F)
Vapor Pressure (Torr @ 25°C) :	Not Available
Vapor Density (Air = 1) :	0.0123 @ 20°C (68°F)
Specific Gravity :	0.840
Solubility in Water :	Negligible

III.- FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

Flash Point (Tag closed up) :	46°C (115°F) Class III Flammable liquid
Ignition Temperature :	237°C (458°F)
Flammable Limits (% by volume) :	Lower : 0.7 Upper : 6.1
Fire Extinguishing Media :	Use media for Class B fires : foam CO2 or dry compound Avoid direct contact with water.
Special fire fighting procedures :	If confined in a container, cool de exterior with water spray.
Unusual fire and explosion hazards :	Dense black smoke produced.
Hazardous products of combustion :	None. NFPA health hazard rating = 0
Stability considerations :	Stable.
Incompatibility with :	Oxidizing agent, acids, peroxides, halogens, vinyl chloride, iodine pentafluoride.
Hazardous polymerization :	Avoid high temperature, contact with reactive monomers (i.e. methacrylates or vinyl chloride)
Hazardous decomposition products:	None
Conditions to avoid :	In typical flavoring uses, no contact with inflammable or explosive chemicals likely.

IV.- HEALTH HAZARD DATA

OSHA permissible exposure limit :	Not listed.
ACGIH threshold limit value :	Not listed.

IR - 000378

Frutech
P.O. Box 2219
Covina, CA. 91722-8219
Phone (818) 966-8361 Fax (818) 332-7921

IV.- HEALTH HAZARD DATA

Carcinogenicity : Not listed in NTP, IARC, or OSHA directories of carcinogenic materials.

Effects of overexposure :

Acute : Vapor irritates eyes and mucous membranes. Skin contact with liquid may cause localized itching.

Chronic : Frequent exposure may induce dermatitis in sensitive individuals. Prolonged contact has caused photosensitivity in some cases.

Primary route of Exposure : Skin contact

Emergency first aids procedures :

Eyes : Flush with water for at least 15 minutes. If irritation

Skin : Wash with soap and water. If persists, see a physician.

Ingestion : See a physician.

Medical conditions generally recognized
As being aggravated by exposure : None known.

V.- SPILL OR LEAK PROCEDURES

Steps to be taken in case material is released or spilled :

Shut off source, if possible to do so without hazard. Keep open flames and spark sources away. Do not allow liquid to enter municipal sewage system.

Water disposal method :

Contain and absorb spilled liquid with sand or earth. Remove spend absorbent and dispose in accordance to State, federal and Local disposal laws.

VI.- PERSONAL PROTECTION, HANDLING AND STORAGE INFORMATION

Personal Protective Equipment : Protective gloves. Safety glasses.

Appropriate Hygienic Practice : Wash thoroughly after handling.

Ventilation : Mechanical ventilation recommended.

Restrictions : No open flames, smoking or unshielded lights

Handling and storage precautions : Store in cool, well ventilated place away from reactive chemicals, spark sources, or open flames. Container should be kept closed and plainly labeled.

Date of Issue : March 05, 1997 Prepared By : V. Onchi

Frutech
International Corporation

Technical Specification Sheet

Orange Terpenes

Product description

This product is the solvent and oil phase of the cold pressed orange oil that is produced by fractionanted vacuum destillation. Its composition is mainly monoterpenic hydrocarbons.

Chemical and Physical characteristics

Prercent of D-Limonene (HP5890 SPB-5)	94.20 - 97.99
Aldehydes (%) w/w - expressed as decanal	0.3 to 0.8
Optical Rotation - 100 mm tube (25°C)	+99.0° to +100.0°
Specific Gravity (25/25°C)	0.840 to 0.841
Refractive Index (20°C)	1.4726 to 1.4740
Evaporation Residue (%) w/w	N.D.

Organoleptic characteristics

Color	Colorless, crystal clear.
Odor	Mildly Citrus odor

Packaging

386 pound fill in a closed, nitrogen sealed, epoxy lined steel drum.

Storage recommendations

= Orange terpenes deteriorate with exposure to air (oxidation), light, heat and water (humidity). Transfer oil from a larger partially filled container to a smaller, well filled container to reduce headspace to a minimum at all times.
= This product is best when used within six months from date of purchase, if it is stored at 45°F (7.2°C) to 65°F (18.3°C) in the unopened original container.

Last revision September 5 th, 1997.

Frutech
International Corporation

QUALITY ASSURANCE CERTIFICATE

Orange Terpenes

Product description

This product is the solvent and oil phase of the cold pressed orange oil that is produced by fractionanted vacuum destillation. Its composition is mainly monoterpenic hydrocarbons.

Product Lot : **09060501** ***Bill of Lading:*** **1609**

Chemical and Physical characteristics	**Average**	**Analysis**
Aldehydes (%) w/w - expressed as decanal	0.3 to 0.8	**0.45%**
Optical Rotation - 100 mm tube (25°C)	+99.0° to +100.1°	**100.0°**
Specific Gravity (25/25°C)	0.840 to 0.841	**0.840**
Refractive Index (20°C)	1.4726 to 1.4740	**1.4740**

Organoleptic characteristics

Color	Colorless, crystal clear.
Odor	Mildly Citrus odor

Chromatographic Analysis ***Chem Station HP 6890 GC, HP 5MS, 30 M, 0.32 mm,0.25 um***	**Analysis** SHIPPING091505B1.D
Percent of α-Pinene :	**0.569**
Percent of Sabinene	**0.277**
Percent of β-Pinene :	**0.020**
Percent of Myrcene :	**1.984**
Percent of Octanal :	**0.270**
Percent of D-Limonene :	**96.332**
Percent of Linalool :	**0.169**
Percent of Decanal :	**0.000**

Storage recommendations

= Orange terpenes deteriorate with exposure to air (oxidation), light, heat and water (humidity). Transfer oil from a larger partially filled container to a smaller, well filled container to reduce headspace to a minimum at all times.

= This product is best when used within six months from date of purchase, if it is stored at 45°F (7.2°C) to 65°F (18.3°C) in the unopened original container.

IR - 000381

Florachem Corporation
PO Box 5366
Jacksonville, FL 32247
Phone: 904-733-5759
Fax: 904-733-5950

Material Safety Data Sheet

------ Section 1 • Chemical Product and Company Identification ------

Product Name: **d-Limonene**

Company:
Florachem Corporation
5209 San Jose Blvd., Suite 202
Jacksonville, FL 32207 USA
Phone 904-733-5759

Emergency Telephone Numbers:
24 hrs Chem-Tel 800-255-3924 [within continental US]
24 hrs 813-248-0585 (collect) [outside continental US]

Revised August 2001

----- Section 2 • Composition, Information on Ingredients ------

Component	CAS No.	OSHA HCS Hazard(s)
d-Limonene	5989-27-5	Flammable Liquid. Skin and eye irritant.

EC Classifications:

Xi	Irritant
R36	Irritating to eyes.
R38	Irritating to skin.
S24	Avoid contact with skin.
S25	Avoid contact with eyes.

------ Section 3 • Hazards Identification ------

Emergency Overview:

- Appearance: Colorless to pale yellow liquid
- Odor: Fresh citrus orange
- Risk Summary: Moderate eye and skin irritant. This substance is flammable and will sustain combustion at temperatures above its flashpoint. Avoid heat, sparks and open flame.

Potential Health Effects:

- Inhalation: Vapors may cause respiratory passage irritation in confined spaces. No known long-term hazards.
- Eyes: Irritating to eyes.
- Skin: Irritating to skin.
- Ingestion: Will be irritating to tissues. May be harmful or fatal if swallowed in sufficient quantity. See Section 11 (Toxicological information) for further information.
- Chronic: Not considered a carcinogen by NTP, IARC, or OSHA. No known chronic indications.

Environmental Hazards:

- Marine Pollutant

------ Section 4 • First Aid Measures ------

Inhalation: Remove person to a ventilated area. See a physician if breathing difficulty persists.
Eyes: Remove contact lenses. Flush with water for at least 15 minutes. See a physician if irritation persists.
Skin: Remove contaminated clothing. Wash affected areas with soap and water. See a physician if irritation persists.
Ingestion: Drink lots of water to dilute substance. See a physician.

------ Section 5 • Fire Fighting Measures ------

Flammable Properties: Flashpoint 46°C (115°F) TCC. Vapors can combust and liquids can burn when temperatures reach or exceed the flashpoint.
Extinguishing Media: Carbon dioxide, dry chemical, foam.
Fire Fighting Instructions:
Use CO2, foam or dry chemical. Use water as a spray only to lower temperature. This substance floats on water. Treat as an oil fire.

------ Section 6 • Accidental Release Measures ------

Personal Precautions: See Section 8, Personal Protection.
Environmental Precautions: Do not discharge into surface waters. May be toxic to aquatic organisms. See Section 3 (Environmental Hazards) and Section 12 (Ecological Information) for further information.
Containment and Cleanup Techniques:
Exercise caution as hard floors coated with this material may be slippery. Small spills may be absorbed by sand or oil-absorbing materials. Large spills should be collected by pumping into closed containers for recovery or disposal. Spills over water will float and may be collected by oil absorbants or by skimming.

------ Section 7 • Handling and Storage ------

Handling: Wear chemical safety glasses or goggles and chemically resistant gloves. A chemically resistant apron may be used to protect clothing. A respirator may be worn to prevent breathing spray mists or heated fumes.
Storage: Store in tightly closed metal or glass containers. Containers should be full or blanketed by inert gas. Do not store in plastic. Avoid heat, sparks, and open flames.

------ Section 8 • Exposure Controls, Personal Protection ------

Ventilation: Mechanical ventillation may be necessary at elevated temperatures to control odor.
Respiratory Protection: Organic vapor cartridge may be used to prevent irritation from mists and vapors and for odor elimination.
Skin Protection: Wear chemically resistant rubber gloves and apron (viton, nitrile, and or PVC) to minimize exposure.
Eye Protection: Wear chemical safely glasses, goggles, or face shield to prevent eye contact.

------ Section 9 • Physical and Chemical Properties ------

Appearance:	Colorless to pale yellow liquid.
Boiling Point:	154°C (310°F).
Flashpoint:	46°C (115°F) TCC.
Odor:	Fresh citrus orange
Oxidizing Properties:	This substance combusts in the presence of strong oxidizers.
pH:	None (not water soluble).
Physical State:	Liquid.
Solubility in water:	less than 0.1%.
Specific Gravity:	0.84 @ 25°C.
Vapor Pressure:	2 mmHg at 20°C.
Vapor Density:	>1 (air = 1.0).

------ Section 10 • Stability and Reactivity ------

Conditions to Avoid: Excessive temperatures and/or contact with air may cause decomposition or oxidation.

Materials to Avoid: Avoid contact with strong acids, strong bases, and oxidizing agents. Reacts explosively with iodine pentafluoroethylene.

Decomposition Products: Incomplete decomposition product may include CO. Ultimate decomposition products are CO_2 and water.

------ Section 11 • Toxicological Information ------

Target Organs: Eyes and skin.
Routes of Entry: Eye and skin contact.
Acute Toxicity: LPR-Mus TD_{LO}: 4800mg/kg/8W-I:ETA.
ORL-Mus TD_{LO}: 67g/kg/39W-I:ETA.
Chronic Toxicity: No known chronic indications.

------ Section 12 • Ecological Information ------

Biodegradability: Not determined. Related chemicals are known to be biodegradable.
Aquatic Toxicity: Marine Pollutant. This substance is immiscible with water. This substance is known to evaporate quickly and biodegrade and should not cause long-term effects.
Bioaccumulation Potential: Not Determined. Related chemicals are known to be non-accumulating in the environment.

------ Section 13 • Disposal Considerations ------

RCRA Hazardous Waste: Classified as a RCRA Hazardous waste (flammability characteristic).
Disposal Methods: Dispose of this material by incineration or recovery at a government-approved disposal facility.

------ Section 14 • Transport Information ------

DOT:
Proper Shipping Name: Terpene hydrocarbons, n.o.s., 3, UN2319, PG III
Exceptions: Chemicals, n.o.i. (Not Regulated) - allowable for shipment in non-bulk containers.
IMO: DIPENTENE., 3, UN2052, PGIII, MARINE POLLUTANT.
IATA: Terpene hydrocarbons, n.o.s., 3, UN2319, PGIII.

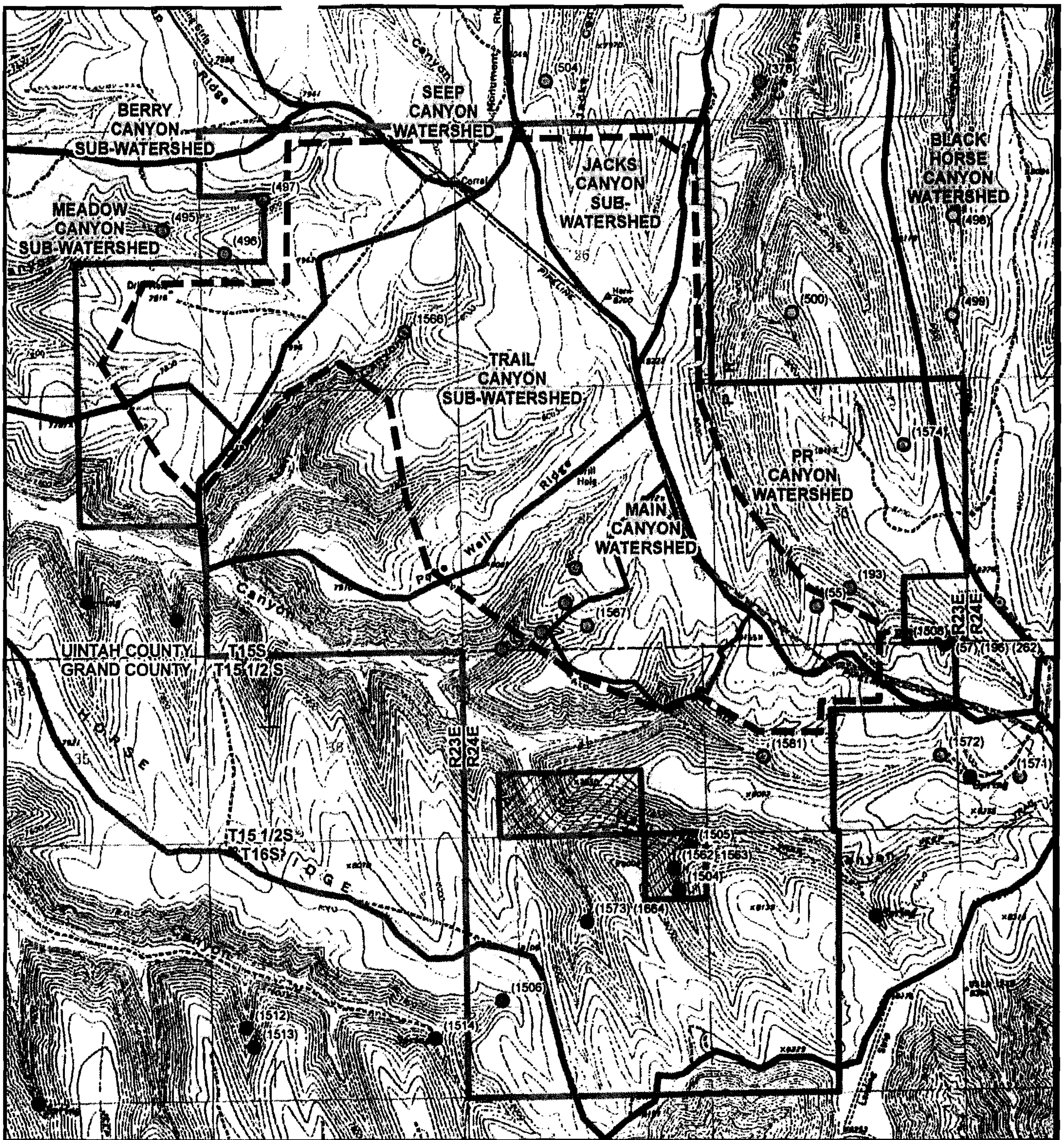
------ Section 15 • Regulatory Information ------

OSHA – Hazardous by definition of 29CFR1910.1200 for flammability.

CERCLA – (SARA Title III) Hazard Category – Fire hazard.

------ Section 16 • Other Information ------

Hazard Ratings (0 = minimal, 1 = slight, 2 = moderate, 3 = serious, 4 = severe)
HMIS: Health = 2 Flammability = 2 Reactivity = 1 Personal Protection = C
NFPA: Health = 1 Flammability = 2 Reactivity = 0



1,000 0 4,000 Feet

1,000 0 1,000 Meters

Contour Interval 40 Feet

N

Legend

- Earth Energy Lease Boundary
- Property Excluded from Lease
- Study Area Boundary
- Affected Area
- Watershed Boundary
- USGS Mapped Spring
- Water Right Filing for Seep or Spring
- Surface Water Right Point of Diversion
- Seep Identified in Field
- (1506) Water Right Number

APPROVED

SEP 19 2009

DIV. OIL GAS & MINING

EARTH ENERGY RESOURCES, INC.

PR SPRING TAR SANDS DEVELOPMENT PROJECT

FIGURE 7
WATER FEATURES

jbr environmental consultants, inc.

DESIGN BY	KK	DRAWN BY	CP	SCALE	1:36,000	DATE DRAWN 9/11/07; REVISION 10/31/08

drawings\Earth Energy\Fig7 Water Features

IR-000385

Mark Novak - RE: Earth Energy Resources - Ground Water Discharge Permit-by-Rule

From:	"Barclay Cuthbert" <barclay.cuthbert@earthenergyresources.com>
To:	"'Mark Novak'" <mnovak@utah.gov>
Date:	2/9/2011 8:14 AM
Subject:	RE: Earth Energy Resources - Ground Water Discharge Permit-by-Rule
CC:	"John Davis" <john.davis@hro.com>, "Christopher R. Hogle" <Chris.Hogle@hro.com>
Attachments:	Earth Energy Resources NOI Approved 09_09_19 Figures.pdf

Mark,

Attached, please find the figures included in the NOI submission to DOGM.

Regards,

Barclay

Best regards,
Earth Energy Resources Inc.

Barclay Cuthbert
Vice President, Operations
Tel: + 1.403.233.9366
Cell: + 1.403.619.4230
Fax: + 1.403.290.0045
E-mail: barclay.cuthbert@earthenergyresources.com

Suite 950, 633 - 6th Avenue SW
Calgary, AB T2P 2Y5

From: Mark Novak [mailto:mnovak@utah.gov]
Sent: February 08, 2011 5:50 PM
To: Barclay Cuthbert
Subject: RE: Earth Energy Resources - Ground Water Discharge Permit-by-Rule

Can you send the figures that go with this report?

>>> "Barclay Cuthbert" <barclay.cuthbert@earthenergyresources.com> 2/8/2011 3:48 PM >>>
Mark,

As you suggested, I have attached the text potion of the Notice of Intent prepared for DOGM to provide information on the PR Spring mine project. Discussion of tailings disposal is included on pages 19-21, 32, and 47-49 of the NOI (pages 22-24, 35, and 50-52 of the attached .pdf file). The information in the NOI is more of an evolution of our plans for tailings handling, rather than changes to the plan; at any rate, you have the

Mark Novak - RE: Earth Energy Resources - Ground Water Discharge Permit-by-Rule

From: Mark Novak
To: Barclay Cuthbert
Date: 2/8/2011 5:49 PM
Subject: RE: Earth Energy Resources - Ground Water Discharge Permit-by-Rule

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>>> "Barclay Cuthbert" <barclay.cuthbert@earthenergyresources.com> 2/8/2011 3:48 PM >>>
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Let me know if you require additional information.

Thanks,

Barclay

Best regards,
Earth Energy Resources Inc.

Barclay Cuthbert
Vice President, Operations
Tel: + 1.403.233.9366
Cell: + 1.403.619.4230
Fax: + 1.403.290.0045
E-mail: barclay.cuthbert@earthenergyresources.com

Suite 950, 633 - 6th Avenue SW
Calgary, AB T2P 2Y5

Mark Novak - Re: Earth Energy Resources - Ground Water Discharge Permit-by-Rule

From: Mark Novak
To: Barclay Cuthbert
Date: 2/8/2011 3:17 PM
Subject: Re: Earth Energy Resources - Ground Water Discharge Permit-by-Rule
CC: rherbert

Barclay,

Can you provide some information on the changes to planned tailings disposal you have made since March '08? What you have already provided to DOGM would probably be enough information for us.

>>> "Barclay Cuthbert" <barclay.cuthbert@earthenergyresources.com> 2/8/2011 2:12 PM >>>
Robert and Mark:

By letter dated March 4, 2008, Earth Energy Resources, Inc.'s ("Earth Energy") PR Spring Tar Sand Project (the "Project") received Ground Water Discharge Permit-By-Rule status from the Utah Department of Environmental Quality, Division of Water Quality ("DWQ"). In the time since this determination was granted, Earth Energy has continued its work on development of the "Ophus Process" and related permitting work with other agencies, principally the Utah Department of Natural Resources, Division of Oil, Gas and Mining. I have prepared a letter that outlines changes to our process and the site configuration over this time period. Please review this letter and attachments and confirm that the original Ground Water Discharge Permit-By-Rule status granted on March 4, 2008 remains valid and in effect.

I will drop an original of this package in the mail to you today. Copies are distributed electronically to those individuals noted on the copy list at the end of the letter.

If you require any further information, please contact me at your convenience.

Best regards,
Earth Energy Resources Inc.

Barclay Cuthbert
Vice President, Operations
Tel: + 1.403.233.9366
Cell: + 1.403.619.4230
Fax: + 1.403.290.0045
E-mail: barclay.cuthbert@earthenergyresources.com

Suite 950, 633 - 6th Avenue SW
Calgary, AB T2P 2Y5

Mark Novak - Earth Energy Resources - Ground Water Discharge Permit-by-Rule

From:	"Barclay Cuthbert" <barclay.cuthbert@earthenergyresources.com>
To:	<rherbert@utah.gov>, <mnovak@utah.gov>
Date:	2/8/2011 2:14 PM
Subject:	Earth Energy Resources - Ground Water Discharge Permit-by-Rule
CC:	"'Bob Bayer'" <rbayer@jbrenv.com>, <danadean@utah.gov>, "'Paul Baker'" <paulbaker@utah.gov>, "John Davis" <john.davis@hro.com>
Attachments:	110208herbert.pdf; DWQ letter March 4 2008.pdf; Florachem MSDS.pdf; Frutech MSDS.pdf; NOI Figure 7 Water Features.pdf

Robert and Mark:

By letter dated March 4, 2008, Earth Energy Resources, Inc.'s ("Earth Energy") PR Spring Tar Sand Project (the "Project") received Ground Water Discharge Permit-By-Rule status from the Utah Department of Environmental Quality, Division of Water Quality ("DWQ"). In the time since this determination was granted, Earth Energy has continued its work on development of the "Ophus Process" and related permitting work with other agencies, principally the Utah Department of Natural Resources, Division of Oil, Gas and Mining. I have prepared a letter that outlines changes to our process and the site configuration over this time period. Please review this letter and attachments and confirm that the original Ground Water Discharge Permit-By-Rule status granted on March 4, 2008 remains valid and in effect.

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If you require any further information, please contact me at your convenience.

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Fax: + 1.403.290.0045
E-mail: barclay.cuthbert@earthenergyresources.com

Suite 950, 633 - 6th Avenue SW
Calgary, AB T2P 2Y5

Mark Novak - Earth Energy Resources - Ground Water Discharge Permit-by-Rule

From: "Barclay Cuthbert" <barclay.cuthbert@earthenergyresources.com>
To: <rherbert@utah.gov>, <mnovak@utah.gov>
Date: 2/5/2011 12:19 PM
Subject: Earth Energy Resources - Ground Water Discharge Permit-by-Rule
CC: "John Davis" <john.davis@hro.com>
Attachments: DWQ letter March 4 2008.pdf; Florachem MSDS.pdf; Frutech MSDS.pdf; NOI Figure 7 Water Features.pdf

Rob and Mark:

By letter dated March 4, 2008, Earth Energy Resources, Inc.'s ("Earth Energy") PR Spring Tar Sand Project (the "Project") received Ground Water Discharge Permit-By-Rule status from the Utah Department of Environmental Quality, Division of Water Quality ("DWQ"). The letter, a copy of which is attached, enumerated 4 factors used in determining that the Project "will have a *de minimis* effect on ground water quality or beneficial uses of ground water resources."

First, based on Material Safety Data Sheets, (which are attached), the reagent used in the extraction process is non-toxic, volatile, and most of it will be recovered and recycled in the extraction process.

Second, extraction will occur using tanks and equipment at a processing facility at the mine site, no impoundments or process water ponds are planned, and most of the water used in the process will be recovered and recycled.

Third, the process tailings will not be free draining, with moisture content in the 10-20% range, and "will not contain any added constituents that are not present naturally in the rock, other than trace amounts of the reagent used for bitumen extraction."

Fourth, the letter addressed the hydrologic setting of the Project.

The letter also states that "[i]f any of these factors change because of changes in your operation or from additional knowledge of site conditions, this permit-by-rule determination may not apply and you should inform DWQ of the changes."

Over the last three years, Earth Energy has continually refined the process for extracting bitumen in an effort to improve recovery and reduce the potential for impacts to the environment. Several of the process improvements that reduce the potential for environmental impacts differ from the description of the process provided to DWQ in the Ground Water Permit-by-Rule Demonstration ("GWDPRD"). These changes include:

Removal of Witconate, a stabilizer component of the emulsion described in the GWDPRD.

Storage of some process tailings within impoundment cells located in the overburden/interburden storage areas only until space is available for process tailings in the pit.

The refinement of the dewatering process (originally identified as "shale shaker (or similar device)") to improve the recovery of water from the process tailing for re-use in the extraction process. We now contemplate using belt or disk filters.

Witconate is an alkyl aryl sulphonate, and is oil soluble, so when the cleaning emulsion was mixed with oil sand, the Witconate would dissolve into the oil phase and would not be present in the tailings. Removal of Witconate has no effect on bitumen recovery and removes a chemical from the process stream. In our process development, we determined that the emulsion can be formed concurrently with introduction to the tar sands, so pre-mixing and stabilization of the emulsion is no longer required.

In our initial request for Permit-by-Rule Determination, we stated that the processed sands and fines remaining after bitumen extraction would be used to backfill the open pit. Initially, the pit opening will not be sufficiently large to accept processed sands and fines, so some of these tailings will be placed in the overburden/interburden storage areas. Earth Energy has worked closely with JBR Environmental Consultants and the Utah Department of Natural Resources, Division of Oil, Gas, and Mining ("DOGM") to ensure that these tailings will be encapsulated within the coarser overburden and interburden, will not migrate, and will not impact surface or ground water below the storage areas.

The Permit-by-Rule Determination stated that the overburden/interburden storage areas would be approximately 25 acres each. Our final approved site design includes two overburden/interburden storage areas of 36 and 34 acres.

These process improvements do not affect the factors used in determining the Projects permit-by-rule status, and, for that reason, had not been reported to DWQ. However, in a challenge to the DOGM's approval of Earth Energy's Notice of Intent to Commence Large Mining Operations ("NOI"), by Living Rivers and its counsel, Western Resources Advocates, these improvements have been raised in an attempt to show that DOGM should not have relied on DWQ's determination in approving the NOI.

Living Rivers and its counsel also focus on the portion of the March 4, 2008 letter, which states: "There are no springs in the Earth Energy leased area." It is true that no springs have been found in the 213-acre mine site. Earth Energy's lease, however, encompasses a much broader area: 5,930 acres, and there are two USGS mapped springs in that area. A map submitted and approved by DOGM, which shows water features in the vicinity, is attached.

If you are available Monday morning, Earth Energy would appreciate the opportunity to discuss these improvements in greater detail to explain how they reduce the potential for environmental impact from the Project, and obtain DWQ's confirmation that these improvements provide further support for Earth Energy's Permit-by-rule status.

Best regards,
Earth Energy Resources Inc.

Barclay Cuthbert
Vice President, Operations
Tel: + 1.403.233.9366
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Fax: + 1.403.290.0045
E-mail: barclay.cuthbert@earthenergyresources.com

Suite 950, 633 - 6th Avenue SW
Calgary, AB T2P 2Y5

From: Mark Novak
To: Barclay Cuthbert
Date: 3/27/2008 10:20 AM
Subject: Re: Locations of water seeps at our PR Spring project site

Thanks, Barclay, I will ask our monitors to sample one or two of these seeps when they go out there.

>>> Barclay Cuthbert <barclay.cuthbert@earthenergyresources.com> 3/27/2008 9:36 AM >>>
Hi Mark,

In April 2007, during one of our trips to PR Spring, we walked down tributary arroyos to Main Canyon where we plan to construct overburden storage repositories. Our geologist, Jerry Park, recorded field notes and locations of observations and plotted these notes on a topographical map, a copy of which is attached to this message. In the south eastern arroyo, we did not see evidence of water seeps. In the other arroyo, on the southeast flank adjacent to Pope Well Ridge, there were three areas where seeps of water were observed:

Seep #1: T15S, R23E, Section 35, 3575' EWL and 1475 NSL, elevation 8040'

Seep #2: T15S, R23E, Section 35, 3230' EWL and 870 NSL, elevation 7950'

Seep #3: T15.5S, R24E, Section31, 845' EWL and 5215 NSL, elevation 7500'

The walk down into the arroyos is fairly rugged and anyone walking down to the seeps should wear some good hiking boots. We will be up at the site once the snow melts this spring and we will check back in the arroyos to see if there is any change in the water flows from these seeps.

Hope this helps to locate the areas of water flow.

Regards,

Barclay

Best regards,

Earth Energy Resources Inc.

Barclay Cuthbert

Vice President, Operations

Tel: + 1.403.233.9366

Cell: + 1.403.619.4230

Fax: + 1.403.668.5097

E-mail: barclay.cuthbert@earthenergyresources.com

Suite # 740, 404 - 6 Avenue SW

Calgary, Alberta T2P 0R9

Subject: FW: sampling plan

-----Original Message-----
From: Barclay Cuthbert
[mailto:barclay.cuthbert@earthenergyresources.com]
Sent: Thursday, April 05, 2007 3:46 PM
To: Bob Bayer; Linda Matthews
Subject: FW: sampling plan

Copy of response from Mark Novak.

Regards,

Barclay

Best regards,
Earth Energy Resources Inc.

Barclay Cuthbert
Vice President, Operations
Tel: + 1.403.233.9366
Cell: + 1.403.619.4230
Fax: + 1.403.668.5097
E-mail: barclay.cuthbert@earthenergyresources.com
Suite # 740, 404 - 6 Avenue SW
Calgary, Alberta T2P 0R9

-----Original Message-----
From: Mark Novak [mailto:mnovak@utah.gov]
Sent: March 30, 2007 4:41 PM
To: Barclay Cuthbert
Cc: Jodi Gardberg; Paul Baker
Subject: sampling plan

Using Crown Ridge samples for the testing would be acceptable for the permit application, but you should mention the sample source in the application, and any known differences between it and the PR Spring tar sand. (for example, stratigraphic position) Once the operation is up and running, I would like similar tests run on the PR Spring tailings, and the proposed tailings management plan modified if the results are any different from the Crown Ridge samples.

I am also concerned with salinity, and would like the SPLP leachate analyzed for TDS and major ions (Na, Ca, Mg, K, Cl, SO4 and alkalinity).

I should be in the office all next week if you would like to call (801 538 6513).

Thank you for this information.

ark

APPROVED
SEP 19 2009
DIV. OIL GAS & MINING

>>> Barclay Cuthbert <barclay.cuthbert@earthenergyresources.com>
>>> 3/30/2007

Subject: FW: sampling plan

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From: Barclay Cuthbert
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Suite # 740, 404 - 6 Avenue SW
Calgary, Alberta T2P 0R9

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Sent: March 30, 2007 4:41 PM
To: Barclay Cuthbert
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I should be in the office all next week if you would like to call (801 538 6518).

Thank you for this information.

ırk

>>> Barclay Cuthbert <barclay.cuthbert@earthenergyresources.com>
>>> 3/30/2007

APPROVED
SEP 19 2009
DIV. OIL GAS & MINING

IR - 000396

10:34 AM >>>
Hi Mark,

I've put together a proposal for the SPLP and Oil & Grease testing required for our permit application and I'd like to discuss this proposal with you.
Once you've had a chance to review the attachment, please let me know of a good time to call and we can discuss.

Hope you have a good weekend.

Regards,

Barclay

Best regards,

Earth Energy Resources Inc.

Barclay Cuthbert

Vice President, Operations

el: + 1.403.233.9366

Cell: + 1.403.619.4230

Fax: + 1.403.668.5097

E-mail: barclay.cuthbert@earthenergyresources.com

Suite # 740, 404 - 6 Avenue SW

Calgary, Alberta T2P 0R9

-----Original Message-----
From: Mark Novak [mailto:mnovak@utah.gov]
Sent: January 31, 2007 8:43 AM
To: barclay.cuthbert@earthenergyresources.com
:: Jodi Gardberg
Subject: RE: MSDS received

www.earthenergyresources.com

To: Mark Novak
State of Utah, Division of Water Quality
Via e-mail: mnovak@utah.gov

From: Barclay Cuthbert

Date: 30 March 2007

Subject: Testing of processed and unprocessed tar sand

Pages: 2

Mark,

In the time since our correspondence concerning testing methods for the chemical we use in our bitumen extraction process, we have completed modifications to our shop demonstration unit in Grande Prairie, Canada. We have commenced run testing with our shop unit and are in position to conduct SPLP testing on both raw tar sand and the solids generated from the process.

The tar sand that we are using for our tests was obtained from the pit at the Crown Asphalt Ridge facility in Vernal. This tar sand is similar in composition to the ore at our leased acreage in PR Spring; we chose to use this sand for our tests because of its availability in the existing pit and the comparatively easier logistics of moving equipment into the pit near Vernal and subsequently trucking the tar sand to Canada.

For our testing program for the Disision of Water Quality, I propose that we conduct the SPLP (metals) testing on solids samples from two different runs our our equipment. Testing will include:

- Both SPLP (metals) and Oil & Grease (EPA Method 1664A) on each of the samples

Suite #740, 404 – 6 Avenue S.W., Calgary, AB T2P 0R9 Canada Office 403.233.9366 Fax 403.668.5097

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www.earthenergyresources.com

- Tests on the raw ore sample (no processing) and on the solids produced from the extraction process, which are recovered separately as sands and fines.
- Representative samples of the sands and fines produced over the course of each run – typically about one hour in duration, processing about one and a half tons of tar sand
- The SPLP and Oil & Grease testing will be conducted by American West Analytical Laboratories and I have discussed proper sample handling and shipping procedures with the laboratory.

I would like to review this proposal with you and ensure that it meets the requirements for our permit application; once you have had a chance to review this information, please let me know of a convenient time to call you.

Best regards,

Barclay

Barclay

Suite #740, 404 – 6 Avenue S.W., Calgary, AB T2P 0R9 Canada Office 403.233.9366 Fax 403.668.5097

From: Mark Novak
To: Barclay Cuthbert
CC: Jodi Gardberg; Paul Baker
Date: 3/30/2007 4:41 PM
Subject: sampling plan

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I am also concerned with salinity, and would like the SPLP leachate analyzed for TDS and major ions (Na, Ca, Mg, K, Cl, SO4 and alkalinity).

I should be in the office all next week if you would like to call (801 538 6518).

Thank you for this information.

Mark

>>> Barclay Cuthbert <barclay.cuthbert@earthenergyresources.com> 3/30/2007 10:34 AM >>>
Hi Mark,

I've put together a proposal for the SPLP and Oil & Grease testing required for our permit application and I'd like to discuss this proposal with you. Once you've had a chance to review the attachment, please let me know of a good time to call and we can discuss.

Hope you have a good weekend.

Regards,

Barclay

Best regards,

Earth Energy Resources Inc.

Barclay Cuthbert

Vice President, Operations

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Cell: + 1.403.619.4230

Fax: + 1.403.668.5097

E-mail: barclay.cuthbert@earthenergyresources.com

Suite # 740, 404 - 6 Avenue SW

From: Mark Novak
To: Barclay Cuthbert
CC: jgardberg
Date: 1/31/2007 8:42 AM
Subject: RE: MSDS received

Because the material is an oil, your management plan for the spent tailings should prevent it from being released to surface water. This should include covering the tailings with topsoil for final disposal and establishing a vegetative cover, and preventing runoff from the tailings from discharging into surface water while the tailings are exposed before final burial. (Berms around the temporary storage area should take care of this.) When you characterize the tailings leachate (from Synthetic Precip. Leaching Procedure) for the permit application, you should analyze it for the parameter Oil & Grease (EPA Method 1664A).

Thank you for sending in this information, and please contact me if you have any questions about other material needed for the permit application.

Best Wishes,

Mark

>>> Barclay Cuthbert <barclay.cuthbert@earthenergyresources.com> 1/30/2007 3:57 PM >>>
Hi again Mark,

To follow up on the second part of your message, I do not foresee a problem with citing specific properties of the chemical, such as its biodegradability, in public documents issued by DWQ. We would not want the public documents to contain any information that would enable other to determine the identity of our process chemical. We would like to work with you to agree on suitable text for any public document to be issued by the Division of Water Quality, so that we can meet the requirements of your work to show that you are protecting waters of the state while complying with our wish not to divulge the identity of the chemical.

Best regards,

Barclay

Best regards,
Earth Energy Resources Inc.

Barclay Cuthbert
Vice President, Operations
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Cell: + 1.403.619.4230
Fax: + 1.403.668.5097
E-mail: barclay.cuthbert@earthenergyresources.com
Suite # 740, 404 - 6 Avenue SW
Calgary, Alberta T2P 0R9

-----Original Message-----
From: Mark Novak [mailto:mnovak@utah.gov]
Sent: January 30, 2007 3:24 PM
To: barclay.cuthbert@earthenergyresources.com

Calgary, Alberta T2P 0R9

-----Original Message-----
From: Mark Novak [mailto:mnovak@utah.gov]
Sent: January 31, 2007 8:43 AM
To: barclay.cuthbert@earthenergyresources.com
Cc: Jodi Gardberg
Subject: RE: MSDS received

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Best Wishes,

Mark

From: Mark Novak
To: barclay.cuthbert@earthenergyresources.com
CC: jgardberg
Date: 1/30/2007 3:24 PM
Subject: MSDS received

Thank you for sending the MSDS on your process chemical. The material looks pretty benign.

In any public documents that DWQ issues regarding this case, such as a permit, statement of basis, permit-by-rule letter, or other correspondence during the permit process, I would like to be able to cite specific properties of this material that are relevant to the potential for ground or surface water pollution. (An example might be the fact that it is biodegradable.) This way the public can be assured that we have made appropriate decisions in this case to protect waters of the state.

State of Utah
GARY R. HERBERT
Governor
GREG BELL
Lieutenant Governor

Department of
Environmental Quality

Amanda Smith
Executive Director

DIVISION OF WATER QUALITY
Walter L. Baker, P.E.
Director

February 15, 2011

Mr. Barclay Cuthbert
Earth Energy Resources, Inc.
Suite # 950
633- 6 Avenue SW
Calgary, AB T2P 2Y5 Canada

Dear Mr. Cuthbert:

Subject: PR Spring Tar Sands Project, Uintah/Grand Counties, Utah
Revised Ground Water Discharge Permit-By-Rule

The Division of Water Quality (DWQ) has reviewed the information submitted by Earth Energy Resources, Inc. (Earth Energy) on February 8, 2011 regarding planned changes to the PR Spring Tar Sands Project since DWQ's original ground water discharge permit-by-rule determination was issued on March 4, 2008. The proposed operation consists of open-pit mining of tar sands, extraction of bitumen, and storage of tailings and waste rock.

Below are the changes that Earth Energy had made to its plans for this project since the original permit-by-rule determination, including DWQ's response to each change.

1. The stabilizer component that was originally planned as part of the cleaning emulsion used for bitumen extraction will not be used. DWQ does not consider this change to affect the original finding of *de minimis* effect on ground water quality, which was made considering use of the stabilizer.

2. Earth Energy will use a horizontal belt filter to remove process water from tailings sands, and a disk filter to dewater fines. The expected water content of the blended tailings will be less than 15% by weight. The original proposal was to use a "shale shaker (or similar device)" to produce tailings with a water content ranging from 10 to 20 percent, which would not be free-draining. As the proposed change will still produce tailings within the original estimated range for water content, this change does not affect the determination of *de minimis* effect on ground water quality.

195 North 1950 West • Salt Lake City, UT
Mailing Address: P.O. Box 144870 • Salt Lake City, UT 84114-4870
Telephone (801) 536-4300 • Fax (801) 536-4301 • T.D.D. (801) 536-4414

3. The original request stated that there would be two overburden/interburden storage areas approximately 25 acres each. Since then, Earth Energy has changed the storage areas for overburden/interburden from two areas of 25 acres each to two areas of 34 and 36 acres, respectively. This change does not affect our original permit-by-rule determination for having a *de minimis* effect on ground water quality.

4. The original project plan was to backfill the open pit with tailings. However, Earth Energy has determined this to be infeasible during the early stages of mine development. Earth Energy now plans to dispose of some tailings in the overburden/interburden storage area. The revised plan is to place tailings generated during the early stages of mine development within the overburden/interburden storage areas, in cells surrounded by coarser waste rock. The original permit-by-rule determination found that natural precipitation leaching through tailings would have *de minimis* effect on ground water quality. Also, proper reclamation of waste rock disposal areas would minimize any potential for increased dissolution of salts and hydrocarbons caused by the increased surface area of the broken-up rock. The proposed changes to the original plan should not affect the original determination that disposal of tailings and waste rock would have *de minimis* effect on ground water quality at this site.

In summary, the proposed changes to the mining and bitumen extraction project do not change the March 4, 2008 permit-by rule determination for having a *de minimis* potential effect on ground water quality and the project still qualifies for permit-by-rule under UAC R317-6-6.2.A(25). If any of the factors considered when making this determination change because of changes in your operation or from additional knowledge of site conditions, this permit-by-rule determination may not apply and you should inform DWQ of the changes. If future project knowledge or experience indicates that ground water quality is threatened by this operation, the Executive Secretary may require the submission of an application for a ground water discharge permit in accordance with UAC R317-6-6.2.C.

If you have any questions about this letter, please contact Mark Novak at (801) 536-4358.

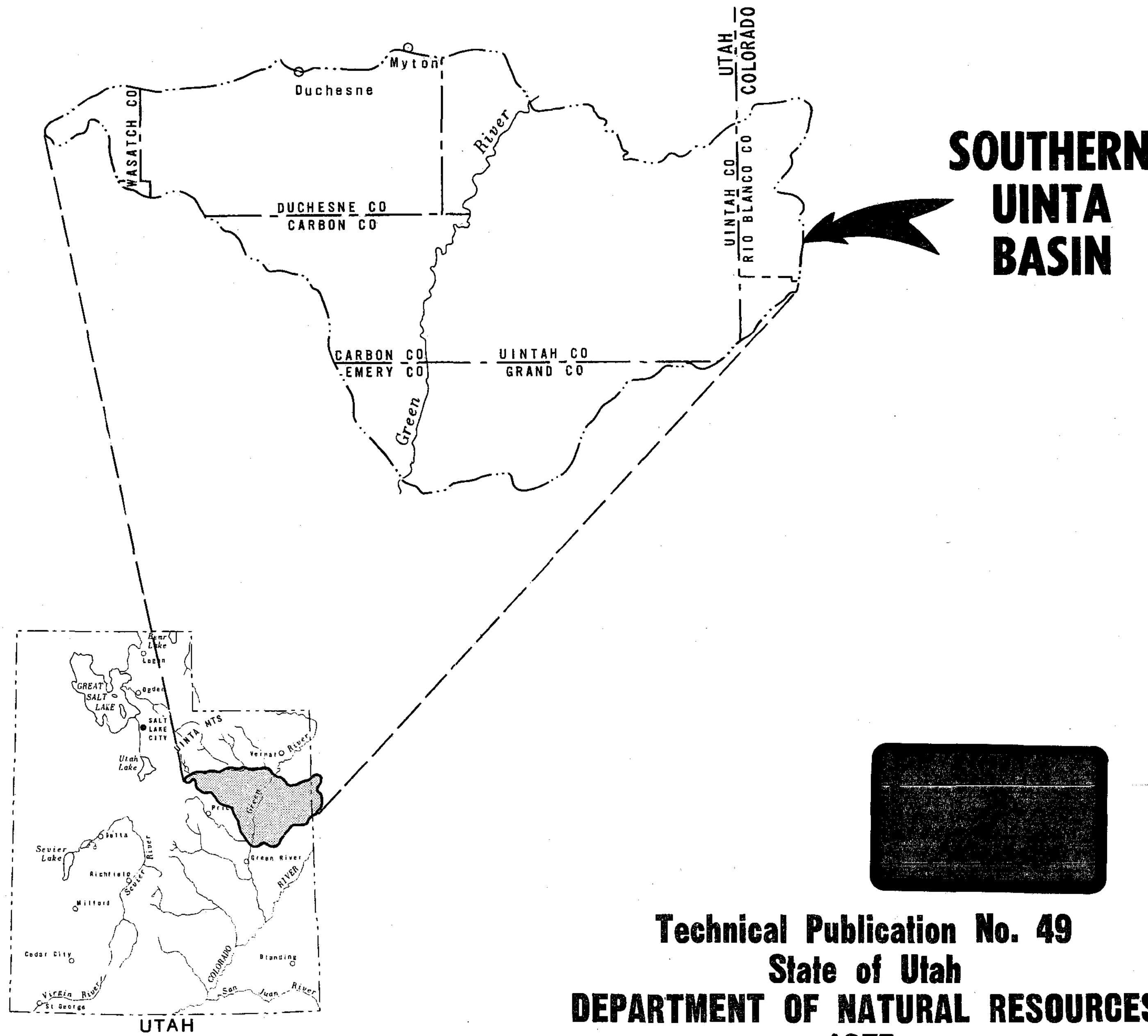
Sincerely,

Rob Herbert, P.G., Manager
Ground Water Protection Section

RFH/MTN/mhf

cc: Paul Baker, DOGM
Scott Hacking, District Engineer
Dave Ariotti, District Engineer
Tri-County Health Department
Southeastern Utah Health Department

HYDROLOGIC RECONNAISSANCE OF THE SOUTHERN UINTA BASIN, UTAH AND COLORADO



Technical Publication No. 49
State of Utah
DEPARTMENT OF NATURAL RESOURCES
1975

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

Technical Publication No. 49

HYDROLOGIC RECONNAISSANCE OF THE SOUTHERN UINTA BASIN, UTAH AND COLORADO

by

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U.S. Geological Survey

Prepared by
the United State Geological Survey
in cooperation with
the Utah Department of Natural Resources
Division of Water Rights

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Metric units

Most numbers are given in this report in English units followed by metric units in parentheses. The conversion factors used are:

English			Metric	
Units (Multiply)	Abbreviation	(by)	Units (to obtain)	Abbreviation
Acres	acre	0.4047	Square hectometres	hm^2
Acre-feet	acre-ft	.0012335	Cubic hectometres	hm^3
Cubic-feet	ft^3	.02832	Cubic metres	m^3
Feet	ft	.3048	Metres	m
Gallons	gal	3.7854	Litres	l
		.0037854	Cubic metres	m^3
Gallons per minute	gal/min	.06309	Litres per second	l/s
Inches	in.	25.4	Millimetres	mm
Miles	mi	1.6093	Kilometres	km
Square miles	mi^2	2.59	Square kilometres	km^2

Chemical concentration and water temperature are given only in metric units. Chemical concentration is given in milligrams per litre (mg/l). For concentrations less than 7,000 mg/l, the numerical value is about the same as for concentrations in mg/l and the English unit, parts per million.

Chemical concentration in terms of ionic interacting values is given in milliequivalents per litre (meq/l). Meq/l is numerically equal to the English unit, equivalents per million.

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation: °F = 1.8(°C) + 32.

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ABSTRACT

The southern Uinta Basin covers about 4,900 square miles (12,690 km^2) in northeastern Utah and northwestern Colorado. For the most part, it is an arid to semiarid region; during the period 1941-70, average annual precipitation ranged from less than 8 inches (203 mm) in the north-central part to more than 26 inches (660 mm) in the extreme western part. The area is sparsely populated, averaging about one person for every 4.5 square miles (12 km^2). It is utilized mainly for livestock grazing and the production of oil and gas; the area is noted for its large reserves of oil shale.

The average annual volume of precipitation that fell on the southern Uinta Basin is estimated to have been about 3.1 million acre-feet (3,800 hm^3) during the period 1941-70. Net imports of water from the Duchesne River for irrigation within the southern Uinta Basin average about 70,000 acre-feet (86.3 hm^3) per year as of 1972.

About 94 percent of the average annual water supply from precipitation and imports is consumed within the southern Uinta Basin by evapotranspiration and sublimation from the winter snowpack. Phreatophytes along perennial and intermittent streams consume an estimated 204,000 acre-feet (252 hm^3) of water annually, and another 184,000 acre-feet (227 hm^3) is estimated to leave the area annually as surface and subsurface runoff and irrigation return flow.

Total recoverable ground water in storage in unconsolidated deposits and in the upper 100 feet (30.5 m) of saturated consolidated rocks is estimated to be on the order of 3.2 million acre-feet (3,947 hm^3), with ground-water recharge providing an estimated average annual replenishable supply of about 120,000 acre-feet (148 hm^3). Most of the ground water occurs in fine-grained sedimentary rocks and is generally yielded slowly to wells and springs--less than 50 gal/min (3.2 l/s)--in most places. The more highly permeable unconsolidated deposits beneath the alluvial plains of larger streams can yield more than 100 gal/min (6.3 l/s), but these deposits are thin and of small extent, containing only about 190,000 acre-feet (234 hm^3) of recoverable water in storage.

Both the surface water and ground water are saline throughout a major part of the southern Uinta Basin. Only in the headwater areas along the south rim of that subbasin can fresh water generally be found. The concentration of dissolved solids in water from streams for which analyses were available ranges from less than 400 mg/l in headwater areas to more than 7,000 mg/l in the lower reaches of some streams. The concentration of dissolved solids in ground water for which analyses were available ranges from less than 200 mg/l from shallow aquifers in headwater areas to more than 100,000 mg/l in samples collected from deep oil tests.

The opportunity to develop large water supplies from sources within the southern Uinta Basin is limited by the generally poor chemical quality and uneven time and areal distribution of the water. The most promising opportunities for obtaining large sustained water supplies are surface reservoir storage of runoff in the headwaters of the larger streams, such as Willow Creek, or development of the alluvial aquifers adjacent to the larger streams, including the Green, White, and Duchesne Rivers.

INTRODUCTION

This report summarizes the findings of an investigation of the water resources of the southern Uinta Basin conducted by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. The purpose of the investigation was to evaluate the water resources of the southern Uinta Basin on a reconnaissance level and to provide information to assist in future planning and development of the water and related land resources.

The investigation was started in July 1971 and continued intermittently through December 1973. Most of the basic data used in the study were gathered from the files of the Geological Survey, the Division of Water Rights, and the Utah Division of Oil and Gas Conservation. Supplementary data on wells, springs, streamflow, and vegetation were collected in the field during five 3-5 day trips during the summer of 1971 and spring and summer of 1972. Much of the basic data collected for the investigation are included in tables 10-15.

A number of agencies provided assistance in obtaining data for the study. Personnel of the Utah Division of Oil and Gas Conservation assisted in obtaining ground-water quality data from oil and gas companies operating in the area; personnel of the U.S. Bureau of Land Management provided information about wells and springs on Bureau-administered land in the area; and personnel of the Ute Indian Tribe provided information about wells and springs on lands in the Uintah-Ouray Indian Reservation. The cooperation and assistance of these people, personnel of oil and gas companies who provided information, and all individual well and spring owners interviewed during the investigation is gratefully acknowledged.

The water resources of the southern Uinta Basin have received little previous study. Woolley (1930) and Thomas (1952) described the hydrology of the Green River, including the reach that passes through the Uinta Basin. Some hydrologic information about the area is included in a comprehensive study of the water resources of the Upper Colorado River Basin by Iorns and others (1964 and 1965). Feltis (1966) compiled some information about availability and chemical quality of water and briefly described the water-bearing properties of some of the geologic units in the Uinta Basin. Weir (1970) compiled considerable geohydrologic data collected from an oil-shale exploration well in the north-central part of the southern Uinta Basin.

The Uinta Basin includes about 10,000 square miles (25,900 km^2) in northeastern Utah and northwestern Colorado. The area described in this report includes that part of the Uinta Basin that lies south of the Strawberry, Duchesne, and White Rivers in Utah and Colorado. It includes approximately 4,900 square miles (12,690 km^2)--mostly in Duchesne and Uintah Counties, Utah, but also in parts of Carbon, Emery, Grand, Utah, and Wasatch Counties, Utah, and Garfield and Rio Blanco Counties, Colo. (See fig. 1.)

The southern Uinta Basin is sparsely populated, averaging about one person for every 4.5 square miles (12 km^2). Most of the total estimated population (about 1,100 in 1972 as estimated from the 1970 U.S. Census) is concentrated along the Duchesne River between Duchesne and Myton. Probably less than 100 people reside in the remaining part of the southern Uinta Basin, which includes mostly Federal and Uintah-Ouray Indian Reservation land. However, the economy of such communities as Roosevelt and Vernal, Utah, which are in the northern Uinta Basin, and Rangely, Colo., is based partly on natural resources of the southern Uinta Basin.

The southern Uinta Basin is noted for its oil and gas production and its large reserves of oil shale. With the exception of exploration for and production of fossil fuels, the land is utilized almost exclusively for livestock grazing and recreation. There are about 26,000 acres (10,520 hm^2) of irrigated cropland in the Duchesne-Myton-Pleasant Valley area, and the principal crops are meadowgrass, alfalfa, and small grains.

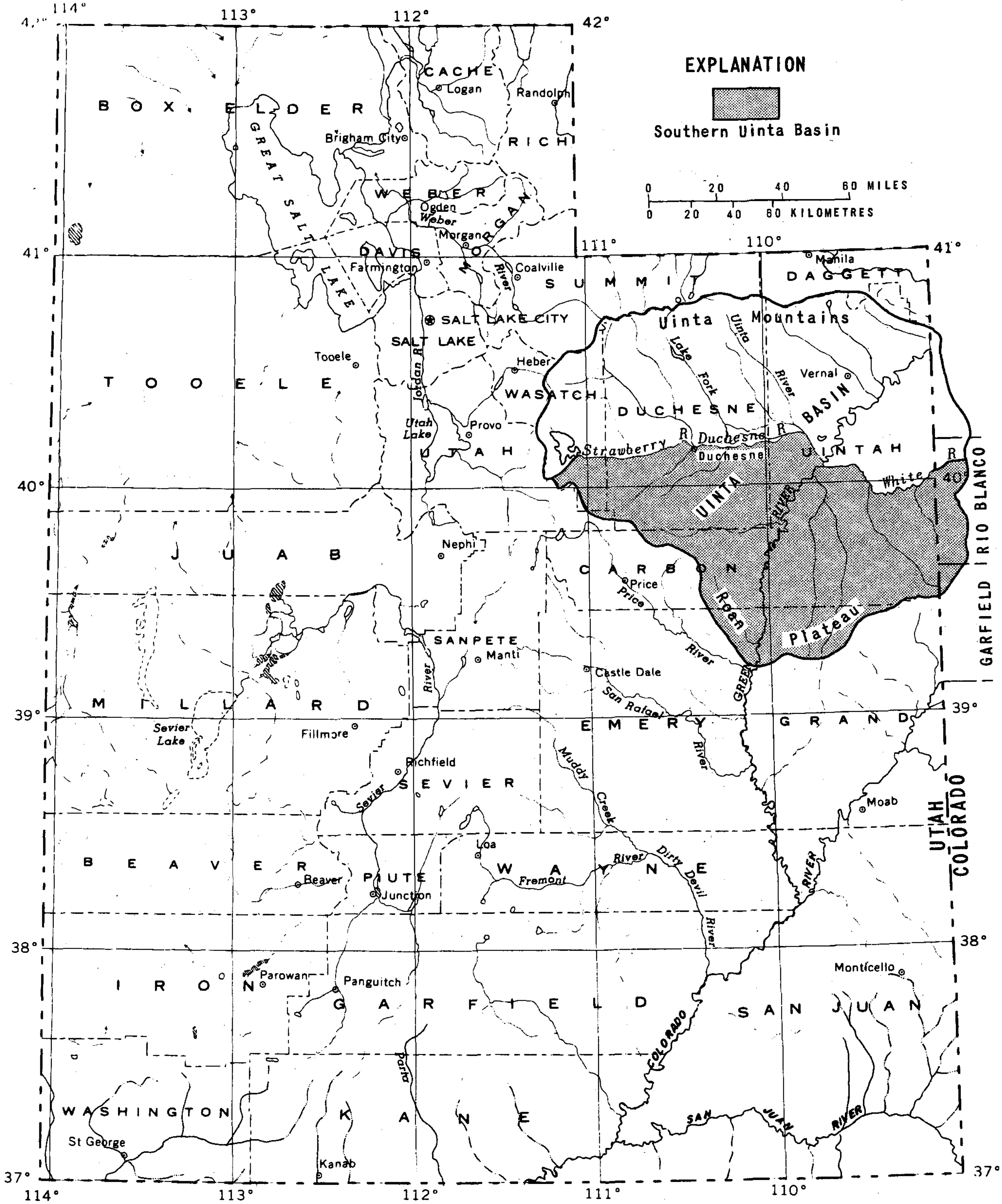

Figure I.— Location of the southern Uinta Basin.

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Well- and spring-numbering system

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well or spring, describes its position in the land net. By the land-survey system, the State is divided into four quadrants by the Salt Lake base line and meridian, and these quadrants are designated by the uppercase letters A, B, C, and D indicating the northeast, northwest, southwest, and southeast quadrants, respectively (fig. 2). Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section--generally 10 acres (4 hm^2);[1] the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring within the 10-acre (4 hm^2) tract; the letter "S" preceding the serial number denotes a spring. If a well or spring cannot be located within a 10-acre (4 hm^2) tract, one or two location letters are used and the serial number is omitted. Thus, the number (D-9-17)21dca-1 designates the first well constructed or inventoried in the NE¼SW¼SE¼ sec. 21, T. 9 S., R. 17 E., and the number (D-16-17)3c-S1 designates the first spring inventoried in the SW¼ sec. 3, T. 16 S., R. 17 E., as related to the Salt Lake base line and meridian.

In the Uinta Basin, part of the "D" quadrant has been subdivided by the Uintah base line and meridian as shown in figure 2. Wells and springs in this land parcel are numbered in the same manner described above, but the numbers are preceded by the letter "U" to show that they are related to the Uintah base line and meridian. Thus well U(C-4-4) 1daa-1 is the first well constructed or inventoried in the NE¼NE¼SE¼ sec. 1, T. 4 S., R. 4 W., Uintah base line and meridian.

[1] Although the basic land unit, the section, is theoretically a 1-mile (1.6 km) square, many sections are irregular. Such sections are subdivided into 10-acre (4 hm^2) tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

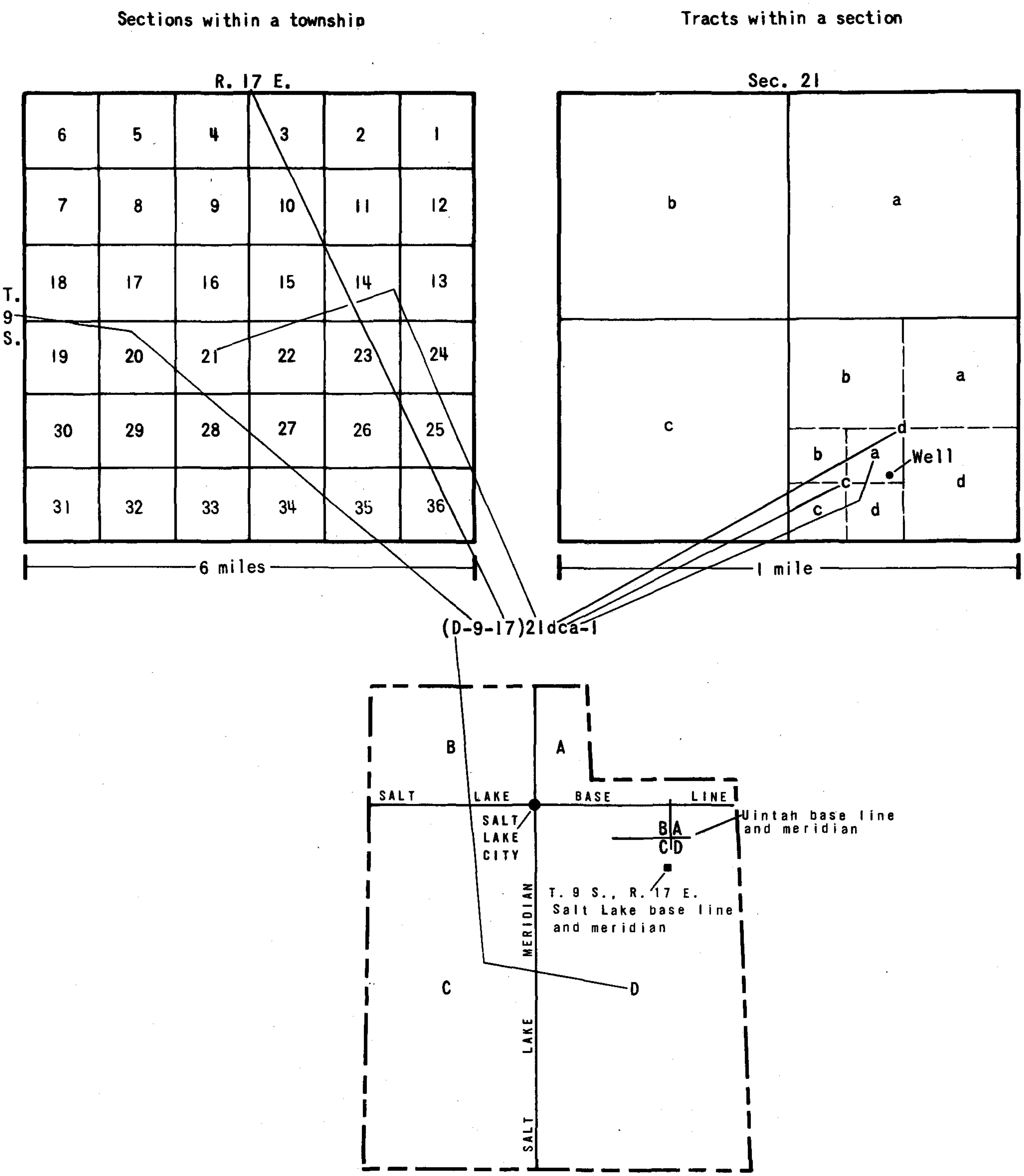

Figure 2.— Well- and spring-numbering system used in Utah.

GENERAL HYDROLOGIC ENVIRONMENT

Physiography and drainage

The Uinta Basin is in the Colorado Plateaus physiographic province (Fenneman and Johnson, 1946). It is a broad east-west trending structural basin bounded on the north by the lofty Uinta Mountains and on the south by the high Roan Plateau. The area of this report lies entirely on the south flank of the basin and is dissected into two nearly equal parts by the deeply incised southward-flowing Green River.

The surface of the southern Uinta Basin ascends rather uniformly from an altitude of about 4,700 feet (1,433 m) above mean sea level near the confluence of the Green, White, and Duchesne Rivers to more than 9,000 feet (2,743 m) along the crest of the Roan Plateau. Continuity of this surface is interrupted by deep narrow canyons of the Green River and its larger tributaries. The canyons have step-back walls whereby harder rock layers form vertical cliffs while the softer rock layers form gentle slopes. Maximum depths in the larger canyons exceed 1,000 feet (305 m), and the floors of even the largest canyons generally are less than half a mile (0.8 km) wide at their widest sections. Prominent mesas, benches, and flats, such as Flat Rock Mesa, Pariette Bench, and Wolf Flat dominate the interstream areas (pl. 1).

The lowest point in the southern Uinta Basin is about 4,200 feet (1,280 m) where the Green River crosses the south boundary; the highest point is about 10,285 feet (3,135 m) at Bruin Point, near the head of Range Creek (pl. 1). Thus, total relief in the area is more than 6,000 feet (1,829 m).

The principal streams that originate in the southern Uinta Basin are consequent. Most of these streams flow generally northward. Exceptions include Nine Mile and Range Creeks and Pariette Draw, which flow generally eastward. All drainage is ultimately to the Green River, which is the largest tributary of the Colorado River.

General geology

The geology of the southern Uinta Basin has been intensely studied from the standpoint of its oil and gas production and evaluation of oil-shale reserves. Selected references that describe the geology of the southern Uinta Basin are given on pages 46-48.

The Uinta Basin is a large synclinal trough formed by the deformation of Tertiary and older rocks. The main axis of the syncline trends generally eastward and lies roughly 10 to 20 miles (16 to 32 km) north of the northern boundary of the southern Uinta Basin (fig. 3). Thus, the rock strata in the southern Uinta Basin dip generally to the north. Exposed rocks range in age from Cretaceous to Holocene but pre-Cretaceous rocks have been penetrated by oil and gas wells and tests. (See pl. 1).

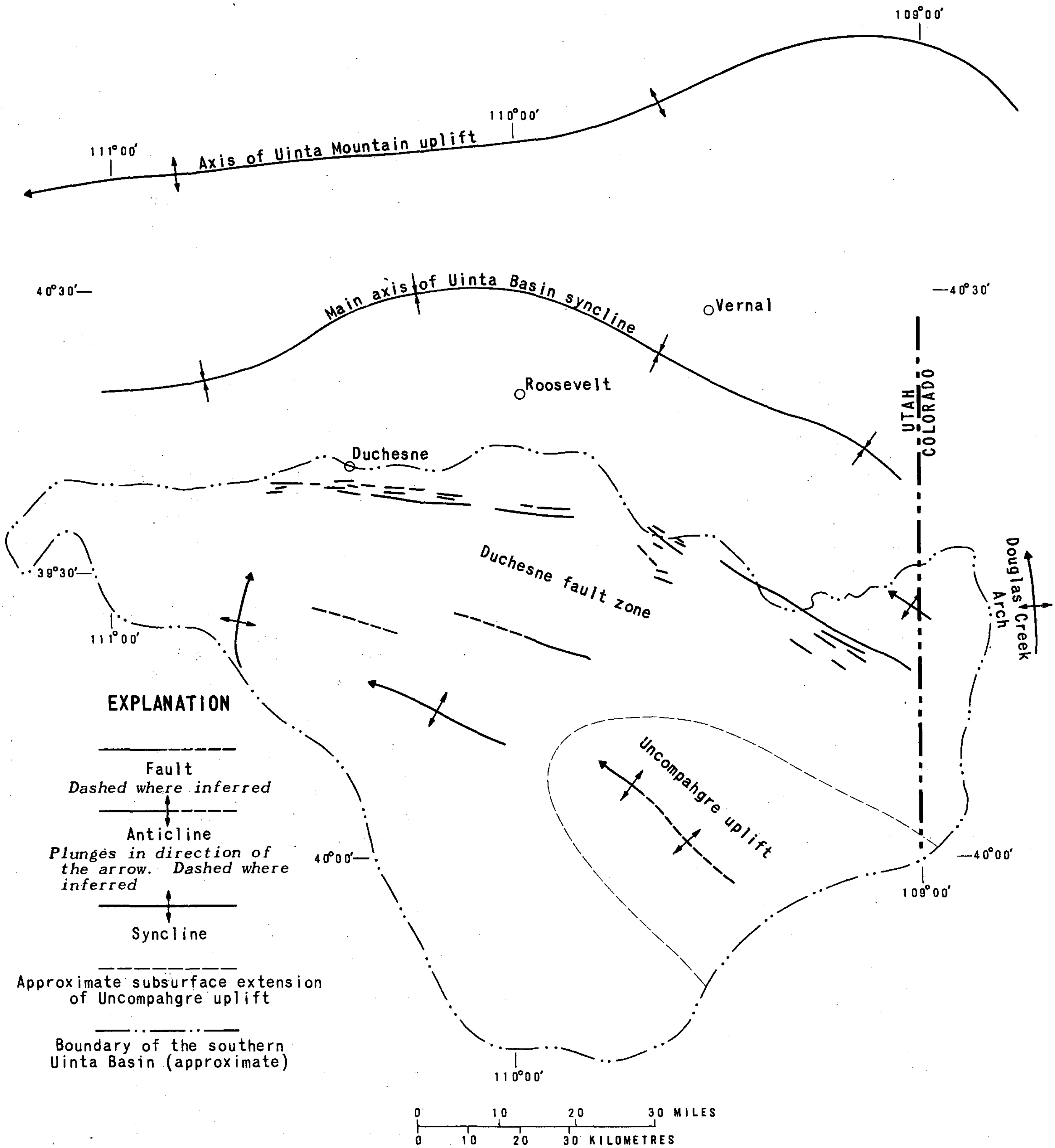

Figure 3.— Sketch showing major structural features in the Uinta Basin (after Ritzma, 1957).

The general lithologic character and water-bearing properties of the geologic formations that are exposed in the southern Uinta Basin are given in table 1. Older rocks that are encountered in the subsurface are exposed along the south flank of the Uinta Mountains, a short distance to the north, or in the Book Cliffs, to the south. The general stratigraphic section of these rocks prepared by Cashion (1967, p. 5) after Kinney (1955) is given in the following table:

System	Unit	Thickness (ft)	Dominant lithology
Cretaceous	Mesaverde Formation (Group)	1,100	Sandstone and shale
	Mancos Shale	5,070-5,290	Shale, siltstone, and sandstone
	Dakota Sandstone	95- 135	Sandstone and shale
	Cedar Mountain Formation[1]	50- 176	Sandstone and shale
Jurassic	Morrison Formation	830- 930	Sandstone, mudstone, and shale
	Curtis Formation	150- 270	Sandstone, shale, and limestone
	Entrada Sandstone	105- 215	Sandstone
	Carmel Formation	125- 390	Shale and sandstone
Jurassic and Triassic	Glen Canyon Sandstone	720-1,030	Sandstone
Triassic	Chinle Formation	230- 355	Shale, sandstone, and conglomerate
	Moenkopi Formation	820-1,120	Sandstone and siltstone
Permian	Park City Formation	70- 195	Limestone and shale
Permian and Pennsylvanian	Weber Sandstone	1,015-1,275	Sandstone
Pennsylvanian	Morgan Formation	1,035-1,450	Limestone and sandstone
Mississippian	Black shale unit	0- 265	Shale and sandstone
	Limestone unit	965-1,220	Limestone
Cambrian	Lodore Formation	0- 155	Sandstone
Precambrian	Uinta Mountain Group	3,000-4,000	Shale and sandstone

[1]Added by writers.

Table 1.--General lithologic character and water-bearing properties of exposed geologic units

Geologic age	Geologic unit	General lithologic character	General water-bearing properties
Quaternary	Unconsolidated deposits	Alluvium, glaciofluvial deposits, terrace gravels, and dune sand. Clay, sand, gravel, and cobbles beneath the alluvial plains of the larger streams and adjacent terraces and in the Pleasant Valley Wash area. Mostly gravel, sand, and silt on benches and in the channels of some ephemeral streams. Thickness generally less than 50 feet (15 m), but locally may be more than 150 feet (46 m) as at well U(C-5-5)34bdd-1 (table 11).	Sand, gravel, and cobble deposits beneath stream valleys generally yield less than 50 gal/min (3.2 l/s), but may yield more than 100 gal/min (6.3 l/s) to large-diameter wells that tap thick saturated sections. Many of the terrace deposits are unsaturated or saturated only part of the year.
Tertiary	Uinta Formation	Mostly thinly bedded shale, siltstone, and fine-grained sandstone with interbedded claystone and limestone. Individual beds generally less than 50 feet (15 m) thick. Maximum aggregate thickness more than 4,000 feet (1,219 m). Many of the strata are oil impregnated and the formation is cut in several places by gilsonite and ozocerite dikes.	Not water bearing in many places, having been drained by deeply incised streams. Where saturated (generally in discontinued perched aquifers) commonly yields less than 5 gal/min (0.32 l/s) to springs; exceptions are in Strawberry River drainage where several springs discharge an estimated 50-500 gal/min (3.2-32 l/s). Yields less than 20 gal/min (1.3 l/s) to most wells.
	Green River Formation	Thinly bedded strata of shale, siltstone, mudstone, fine-grained sandstone; some limestone and tuff. The percentage of thicker, more massive sandstone strata increases to the south. Maximum thickness of the formation exceeds 5,000 feet (1,524 m) in the north-central part of the area. Formation is noted as a source of oil and gas; the Parachute Creek Member, which comprises more than 95 of the exposed formation, contains extensive deposits of oil shale.	Overall permeability is low. All known springs that discharge from the formation discharge from the Parachute Creek Member; most yield less than 10 gal/min (0.63 l/s), and many yield less than 1 gal/min (0.06 l/s). Reported yields to the few wells that tap the formation are generally less than 10 gal/min (0.63 l/s), but several oil tests that tap the formation reportedly had initial flows of more than 100 gal/min (6.3 l/s). Upper part of the formation is not water bearing in many places owing to low permeability or having been drained by deeply incised streams.
	Wasatch Formation	Mostly shale, siltstone, and fine- to medium-grained sandstone with some lenticular conglomerate. Maximum thickness of formation exceeds 4,000 feet (1,219 m). The formation is an important source of oil and gas in the Uinta Basin.	Test data from oil and gas wells indicate that overall permeability is generally low. The formation generally yields less than 50 gal/min (3.2 l/s) of water to springs and wells (oil and gas wells), but more than 100 gal/min (6.3 l/s) to two springs in the area. No water wells are known to tap the formation in the study area.
Tertiary and Cretaceous	Sedimentary rocks, undivided	Includes Colton Formation, Flagstaff Limestone, North Horn Formation, and Mesaverde Group (Tuscher Formation). Consist chiefly of shale, siltstone, mudstone, and fine-grained sandstone; some limestone and lenticular conglomerate and coal beds. Maximum exposed thickness exceeds 2,000 feet (610 m). Maximum aggregate thickness (including units in the subsurface) exceeds 7,000 feet (2,134 m).	Permeability generally low. Support the flow of several widely scattered springs. Yields of three springs discharging from the North Horn Formation ranged from less than 1 gal/min (0.06 l/s) to about 6 gal/min (0.38 l/s). Oil-test data indicate that the rocks would yield less than 10 gal/min (0.63 l/s) of water to individual wells.

Little is known of the water-bearing properties of the older formations where they underlie the southern Uinta Basin. In adjacent areas, those of the older formations that contain sandstone and limestone as dominant lithologies locally have moderate to high permeablity. For example, the Weber Sandstone of Permian and Pennsylvanian age, which was reportedly penetrated by Continental Oil Co. test well no. 22-1 (pl. 2), is a major aquifer in the Ashley Valley oil field just north of the area. (See Goode and Feltis, 1962, and Feltis, 1966.) However, data from the few oil and gas wells and tests that penetrate the older rocks within the southern Uinta Basin indicate that these rocks generally have low permeability and commonly yield very saline to briny water.

Climate

Most of the southern Uinta Basin is arid to semiarid. Above an altitude of about 8,000 feet (2,438 m), the climate is subhumid to humid.

Average annual precipitation (1941-70) ranged from less than 8 inches (203 mm) in the north-central part of the southern Uinta Basin to more than 26 inches (660 mm) in the extreme western part (pl. 1). Annual precipitation at Duchesne ranged from 4.60 to 15.70 inches (117 to 399 mm) and averaged 9.19 inches (233 mm) during 1906-72. A curve of cumulative departure from the 1906-72 average (fig. 4) indicates that dry cycles occurred in the area during the mid-1930's, the late 1950's, early 1960's, and from 1965 to 1972.

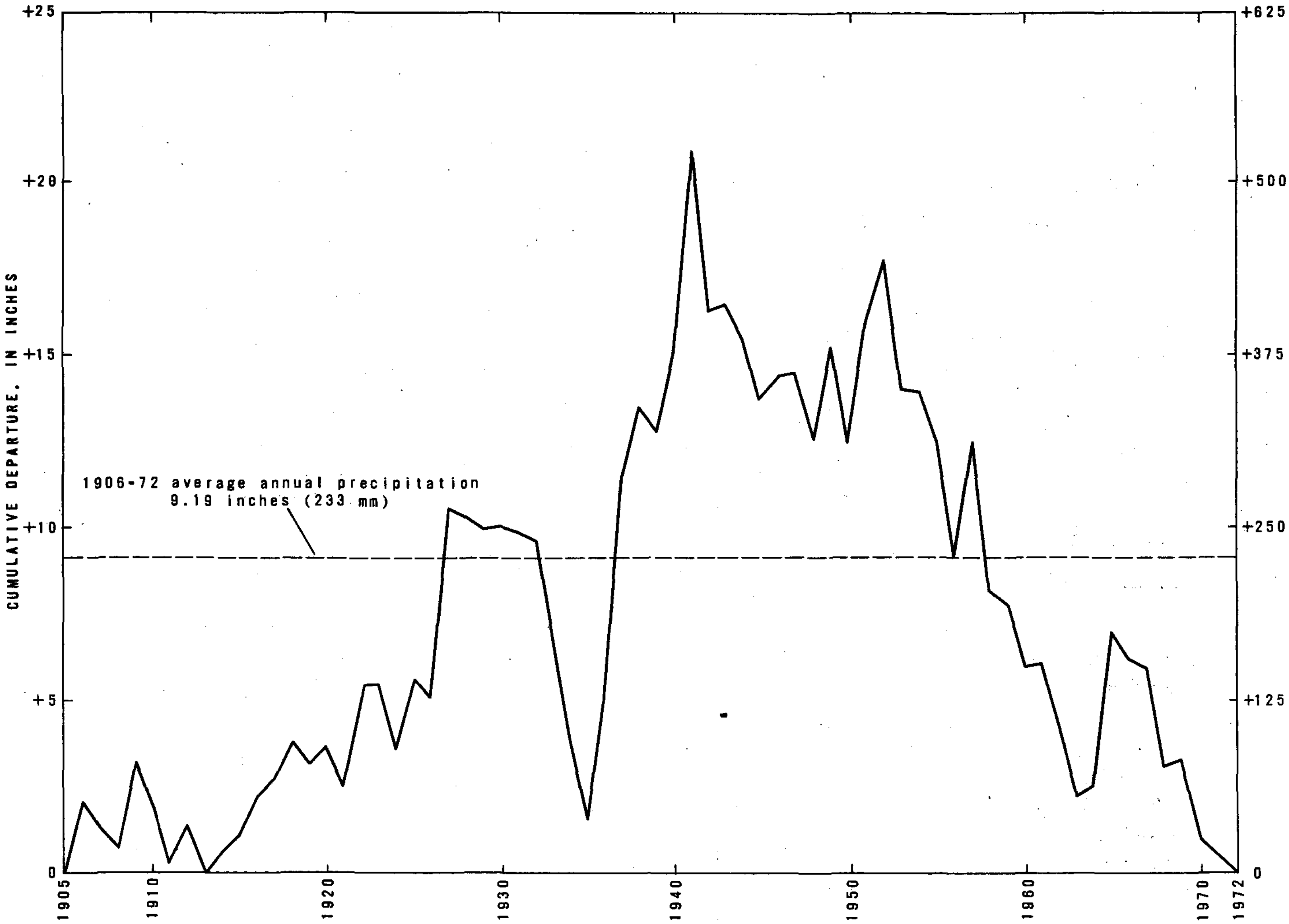

Figure 4.— Cumulative departure from average annual precipitation (1906-72) at Duchesne, Utah.

According to figure 5, most of the precipitation in the Duchesne area falls during the late summer months. This is the season of peak thunderstorm activity in the Uinta Basin. During these storms, local torrential rains result in rapid runoff and flash floods.

The Uinta Basin has hot summers and cold winters. During the period 1941-72, the mean annual temperature at Duchesne ranged from less than 20°F (-6.5°C) in January to about 70°F (21.0°C) in July (fig. 5). However, minimum midwinter temperatures commonly fall below 0°F (-18.0°C) and maximum midsummer temperatures commonly exceed 90°F (32.0°C).

Despite the cold winters, the growing season is fairly long. The average number of days between the last spring-first fall temperature of 28°F (-2.0°C) ranged from 150 at Myton to 186 at Bonanza for the respective periods of record (table 2).

Table 2.--Number of days between last spring and first fall freeze at four stations

(Data from U.S. Environmental Data Service. Numbers in parentheses are number of years of record; stations are shown on pl. 1)

	Myton	Ouray	Bonanza	Nutter Ranch
Number of days between the last spring and first fall temperature of:				
32°F (0.0°C) or below				
Average	127(19)	130(17)	155(20)	129(9)
Maximum	169	158	188	164
Minimum	95	89	126	97
28°F (-2.0°C) or below				
Average	150(19)	158(17)	186(19)	152(9)
Maximum	191	178	261	176
Minimum	99	146	145	122
24°F (-4.5°C) or below				
Average	173(22)	178(17)	207(17)	163(9)
Maximum	196	215	273	200
Minimum	139	152	159	135

Potential evapotranspiration in the southern Uinta Basin is high. Acccording to Iorns and others (1965, pl. 6), average annual lake evaporation in most of the area exceeds 36 inches (914 mm), which is considerably greater than the average annual supply from precipitation. Potential evapotranspiration at Ouray as determined by the Blaney-Criddle

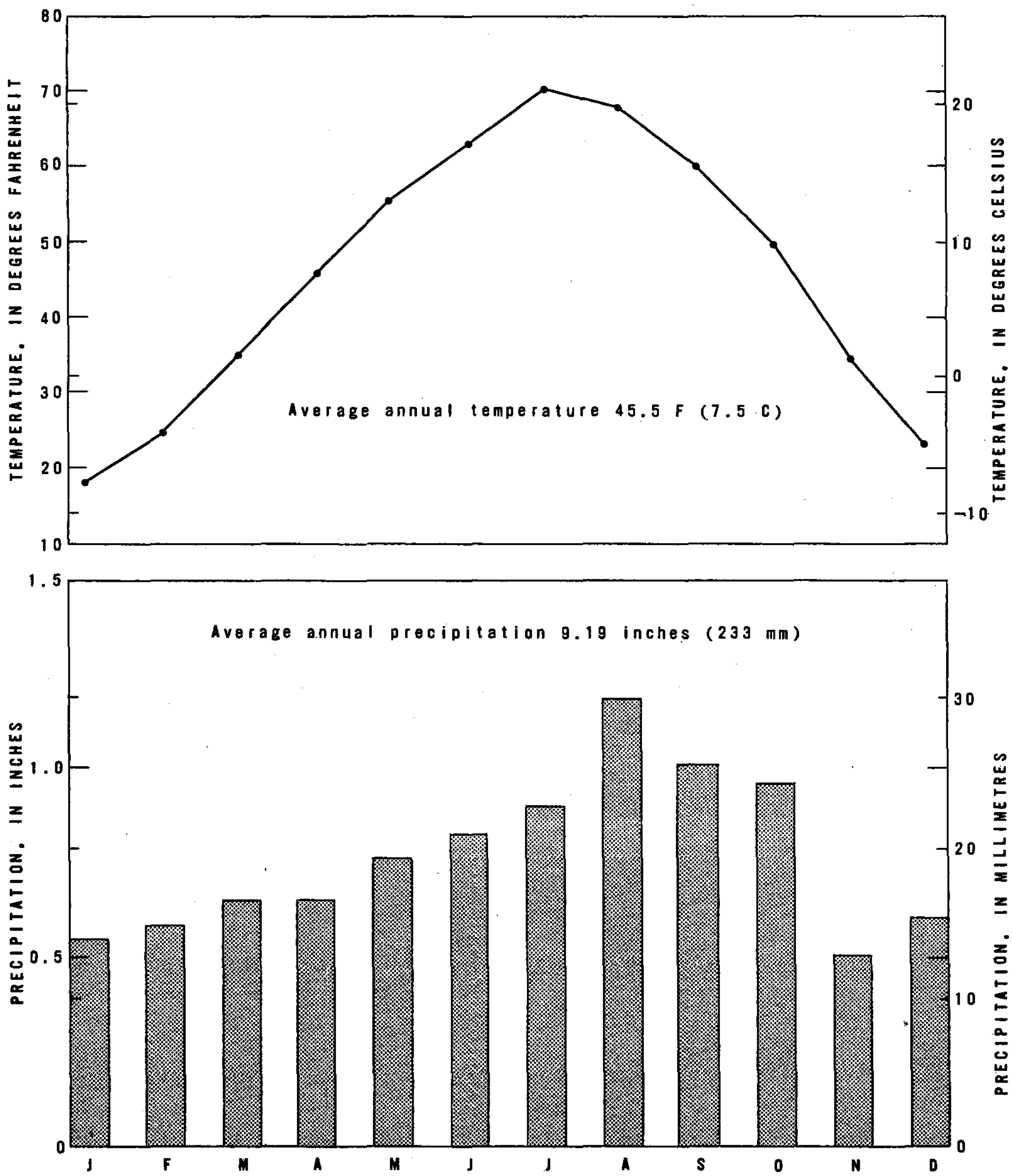

Figure 5.— Average monthly precipitation (1906-72) and average monthly temperature (1941-72) at Duchesne, Utah.

method (Cruff and Thompson, 1967, p. M15-M18) is about 51 inches (1,295 mm), or about nine times the measured average annual precipitation at that station.

Vegetation

Distribution of natural vegetation reflects the availability and chemical quality of water in the southern Uinta Basin. Along the alluvial plains of the Green, White, and lower Duchesne Rivers, where there is a perennial supply of water, the vegetative assemblage consists of a ground cover of greasewood (*Sarcobatus vermiculatus*), with scattered groves of cottonwood (*Populus* sp.), and patches of saltcedar (*Tamarix* sp.) and saltgrass (*Distichilis stricta*). Greasewood also covers most of the lower alluvial plains of the larger intermittent and perennial tributary streams that flow from the southern Uinta Basin, while saltcedar lines the stream channels. This assemblage of greasewood and saltcedar persists in larger stream valleys from the mouths up to about the 6,000-foot (1,829 m) altitude. These two phreatophye types thrive in areas where the soil is too saline or alkaline for most other plants, and they consume tremendous quantities of water.

Rabbitbrush (*Chrysothamnus* sp.), a common phreatophyte that requires a somewhat better quality water than greasewood, was observed only in Evacuation Creek above the Colorado-Utah State line and in Sams Canyon.

The upper reaches of the largest tributary streams support a vegetative assemblage that requires good quality water. This assemblage includes willow (*Salix* sp.), wild rose (*Rosa* sp.), chokecherry (*Prunus virginiana*), and native meadowgrass (*Glyceria* sp.).

Along the lower slopes of the southern Uinta Basin between streams where surface water is scarce and ground water occurs at great depths, the vegetative assemblage consists of sparse growths of shadscale (*Atriplex confertifolia*), sage (*Artemesia* sp.), and various other xerophytic plants. Upslope in the zones of increasingly greater precipitation, the vegetation changes to a sage-juniper (*Juniperus* sp.) -pinyon (*Pinus* sp.) assemblage, which eventually gives way to an assemblage of aspen (*Populus tremuloides*), various conifers, and mountain meadows along the crest of the Roan Plateau.

WATER RESOURCES

In this report the Strawberry-Duchesne-White-Green River system is considered as a drain for the southern Uinta Basin. The main stem flow of these streams is not included in the following quantitative estimates. The streams are, however, a source of supply for the southern Uinta Basin and imports from them to the southern Uinta Basin are noted in the quantitative estimates.

Volume of precipitation

The average annual volume of precipitation that fell on the southern Uinta Basin during the period 1941-70 is estimated to be about 3.1 million acre-feet (3,800 hm^3). This estimate (table 3) is based on an isohyetal map compiled by Fields and Adams (1975) for northeastern Utah. The isohyets for the southern Uinta Basin are on plate 1. In compiling the map, several low-altitude stations south of the basin were used for control because of the meager high-altitude precipitation data available in the southern Uinta Basin. Therefore, the estimated volumes of precipitation and ground-water recharge (table 3) may be low.

Table 3.--Estimated average annual precipitation and ground-water recharge from precipitation, 1941-70

Precipitation zone (inches)	Area (acres)	Precipitation		Ground-water recharge	
		Feet	Acre-feet	Percent of precipitation	Acre-feet
		Area underlain by Uinta and Green River Formations[1]			
Less than 8	508,600	0.58	295,000	0	0
8 - 10	510,900	.75	383,200	0	0
10 - 12	602,100	.92	553,900	1	5,500
12 - 14	418,400	1.08	451,900	2	9,000
14 - 16	263,800	1.25	329,800	2	6,600
16 - 18	206,700	1.42	293,500	5	14,700
18 - 20	122,000	1.58	192,800	10	19,300
20 - 22	84,100	1.75	147,200	10	14,700
22 - 24	31,600	1.92	60,700	15	9,100
24 - 26	11,800	2.08	24,500	20	4,900
More than 26	14,200	2.25	32,000	25	8,000
		Area underlain by Wasatch Formation and undivided rocks[1]			
Less than 8	33,400	0.58	19,400	0	0
8 - 10	126,300	.75	94,700	1	900
10 - 12	109,100	.92	100,400	2	2,000
12 - 14	43,400	1.08	46,900	5	2,300
14 - 16	24,500	1.25	30,600	5	1,500
16 - 18	14,500	1.42	20,600	10	2,100
Totals (rounded)	3,125,000		3,100,000		100,000

[1]Includes local mantle of unconsolidated surficial deposits.

Most of the precipitation that falls within the southern Uinta Basin is consumed by evapotranspiration and by sublimation from the winter snowpack at or near the place of fall. Some of the precipitation results in overland runoff, most of which also is consumed by evapotranspiration within the southern Uinta Basin. A small percentage of the precipitation seeps to the zone of saturation as ground-water recharge. Some of the recharge occurs as seepage through the rocks and soils upon which the precipitation falls and some occurs as seepage from streambeds.

Surface water

Principal streams

The Green, White, Duchesne, and Strawberry Rivers are the largest streams in the Uinta Basin. They all head beyond the boundaries of the southern Uinta Basin and mainly are confined to deep, narrow canyons where they touch on or flow through the area. These rivers receive runoff from the southern Uinta Basin by way of several perennial streams and numerous intermittent and ephemeral streams. The largest of the perennial and intermittent streams are Pariette Draw and Avintaquin, Antelope, and Nine Mile Creeks west of the Green River, and Willow, Bitter, and Evacuation Creeks east of the Green River (pl. 1). These streams drain about 58 percent of the southern Uinta Basin.

Streamflow measurements have been made at existing or former gaging stations along the Green, White, Duchesne, and Strawberry Rivers as well as several of the perennial and intermittent streams that flow from the southern Uinta Basin. Streamflow records collected at these stations are summarized in table 4.

Runoff characteristics

Runoff from the southern Uinta Basin is highly variable. For example, during the 20 years of record at gaging station 09308500 on Minnie Maud Creek, total annual runoff ranged from less than 1,000 acre-feet (1.2 hm^3) to more than 11,000 acre-feet (13.6 hm^3); and during the 18 years of record at gaging station 09307500 on Willow Creek, total annual runoff ranged from less than 10,000 acre-feet (12.3 hm^3) to more than 24,000 acre-feet (29.6 hm^3) (fig. 6).

Most of the runoff is during the spring and early summer (fig. 7) and is produced by melting of the winter snowpack along the high southern rim of the Uinta Basin. During the late summer months, however, cloudburst storms may result in severe local floods. This is evidenced in table 5, which shows that the annual peak discharge at three partial-record gaging stations in the southern Uinta Basin most commonly occurred in July, August, or September. In some parts of the area, stream channels are dry most of the year; consequently, a single summer cloudburst flood may account for a large percentage of the total annual runoff.

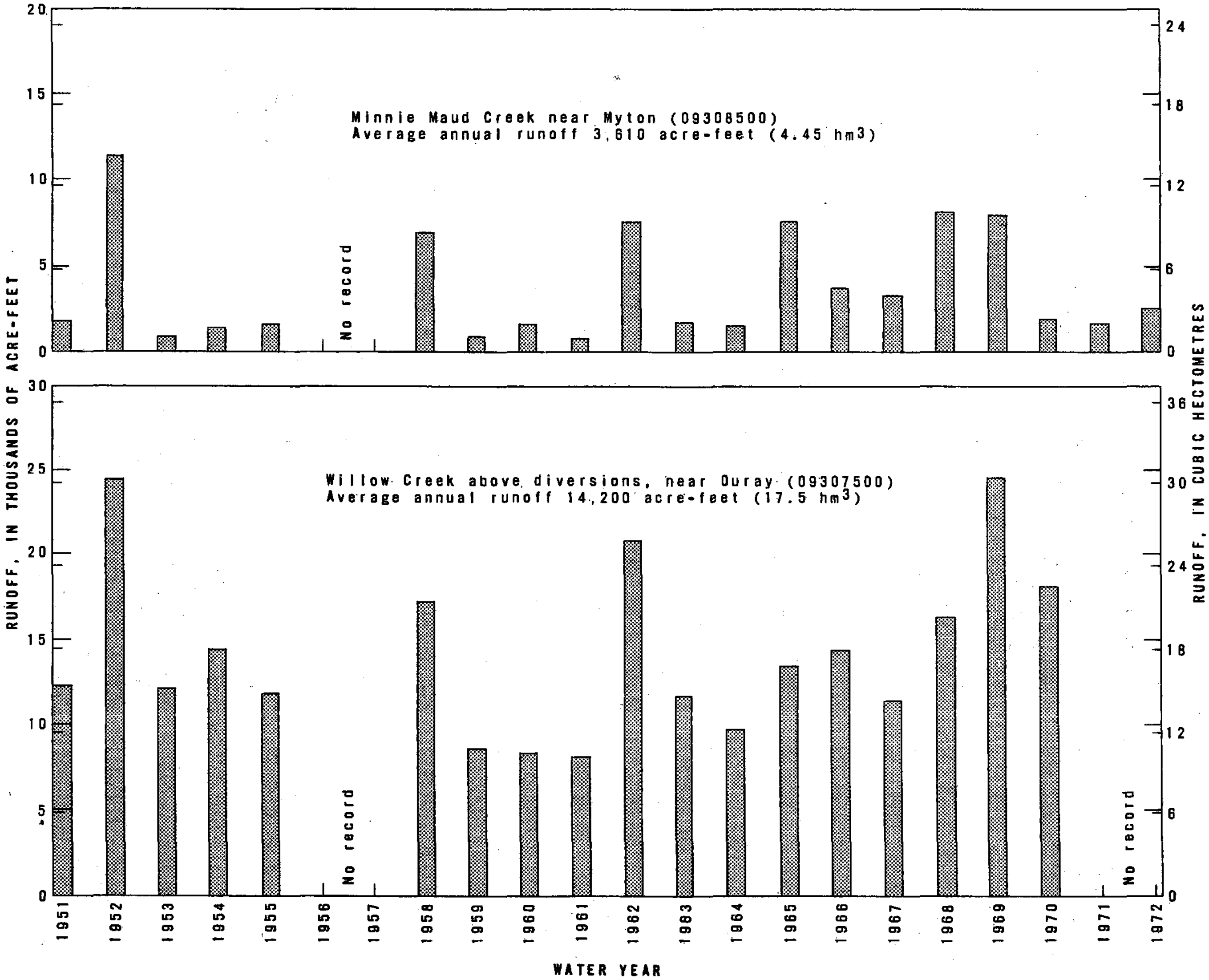

Figure 6.— Total annual runoff at two gaging stations. (Number identifies station on pl. 1.)

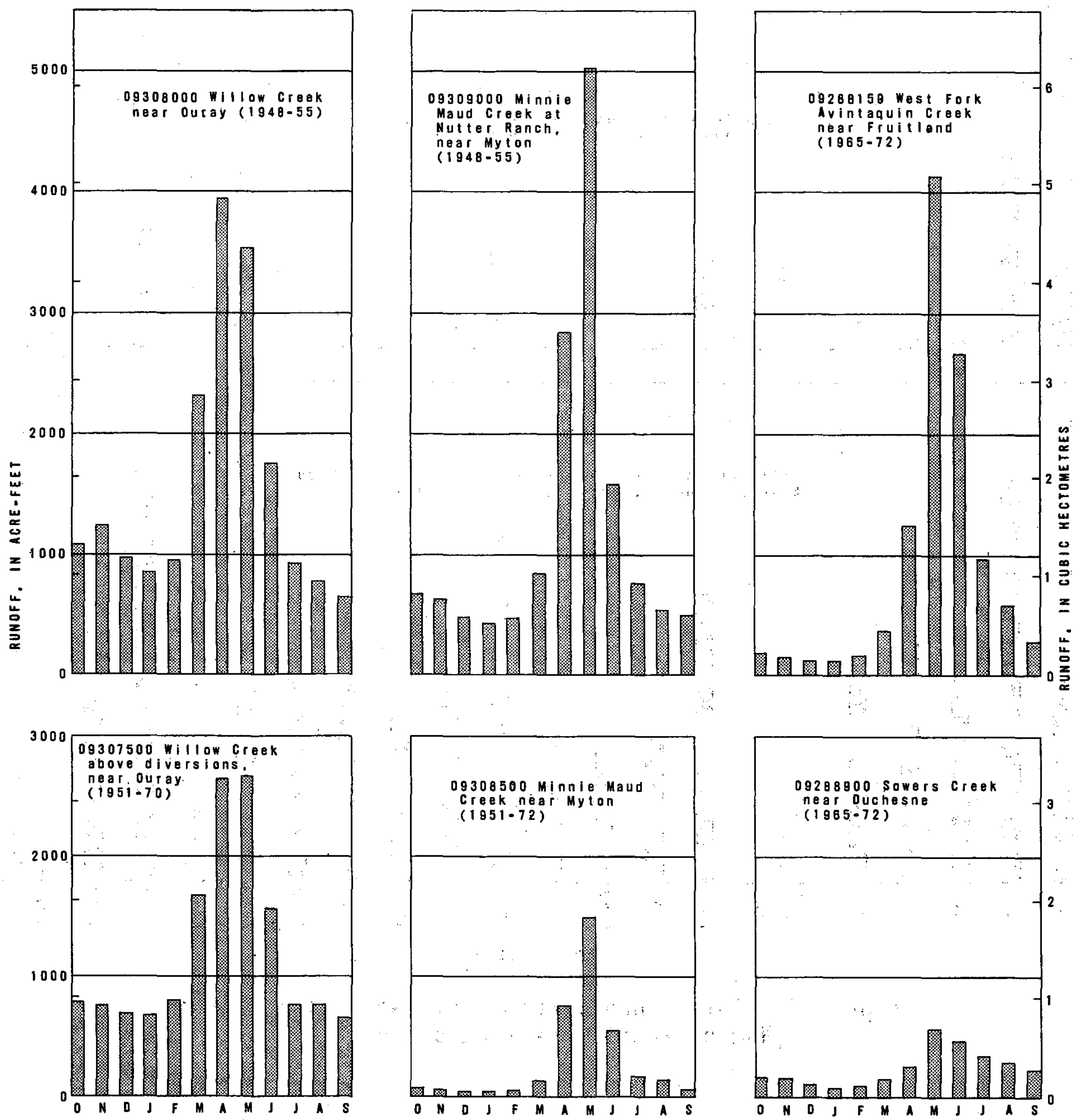

Figure 7.— Average monthly runoff at selected gaging stations. (Number identifies station on pl. 1.)

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Table 4.--Summary of streamflow records collected at selected stream-gaging stations

Period of record: Stations with records extending to September 1972 were still in operation as of that date.

Station number (see pl. 1)	Name	Drainage area (mi^2)	Period of record	Average discharge			Extremes (ft^3/s)			
				ft^3/s	Acre-ft/yr	Number of years	Maximum	Date	Minimum	Date
09285000	Strawberry River near Soldier Springs	1/210	Oct. 1942-Sept. 1956; Oct. 1963-Sept. 1972	31.0	22,500	23	1,020	5- 4-52	6.5	1-23-64
09285500	Willow Creek near Soldier Springs	44	June 1943-Sept. 1947	5.3	3,865	4	192	7-30-43	0	During several months of the year
09285700	Strawberry River above Red Creek, near Fruitland	1/360	Oct. 1963-Sept. 1972	58.8	42,600	9	610	5-14-64	9.7	12-8-63
09288150	West Fork Avintaquin Creek near Fruitland	56	June 1964-Sept. 1972	15.0	10,870	8	1,830	8-22-71	.2	1-24-65
09288500	Strawberry River at Duchesne	1/950	June 1908-Nov. 1910; Mar. 1914-Sept. 1968	151	109,300	54	3,490	5- 7-52	1.0	Several days in July 1931
09288900	Sowers Creek near Duchesne	43	May 1964 - Sept. 1972	3.9	2,830	8	202	8- 3-66	0	Part of winter of 1964-65
09295000	Duchesne River at Myton	2,750	Discontinuous, Oct. 1899-Nov. 1910; continuous, July 1911-Sept. 1972	533	386,200	64	12,800	6-10-22	Less than 1.0	7-16-31, several days in Aug. and Sept. 1934
09302000	Duchesne River near Randlett	3,920	Oct. 1942-Sept. 1972	589	426,700	30	10,300	6-13-65	2.2	8-12-61
09306500	White River near Watson	4,020	Apr. 1904-Oct. 1906; May-Nov. 1918; Apr. 1923-Sept. 1972	700	507,200	49	8,160	7-15-29	53	7-19-34
09306800	Bitter Creek near Bonanza	324	Oct. 1970-Sept. 1972	-	-	-	507	8-30-71	0	Many days each year
09307000	Green River near Ouray	35,500	Oct. 1947-Sept. 1955; Oct. 1956-Sept. 1966	5,428	3,930,000	18	43,600	6-11-52	470	July 31, Aug. 1, 1933
09307500	Willow Creek above diversions, near Ouray	300	Aug. 1950-Sept. 1955; Sept. 1957-Sept. 1970	19.6	14,200	18	668	8- 6-63	.3	Aug. 21-23, 1960
09308000	Willow Creek near Ouray	890	July 1947-Sept. 1955; (annual max. 1961, 1962-68)	27.0	19,550	8	2,320 2/2,600	8-27-52 7-31-64	0	Several times
3/09308200	Pleasant Valley Wash tributary near Myton	15	Oct. 1959-Sept. 1972	-	-	-	2,590	7- 9-68	0	Most of the time
09308500	Minnie Maud Creek near Myton	30	Aug. 1950-Sept. 1955; Sept. 1957-Sept. 1972	5.0	3,610	20	1,370	8-25-61	0	Several times
09309000	Minnie Maud Creek at Nutter Ranch, near Myton	230	July 1947-Sept. 1955 2/; (annual max. Oct. 1959-Sept. 1972)	20.4	14,770	8	1,370	8-25-55	0	Do.
3/09309100	Gate Canyon near Myton	5.4	Oct. 1959-Sept. 1972	-	-	-	2/860 860	8- 2-61 9- 6-63	0	Most of the time

1/ Includes approximately 170 square miles tributary to Strawberry Reservoir, from which water is diverted out of the Uinta Basin to the Great Basin.
2/ Estimated.
3/ Records annual maximum discharge only.

The magnitude and frequency of the annual peak discharges at the three stations listed in table 5 are shown in figure 8 by the Log-Pearson Type III analysis data. As shown in figure 8 at station 09309000 on Minnie Maud Creek, a discharge of about 750 ft^3/s (21.2 m^3/s) will be equaled or exceeded on the average of once every 2 years or has a 50 percent probability of occurring in any 1 year. At station 09309100 on Gate Canyon, a discharge of about 300 ft^3/s (8.51 m^3/s) will be equaled or exceeded on the average of once every 2 years or has a 50 percent chance of occurring in any 1 year. At station 09308200 on Pleasant Valley Wash tributary, a discharge of about 1,100 ft^3/s (31.1 m^3/s) would be equaled or exceeded on the average of once every 5 years and has a 20 percent probability of occurring in any 1 year.

Table 5.--Annual peak discharges at three partial-record gaging stations for water years, 1960-72

Annual peak discharge (ft^3/s)	Date
Minnie Maud Creek at Nutter Ranch, near Myton (station 09309000)	
400	Sept. 1, 1960
1,000	Sept. 18, 1961
680	Sept. 22, 1962
690	Sept. 7, 1963
240	July 13, 1964
850	Aug. 16, 1965
620	Aug. 1, 1966
495[1]	Aug. 31, 1967
250	Oct. 5, 1967
460	Sept. 10, 1969
591	Sept. 1, 1971
143	June 17, 1972
Gate Canyon near Myton (station 09309100)	
34[2]	Sept. 17, 1960
860[2]	Aug. 2, 1961
125	Mar. 24, 1962
860	Sept. 6, 1963
840	Aug. 16, 1965
466[2]	Aug. 3, 1966
8.2	June 5, 1967
280	Between May 10 and Oct. 21, 1968
390	Sept. 7, 1969
280	Sept. 6, 1970
280	Sept. 1, 1971
180	June 18, 1972
Pleasant Valley Wash tributary near Myton (station 09308200)	
3.5[2]	Sept. 17, 1960
183	Sept. 9, 1961
230[2]	Feb. 13, 1962
969	Aug. 6, 1963
1,350	June 12, 1965
20	July 1, 1966
2,590[1]	July 9, 1968
93	Sept. 17, 1969
31	Sept. 6, 1970
1,110	Aug. 27, 1971

[1]Determined by field survey.
[2]Estimated.

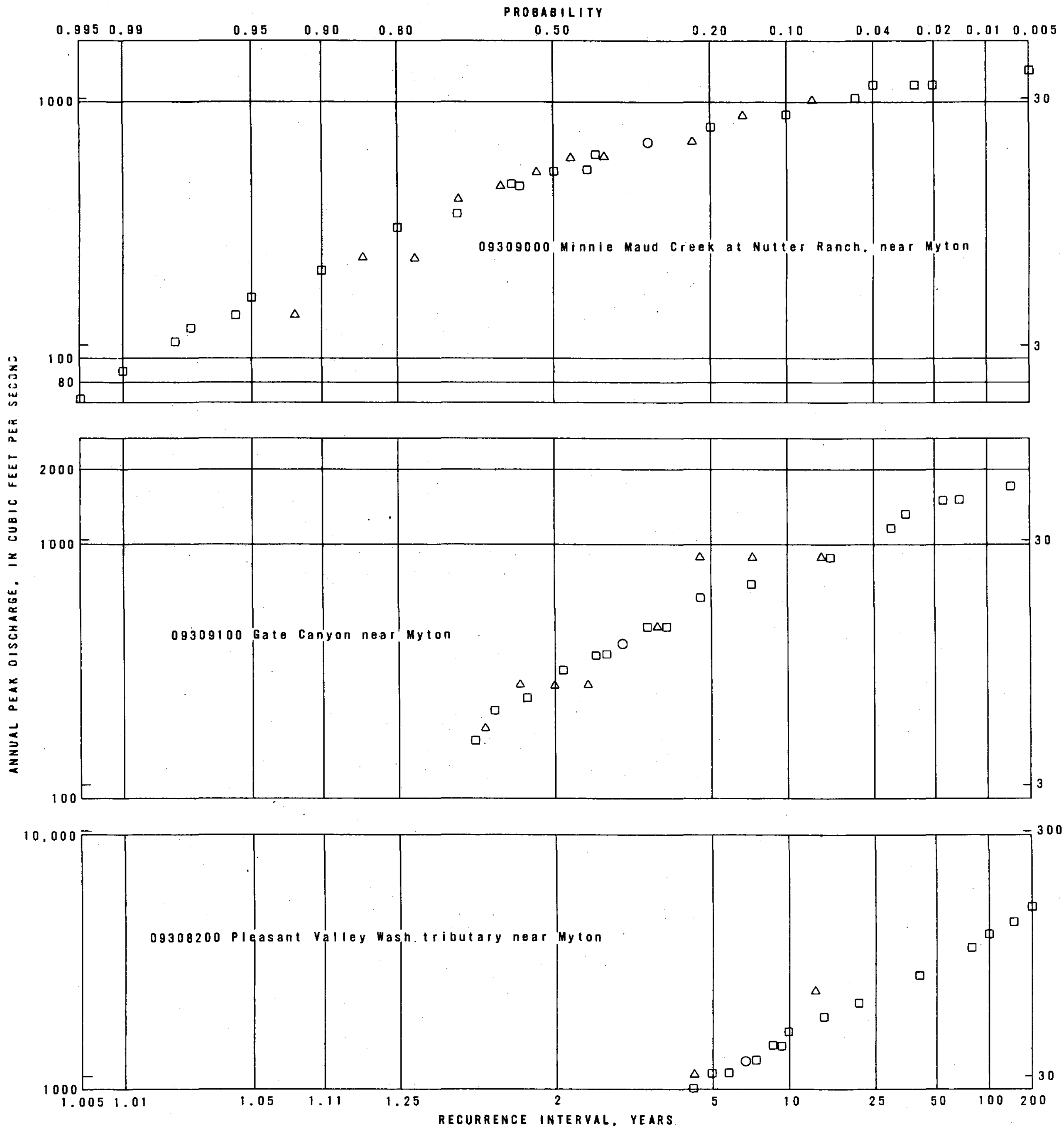

Figure 8.– Magnitude and frequency of annual peak discharges at three partial-record gaging stations. (See pl. I for locations of stations.) △, estimated value from partial-record station; □, calculated value from Log-Pearson Type III analysis; ○, estimated value and calculated value in same position.

Estimated mean annual runoff

Mean annual runoff from the southern Uinta Basin is estimated to be on the order of 134,000 acre-feet (165 hm^3). This estimate is based partly on a method described by Moore (1968) to determine mean annual runoff from ungaged areas using stream-channel geometry characteristics. Estimates of runoff at selected sites are given in table 6.

The channel-geometry method of estimating mean annual runoff assumes that the cross-sectional area of a stream channel at a given site is determined by the long-term runoff past that site; it has proven reasonably accurate when tested in gaged drainage basins. The error of estimate using stream-channel geometry is lowest for perennial streams with high annual runoff and highest for ephemeral streams with low annual runoff. According to F. K. Fields (U.S. Geol. Survey, oral commun., 1973) the error of estimate for gaged streams in the Utah part of the Colorado River system was about 14 percent for perennial streams and about 20 percent for ephemeral streams. In the southern Uinta Basin, the estimated runoff in Willow Creek at the site of former station 09308000 (table 6, site 13) was within 3 percent of the average annual gaged runoff for 8 years of record (table 4). The estimated mean annual runoff from Avintaquin Creek is 14,600 acre-feet (18 hm^3) (table 6, site 2). This estimated runoff is only about 7 percent greater than the average annual runoff (1969-72) from that basin as determined by the difference of the gaged discharge of the Strawberry River immediately above (including inflow from Red Creek) and below the mouth of Avintaquin Creek.

The largest discrepancy (about 40 percent) between estimated mean annual runoff and average annual gaged runoff was for Willow Creek at the site of station 09307500 (see tables 4 and 6). Recent high runoff and streambank erosion at the site made it unusually difficult to determine the channel characteristics that result from long-term mean annual runoff.

Stream-channel geometry measurements were made at or near the mouths of all principal streams draining to the Green, White, Duchesne, and Strawberry Rivers. This provided an estimate of runoff from about 3,300 square miles (8,547 km^2) or 67 percent of the southern Uinta Basin.

Most of the area for which channel-geometry determinations were not made included the largely inaccessible areas that drain to the Green River in Desolation Canyon and several of the upland areas that drain to the upper Strawberry River. In order to estimate mean-annual runoff from these areas, an altitude-runoff relation using data given in table 6 was calculated and applied to the inaccessible areas. Because of the numerous small individual drainages in these areas, however, the results proved unsatisfactory. They were too high. Therefore, an estimate for runoff-per-unit-area--27.3 acre-feet (0.03 hm^3) per square mile (2.6 km^2) per year--was determined from data given in table 6 and applied to the entire southern Uinta Basin. This gave an estimate for total annual runoff from the southern Uinta Basin of about 134,000 acre-feet (165 hm^3)--about 90,000 acre-feet (111 hm^3) from basins listed in table 6 and

Table 6.--Estimated mean-annual runoff at selected sites
(Estimates by F. K. Fields and Don Price)

Type: EI, ephemeral or intermittent; P, perennial.

Number on plate 1	Name	Type	Drainage basin: Area (mi²)	Drainage basin: Mean altitude (ft)	Runoff (acre-ft/yr)
1	Timber Canyon	P	47	4,450	5,800
2	Avintaquin Creek	P	140	8,100	14,600
3	Sams Canyon	EI	24	7,565	1,680
4	Indian Canyon	P	98	7,595	1,270
5	Right Fork Indian Canyon	P	28	7,960	450[1]
6	Coyote Canyon	EI	17	6,295	220
7	Cottonwood Canyon	EI	30	6,935	760
8	Antelope Creek	P[2]	200	7,280	1,270
9	Unnamed	EI	8.6	5,550	840[1]
10	Big Wash	EI	42	6,465	520[1]
11	Peters Wash	EI	14	6,210	730[1]
12	Pariette Draw	P[3]	310	5,875	18,900
13	Willow Creek (At gaging station 09308000)	P[2]	940	7,000	20,100
14	Willow Creek (At gaging station 09307500)	P	310	7,650	8,400[1]
15	Ute Canyon	EI	4.5	6,675	140[1]
16	Cottonwood Wash	EI	140	5,445	850
17	Bitter Creek (At gaging station 09306800)	EI	320	6,945	800
18	Evacuation Creek	EI	300	6,560	2,630
19	do	EI	220	6,860	780[1]
20	Park Canyon	EI	32	6,425	10[1]
21	Hells Hole Canyon	EI	28	6,240	40
22	Gilsonite Draw	EI	8.5	6,160	70
23	Cottonwood Creek	EI	48	5,970	720
24	Shavetail Draw	EI	10	5,660	290
25	Sand Wash	EI	1.1	6,560	110[1]
26	do	EI	10	5,895	1,650
27	Nine Mile Creek	P	230	7,890	14,800[1]
28	do	P	460	7,500	15,800
29	Range Creek	EI	150	7,195	2,160

[1]Represents runoff past the site but not from the project area. Not used to estimate total runoff from the project area.

[2]Intermittent at mouth owing to upstream diversions for irrigation and to consumptive use by native vegetation.

[3]Receives tailwater from the Duchesne River diversions for irrigation in the Pleasant Valley area.

about 44,000 acre-feet (54 hm^3) from those basins for which channel-geometry determinations were not available.

Using runoff maps for Utah compiled by Bagley and others (1964), potential mean annual runoff from the southern Uinta Basin (including the part in Colorado) was estimated to be on the order of 240,000 acre-feet (296 hm^3). This assumes an average mean annual runoff of 0.25 inch (6 mm) for the areas shown on the maps of Bagley and others (1964) that produce less than 1 inch (25 mm) of runoff. This estimate is about 106,000 acre-feet (131 hm^3) greater than the estimate based on channel geometry; and it may be too high because the runoff maps were compiled largely from data collected along the Wasatch Front where consumptive use of streamflow by phreatophytes is not as pronounced as in the southern Uinta Basin (see Bagley and others, 1964, p. 65). Assuming both estimates to be reasonably correct, however, then as much as 106,000 acre-feet (131 hm^3) of the water available for runoff is consumed by evapotranspiration along the principal waterways where consumptive use of water by phreatophytes and other vegetation is greatest. An example of the depletion of streamflow by phreatophytes is illustrated by streamflow data collected along Willow Creek. (See table 7.)

Table 7.--Streamflow data collected along Willow Creek, September 27 and 28, 1972

Specific conductance: f, determined by field conductivity meter; L, determined by laboratory analysis; see also table 13.

Location number (see pl. 1)	Date	Discharge (ft^3/s)	Specific conductance (micromhos/cm at 25°C)	Miles downstream from site S1	Miles between sites
S1	9-27-72	3.52	1,000f	-	-
S2	do	3.07	1,000f	3.2	3.2
S3	do	3.06	1,000f	5.5	2.3
S4	do	2.85	1,010L	8.7	3.2
S5[1]	do	.26	-	19.4	10.7
S6	9-28-72	.25	6,000L	21.5	2.1
S7	do	.08	5,970L	23.0	1.5
S8	do	0	-	25.4	2.4

[1]Undetermined amount of water diverted for irrigation above this site.

According to table 7, there is a streamflow depletion of 0.45 ft^3/s (0.013 m^3/s) in the 3.2-mile (5.1 km) reach of Willow Creek between sites S1 and S2. Along this reach the valley floor is covered with a luxuriant growth of greasewood, and the stream is lined locally with saltcedar. There are no manmade streamflow diversions. Also, it seems unlikely that there is any stream loss to the underlying bedrock formations because artesian conditions apparently exist along this reach as indicated by Sulphur Spring, (D-12-21)19bdd-S1, and artesian well

(D-11-21)31bdd-1 just below the reach. Under such conditions, the stream would be gaining water from rather than losing water to the bedrock aquifers. Therefore, it is assumed that, except for a small amount of evaporation from the stream surface and streambanks, the depletion of 0.45 ft^3/s (0.013 m^3/s) along the reach between sites S1 and S2 is caused entirely by the draft of phreatophytes growing on the alluvial plain. The water is induced to move from the stream to adjacent alluvial aquifers by the pumping effect of the phreatophytes, as shown in figure 9.

This condition exists along the lower reaches of all the larger perennial and intermittent streams in the southern Uinta Basin. It is interesting to note that the stream-loss rate of about 0.14 ft^3/s (0.004 m^3/s) per mile (1.6 km) between sites S1 and S2 approximately equals the average stream-loss rate along the entire 25.4-mile (40.9 km) reach between sites S1 and S8, which includes at least 250 acres (101 hm^2) of irrigated land. Because of the similiarity of physiography, geology, natural vegetation, and irrigated crops in the southern Uinta Basin, this factor might apply to the lower reaches of most of the perennial streams. Probably a higher stream-loss factor exists in lower Nine Mile Creek where natural vegetation is more dense and includes more saltcedar.

It should be noted that the above stream-loss factor was determined at the end of September, when the phreatophytes were going into dormancy. Midsummer consumptive use rate by these plants doubtless would be greater whereas midwinter rates, if any, would be much less. Consumptive use in late September (and the determined stream-loss factor), therefore, might represent the annual mean. These figures are used in the section on ground-water discharge to estimate the annual rate of ground-water discharge by evapotranspiration along major stream courses.

Imports

Water is imported from the Duchesne River for irrigation in the Pleasant Valley area and along the alluvial plain south of the Duchesne River downstream from the town of Duchesne. The largest imports are through the Grey Mountain-Pleasant Valley and Myton Townsite Canals (not discernible on map). Average annual diversions into these two canals were about 70,400 acre-feet (87 hm^3) during the period 1935-72 according to the annual reports of the Duchesne and Strawberry River Commissioner. Several smaller canals and ditches also divert Duchesne River water into the southern Uinta Basin for irrigation on the alluvial plain south of the river. Total diversions into these smaller canals and ditches are not known but probably average less than 5,000 acre-feet (6.2 hm^3) per year. Therefore, total gross annual imports as of 1972 probably averaged about 75,000 acre-feet (92.5 hm^3).

Some streamflow from the westernmost part of the southern Uinta Basin is stored in Starvation Reservoir and some of this water is eventually returned to the area together with the imported water. Average

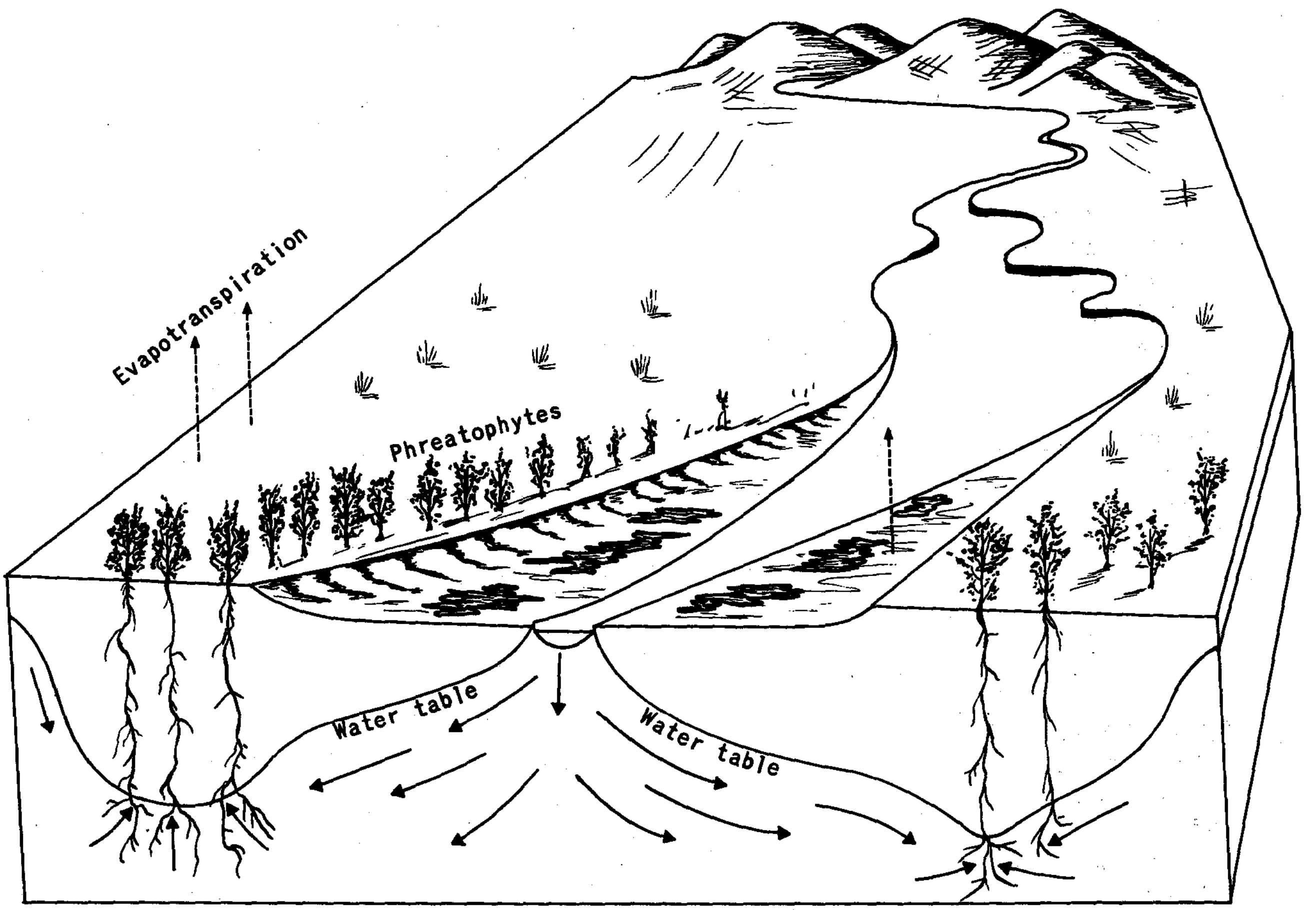

Figure 9.— Sketch illustrating how water moves from streams to adjacent alluvial aquifers and is consumed by phreatophytes.

annual inflow to Starvation Reservoir from the western part of the area is estimated to be on the order of 26,000 acre-feet (32.1 hm^3). Nearly all of this inflow is from Avintaquin, Timber Canyon, and Sams Canyon Creeks (table 6) and from Willow Creek (station 09285500 in table 4). There is no direct method to determine how much water from these streams is returned to the southern Uinta Basin with the imported water. Considering evaporation losses in the reservoir perhaps 91 percent of this water could be released from the reservoir to the Duchesne River and returned to the area with the imported water. This is roughly 24,000 acre-feet (29.6 hm^3) per year, or about 6 percent of the flow of the Duchesne River at Myton. Therefore the estimated average annual import of 75,000 acre-feet (92.5 hm^3) per year is reduced by 6 percent, and the net import is on the order of 70,000 acre-feet (86.3 hm^3) per year.

Some of the imported irrigation water is returned as tailwater to the Duchesne River, and water from the Pleasant Valley area reaches the Green River through Pariette Draw. Records are not available from which to determine the volume of imported irrigation water that is returned to the Duchesne and Green Rivers; but it could average as much as 30 percent of the total diversion, or on the order of 20,000 acre-feet (24.7 hm^3) per year.

Some water also is imported from various sources in the northern Uinta Basin for culinary use in the Duchesne-Myton-Pleasant Valley area. The amount is not known but probably is less than 500 acre-feet (0.6 hm^3) per year. All this water is consumed within the southern Uinta Basin.

Ground water

Recharge

Ground-water recharge in the southern Uinta Basin is derived from precipitation that falls within that subbasin and seepage losses of water imported for irrigation. Geologic structure may permit subsurface inflow through pre-Tertiary rocks, as in the northwestward plunging Uncompahgre uplift (see fig. 3), but there are no data to support this assumption. Also the northward-dipping strata that crop out in the Book Cliffs to the south probably convey some water into the area. However, the amount of inflow is assumed to be small because the zone of potential ground-water recharge high in the Book Cliffs is confined to a few narrow outcropping bands of permeable strata that are capable of intercepting precipitation and runoff and conveying it into the southern Uinta Basin.

The principal source of ground-water recharge is precipitation that falls on the high southern rim of the Uinta Basin. Water from rain and melting snow percolates directly, or from streams, into the underlying sedimentary rocks. Recharge from precipitation was estimated using a method developed by Eakin and others (1951, p. 79-81) and modified by Hood and Waddell (1968, p. 22-23). The method assumes that a fixed percentage of the average annual precipitation becomes ground-water recharge, taking into account such factors as volume, time, and area of distribution of precipitation, geology, and physiography. The estimate includes not only direct recharge from precipitation but also recharge from streamflow.

Because of the predominantly fine-grained nature and low permeability of the rocks in the recharge area, percolation rates are very slow. It is assumed, therefore, that most recharge occurs during the winter when rain and snowstorms are more widespread and of longer duration. The torrential late summer storms, which produce most of the total annual precipitation (p. 12) and significant runoff, are generally of too short duration to significantly add to ground-water recharge. Therefore, it is estimated that only about 100,000 acre-feet (123 hm^3) or about 3 percent of the estimated average annual precipitation becomes ground-water recharge. (See table 3.)

Ground-water recharge from imported irrigation water is significant in the Pleasant Valley area and along the alluvial plain of the Duchesne River. R. W. Cruff and J. W. Hood (U.S. Geol. Survey, written commun., 1974) found that the net loss from the Grey Mountain and Pleasant Valley Canal system averaged 24.5 ft^3/s (0.7 m^3/s) during seepage studies made between May 1972 and June 1973. Part of this water apparently reappears at the surface near the canals where it is consumed by evapotranspiration. This is indicated by patches of phreatophytes and areas of barren soil on which evaporated water has left a crust of alkali. Some of the water that seeps from the canal system, however, does percolate to the ground-water reservoir, as does water from ditches and irrigated fields. Several well owners report that water from their wells is of better chemical quality during the irrigation season than during the nonirrigation season, consistent with the much lower concentration of dissolved solids in water from the Duchesne River. (See tables 13 and 14.)

Assuming that at least 25 percent of the 75,000 acre-feet (92.5 hm^3) of water that is imported from the Duchesne River annually seeps to aquifers from local canals and irrigated land, then total annual recharge from imported water may be on the order of 20,000 acre-feet (24.7 hm^3). Total ground-water recharge from precipitation and imported water, therefore, is on the order of 120,000 acre-feet (148 hm^3).

Occurrence

Ground water in the southern Uinta Basin is in a complex system of shallow unconfined, perched, and deep confined aquifers. Shallow unconfined aquifers exist in the principal recharge area, along the southern rim of the Uinta Basin, where they support the flow of many perennial springs such as PR and Marble Springs (table 12), and in unconsolidated deposits underlying the Pleasant Valley area and the alluvial plains of the larger perennial streams. Most of the wells in the southern Uinta Basin tap the unconsolidated deposits in the Duchesne-Myton-Pleasant Valley area. Perched aquifers exist beneath the tablelands between the major streams where they support the flow of small widely scattered intermittent springs such as (D-10-17)12baa-S1 and (D-11-15) 15dbb-S1 (table 12).

Deep artesian aquifers in bedrock underlie a major part of the southern Uinta Basin. Such aquifers have been penetrated by a number of oil and gas wells such as wells (D-11-24)6dbc-1 and 7cac-1, which have been converted to stockwater wells (table 10).

Movement

The available water-level data in the southern Uinta Basin are insufficient to determine the direction of ground-water movement with any degree of accuracy. The few available data indicate that west of the Green River, ground water moves generally northward to the Strawberry and Duchesne Rivers and eastward toward the Green River, with local components of movement toward the larger tributary streams. East of the Green River, ground water generally moves northward toward the White River and westward toward the Green River, with local components of movement toward the larger tributary streams.

The rate of ground-water movement is slow in most places because of the generally low permeability of the rocks through which the water moves. This slow rate of movement allows longer periods of contact between the water and the rock minerals and contributes to the consistently high concentration of dissolved solids in the water. The slow rate of movement is also responsible for the low yields and large water-level drawdowns in many wells that tap these rocks (see table 10).

Some ground water moves from the Colorado part of the southern Uinta Basin to the Utah part, but the annual volume of movement is relatively small. Only about 3,000 acre-feet (3.7 hm^3) of the total estimated average annual recharge to the ground-water system in the southern Uinta Basin (table 3) is in Colorado. It is estimated that about 1,500 acre-feet (1.8 hm^3) per year of this water is consumed within Colorado--about 1,200 acre-feet (1.5 hm^3) by evapotranspiration along the alluvial plains of the White River, Evacuation Creek, and several intermittent creeks, and about 300 acre-feet (0.4 hm^3) by diffuse seepage to the White River (from ground-water discharge factors developed on pages 33-35). Discharge of ground water from wells and springs in the Colorado part of the southern Uinta Basin is insignificant. The remaining 1,500 acre-feet (1.8 hm^3) per year enters Utah as subsurface inflow.

Storage

Estimated recoverable storage.--Large quantities of water are stored in the rocks that underlie the southern Uinta Basin. Because of the generally low permeability of these rocks, however, only a fraction of the water can be withdrawn, and it generally is yielded slowly to wells. Furthermore, the water occurs at great depths beneath the land surface at places along the lower slopes of the southern Uinta Basin, and although physically recoverable, recovery may not be economically feasible.

For this report, the volumes of recoverable water in storage in unconsolidated deposits and in the consolidated rocks are estimated separately and without regard to chemical quality. The unconsolidated deposits have a much greater specific yield (ratio of volume of water yielded by saturated rocks to the total volume of those saturated rocks) than the unconsolidated rocks, but because of their small extent and thickness, the unconsolidated deposits have a much lower storage capacity. The areal extent of the saturated unconsolidated deposits is about 96,000 acres (38,850 hm^2) and their average saturated thickness is about 20 feet (6.0 m). Assuming that they have an average specific yield of 0.10, the volume of recoverable water in them is about 190,000 acre-feet (234 hm^3).

Although water is stored to great depths in the consolidated rocks, recoverable water is estimated for only the upper 100 feet (30.5 m) of saturation in these rocks. Beneath the alluvial plains of the larger streams, the top of the zone of saturation is within 100 feet (30.5 m) of the land surface; but between streams along the lower slopes of the southern Uinta Basin, it is more than 500 feet (152 m) deep. The average specific yield of the consolidated rocks is estimated to be only about 0.01 based on data from well (D-9-20)36ddc-1 (Weir, 1970) and on low yields of most wells and springs that discharge from these rocks. The total volume of rocks in the upper 100 feet (30.5 m) of saturation is on the order of 300 million acre-feet (370,000 hm^3), and, therefore, the volume of recoverable water may be on the order of 3 million acre-feet (3,700 hm^3). Because of the low permeability of these rocks, however, the water is not easily recovered by wells. In most places, yields to individual wells can be expected to be less than 50 gal/min (3.6 l/s).

Water-level fluctuations.--Water-level fluctuations in wells reflect changes in ground-water storage. Rising water levels indicate increases in storage whereas declining water levels indicate decreasing storage. Under natural conditions the ground-water system is in dynamic equilibrium. Average annual recharge and discharge are equal, and the volume of ground water in storage remains constant over a long period of time.

Periodic measurements of water levels have been made in an number of wells in the Uinta Basin to record changes in storage. Measurements at well U(C-4-2)5bba-2, the only water-level observation well in the southern Uinta Basin, are shown by the hydrograph in figure 10. The well taps unconsolidated deposits in the general area of greatest well density in the southern Uinta Basin.

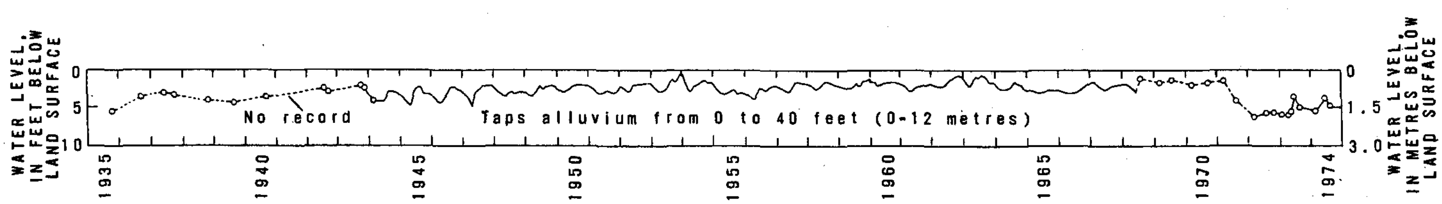

Figure 10.— Depth to the water level in well U(C-4-2)5bba-2 near Myton, Utah.

According to the hydrograph, water levels fluctuated seasonally during the period 1935-70, reflecting seasonal changes in ground-water storage with little overall change from year to year. During 1971, however, the water level in the well declined about 5 feet (1.5 m). Because there was no known significant increase in ground-water withdrawals in the area during that period, the decline must be attributed to a change in ground-water recharge. There probably has been a decrease in natural recharge owing to recent below normal precipitation in the area (fig. 4), and there may have been a decrease in recharge from irrigation. The unconsolidated deposits in this area apparently receive some recharge by seepage from canals and irrigated land. Probable changes in irrigation diversions and practices in the area may have caused a reduction of recharge from irrigation and resulting water-level decline in the well.

Local year-to-year declines of water levels in consolidated rocks in the northern Uinta Basin have been attributed to continued or increased ground-water withdrawals (Price and Arnow, 1974, p. C16). In the northern Uinta Basin availability of water for recharge is much greater than it is in the southern Uinta Basin. It seems reasonable, therefore, to conclude that any local large-scale withdrawals of ground water from consolidated rocks in the southern Uinta Basin would result in a depletion of storage and a decline of water levels.

Discharge

Ground water is discharged from the southern Uinta Basin by seeps and springs, evapotranspiration, diffuse seepage to the Green, White, Duchesne, and Strawberry Rivers, and by wells. Some ground water may move to the northern Uinta Basin in deep, confined aquifers which dip northward into the northern Uinta Basin. Also, ground water might possibly move along fault and gilsonite-dike zones that cross into the northern Uinta Basin. However, no direct data exist to confirm such movement to the northern Uinta Basin. It is most probable, therefore, that ground water moving northward through the area (at least in the upper 100 feet or 30.5 m of saturated rock) discharges by diffuse seepage to the Strawberry, Duchesne, and White Rivers or their alluvial deposits.

Seeps and springs.--Discharge of ground water through individual seeps and springs in the southern Uinta Basin is estimated to be on the order of 4,500 acre-feet (5.6 hm^3) per year. Most of the springs and seeps are above the 7,000-foot (2,134 m) altitude and are concentrated mostly in the headwater areas of Avintaquin, Willow, and Bitter Creeks (pl. 1). However, a number of springs, including those with the largest yields, are at lower altitudes.

All springs known to have estimated or reported yields of more than 100 gal/min (6 l/s) and a representative sampling of springs with smaller yields are listed in table 12. Assuming that the recorded yields of the four large springs in table 12 approximate the annual average yield of those springs, then they would have a total annual discharge of about 1,300 gal/min (82 l/s) or about 2,100 acre-feet (2.6 hm^3) per year.

At least 270 springs are shown on the U.S. Geological Survey 7½' and 15' topographic quadrangle maps of the southern Uinta Basin. Field observations indicate that the maps show only about half of the springs and seeps actually in the mapped area. Therefore, it is estimated that there are at least 500 individual springs and seeps in the area. Of these 500 springs and seeps, several have reported yields of as much as 60 gal/min (3.8 l/s) (table 12), but most of the springs observed by the writers had yields of 0.5 to 5 gal/min (0.03 to 0.32 l/s). It is concluded from these observations that the average yield per spring is about 3 gal/min (0.19 l/s), and that total annual discharge from them averages about 1,500 gal/min (95 l/s) or about 2,400 acre-feet (3.0 hm^3) per year. This, plus the 2,100 acre-feet (3.0 hm^3) per year from the four large-yield springs, gives a total discharge from springs and seeps of about 4,500 acre-feet (5.6 hm^3) per year.

Some of the water from Stinking Springs, Camel Rocks Springs, and several springs observed by Thomas (1952, p. 23) in Desolation Canyon reaches the Strawberry and Green Rivers and leaves the area as streamflow. Essentially all the water discharged by the other seeps and springs in the southern Uinta Basin is consumed at or near the point of discharge.

Evapotranspiration.--A large volume of ground water is consumed annually by evapotranspiration in the southern Uinta Basin. Most of this water is consumed by greasewood, saltcedar, and saltgrass along the lower reaches of the perennial and larger intermittent streams. The plants are all phreatophytes (water-loving plants that thrive on ground water) that have a high salt tolerance. Under ideal growing conditions and 100 percent plant density, greasewood may consume 2 feet (0.6 m) or more of water annually, and saltcedar may consume as much as 9 feet (2.7 m) (Mower and Nace, 1957, p. 21, and Robinson, 1958, p. 75). The figure for greasewood probably is representative for the southern Uinta Basin, but the figure for saltcedar is somewhat high as it was obtained in a warmer climatic zone with a longer growing season.

As noted earlier, these plants are the dominant vegetation along the alluvial plains of the Green, White, and the lower Duchesne Rivers and the larger streams that head in the southern Uinta Basin. Estimated consumptive use of water in the southern Uinta Basin by these phreatophytes ranges from about 1.5 to 3.5 feet (0.5 to 1.1 m) and totals about 204,000 acre-feet (252 hm^3) per year (table 8). Although essentially all the water consumed by phreatophytes along the flood plains of the perennial streams (the first three groups in table 8) is ground water, much of this water is derived from streamflow induced into the adjacent alluvial aquifers by the pumping effect of the phreatophytes as shown in figure 9 and discussed on pages 24-25. Because this water simply passes through the aquifer to the plant roots at a relatively rapid rate, it has not been regarded as a source of ground-water recharge in this report, nor is it counted as ground-water discharge by evapotranspiration. However, some of the water consumed by phreatophytes is derived directly from the ground-water system (from alluvium that would be saturated even if the phreatophytes did not exist).

Table 8.--Estimated consumptive use of water by phreatophytes in nonirrigated areas

Area	Phreatophyte	Areal extent (acres)	Average use factor (ft/yr)	Consumptive use (acre-ft/yr)
Flood plains of the Green and White Rivers	Greasewood, cottonwood, saltcedar, and saltgrass	22,100	3.5	77,400
Flood plains of Duchesne and Strawberry Rivers	Greasewood, saltcedar, saltgrass, cottonwood, and willow	3,700	3.0	11,100
Flood plains of the following streams and their tributaries: Avintaquin, Indian Canyon, Antelope, Willow, Bitter, Evacuation, Nine Mile, and Range Creeks, and Pariette Draw	Greasewood, saltcedar, saltgrass, and some rabbitbrush; cottonwood and willow in upper reaches of streams	45,000	2.5	112,500
Sams, Lake, and Coyote Canyons; Cottonwood Wash; Cottonwood Creek, Colo.	Rabbitbrush in Sams Canyon; greasewood in other drainages	3,200	.75	2,400
		Total (rounded)		204,000

The percentage of consumed water that is derived from induced seepage from streamflow may be approximated from measured streamflow depletion between sites S1 and S2 on Willow Creek (table 7). Discharge of ground water only by evapotranspiration is equal to the total estimated consumptive use of water by phreatophytes (table 8) minus that percentage estimated to be from induced seepage from streamflow. According to table 7, the streamflow depletion between sites S1 and S2 on September 27, 1972, was 0.45 ft^3/s (0.013 m^3/s). As noted on pages 24-25, this loss is attributed entirely to consumptive use of water by phreatophytes growing along the alluvial plain of the stream between the two sites, and the consumptive use rate may approximate the annual mean. Therefore, the consumptive use of streamflow by phreatophytes between sites S1 and S2 may total about 300 acre-feet (0.4 hm^3) per year. About 200 acres (80.9 hm^2) of phreatophytes in this reach have an estimated annual water requirement of about 2.5 feet (0.8 m) or 500 acre-feet (0.6 hm^3). With an annual contribution of 300 acre-feet (0.4 hm^3) from induced streamflow, the annual draft from ground water without the induced streamflow component is about 200 acre-feet (0.2 hm^3), or 40 percent of the total consumptive use. If this factor were applied to the estimated consumptive use of water by phreatophytes along perennial streams (the first three categories in table 8) in the southern Uinta Basin, about 80,400 acre-feet (99.2 hm^3) would be from ground water. An estimated additional 2,400 acre-feet (3.0 hm^3) of ground water is consumed along intermittent and ephemeral streams. Therefore, the total estimated discharge of ground water by evapotranspiration is estimated to be on the order of 83,000 acre-feet (102 hm^3) per year.

Diffuse seepage to the Green, White, Duchesne, and Strawberry Rivers.--Some ground water discharges from the southern Uinta Basin to the Green, White, Duchesne, and Strawberry Rivers. Part of this water is consumed by evapotranspiration along the courses of those streams and part leaves the Uinta Basin in the Green River.

The volume of ground water that leaves the southern Uinta Basin by diffuse seepage to the Green, White, Duchesne, and Strawberry Rivers cannot be determined with any degree of accuracy from available data. A provisional estimate is made from the meager stream discharge records, which themselves are partly estimated.

Streamflow records in the files of the Geological Survey indicate that the average (1941-70) rate of gain in flow of the Green River between the gaging stations near Ouray (site 3070 on pl. 1) and Green River, Utah (about 9 miles or 14.5 km south of the southern Uinta Basin), was about 200 ft^3/s (5.7 m^3/s) (F. K. Fields and D. B. Adams, U.S. Geol. Survey, written commun., 1974). Subtracting the average (1941-70) rate of inflow (102 ft^3/s or 2.9 m^3/s) from the Price River, which enters the Green River just downstream from the southern Uinta Basin, the net measured gain in flow of the Green River between Ouray and Green River, Utah, was found to be about 100 ft^3/s (2.9 m^3/s) during the period 1941-70. To this should be added the unmeasured evapotranspiration loss along this reach of the river. Thomas (1952, p. 29) estimated that the rate of evapotranspiration loss in the reach between Ouray and Green River, Utah, totaled 54 ft^3/s (1.5 m^3/s) during a reconnaissance of the river in September 1948. Assuming this approximates the average rate of loss during the period 1941-70, then the actual rate of gain in flow (net measured gain plus evapotranspiration loss) during that period would have been about 150 ft^3/s (4.2 m^3/s), or on an annual basis--about 108,600 acre-feet (134 hm^3) per year. For practical purposes, all this gain in flow is attributed to inflow from the southern Uinta Basin. (Other than from the Price River, there is insignificant inflow between the southern Uinta Basin and Green River, Utah.)

Estimates of mean annual runoff in the streams listed in table 6 that drain to the Green River below Ouray totaled about 57,000 acre-feet (70.3 hm^3). Using the area-runoff relation--27.3 acre-feet (0.03 hm^3) per year per square mile (2.6 km^2)--discussed on page 22, total runoff from all other streams draining to the Green River below Ouray is estimated to be about 25,000 acre-feet (30.8 hm^3) per year. Another 2,000 acre-feet (2.5 hm^3) per year probably enters the Green River in this reach from individual springs, according to Thomas (1952, p. 23). Therefore, total inflow to the Green River from streams and individual springs is estimated to be on the order of 84,000 acre-feet (104 hm^3). Subtracting this from the total gain in flow of 108,600 acre-feet (134 hm^3) per year leaves about 25,000 acre-feet (30.8 hm^3) per year, which may be attributed to diffuse seepage of ground water directly into the stream channel. This is about 200 acre-feet (0.24 hm^3) per river mile (1.6 km), of which 100 acre-feet (0.1 hm^3) per river mile (1.6 km) is assumed to be contributed from each side of the river.

The rocks that bound the Green, White, Duchesne, and Strawberry Rivers are lithologically similar; therefore, on the average, they are assumed to have similar permeabilities. Ground-water gradients toward the White, Duchesne, and Strawberry Rivers from the south are on the average about half as steep as gradients to the Green River (see pl. 1). Therefore, the diffuse seepage of ground water to the former three streams from the south probably averages only about 50 acre-feet (0.06 hm^3) per mile (1.6 km) per year. Along the total 137-mile (220 km) courses of these streams, therefore, total ground-water inflow from the southern Uinta Basin may be on the order of 7,000 acre-feet (8.6 hm^3) per year. Total annual discharge of ground water by diffuse seepage to the Green, White, Duchesne, and Strawberry Rivers then is estimated to be on the order of 30,000 acre-feet (37.0 hm^3) per year, all of which leaves the area as part of the ground-water component of streamflow.

Wells.--Ground water is discharged from both water wells and oil and gas wells in the southern Uinta Basin. According to the records of the Utah Division of Oil and Gas Conservation, approximately 600,000 gallons (2,271 m^3) of water were produced from oil and gas wells in the area during 1972. This is less than 2 acre-feet (0.002 hm^3). Total discharge from the few known flowing artesian wells (table 10) amounts to about 400 acre-feet (0.5 hm^3) per year. Annual discharge from all other wells in the area is estimated to total about 100 acre-feet (0.1 hm^3). Most of these wells are concentrated in the Duchesne-Myton-Pleasant Valley area where many are used only for stock or standby-domestic supply. Total annual discharge from all wells in the southern Uinta Basin, therefore, is estimated to be on the order of 500 acre-feet (0.6 hm^3).

SUMMARY OF QUANTITATIVE ESTIMATES

Table 9 summarizes the estimated values for various components of the hydrologic system in the southern Uinta Basin.

About 94 percent of the average annual volume of water entering the southern Uinta Basin from precipitation and imports is consumed by evapotranspiration within that subbasin. The remaining 6 percent enters the Green, White, Duchesne, and Strawberry Rivers--mostly as overland runoff.

CHEMICAL QUALITY OF WATER

General

The types and amounts of dissolved solids in water in the southern Uinta Basin vary greatly over short distances both areally and with depth. The dissolved-solids concentrations of most streams increase rapidly in a downstream direction, especially during low-flow periods in late summer; and the dissolved-solids concentrations of the ground water change markedly from one aquifer to another. Streamflow ranges from fresh to moderately saline and ground water ranges from fresh to briny, according to the following classification used by the U.S. Geological Survey.

Class	Dissolved solids (milligrams per litre)
Fresh	0- 1,000
Slightly saline	1,000- 3,000
Moderately saline	3,000-10,000
Very saline	10,000-35,000
Briny	More than 35,000

Table 9.--Summary of quantitative hydrologic estimates

Component	Hydrologic balance Long-term average in acre-feet per year
Inflow:	
Precipitation (p. 15)	3,100,000
Imported water, net (p. 25)	70,000
Total	3,170,000
Outflow:	
Overland runoff (p. 22)	134,000
Irrigation return flows (p. 27)	20,000
Ground-water outflow (p. 35)	30,000 [1]
Subtotal (rounded)	184,000
Evapotranspiration in subbasin	2,986,000 [2]
Ground-water system:	
Recharge:	
From precipitation (p. 28)	100,000
From imported water (p. 28)	20,000
Total	120,000
Discharge:	
Evapotranspiration along waterways (p. 33)	83,000
Subsurface outflow (p. 35)	30,000
Seeps and springs (p. 31)	4,500
Wells (p. 35)	500
Total	118,000
Recoverable ground water in storage:	Acre-feet
In unconsolidated deposits (p. 30)	190,000
In consolidated rocks [3] (p. 30)	3,000,000
Total (rounded)	3,200,000

[1] Includes about 2,000 acre-feet of surface flow to the Green and Strawberry Rivers from individual springs.

[2] Calculated difference between total inflow and other components of outflow.

[3] Upper 100 feet of saturated rock only.

In general, water at the higher altitudes is freshest. There appears to be no clear correlation between water quality and geology, although water from the Uinta Formation, which crops out in the lower altitudes, seems to be consistently more saline. The ratio of individual dissolved constituents seems to be more closely related to the relative concentration of total dissolved solids rather than to the geologic source of the water. The general chemical quality of water in the southern Uinta Basin is shown on plate 3.

Surface water

Table 13 contains chemical analyses of water collected from streams at miscellaneous sites throughout the southern Uinta Basin. Only selected analyses are included in table 13. For regular water-quality stations on the Green, White, and Duchesne Rivers (stations 09307000, 09306500, and 09302000 on pl. 1, and sites 22, 21, and 20 on pl. 3). Additional analyses, beginning in 1950, of water from those sites are available in the files of the Geological Survey.

The discharge weighted average concentrations of dissolved solids in the Green, White, and Duchesne Rivers at sites 22, 21, and 20, for the period 1964-66, respectively, were 457, 484, and 702 mg/l. Recorded concentrations of dissolved solids in the Green and White Rivers generally are less than 1,000 mg/l throughout the year, but the concentrations of dissolved solids in the Duchesne River commonly exceed 1,000 mg/l and occasionally exceed 2,000 mg/l during late irrigation and low-flow periods.

The dissolved-solids concentrations in water samples from streams that head in the southern Uinta Basin ranged from 343 mg/l near the head of Minnie Maud Creek (site 8) to 7,240 mg/l near the lower end of Bitter Creek (site 18). There is a marked increase in the dissolved-solids concentration of water collected from downstream sites (sites 14 and 17) over that from upstream sites (sites 12 and 16) on Hill and Willow Creeks. The higher concentrations of dissolved solids in water in the lower stream reaches is common to all streams sampled; it is attributed to inflow of saline ground water, to irrigation return flows, and to concentration of dissolved solids by evapotranspiration of the stream water.

In the headwater areas, where dissolved-solids concentrations are low, the stream water is of a calcium bicarbonate type, whereas water in the lower stream reaches generally contains magnesium and sodium as the dominant cations, and sulfate is the dominant anion. Exceptions occur during high runoff periods in the lower reaches of streams that drain the extreme western part of the study area. Because of rapid runoff from these relatively short drainage basins, water in the lower reaches is fresh and either of a mixed or calcium bicarbonate type, as indicated by analyses of water from Timber Canyon and Avintaquin Creeks (table 13).

Ground water

Chemical analyses of water sampled from water wells and springs are given in table 14; analyses of water from oil and gas wells and tests are given in table 15. The dissolved-solids concentrations in water sampled from springs ranges from 190 mg/l at Horse Ridge Spring(?) to 7,702 mg/l at Stinking Spring. Water from springs in the headwater areas of the principal streams above an altitude of about 8,000 feet (2,438 m) generally contains less than 1,000 mg/l of dissolved solids, whereas water from springs in the lower altitudes generally contains more than 1,000 mg/l. The high-altitude springs are near their recharge areas, whereas the low-altitude springs sampled are generally far removed from their recharge areas. Therefore, water discharging from the high-altitude springs has had less time of travel in the aquifer system and less opportunity to dissolve minerals.

The dissolved-solids concentrations in water from water wells (including several water-producing oil and gas tests that were converted to water wells) range from 327 mg/l in well (D-13-14)24dba-1, which is the Green River Formation, to 4,480 mg/l in well U(C-4-2)5bba-2, which taps unconsolidated deposits near their contact with the underlying Uinta Formation. The high concentrations of boron, sulfate, and dissolved solids in water from the latter well indicate that the original source of a large percentage of the water is the Uinta Formation.

Waters sampled from most oil and gas wells and tests were collected from depths of more than 1,000 feet (305 m) and generally are slightly saline to briny. (See table 15.) The only freshwater sampled from oil tests was from wells (D-11-12)14baa-1 and (D-14-20)30bab, which tapped the Green River Formation between depths of 635-650 and 1,883-1,910 feet (194-198 and 574-582 m), respectively. These waters contained only 619 and 818 mg/l of dissolved solids, respectively. The dissolved-solids concentration in water from other oil and gas wells and tests listed in table 15, however, ranges from 1,086 to more than 100,000 mg/l.

Plate 3 shows the ranges of dissolved-solids concentrations that can be expected from at least one aquifer in the southern Uinta Basin. It shows that the only areas where fresh ground water generally is available are along the higher south rim of this subbasin.

In many cases, the dissolved-solids concentrations in the ground water increase with depth. Consequently, even at higher altitudes where freshwater is obtained from springs and shallow wells, deep aquifers are likely to contain saline water. For example, although well (D-14-20)30bab produced freshwater from the Green River Formation at a depth of 1,883-1,910 feet (574-582 m), well (D-14-20)30ac, less than half a mile (0.8 km) to the southeast, produced very saline water from a depth of 3,790-3,820 feet (1,155-1,164 m).

There is no clear correlation between the chemical type of ground water and the geologic source of the water in the southern Uinta Basin. Most of the waters containing less than about 1,000 mg/l of dissolved solids are of the calcium bicarbonate or magnesium bicarbonate type (pl. 3), regardless of geologic source. However, most of the freshest waters are from high-altitude springs that discharge from the Green River Formation. Slightly to moderately saline waters generally are of the sodium bicarbonate or sodium sulfate types. Chloride is a minor constituent in water from water wells and springs in the area but is a major constituent in the very saline to briny waters from deep oil and gas wells and tests.

Although not shown by Stiff diagrams on plate 3, table 15 indicates that a number of the more highly concentrated water samples collected from oil and gas wells and tests in the Uinta and Green River Formations, such as U(C-4-5)14dca-1, are of the sodium carbonate type. Similarly, three water samples from Stinking Spring had sodium and carbonate as the principal cation and anion (table 14). All these waters apparently were in contact with evaporite deposits that contain beds of trona, a hydrous sodium carbonate mineral.

Chemical quality in relation to use

Domestic and stock

The U.S. Public Health Service (1962) has established water-quality standards for drinking water which include dissolved mineral constituents among other parameters. The following table lists the maximum limits recommended by the Public Health Service for some of the more common mineral constituents for which analyses are given in tables 13, 14, and 15.

"The following chemical substances should not be present in a water supply in excess of the listed concentrations * * * where other more suitable supplies are or can be made available." (U.S. Public Health Service, 1962, p. 7.)

Substance	Recommended limit (milligrams per litre)
Chloride (Cl)	250
Fluoride (F)	1.3[1]
Iron (Fe)	.3
Nitrate (NO_3)	45 (10 mg/l expressed as N)
Sulfate (SO_4)	250
Dissolved solids	500

[1]Based on the average maximum daily air temperature of 60.7°F (15.9°C) at Duchesne, Utah (1968-72).

According to the foregoing table most of the waters in the area, except those from the upper reaches of streams and high-altitude springs, exceed the maximum limit of 500 mg/l for dissolved-solids concentrations. The recommended limit of 250 mg/l for sulfate also is exceeded in many of the water sources, and the maximum recommended limit of 1.3 mg/l for fluoride is exceeded in a number of sources.

The generally poor chemical quality of water in the southern Uinta Basin with regard to suitability for domestic use has made it necessary for water suppliers in the population centers of Duchesne, Myton, and Pleasant Valley to import better quality water from the northern Uinta Basin. Water from many sources in the southern Uinta Basin may not be chemically suitable for drinking.

The State of Montana (McKee and Wolf, 1963, p. 113) rates water for livestock on the basis of dissolved solids as follows:

Rating	Dissolved solids (milligrams per litre)
Good	Less than 2,500
Fair	2,500-3,500
Poor	3,500-4,000
Unfit	More than 4,500

According to this rating, water from most springs, water wells, and upper stream reaches is suitable (but only poor to fair in many cases) for livestock. Water from the lower reaches of some streams, such as Bitter Creek (during low flow), an orifice of Stinking Spring, and certain oil and gas wells, may be unfit for livestock. However, cattle are known to drink water with more than 4,500 mg/l of dissolved solids where better water is not available.

Irrigation

Important characteristics that help to determine the chemical suitability of water for irrigation in arid and semiarid areas are the specific conductance (electrical conductivity) and sodium-adsorption ratio (SAR) of the water (see table 13, 14, and 15). Specific conductance is an index of dissolved-solids concentration of the water and SAR is an index of the ratio of sodium to other cations in the water according to the following equation:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

where the concentrations of the ions are expressed in milliequivalents per litre.

The U.S. Salinity Laboratory Staff (1954, p. 69-81) has devised a method of classifying irrigation water by plotting SAR against conductivity of the water in the diagram shown in figure 11. The classification is based on average conditions with respect to soil texture, infiltration rate, drainage, amount of water applied, climate, and salt tolerance of crops.

According to this classification, water from the Green, White, and Duchesne Rivers at water-quality stations 09307000, 09306500, and 09302000 (sites 22, 21, and 20 in table 13) and from the upper reaches of the streams that drain the southern Uinta Basin has a low sodium-medium to high salinity hazard for irrigation under average conditions. However, water from the lower reaches in Willow, Evacuation, and Antelope Creeks probably would have high to very high sodium and salinity hazards, except perhaps during peak runoff periods.

Although waters from the high-altitude springs have a low sodium-medium to high salinity hazard, ground water in the lower altitudes most likely would have a high to very high sodium and salinity hazard as indicated by the analyses of water from spring (D-12-21)19bdd-S1 and well U(C-4-3)9bbd-1 (table 14). It is interesting to note that water from the only well in the southern Uinta Basin known to be drilled specifically for irrigation--well U(C-5-5)34bdd-2--has a high salinity hazard but a low sodium hazard.

Relative concentrations of boron in water also determine the suitability of the water for irrigation. Wilcox (1958, p. 5) has classified plants as sensitive, semitolerant, and tolerant, according to their ability to withstand the toxic effects of various concentrations of boron. Irrigation water with boron in concentrations of less than 0.3 mg/l is considered suitable for even the most boron-sensitive crops such as corn and legumes, whereas water with concentrations of boron in excess of 4.0 mg/l may be unsuitable for the most boron-tolerant plants such as alfalfa.

According to tables 13 and 14, the concentrations of boron in the southern Uinta Basin range from 0.07 to 10.00 mg/l in water from streams and 0.00 to 22.6 mg/l in water from springs and water wells. The concentration of boron in the Duchesne River near site 20 ranged from 0.12 to 2.99 mg/l and averaged 0.75 mg/l in 22 samples collected between 1942 and 1958 (Iorns and others, 1964, p. 586-587). However, the boron concentration may be somewhat lower upstream where water is diverted for irrigation in the southern Uinta Basin. Major contributions of boron to the Duchesne River come from Indian Canyon Creek, which enters the Strawberry River near its confluence with the Duchesne River above the Grey Mountain-Pleasant Valley Canal diversion, and Antelope Creek, which enters the Duchesne River above the Myton Townsite Canal Diversion. (See table 13.)

The initial source of boron apparently is the evaporite deposits in the Uinta and Green River Formations. Seeps and individual springs, such as U(C-5-6)1caa-S1 and S2, probably contribute most of the boron to the streams, and the boron content is concentrated as the streamflow is depleted by evapotranspiration.

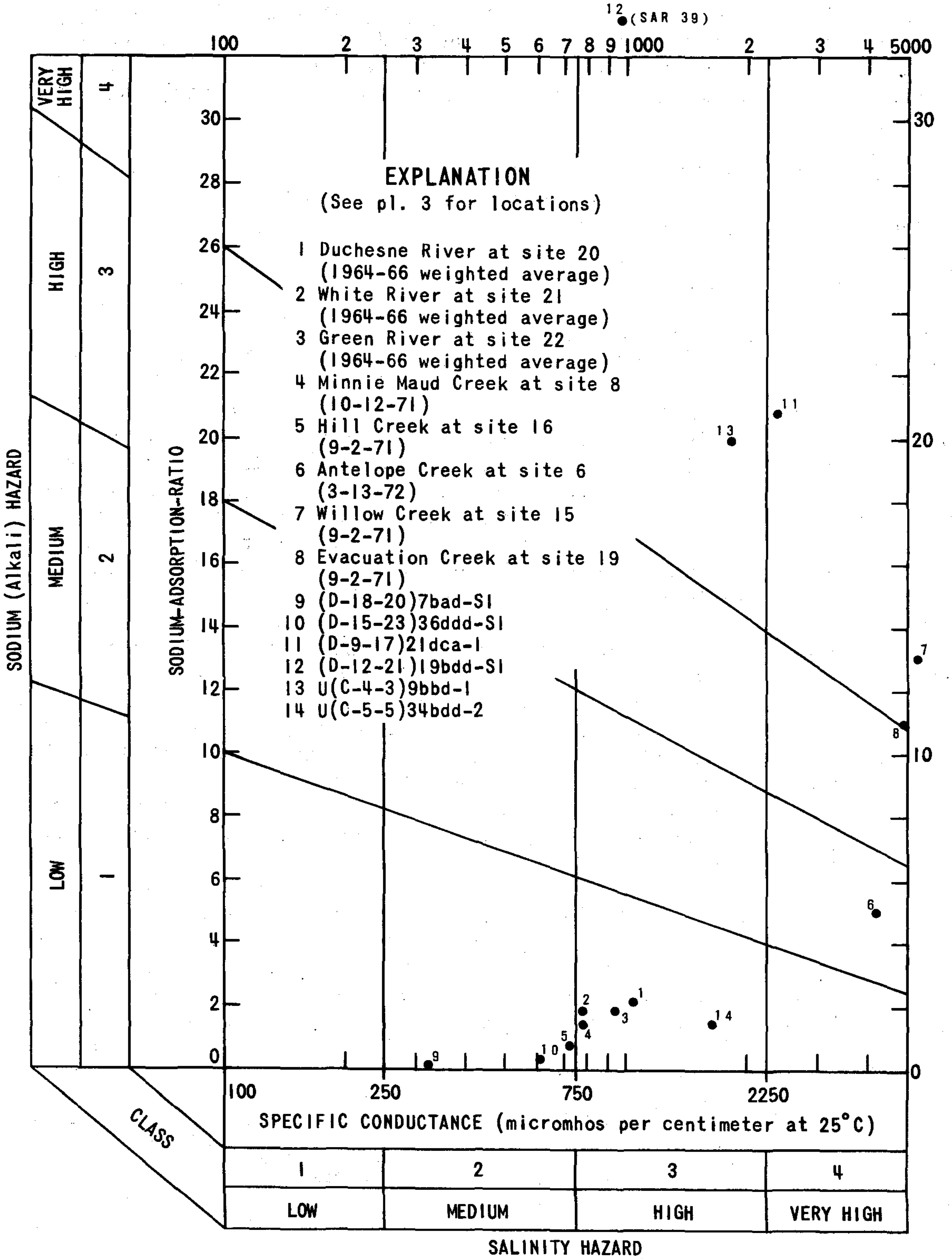

Figure 11.— Diagram used to classify water for irrigation. (From U.S. Salinity Laboratory Staff, 1954.)

AVAILABILITY OF WATER FOR FUTURE DEVELOPMENT

The largest future water needs in the southern Uinta Basin most likely will be for development of oil-shale reserves (including related municipal and satellite industrial needs) in this subbasin and for supplementary irrigation. The amount of water needed for oil-shale development is not known, but preliminary estimates given by the U.S. Department of the Interior (1973, Table III-5) indicate that it might range from about 6,000 to 9,600 acre-feet (7.5-11.8 hm^3) per year for an oil-production capacity of 50,000 barrels per day. Associated public supply and industrial needs could exceed 1,000 acre-feet (1.2 hm^3) per year.

Considerably more irrigation water will be needed in the southern Uinta Basin if all land classified as arable is to be placed under irrigation. Austin and Skogerboe (1970, p. 46-49), for example, indicate that there are about 33,000 acres (13,355 hm^2) of arable land on Pariette Bench, along the White River, and in the Green River bottom between the White River and Willow Creek. Most of this land currently is not irrigated. At a crop requirement of 3 feet (0.9 m) per year, the amount of water needed to irrigate all the land would exceed 100,000 acre-feet (123 hm^3) per year.

Water to meet some of the potential future needs in the southern Uinta Basin could be obtained by increased utilization of the water supply that originates from precipitation entirely on this subbasin. Development of such a supply would be deterred, however, by such factors as uneven time and areal distribution of the supply and generally poor chemical quality of the water.

The water supply from precipitation on the southern Uinta Basin averaged about 3.1 million acre-feet (3,800 hm^3) annually during the period 1941-70. Annual runoff from this subbasin is estimated to average about 134,000 acre-feet (165 hm^3). An estimated 3.2 million acre-feet (3,947 hm^3) of recoverable ground water is stored in the unconsolidated deposits and upper 100 feet (30.5 m) of saturated consolidated rocks in this subbasin, with an estimated average annual replenishable ground-water supply of about 120,000 acre-feet (148 hm^3). Although these figures seem quite impressive, only a small fraction of the water is readily available for development.

Runoff is highly irregular; much of it is in intermittent and ephemeral streams and cannot be relied on for large sustained supplies. The only basins in which development of large sustained supplies by regulation seems possible are the Evacuation, Willow, Nine Mile, Range, and Avintaquin Creek basins. Estimated mean annual runoff from these basins totals about 55,000 acre-feet (61.7 hm^3) per year (table 6). Reservoir storage of runoff from these basins would provide a supply of high-quality water for use during low-flow periods.

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The best potential source for future large-scale development of ground water in the southern Uinta Basin lies in the unconsolidated alluvial deposits along the Green, White, and Duchesne Rivers. These deposits, where saturated, generally are less than 50 feet (15.2 m) thick and are of small extent. Because of their relatively high permeability, however, they seem capable of supporting sustained yields of more than 100 gal/min (6.3 l/s) to large-diameter wells or infiltration systems. The close relation between the surface water and ground water along the major streams in the southern Uinta Basin, however, indicates that such development doubtless would affect streamflow. However, pumping water from the unconsolidated deposits may, by lowering the water table, help to reduce nonbeneficial consumptive use of water by phreatophytes.

The bedrock formations that underlie the southern Uinta Basin are generally not permeable enough to support large sustained withdrawals (more than 500 gal/min or 31.5 l/s) from wells. Much of the Uinta Formation is drained by the deeply incised streams that dissect it, and where it is saturated it yields water slowly to most wells and springs. The Green River Formation seems relatively permeable in the general vicinity of well (D-11-24)7cac-1, but data collected during this study failed to indicate the existence of an extensive permeable "leached zone" such as was reported in the Green River Formation where it underlies the Piceance Creek Basin of Colorado just east of the Uinta Basin (Coffin and others, 1971). The Wasatch and North Horn Formations and sandstone units of the Mesaverde Group appear to be relatively permeable in areas of outcrop in the Range Creek area, but oil-test data indicate that they have low permeability in the subsurface beneath most of the southern Uinta Basin.

A major problem affecting the future development of water that originates from precipitation in the southern Uinta Basin is the generally poor chemical quality of the water. Any plan to develop freshwater supplies for use in the lower parts of this subbasin probably would have to consider conveying the water from higher areas or desalting the water from a local source.

FUTURE STUDIES

The information given in this report provides a general regional appraisal of the water resources of the southern Uinta Basin. Considerable detailed study is needed on a local scale to provide information for better delineation of the chemical quality of the water, for refinement of quantitative estimates given herein, and for evaluation in greater detail of the best potential sources for future development. Additional study may also be required to provide information needed to minimize the effects of oil-shale development on the water quality of the Colorado River system and the environment in general.

Several studies that could be done in the near future are:

1. A systematic study of the hydrologic properties of the Green River Formation, with emphasis on the Parachute Creek Member. The Parachute Creek Member contains the richest oil-shale deposits in the area and may contain a permeable "leached zone" beneath the shale similar to that found in the Piceance Creek Basin of Colorado. Such a study would require detailed examination of all available oil-field geophysical data, test drilling, and aquifer tests.

2. A detailed study of consumptive use of water by phreatophytes along perennial streams such as Willow and Nine Mile Creeks. Determination of water salvage by phreatophyte eradication or replacement would be included in the study. Such a study would require construction of observation wells and installation of special instruments to monitor streamflow, ground-water levels, evaporation, precipitation, and water quality.

3. A qualitative evaluation of the stream-aquifer systems, especially along the Duchesne River.

4. A study to determine the feasibility of upstream regulations of such streams as Willow and Nine Mile Creeks to conserve the water of good quality that normally is lost by outflow during periods of high runoff. The study would include evaluation of possible damsites and methods to convey, distribute, and use the water.

5. A study to determine means of minimizing the effect of oil-shale development on the chemical quality of the Colorado River systems. Such a study would include examination of sites for surface disposal of spent shale and for evaporation of produced brines. It would also include evaluation of sites for subsurface injection of brines. This would require drilling of injection and observation wells and installation of monitoring equipment to determine the environmental impact and the economic feasibility of subsurface injection.

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Table 10.--Records of selected water wells

Casing depth: Depth to bottom of casing or to uppermost opening in casing.
Water-bearing zone(s): Character of material; G, gravel; Ls, limestone; S, sand; Sh, shale; Ss, sandstone.
Altitude of land surface: Above mean sea level, as interpolated from U.S. Geological Survey topographic maps.
Water level: F, well flows under unknown artesian head; figures are feet below land surface and are reported, except for those shown to nearest tenth which were measured by the U.S. Geological Survey.
Yield: Reported, rate assumed to be by pumping except (b) bailing or (f) artesian flow; drawdown assumed to be feet below static water level.
Use: D, domestic; I, irrigation; N, industrial; S, livestock; U, unused.
Remarks and other data available: C, chemical analysis of water in table 14; FC, field determination of specific conductance of the water (micromhos per cm at 25°C); L, lithologic log in table 11.

Location	Owner	Year drilled	Well depth (ft)	Casing depth (ft)	Casing diameter (in.)	Water-bearing zones(s)			Altitude of land surface (ft)	Water level		Yield		Use of water	Remarks and other data available
						Depth to top (ft)	Thickness (ft)	Character of material		Feet	Date measured	Rate (gal/min)	Drawdown (ft)		
(D-9-17)21dca-1	U.S. Bureau of Land Management	1935	22	-	48	6	16	Ls	5,295	2	9- -71	3	-	U	Excavation at Snyder Spring; soil, 0-6 ft; solid lime, 6-22 ft; C.
(D-9-20)20acd-1	Sun Oil Co.	1952	166	-	-	140	15	Ss	4,780	-	-	8b	-	U	Water reported salty; L.
(D-10-20)35bbc-1	U.S. Bureau of Land Management	1964	5,672	168	13 3/8	1,700	-	-	5,240	F	-	58f	-	S	Former gas-producing well; casing 13 3/8 in. to 168 ft; 5 in. to 5,672 ft; C.
(D-10-24)2acc-3	American Gilsonite Co.	1960	31	10	30	10	-	S,G	4,955	10	12-21-60	55	-	N	Representative of several wells that tap alluvium of White River in this area; boulders, 0-22 ft; gravel, 22-31 ft; water from these wells generally is fresh and similar to water in the White River.
(D-11-15)32dcd-1	Preston Nutter Corp.	-	-	-	6	-	-	-	5,780	42.9	4-11-72	-	-	D	C.
(D-11-21)21caa-1	U.S. Bureau of Land Management	1951	610	460	5	350	150	Sh	5,755	300	7- -51	25b	50	S	Blue shale, 0-610 ft.
30bdb-1	L. M. Thorne	1934	18	-	48	-	-	-	5,139	16	-	-	-	S	
31bdd-1	Golden Hatch	1952	711	610	4	701	10	Ss	5,190	F	8-31-71	2f	-	S	C, L.
(D-11-24)6dbc-1	U.S. Bureau of Land Management	1962	5,950	223	13 3/8	1,210 1,350	30 20	- -	5,196	F	-	-	-	S	Former gas-test well; casing 13 3/8 in. to 223 ft; 9 5/8 in. to 2,207 ft; 4½ in. to 4,598 ft; water enters well through annulus between 4½ and 9 5/8 in. casing; C.
7cac-1	do	1962	5,840	216	13 3/8	1,159	241	-	5,268	F	-	175f	-	U	Former gas-test well; casing 13 3/8 in. to 216 ft; 9 5/8 in. to 2,396 ft; water enters well through annulus between 13 3/8 and 9 5/8 in. casing; C.
33dcc-1	do	1936	82	-	-	80	2	Ls	5,780	72	2- -36	8	-	U	Abandoned mine shaft; water reported good; appeared to be also abandoned as well 9-1-71; L.
(D-12-19)13cad-1	-	-	-	-	-	-	-	-	5,505	54.9	9- 2-71	-	-	U	
(D-12-22)34abc-1	Willis Stevens	1961	120	20	20	-	-	-	6,230	78	4- -61	-	-	U	L.
(D-13-14)24dba-1	Pan American Petroleum Corp.	-	-	-	-	-	-	-	8,225	150	7- -66	-	-	-	Assumed to be water supply for oil-test drilling; C.
(D-13-21)15ddc-1	Willis Stevens	1961	52	52	6	35	17	S,G	5,590	35	4- -61	-	-	U	Soil, 0-6 ft; silt and gravel, 6-29 ft; sand and coarse gravel 29-52 ft; water reported brackish.
22aab-1	do	1961	40	15	5	18	7	S,G	5,600	10	4- -61	-	-	U	Water reported brackish; L.
(D-14-18)1bbd-1	Ute Indian Tribe	1964	130	14	8	-	-	-	7,045	68.9	8- 8-72	3	-	S	Original depth, 212 ft; temperature 13.0°C; FC, 7,000; L.
(D-14-19)3cdb-1	do	1960	96	65	5	-	-	-	6,880	80	12- -60	5	96	S	L.
(D-14-22)26aca-1	Willis Stevens	1959	150	-	-	-	-	-	7,080	-	-	-	-	U	Reportedly a dry hole; sand, 0-21 ft; blue shale, 21-150 ft.
(D-15-20)3bab-1	Ute Indian Tribe	1960	108	60	5	-	-	Ss	7,440	52	12- -60	15b	-	S	Water reportedly contained 280 mg/l of dissolved solids; L.
12cca-1	do	1964	120	12	8	-	-	-	7,425	60	6- -64	4b	60	U	Sandstone, 0-60 ft; shale, 60-120 ft; water reported good.
U(C-3-1)33cbc-1	John Uresk	1967	20	20	6	-	-	S,G	5,045	-	-	-	-	D	Temperature 10.0°C; FC, 2,200.
U(C-3-5)31dcd-1	D. T. Jones	1969	200	42	6	31	169	Sh	5,790	24	7- -69	9	169	D	Casing 8 in. to 31 ft; 6 in. 31-42 ft; C.
U(C-4-1)7ccb-1	R. J. Marti	1949	36	16	6	16	9	S,G	5,182	16	4- -49	12b	-	U	L.
17ccc-1	Ken Higley	1951	25	15	48	24	1	S	5,155	10	3- -51	30b	5	D	Blue clay, 0-24 ft; sand, 24-25 ft; water reported hard.
18dcc-1	C. Van Tassell	1945	80	15	6	15	5	S,G	5,185	15	4- -45	60b	10	U	L.
28aba-1	Louis Roberts	1948	150	20	6	125	-	Sh	5,155	20	10- -48	15b	10	U	Topsoil, 0-10 ft; blue shale 10-150 ft.
U(C-4-2)2cda-1	Salt Lake Pipe Co.	1950	108	91	12	93	1	Ss	5,295	25	6- -50	25	49	U	Water "very salty"; original depth, 700 ft; L.
5abb-1	Guy Giles	1945	23	20	6	21	2	G	5,180	8	4- -45	20	2	U	L.
5bba-2	Lamar Neilson	1935	40	-	8	5	27	S,G	5,185	1.8	3- 9-71	-	-	D	Formerly reported as 4-bba-1. Original depth, 1,120 ft; hydrograph in figure 10; C, L.
13daa-2	Alden Kynaston	1969	28	28	6	-	-	Sh	5,195	16.7	5- 6-72	20b	25	S	Clay, 0-6 ft; shale, 6-28 ft; C.
14bbb-1	Marion Ross	1954	65	50	6	63	2	Ss	5,237	24	12- -54	8b	16	U	Boulders, gravel, and sand, 0-36 ft; shale and sandrock, 36-65 ft.
14bcc-1	J. E. Wilkens	1957	80	-	6	10	8	G	5,245	10	11- -57	10b	5	U	L.
U(C-4-3)4daa-1	Jack Liddell	1953	55	33	6	15	15	S,G	5,277	18	12- -53	12	5	D	Reportedly yields soft water; L.
9bbd-1	Latter-day Saints Church	1966	70	46	6	63	7	Ss	5,327	30.7	5- 6-72	10b	30	D	C, L.
10aba-1	John Liddell	1946	250	81	6	71	-	Sh	5,282	12	5- -46	2	-	D	Temperature 10.0°C; FC, 2,900; L.
10abb-1	Roger Hicken	1953	180	70	4	-	-	-	5,280	12	12- -53	10b	4	S	Temperature 12.0°C; FC, 2,450.
10cbb-1	Willis Shepard	1948	56	56	7	40	16	S,G	5,325	38	12- -48	30b	2	D	Clay, 0-40 ft; sand and gravel, 40-56 ft; C.
11dcb-1	R. D. Peatress	1945	95	43	6	45	-	Sh	5,310	31	4- -45	4b	13	D	Well reportedly goes dry in late winter; temperature 11.5°C; FC, 2,750; L.
12aca-1	Robert Alred	1945	40	37	6	37	3	G	5,265	23	3- -45	20b	0	D	FC, 860; L.
12cab-1	Wallace Pitt	-	70	-	6	-	-	-	5,291	-	-	-	-	D	C.
16acb-1	D. Farnsworth	1964	67	62	6	-	-	S,G	5,405	44.8	5- 6-72	12b	44	D	Sand and gravel, 0-62 ft; sandstone, 62-67 ft; temperature 10.0°C; FC, >8,000; water not used for drinking.
U(C-4-4)1daa-1	D. W. Covington	1961	43	-	6	18	22	G	5,360	14	7- -61	10b	8	D	Silt, 0-18 ft; gravel and cobbles, 18-40 ft; bedrock, 40-43 ft; FC, 720.
17acb-1	Carter Oil Co.	1951	715	-	-	701	2	S,Sh	5,850	285	-	18b	-	U	Well yielded briny water; plugged and abandoned.

Table 10.--Records of selected water wells - Continued

Location	Owner	Year drilled	Well depth (ft)	Casing depth (ft)	Casing diameter (in.)	Water-bearing zone(s)			Altitude of land surface (ft)	Water level		Yield		Use of water	Remarks and other data available
						Depth to top (ft)	Thickness (ft)	Character of material		Feet	Date measured	Rate (gal/min)	Drawdown (ft)		
U(C-4-6)9abb-1	Peatress	1948	25	20	6	22	3	S	5,748	16	12- -48	8	4	D	Original depth, 120 ft but plugged back because it produced "very bad" water with gas; temperature 11.0°C; FC, 1,340; L.
U(C-4-7)14aaa-1	Pender Ranch	1947	12	12	4	-	-	-	5,875	-	-	-	-	D	Temperature 9.0°C; FC, 1,050.
17dbc-1	Sam Mott	1944	19	15	6	12	-	G	5,945	7	11- -44	7	-	D	Temperature 11.0°C; FC, 660.
35dcd-1	Thomas Olsen	1948	500	-	4	-	-	-	6,960	84	-	15	-	U	Casing pulled, well abandoned; L.
U(C-5-5)34bdd-1	W. C. Foy	1960	170	169	6	170	-	G	6,740	F	7- -60	120	21	-	Water reportedly of good quality; L.
34bdd-2	do	1961	161	65	12	-	-	-	6,610	F	-	300	18	I	Reported flow, 12 gal/min on completion; found flowing about same rate 4-13-72; C, L.
U(C-5-8)25aab-1	Thomas Olsen	1948	175	155	4	165	6	Ss	7,599	140	7- -48	5	15	S	L.

Table 11.--Selected drillers' logs of wells

Altitudes are in feet above sea level for land surface at well as interpolated from U.S. Geological Survey 7½-minute topographic maps.
Thickness, in feet.
Depth, in feet below land surface.

Material	Thickness	Depth
(D-9-20)20acd-1. Log by Garnett Birchell. 1952. Alt. 4,780 ft.		
Topsoil	3	3
Shale, blue	57	60
Sandstone, gray	13	73
Shale, blue; interbeds of brown shale	67	140
Sandstone, soft, light; salty water	25	165
Not reported	1	166
(D-9-20)27aac-1. Log by De Kalb Agricultural Association. 1959. Alt. 4,845 ft.		
Clay, varicolored, and silt	460	460
Sand, fine to coarse, light green	10	470
Limestone	30	500
Clay, silt, and sand, light gray	30	530
Clay, silt, and sand, gray, green, and purple	90	620
Clay, silt, and dolomite	10	630
Alternating shale, siltstone, and sandstone beds	660	1,290
Shale, silty, brown, and dolomite, "oil"; water at 2,720 ft	1,670	2,960
Clay, silt, and sand, light gray	110	3,070
Limestone, gray and gray green	210	3,280
Clay, silt, and sand, light gray, green gray, and tan	40	3,320
Clay and silt, gray, green, and tan, with trace of sandstone	320	3,640
Dolomite and limestone, tan	60	3,700
Clay, silt, and sand, green and light gray	280	3,980
Silt and sand, white and light gray, friable and oolitic; water bearing	50	4,030
Clay, silt, and sand, gray and green, with trace of limestone	930	4,960
Clay, tan, dense; fossils(?)	100	5,060
Clay and silt, varicolored	75	5,135
(D-11-21)31bdd-1. Log by C. W. Anderson. 1952. Alt. 5,190 ft.		
Topsoil	15	15
Gravel; water (salty) bearing	235	250
Shale, dark red	250	500
Shale, blue	198	698
Sandstone, porous	13	711
(D-11-24)33dcc-1. Log by C. M. Erb. 1936. Alt. 5,780 ft.		
Soil and gravel	15	15
Limestone	57	72
Gilsonite, low grade	8	80
Lime bed, fractured; water bearing	2	82
(D-12-22)34abc-1. Log by Everett Osborne. 1961. Alt. 6,230 ft.		
Sand, gravel, and conglomerate	12	12
Shale, blue gray	66	78
Sandstone, gray	24	102
Shale, green and buff	18	120
(D-13-21)22aab-1. Log by Everett Osborne. 1961. Alt. 5,600 ft.		
Topsoil	8	8
Clay, silty, sandy	10	18
Sand and gravel	7	25
Mud and silt, blue	15	40
(D-14-18)1bbd-1. Log by Uintah Basin Drilling Co. 1964. Alt. 7,045 ft.		
Clay and sand	14	14
Bedrock	32	46
Sandstone	6	52
Shale, blue	108	160
Shale; oil bearing	52	212
(D-14-19)3cdb-1. Log by Uintah Basin Drilling Co. 1960. Alt. 6,880 ft.		
Bedrock and clay	10	10
Shale, gray	26	36
Shale, gray and green	44	80
Sand, white	4	84
Shale, gray and green	12	96
(D-15-20)3bab-1. Log by Uintah Basin Drilling Co. 1960. Alt. 7,440 ft.		
Clay and rock	7	7
Sandstone, yellow	57	64
Sand, white	3	67
Sandstone, yellow	38	105
Sand, white	3	108
U(C-4-1)7ccb-1. Log by Garnett Birchell. 1949. Alt. 5,182 ft.		
Topsoil and gravel	16	16
Sand and gravel	9	25
Clay, blue	11	36
U(C-4-1)18dcc-1. Log by J. C. Zimmerman. 1945. Alt. 5,185 ft.		
Clay, yellow	2	2
Sand and gravel	18	20
Clay, blue	60	80
U(C-4-2)2cda-1. Log by Robinson Drilling Co. 1950. Alt. 5,295 ft.		
Topsoil	3	3
Clay, coarse gravel, and sand	7	10
Gravel, coarse, boulders, and little clay	4	14
Gravel and boulders; some water	4	18
Sandrock	4	22
Clay, dark yellow	11	33
Sandrock	2	35
Clay, blue	13	48
Sandrock	6	54
Clay, blue	6	60
Clay, blue and red	5	65
Clay, blue	28	93
Sandrock; water bearing	1	94
Clay, sandy, blue	6	100
Clay, sandy, blue, with hard shells	11	111
Shale, blue	23	134
Shale, red	9	143
Shale, blue	17	160
Shale, sandy, blue	41	201
Sandrock	4	205
Shale, sandy, blue	145	350
Shale, sandy, red	5	355
Sandrock	15	370
Shale, sandy, blue	32	402
Shale, sandy, brown	5	407
Shale, sandy, blue	10	417
Shale, sandy, brown	11	428
Shale, sandy, blue	82	510
Shale, sandy, brown	70	580
Shale, blue	20	600
Shale, brown	15	615
Shale, blue	55	670
Shale, red	10	680
Shale, blue	20	700
U(C-4-2)5abb-1. Log by Klippel Bros. 1945. Alt. 5,180 ft.		
Topsoil	6	6
Clay, sandy	7	13
Sandstone, fine	8	21
Gravel, coarse; water bearing	2	23
U(C-4-2)5bba-2. Log by Ellery Grant. 1935. Alt. 5,185 ft.		
Soil, clayey	5	5
Sand and gravel; water bearing	27	32
Clay, blue	5	37
Sand; water bearing	24	61
Shale, blue	99	160
Sandstone, water bearing	6	166
Shale, blue	302	468
Sandstone	24	492
Slate rock	8	500
Shale, blue	42	542
Unknown	578	1,120
(Well plugged back to 40-foot depth)		
U(C-4-2)14bcc-1. Log by Uintah Basin Drilling Co. 1957. Alt. 5,245 ft.		
Topsoil	10	10
Gravel	8	18
Sandrock	62	80
U(C-4-3)4daa-1. Log by Uintah Basin Drilling Co. 1953. Alt. 5,2 7 ft.		
Clay	15	15
Gravel and sand	25	40
Clay, blue	15	55
U(C-4-3)9bbd-1. Log by Uintah Basin Drilling Co. 1966. Alt. 5,327 ft.		
Clay	8	8
Clay and gravel	7	15
Sand and cobbles	26	41
Slate	22	63
Sandrock	7	70
U(C-4-3)10aba-1. Log by Klippel Bros. 1946. Alt. 5,282 ft.		
Topsoil	18	18
Sand and gravel	14	32
Shale, blue	6	38
Shale, gray, with cobble rocks and gravel	33	71
Shale, blue	3	74
Sandstone	1	75
Shale, gray, rotten	1	76
Sandstone	1	77
Shale, sandy, gray	31	108
U(C-4-3)10aba-1. - Continued		
Shale, hard, with thin shells	7	115
Shale, sandy	30	145
Shale, blue, sticky	35	180
Sandstone, soft	8	188
Shale, blue, sticky	2	190
Shale, sandy	10	200
Shale, brown, hard	2	202
Shale, blue	43	245
Shale, brown	5	250
U(C-4-3)11dcb-1. Log by Klippel Bros. 1945. Alt. 5,310 ft.		
Topsoil	2	2
Boulders and yellow clay	12	14
Clay, yellow	13	27
Shale, gray	12	39
Shale, red	5	44
Shale, gray, crumbly	1	45
Shale, gray	50	95
U(C-4-3)12aca-1. Log by Klippel Bros. 1945. Alt. 5,265 ft.		
Topsoil	2	2
Clay, sandy, with boulders	12	14
Clay, sandy	21	35
Sandstone, fine grained	2	37
Gravel, medium; water bearing	3	40
Clay, heavy	-	-
U(C-4-6)9abb-1. Log by Klippel Bros. 1948. Alt. 5,748 ft.		
Alluvium	22	22
Sand; water bearing	3	25
Shale, slatey gray	10	35
Sand, black	15	50
Shale, slatey gray	17	67
Limestone, shelly	2	69
Shale, slatey gray	5	74
Sand; water bearing	3	77
Sand, black; water bearing	43	120
U(C-4-7)35dcd-1. Log by Klippel Bros. 1948. Alt. 6,960 ft.		
Alluvium	36	36
Sandstone, brown	6	42
Limestone	8	50
Sandstone, brown	18	68
Sandstone, gray	16	84
Sandstone, black; water bearing	12	96
Limestone	21	117
Shale, sandy, yellow	47	164
Shale, gray	17	181
Unknown	3	184
Sandstone, gray	11	195
Limestone	17	212
Shale, sandy, yellow	41	253
Limestone	8	261
Shale, sandy, yellow	33	294
Sandstone, red	26	320
Shale, sandy, yellow	45	365
Shale, sandy, brown	45	410
Sandstone, black, hard	42	452
Shale, bentonitic	29	481
Sandstone, yellow, hard	7	488
Shale, bentonitic	12	500
U(C-5-5)34bdd-1. Log by Uintah Basin Drilling Co. 1960. Alt. 6,740 ft.		
Sand, silty	12	12
Gravel and cobbles	157	169
Not reported	1	170
U(C-5-5)34bdd-2. Log by Uintah Basin Drilling Co. 1961. Alt. 6,610 ft.		
Soil and clay	20	20
Clay	45	65
Gravel	2	67
Clay	9	76
Gravel	4	80
Clay	7	87
Gravel	8	95
Sand and gravel	5	100
Clay	5	105
Gravel	25	130
Clay and sand	5	135
Sand	8	143
Shale; oil bearing	4	147
Rock, solid	3	150
Shale; oil bearing	11	161
U(C-5-8)25aab-1. Log by Klippel Bros. 1948. Alt. 7,599 ft.		
Alluvium	114	114
Sandstone	40	154
Shale, sandy, gray	11	165
Sandstone; water bearing	6	171
Sandstone, hard	4	175

Table 12.--Records of selected springs

Altitude of land surface: Above mean sea level as interpolated from U.S. Geological Survey topographic maps.
Geologic source: Qay, unconsolidated deposits; Tu, Uinta Formation; Tgp, Parachute Creek Member, Green River Formation; Tw, Wasatch Formation; KTnh, North Horn Formation.
Discharge: Rate estimated or measured (m) by U.S. Geological Survey; otherwise reported (r) by owner or user; <, less than.
Use: D, domestic; I, irrigation; S, livestock; U, unused.
Remarks and other data available: C, chemical analysis of water in table 14; FC, field determination of specific conductance of the water (micromhos/cm at 25°C).

Location	Name or owner	Altitude of land surface (ft)	Geologic source	Discharge			Use	Remarks and other data available
				Rate (gal/min)	Temperature (°C)	Date		
(C-10-17)12baa-S1	Unknown	5,420	Tu	<0.5	-	3-16-72	-	Undeveloped; probably intermittent and used by livestock; C.
(D-11-15)15dbb-S1	do	6,660	Tgp	<.5	-	3-16-72	-	Do.
(D-11-17)20aca-S1	do	5,600	Tgp	<.5	-	3-16-72	-	Do.
(D-11-18)20cba-S1	do	4,800	Tgp	1		3-16-72	S	Undeveloped; rises from streambed, nearby seeps along canyon walls; C.
(D-12-21)19bdd-S1	Sulphur Spring	5,335	Tgp	20	19.5	8-30-71	U	Part of flow is collected in small tank that overflows to marshy area; entire flow is consumed by rushes and other vegetation in the general area; C.
(D-13-14)24adb-S1	Pan American Oil Corp.	8,275	Tgp	-	-	-	-	C.
(D-13-19)8aa-S1	Unknown	6,150	Tgp	.25	-	8- 8-72	-	FC, 2,200.
(D-13-23)27acd-S1	do	6,180	Tgp	<.5	-	4-12-72	-	Undeveloped; probably intermittent and used by livestock; C.
(D-13-25)13add-S1	Mud Spring	6,475	Tw	Dry	-	9- 1-71	U	Formerly used for domestic and stock supply; reportedly dry in recent years.
17bdb-S1	Flat Rock Spring	7,230	Tgp	Dry	-	9- 1-71	-	Reportedly dry in recent years.
29bab-S1	Indian Spring	7,050	Tgp	2	11.5	9- 1-71	S	Piped to stockwatering troughs; reported to yield as much as 10 gal/min; C.
(D-14-14)4abd-S1	Pan American Oil Corp.	9,500	Tgp	-	-	-	-	C.
(D-14-19)33aad-S1	Charlie Brown Spring	7,120	Tgp	<.5	-	9- 2-71	S	Piped to two stockwatering troughs; C.
(D-14-22)25cac-S1	Pine Spring	7,060	Tgp	4.5m	8.0	8- 9-65	S	Piped to stockwatering trough; discharge measured by U.S. Bureau of Land Management; C.
(D-14-24)21ccc-S1	Unknown	6,580	Tgp	10	10.0	9-12-72	S	Piped to stockwatering trough; C.
(D-15-19)4bba-S1	Secret Spring	7,190	Tgp	<.5	-	9- 2-71	-	Undeveloped; almost completely desiccated when visited; C.
(D-15-20)15bbd-S1	Flat Rock Spring	7,240	Tgp	.13m	-	8-31-71	S	Piped to stockwatering trough; C.
(D-15-23)36ddd-S1	PR Spring	8,010	Tgp	5.6m	8.5	9-17-64	S	Piped to stockwatering trough; discharge measured by U.S. Bureau of Land Management; C.
(D-15-25)7bcc-S1	Unknown	7,438	Tgp	.2m	10.5	9-23-73	S	Piped to stockwatering trough; C.
(D-16-16)31aaa-S1	Waldo Wilcox	5,590	Qay	15	11.0	4-11-72	I	Flows directly to Range Creek; discharge reportedly increases in response to irrigation upvalley from spring; FC, 860.
32dda-S1	do	5,430	Tw	150r	11.0	4-11-72	I	Piped from collector box to nearby field; owner measured discharge of 150 gal/min and reported the rate to be fairly constant throughout the year; C.
(D-16-17)3c-S1	Camel Rock Spring	4,800	Tw	225	-	9-25-48	-	C.
(D-16-18)24bcd-S1	Pinto Springs	7,925	Tgp	<1	-	8-31-71	S	Discharges to small ravine which appears to gain in flow along about a 50-foot reach; water ponded for stockwatering; C.
(D-16-22)23dcd-S1	Cedar Camp Spring	7,900	Tgp	5	-	7- 2-60	D,S	Piped to stockwatering trough; discharge measured by U.S. Bureau of Land Management.
(D-17-16)10cac-S1	Waldo Wilcox	5,040	KTnh	6r	-	-	D	Combined flow of (D-17-16)10cac-S1 and 10cca-S1 piped to several ranch houses for culinary use; C.
10cca-S1	do	5,040	KTnh	6r	-	-	D	Do.
15bac-S1	do	5,030	KTnh	<1	11.5	4-11-72	U	Undeveloped; discharges from fractured rock directly into Range Creek; FC, 1,000.
(D-17-17)20ccc-S1	Unknown	4,240	KTnh	-	-	-	-	C.
(D-17-19)9aca-S1	Bolon Spring	8,400	Tgp	5	-	8-31-71	S	Ponded just below spring area for livestock watering; FC, 400.
28bab-S1	Seeley Spring	8,920	Tgp	1.7m	6.0	8-31-71	S	Piped to small pond; C.
(D-18-19)25cbb-S1	Unknown	8,710	Tgp	5	5.0	8-31-71	S	C.
(D-18-20)7bad-S1	Marble Spring	8,970	Tgp	7m	5.0	8-31-71	S	Piped to stockwatering trough; C.
U(C-4-6)17cdc-S1	M. N. McKinnon	6,030	Tu	450r	11.0	9- 3-71	-	Largest of several springs diverted to fish culture ponds; C.
U(C-4-7)14aac-S1, 14bcd-S1, and 14bdd-S1	Stinking Spring	5,880	Tu	5	14.5	5-15-60	U	Discharges from a number of openings into a marshy area on flood plain of the Strawberry River; C.
21daa-S1	Unknown	6,160	Tu	500	8.0	4-10-72	U	Spring rises from streambed; sinks back into streambed within about half of a mile from source; C.
22ccb-S1	do	6,220	Tu	5	5.0	4-10-72	U	Melting snow directly above spring area when sampled; C.
U(C-4-9)35add-S1	do	7,515	Tu	50	5.0	4-10-72	-	Undeveloped; probably used by stock; melting snow directly above spring area when sampled; C.
U(C-5-6)1caa-S1	do	6,240	Tu	30	10.5	5-15-60	-	C.
1caa-S2	do	6,220	Tu	60	9.5	5- 5-60	-	C.
U(C-5-7)12cda-S1	do	6,880	Tu	-	-	-	-	C.
18acd-S1	-	7,450	Tu	<1	4.0	4-10-72	S	Melting snow directly above spring; water piped to storage tank and hence to stockwatering trough; C.
U(C-5-10)10dcb-S1	Big Beaver Spring	9,360	Tu	.1m	7.5	9-17-72	S	Piped to stockwatering trough; C.
U(C-5-12)25aad-S1	Race Track	8,600	Tu	17r	-	-	S	Has concrete headbox.
U(C-7-8)1acd-S1	Ross Station Spring	8,290	Tgp	5	9.0	8- 9-71	S	Piped to stockwatering trough.
U(C-7-9)9dcd-S1	Horse Ridge Spring(?)	9,770	Tgp	-	-	-	-	Assumed to be Horse Ridge Spring from reported general location; C.

Table 13.--Selected chemical

Discharge: e, estimated; m, measured.
Sodium: Where no value is reported for potassium, Na + K has been calculated and is reported as sodium.

Number (see pl. 3)	Stream	Date of collection	Temperature (°C)	Discharge (ft^3/s)	Milligrams							
					Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)
1	Timber Canyon Creek	4-10-72	-	-	28	47	34	40	1.6	366	6	29
2	Avintaquin Creek	4-10-72	-	-	24	43	31	56	1.8	350	0	60
3	Indian Canyon Creek	5- 7-58	-	12m	34	50	59	149		526	0	226
		9- 3-71	10.0	3e	27	76	140	490	7.9	948	0	1,000
4	Sowers Creek	4-13-72	2.0	3e	39	78	72	93	5.2	439	0	320
5	do	4-13-72	4.5	3e	28	170	170	290	8.2	549	0	1,200
6	Antelope Creek	3-13-72	11.0	3e	26	200	270	450	11	573	0	2,000
7	Pariette Draw	3-16-72	7.0	10e	11	210	130	1,100	4.5	345	0	2,800
8	Minnie Maud Creek	5- 6-58	-	107m	19	59	27	29		294	-	69
		8-27-58	-	1.4m	18	51	42	60		329	-	145
		10-12-71	9.5	.6m	18	56	44	61	1.8	350	0	150
9	do	5- 6-58	-	211m	23	60	32	42		338	-	84
		6-12-58	-	2.0m	19	58	94	168		606	0	361
10	Rock Creek	6-19-47	-	5.7m	26	47	28	72		270	-	53
		9-19-47	-	5.5m	-	53	35	30		301	-	81
11	Range Creek	4-11-72	13.5	2-3e	20	52	60	110	1.8	471	0	190
12	Willow Creek	9-27-72	19.0	2.85m	17	59	51	97	2.6	396	0	240
13	do	9-28-72	14.5	.25m	11	63	230	1,100	6.3	909	82	2,500
14	do	9-28-72	12.5	.08m	10	74	230	1,100	5.7	965	61	2,500
15	do	9- 2-71	17.0	-	15	62	190	930	8.7	831	0	2,300
16	Hill Creek	9- 2-71	17.0	2e	18	72	40	34	2.0	417	0	82
17	do	9- 2-71	16.5	1e	12	42	210	1,000	6.4	960	0	2,300
18	Bitter Creek	4-12-72	18.5	1e	.4	330	610	990	10	410	0	5,000
19	Evacuation Creek	9- 2-71	25.0	.05e	15	160	160	830	8.9	400	0	2,500
20	Duchesne River	(1/)	-	-	-	-	-	186	-	266	0	292
21	White River	(1/)	-	-	-	-	-	72	-	206	-	149
		5- 4-73	7.5	700m	14	67	26	62	2.4	224	0	180
22	Green River	(1/)	-	-	-	-	-	59	-	189	-	170
		4- 6-66	9.0	8,240m	10	46	22	39	4.1	162	0	120
		10- 3-66	14.0	2,910m	5.8	77	34	80	3.5	208	0	266

1/ Constituents are discharge-weighted averages for water years 1964-66.

analyses of water from streams

per litre											Specific conductance (micromhos/cm at 25°C)	Sodium-adsorption ratio	pH
Chloride (Cl)	Fluoride (F)	Nitrate (NO_3) + Nitrite (NO_2) as N	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Iron (Fe)	Manganese (Mn)	Dissolved solids (calculated)	Hardness as $CaCO_3$: Calcium (Ca), Magnesium (Mg)	Hardness as $CaCO_3$: Non-carbonate			
5.1	-	-	-	-	-	-	-	371	260	0	584	1.1	8.4
8.0	0.4	0.10	-	0.09	0.30	0.04	0.01	397	230	0	630	1.6	8.3
14	-	-	2.6	-	2.7	-	-	806	365	0	1,180	3.4	8.1
49	.8	1.70	-	.12	10.00	.16	.05	2,270	770	0	3,090	7.7	8.0
12	-	-	-	-	-	-	-	835	490	130	1,160	1.8	8.2
48	-	-	-	-	-	-	-	2,180	1,100	670	2,810	3.8	8.1
97	2.4	1.60	-	.06	7.80	.05	.00	3,350	1,600	1,100	4,170	4.9	7.9
230	1.1	7.40	-	.06	2.20	.02	.00	4,690	1,100	780	5,730	15	8.0
3.5	-	-	2.3	-	-	-	-	343	258	17	570	.8	8.1
6.0	-	-	.5	-	-	-	-	465	298	28	750	1.5	8.2
7.8	.3	0	-	.03	.10	.03	.01	511	320	34	788	1.5	8.3
5.0	-	-	2.2	-	-	-	-	296	282	5	658	1.1	8.0
15	-	-	4.1	-	-	-	-	1,000	532	35	1,470	3.2	8.2
80	-	-	1.0	-	-	-	-	440	232	12	513	2.1	-
6.0	-	-	1.2	-	-	-	-	354	276	30	585	.8	-
13	.4	.15	-	.12	.11	.01	.01	680	380	0	1,040	2.5	6.2
9.0	-	-	-	-	-	-	-	670	360	32	1,010	2.2	8.2
120	-	-	-	-	-	-	-	4,560	1,100	220	6,000	14	8.6
120	-	-	-	-	-	-	-	4,580	1,100	240	5,970	14	8.4
76	.4	.21	-	.15	6.50	.12	.04	4,000	940	260	5,190	13	8.3
3.8	.1	.00	-	.15	.07	.07	.03	457	340	2	712	.8	8.1
100	.3	.12	-	.28	5.80	.02	.02	4,150	970	180	5,250	14	8.2
88	1.6	.58	-	.00	2.60	.04	.03	7,240	3,300	3,000	7,520	7.5	8.3
44	.3	.62	-	.15	.41	.03	.05	3,900	1,100	730	4,820	11	8.0
49	-	-	-	-	-	-	-	702	346	154	1,003	2.2	7.9
58	-	-	-	-	-	-	-	484	250	81	756	1.9	7.8
35	.4	.20	-	.15	.09	-	-	499	270	91	774	1.6	8.2
28	-	-	-	-	-	-	-	457	245	89	684	1.6	7.9
18	.4	-	2.7	-	.08	-	-	356	206	73	540	1.2	7.6
38	.4	-	6.3	-	.17	-	-	651	330	159	932	1.9	7.4

Table 14.--Chemical analyses of water

Geologic source: Qay, unconsolidated deposits; Tu, Uinta Formation; Tgp, Parachute Creek Member, Green River Formation; Tgu, Green River Formation, undivided; Tw, Wasatch Formation; KTnh, North Horn Formation.
Sodium: Where no value is reported for potassium, Na + K has been calculated and is reported as sodium.

Location	Name or owner	Geologic source	Date of collection	Temperature (°C)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)
					Milligrams							
(D-9-17)21dca-1	U.S. Bureau of Land Management	Tu	9- 3-71	-	11	20	16	510	2.2	467	0	720
(D-10-17)12baa-S1	Unknown	Tu	3-16-72	11.0	14	60	27	980	5.1	571	0	1,600
(D-10-20)35bbc-1	U.S. Bureau of Land Management	Tgu	7-24-64	-	15	.0	7.3	859		1,420	189	9.1
(D-11-15)15dbb-S1	Unknown	Tgp	3-16-72	-	37	32	29	810	5.6	983	0	980
32dcd-1	Preston-Nutter Corp.	-	4-11-72	-	22	75	100	170	2.8	726	0	360
(D-11-17)20aca-S1	Unknown	Tgp	3-16-72	-	-	75	63	1,000	-	690	-	-
(D-11-18)20cba-S1	do	Tgp	3-16-72	8.0	29	78	73	1,000	6.2	809	0	1,800
(D-11-21)31bdd-1	Golden Hatch	Tgu	8-31-71	16.0	15	.7	.7	370	.9	562	65	220
(D-11-24)6dbc-1	U.S. Bureau of Land Management	Tgu	8-26-65	-	12	3.2	.5	438		644	0	334
7cac-1	do	Tgu	8-26-65	-	12	3.2	.5	418		691	0	310
(D-12-21)19bdd-S1	Sulphur Spring	Tgp	8-30-71	-	15	1.6	.6	230	.8	353	32	150
(D-13-14)24adb-S1	Pan American Oil Corp.	Tgp	7-15-66	-	-	73	31	25	1.0	415	0	15
24dba-1	do	Tgp	7-15-66	-	-	59	29	30	1.0	366	0	20
(D-13-23)27acd-S1	Unknown	Tgp	4-12-72	10.5	17	160	200	410	7.3	576	0	1,500
(D-13-25)29bab-S1	Indian Spring	Tgp	9- 1-71	-	24	150	110	140	.7	308	0	850
(D-14-14)4abd-S1	Pan American Oil Corp.	Tgp	7-15-66	-	-	36	60	37	1.0	293	0	153
(D-14-19)33aad-S1	Charlie Brown Spring	Tgp	9- 2-71	-	28	84	61	93	1.3	438	0	300
(D-14-22)25cac-S1	Pine Spring	Tgp	4-12-72	8.0	19	63	86	92	1.9	506	0	240
(D-14-24)21ccc-S1	Unknown	Tgp	9-13-72	10.0	21	130	72	74	1.2	319	0	500
(D-15-19)4bba-S1	Secret Spring	Tgp	9- 2-71	-	-	81	-	130	-	370	-	390
(D-15-20)15bbd-S1	Flat Rock Spring	Tgp	8-31-71	17.0	16	57	16	24	.4	242	0	57
(D-15-23)36ddd-S1	PR Spring	Tgp	9-17-64	8.5	17	65	36	17		302	0	94
(D-15-25)7bcc-S1	Unknown	Tgp	9-12-72	10.5	16	74	48	36	.5	275	0	200
(D-16-16)32dda-S1	Waldo Wilcox	Tw	4-11-72	11.0	23	58	52	66	1.0	449	0	120
(D-16-17)3c-S1	Camel Rock Spring	Tw	9-25-48	-	26	70	41	73		321	0	220
(D-16-18)24bcd-S1	Pinto Springs	Tgp	8-31-71	-	22	58	17	10	.6	248	0	33
(D-17-16)10cac-S1 } 10cca-S1 }	Waldo Wilcox	KTnh	4-11-72	-	23	58	54	100	1.2	483	0	190
(D-17-17)20ccc-S1	Unknown	KTnh	9-25-48	-	18	10	5.7	250		492	0	176
(D-17-19)28bab-S1	Seeley Spring	Tgp	8-31-71	6.0	15	57	16	6.4	.4	267	0	13
(D-18-19)25cbb-S1	Unknown	Tgp	8-31-71	5.0	11	60	24	2.7	.7	297	0	29
(D-18-20)7bad-S1	Marble Spring	Tgp	8-31-71	5.0	8.3	49	10	3.3	.3	193	0	16
U(C-3-5)31dcd-1	D. T. Jones	Tu	3-30-72	10.0	18	4.6	6.4	450	1.4	496	52	310
U(C-4-2)5bba-2	Lamar Neilson	Qay	5-22-72	11.5	23	400	230	620	3.9	414	0	2,900
13daa-2	Alden Kynaston	Tu	5- 7-72	14.0	23	95	34	110	3.7	411	0	280
U(C-4-3)9bbd-1	Latter-day Saints Church	Tu	5- 7-72	-	8.6	18	6.2	380	2.4	281	0	530
10cbb-1	Willis Shepard	Qay	5- 3-72	-	17	150	87	460	2.6	278	0	1,400
12cab-1	Wallace Pitt	-	5- 7-72	-	18	66	36	87	1.8	384	0	160
U(C-4-6)17cdc-S1	M. N. McKinnon	Tu	9- 3-71	11.0	15	25	140	790	7.3	761	0	1,200
			5-15-60	13.5	11	23	126	865		1,290	106	1,000
U(C-4-7)14acc-S1	Stinking Spring	Tu	5-18-41	-	10	1.0	6.1	1,760	2.3	1,470	1,060	110
14bcd-S1	do	Tu	5-18-41	-	12	5.6	5.5	3,220	7.0	1,990	2,580	188
14bdd-S1	do	Tu	5-15-60	14.5	34	0	0	3,110		1,380	2,800	11
21daa-S1	Unknown	Tu	4-10-72	8.0	23	32	120	420	4.9	803	17	670
22ccb-S1	do	Tu	4-10-72	5.0	28	140	160	170	4.0	424	0	940
U(C-4-9)35add-S1	do	Tu	4-10-72	5.0	23	86	59	23	2.0	370	0	190
U(C-5-5)34bdd-2	W. C. Foy	-	4-13-72	8.5	30	140	100	100	4.4	474	0	570
U(C-5-6)1caa-S1	Unknown	Tu	5-15-60	10.5	22	61	125	420		988	0	682
1caa-S2	do	Tu	5-15-60	9.5	23	63	118	437		1,020	0	670
U(C-5-7)12cda-S1	do	Tu	5-15-60	10.0	6.3	37	131	779		1,200	144	887
18acd-S1	do	Tu	4-10-72	4.0	45	160	180	21	5.6	467	0	780
U(C-5-10)10dcb-S1	Big Beaver Spring	Tu	9-11-72	7.5	13	77	33	3.4	.8	348	0	52
U(C-7-8)1acd-S1	Ross Station Spring	Tgp	8- 9-71	9.0	47	57	45	62	3.6	475	0	33
U(C-7-9)9dcd-S1	Horse Ridge Spring(?)	Tgp	7-18-60	12.5	12	42	17	3.8		211	0	7.8

from selected springs and water wells

per litre													
Chloride (Cl)	Fluoride (F)	Nitrate (NO_3) + Nitrite (NO_2) as N	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Iron (Fe)	Manganese (Mn)	Dissolved solids (calculated)	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$	Specific conductance (micromhos/cm at 25°C)	Sodium-adsorption ratio	pH
91	0.2	0.46	-	0.12	0.71	-	-	1,600	120	0	2,350	21	8.3
210	2.1	.65	-	.21	4.90	0.04	0.00	3,190	260	0	4,170	26	7.9
290	-	-	0.3	-	-	-	-	2,070	30	0	3,340	68	9.0
48	3.8	.63	-	.64	11.0	.20	.00	2,440	200	0	3,410	25	8.1
15	-	-	-	-	-	-	-	1,100	600	3	1,620	3.0	7.4
-	-	-	-	-	-	-	-	3,580	450	0	-	21	-
56	4.0	3.60	-	.25	15.0	.02	.00	3,480	490	0	4,580	20	7.8
9.3	.9	.07	-	.06	.29	.03	.02	959	5	0	1,490	75	8.7
60	-	-	1.	-	-	-	-	1,170	10	0	1,800	60	8.2
21	-	-	1.4	-	-	-	-	1,110	10	0	1,720	58	8.2
6.3	.2	.51	-	.06	.15	.02	.00	613	6	0	968	39	8.5
6.0	-	-	-	-	-	-	-	356	310	-	550	.6	7.9
8.0	-	-	-	-	-	-	-	327	266	-	499	.8	8.2
140	-	-	-	-	-	-	-	2,720	1,200	750	3,850	5.1	7.8
33	.1	.01	-	.06	.06	.00	.02	1,460	830	570	1,980	2.1	7.7
14	-	-	-	-	-	-	-	445	337	-	688	.9	8.4
18	.2	.13	-	.06	.16	.04	.00	802	460	100	1,160	1.9	7.9
29	1.4	.42	-	.03	.13	.03	.01	783	510	96	1,220	1.8	7.9
13	.3	1.60	-	.06	.07	.02	.00	976	620	360	1,340	1.3	7.4
-	-	-	-	-	-	-	-	-	-	-	1,270	-	7.8
7.9	.1	.68	-	.09	.07	.01	.00	301	210	10	478	.7	7.6
2.8	-	-	.5	-	-	-	-	381	312	64	606	.4	7.7
14	-	-	-	-	-	-	-	524	380	160	851	.8	7.5
7.9	.3	.24	-	.09	.06	.00	.00	550	360	0	876	1.5	7.4
7	-	-	.7	-	-	-	-	596	340	80	842	1.7	-
2.1	.1	1.2	-	.28	.02	.08	.02	270	210	11	443	.3	7.4
11	.4	.17	-	.09	.08	.00	.00	676	370	0	1,050	2.3	7.5
5	-	-	.1	-	-	-	-	707	48	0	1,060	16	-
1.4	.0	.36	-	.21	.00	.01	.01	242	210	0	405	.2	7.7
1.6	.0	.18	-	.03	.01	.00	.04	276	250	5	459	.1	7.7
1.9	.0	2.30	-	.03	.01	.02	.00	194	160	5	326	.1	7.8
140	1.2	.03	-	.12	2.70	.02	.00	1,230	38	0	1,950	32	8.9
84	2.3	.06	-	.03	9.0	1.6	.53	4,480	1,900	1,600	4,700	6.1	7.0
21	-	-	-	-	-	-	-	769	380	40	1,200	2.5	7.7
82	1.4	.17	-	.00	.82	.02	-	1,170	70	0	1,820	20	8.2
94	1.0	3.40	-	.00	.97	.05	.01	2,360	730	500	3,110	7.4	7.7
14	-	-	-	-	-	-	-	572	310	0	926	2.1	7.7
140	.6	7.10	-	2.60	8.20	.01	.00	2,730	640	15	4,300	14	8.1
128	-	-	2.2	-	7.7	-	-	2,910	576	0	3,980	16	8.5
594	-	-	.6	-	12.8	-	-	4,270	28	0	6,790	146	9.3
704	-	-	1.2	-	22.6	-	-	7,702	37	0	11,380	232	9.6
668	-	-	1.3	-	20.0	-	-	7,320	0	0	10,700	-	10.1
92	-	-	-	-	-	-	-	1,770	570	0	2,500	7.6	8.5
52	-	-	-	-	-	-	-	1,700	1,000	660	2,230	2.3	7.9
10	-	-	-	-	-	-	-	575	460	150	884	.5	7.5
26	1.9	.04	-	.12	2.7	.10	.09	1,210	760	370	1,680	1.6	7.3
41	-	-	.9	-	6.3	-	-	1,840	666	0	2,520	7.1	8.0
41	-	-	1.2	-	6.5	-	-	1,860	642	0	2,590	7.5	8.1
124	-	-	4.1	-	6.6	-	-	2,710	632	0	3,690	13	8.8
18	2.9	.08	-	.00	.23	.03	.00	1,440	1,100	760	1,820	.3	8.1
1.6	.4	.12	-	.03	.02	.01	.00	353	330	43	604	.1	7.4
35	.8	1.70	-	.09	.51	.01	.00	525	330	0	800	1.5	7.9
2.8	-	-	.4	-	-	-	-	190	177	4	332	.1	7.3

Table 15.--Chemical analyses of water

Geologic source: Tgu, Green River Formation, undivided; Tw, Wasatch Formation; Kmv, Mesaverde Group; Km, Mancos Shale; Jm, Morrison Formation; Je, Entrada Sandstone; Jn, Navajo Sandstone; M, Mississippian rocks, undivided.
Interval sampled: Depth below land surface.
Source of sample: CP, circulation pit; DST, drill-stem test; F, natural flow; PW, water produced with oil or gas; RL, return line; ST, swab test; Tr, treater; WT, wash tank; numbers in parentheses are reported or estimated water yields, in gallons per minute, at time sample was collected.
Date of collection; P, concentrations are in parts per million (conversion to milligrams per liter not possible because data for density were not available).
Sodium: Where no value is reported for potassium, Na + K has been calculated and is reported as sodium.
Specific conductance: Determined in analyses by U.S. Geological Survey, otherwise calculated from determined specific resistivity.
Source of analysis: CGL, Chemical and Geological Laboratories; GS, U.S. Geological Survey; OL, operator or lessee; RME, Rocky Mountain Engineering Co.; UC, Utah State Chemist.

Location	Operator or lessee	Geologic source	Interval sampled (ft)	Source of sample	Date of collection	Milligrams per litre: Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
(D-9-16)5ddb-1	Diamond Shamrock Corp.	Tgu	4,602- 5,747	WT	3-20-68	-	-	-	-	-
15cbb-1	do	Tgu	4,440- 5,180	DST	3-20-68	-	-	-	-	-
(D-9-20)22ccb-1	Continental Oil Co.	Jn	17,350-17,851	DST	6-20-72	-	910	120	13,000	-
		M	19,350-20,053	DST	6-19-72	-	7,300	1,300	33,000	4,300
27aac-1	De Kalb Agricultural Association	Tgu	2,726- 2,780 3,970- 4,005	F	4- 2-64	-	-	-	-	-
36ddc-1	Western Oil Shale Corp.	Tgu	1,900- 2,822	DST	7-31-69	9.2	2.8	.8	28,500	102
		Tgu	1,900- 2,959	DST	7-29-69	9.2	4.1	1.2	28,000	104
		Tgu	1,900- 3,234	DST	7-30-69	8.6	4.1	1.2	14,600	53
		Tgu	1,900- 3,234	DST	7-31-69	12	2.0	1.2	16,600	62
(D-10-16)11acd-1	Mountain Fuel Supply Co.	Tgu	4,289- 4,321	DST	10- 1-64	-	139	67	11,561	118
16dac-1	do	Tgu	3,616- 3,646	DST	4- -63	-	395	78	2,029	105
(D-10-17)30bbd-1	Miami Oil Producers Inc.	Tgu	3,777- 3,789	DST	8-10-67	-	783	33	4,023	33
		Tgu	4,071- 4,116	DST	8-10-67	-	864	295	19,675	80
(D-10-18)13cdb-1	Mountain Fuel Supply Co.	Tgu	4,045- 4,080	DST	P11-14-61	-	2,057	269	23,639	
14bbd-1	do	Tgu	2,162- 2,282	DST	3-26-61	-	10	3.0	2,613	
		Tgu	3,681- 3,746	DST	P 4- 1-61	-	592	308	28,667	
		Tgu	3,877- 3,915	DST	P 4- 2-61	-	987	274	26,780	
		Tgu	4,231- 4,310	DST	P 4- 4-61	-	1,918	359	21,560	
(D-10-19)1cbd-1	do	Tgu	2,850- 2,875	F	10-15-63	-	11	10	3,449	28
(D-10-20)4ccb-1	do	Tgu	2,900- 3,000	F(120)	7- -63	-	6.0	2.0	1,977	5.0
7cdb-1	do	Tgu	2,070- 2,096	DST	P10-16-60	-	11	8.0	39,367	
		Tgu	3,102- 3,142	DST	10-21-60	-	11	1.0	812	
8cab-1	do	Tgu	3,310- 3,337	DST	7-10-62	-	6.0	-	928	
		Tgu	3,488- 3,514	DST	7-12-62	-	272	92	10,506	
(D-10-21)16add-1	Tenneco Oil Corp.	Tgu	1,900- 3,520	F(125)	4- 2-64	13	.0	2.4	785	
(D-10-23)24bba-1	Consolidated Oil and Gas Co.	Tgu	At 3,066	RL	10-15-61	-	2.0	1.0	572	
(D-10-24)28dcd-1	El Paso Natural Gas Co.	Kmv	5,295- 5,305	ST	6-11-59	-	1,929	82	5,210	
32ca-1	Shell Oil Co.	Tw	4,390- 4,497	DST	P 1-21-62	-	21	11	3,068	
		Kmv	5,230- 5,303	DST	P 1-28-62	-	304	63	10,580	
		Kmv	6,187- 6,494	PW(1)	P 4-30-62	-	648	238	7,917	
		Kmv	6,570- 6,947	ST	P 3-22-62	-	1,040	298	6,323	
(D-11-12)14baa-1	McCarthy Oil Co.	Tgu	635- 650	F(0.5)	7-22-65	9.8	6.4	4.4	221	
(D-11-15)2ccc-1	Miami Oil Producers Inc.	Tgu-Tw	4,148- 4,163	DST	10- 3-67	-	559	426	11,704	30
(D-11-16)3bbc-1	do	Tgu	4,119- 4,170	DST	9-11-67	-	27	10	2,419	16
		Tgu	4,197- 4,218	DST	9-11-67	-	10	-	1,200	6.0
(D-11-24)8caa-1	Diamond Shamrock Corp.	Tgu	At 1,275	F(70)	9- 6-61	13	3.6	1.5	437	1.6
(D-11-25)22cda-1	Continental Oil Co.	Km	At 6,225	RL	8- 1-61	-	49	78	1,500	62
(D-12-14)13acb-1	Carter Oil Co.	Kmv	8,505- 8,617	DST	P 6-27-52	-	350	64	8,198	
		Kmv	8,604- 8,789	DST	P 7- 9-52	-	139	26	4,596	
(D-13-23)26acd-1	Skyline Oil Co.	Tgu	At 2,000	-	6-15-60	40.5	10.4	7.1	261	
(D-14-20)7adb-1	Phillips Petroleum Co.	Kmv	7,080- 7,180	DST	9-17-62	-	8.0	2.0	1,672	
30ac	Hiko Bell Mining and Oil Co.	Tw	3,790- 3,820	F(<1)	7-13-65	23	625	93	12,114	
30bab	do	Tgu	1,883- 1,910	ST	7-22-63	-	10	7.0	274	13
(D-15-21)22dcc-1	Atlantic Refining Co.	Tw	3,134- 3,142	DST	9-26-63	-	20	36	664	
		Tw	3,466- 3,480	DST	9-28-63	-	80	36	3,766	
		Kmv	5,518- 5,541	DST	10-12-63	-	600	109	11,643	
(D-15-22)36dac-1	Texaco Inc.	Je	9,232- 9,349	ST(3)	P 4- -60	-	5,115	534	28,237	
(D-15½-23)33dca-1	do	Jm-Je	8,630- 8,714	-	P 9- -61	-	5,789	454	34,077	
U(C-4-1)13dad-1	Gulf Oil Co.	Tgu	4,020- 4,080	DST	4-10-69	-	17	-	23,836	151
		Tgu	5,140- 5,306	DST	4-10-69	-	22	20	17,264	174
U(C-4-4)13dda-1	Carter Oil Co.	Tgu	3,281- 3,569	DST	2-23-52	-	-	-	1,117	
		Tgu	5,871- 5,935	DST	P 4-11-52	-	16	7.0	4,287	
16aca-1	Friar Oil Co.	Tgu	2,770- 3,350	Tr	P 3- -62	-	8.0	3.0	72,820	
17aca-1	do	Tgu	2,438- 3,582	WT	P 6- 7-62	-	37	-	15,908	
17bcd-1	do	Tgu	2,410- 3,408	RL	11-30-64	-	.0	87	49,139	
U(C-4-5)8bdd-1	Gulf Oil Co.	Tw	7,366- 8,122	PW	1-12-67	22	56	17	2,750	27
					5- 7-70	-	75	9	2,594	32
10bdd-1	Brinkerhoff Drilling Co.	Tgu	6,335- 6,483	DST	1- 4-72	-	20	16	3,015	24
14dca-1	Friar Oil Co.	Tu	At 915	CP(30)	P 4-19-62	-	10	Trace	9,868	
U(C-6-6)35bdd-1	Humble Oil and Refining Co.	Tgu	3,190- 3,260	DST	11- -61	-	32	8.0	3,979	

collected from oil and gas wells and tests

(parts per million where P precedes date of collection)

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids: Determined	Dissolved solids: Sum of constituents	Hardness as $CaCO_3$	Noncarbonate hardness	Sodium-adsorption ratio	Specific conductance (micromhos/cm at 25°C)	pH	Source of analysis
-	-	-	49,128	-	-	-	-	-	-	131,000	-	GS
-	-	-	6,941	-	-	-	-	-	-	21,600	-	GS
-	-	3,300	14,000	-	-	-	280	-	108	-	6.8	GS
-	-	630	76,000	-	-	-	24,000	-	94	-	6.6	GS
-	-	-	4,000	-	-	-	-	-	-	55,900	-	GS
5,910	1,230	464	37,500	0.1	72,700	-	12	0	-	85,000	8.9	GS
5,710	832	917	37,100	.1	72,200	-	16	0	-	82,000	8.8	GS
3,830	856	35	18,600	.1	37,000	-	16	0	-	48,000	8.9	GS
5,940	319	400	21,500	.1	41,800	-	11	0	-	54,000	8.6	GS
561	-	216	17,900	-	-	30,278	8,000	-	-	-	8.2	CGL
488	-	5,100	120	-	-	8,068	-	-	-	-	7.8	CGL
305	-	2,900	5,400	-	-	13,322	-	-	-	-	7.2	CGL
1,110	0	7,000	27,000	-	-	55,461	-	-	-	-	7.6	CGL
425	-	3,580	38,000	-	67,720	67,754	-	-	-	-	7.9	CGL
1,342	600	26	2,549	-	6,840	6,462	-	-	-	-	8.6	CGL
427	36	11,827	37,152	-	-	78,792	-	-	-	-	8.4	CGL
878	-	2,798	41,280	-	-	72,551	-	-	-	98,200	8.1	CGL
647	-	3,728	34,572	-	-	62,456	-	-	-	83,300	8.1	CGL
2,452	72	1,600	2,700	-	-	9,078	-	-	-	12,940	8.4	CGL
2,721	180	130	1,190	-	-	4,832	-	-	-	7,430	8.9	CGL
9,150	8,520	525	45,000	-	98,250	97,937	-	-	-	108,840	9.7	CGL
1,379	216	107	140	-	2,032	1,966	-	-	-	4,000	8.7	CGL
1,440	228	54	296	-	2,486	2,221	-	-	-	3,330	8.8	CGL
1,720	-	3,870	13,100	-	30,480	26,489	-	-	-	40,290	8.0	CGL
1,480	128	14	195	.7	-	1,870	10	0	99	3,080	8.8	GS
1,074	48	145	99	-	1,367	1,941	8	-	88	-	8.9	OL
19	-	481	11,284	-	20,561	19,595	-	-	-	-	4.8	RME
1,220	72	620	3,550	-	7,950	8,562	96	-	-	-	8.7	OL
1,244	0	770	15,762	-	29,410	28,723	1,020	-	-	-	7.8	OL
903	0	308	13,312	-	25,266	23,326	2,600	-	-	-	6.6	OL
464	0	470	11,857	-	23,996	20,452	3,825	-	-	-	6.2	OL
392	0	179	5.1	.1	603	619	34	0	16	942	7.8	GS
2,769	-	10,576	10,900	-	-	35,559	-	-	-	-	7.9	CGL
2,440	300	2,262	380	-	-	6,616	-	-	-	-	8.7	CGL
2,428	300	10	100	-	-	2,822	-	-	-	-	8.9	CGL
606	12	422	4.0	.6	-	1,200	15	0	49	1,820	8.5	GS
375	-	2,900	186	-	-	5,800	-	-	-	-	7.6	OL
1,015	-	2,523	11,000	-	-	26,630	-	-	-	-	6.9	CGL
915	60	1,638	5,600	-	-	12,511	-	-	-	-	-	CGL
311	-	423	17	-	-	1,086	-	-	-	-	7.6	UC
964	264	2,150	140	-	4,714	4,711	-	-	-	-	9.3	CGL
539	0	1,517	18,625	25	33,899	-	1,944	1,496	119	48,900	7.3	GS
366	12	290	32	-	-	818	-	-	-	-	8.7	CGL
149	12	3.0	1,065	-	-	1,966	-	-	-	-	8.4	OL
156	14	7,579	355	-	-	11,986	-	-	-	-	8.6	OL
107	0	5,813	14,981	-	-	33,253	-	-	-	-	7.3	OL
190	-	72	54,000	-	91,800	88,052	-	-	-	-	7.3	CGL
207	-	16	64,000	-	106,800	104,438	-	-	-	-	6.3	CGL
4,355	276	102	34,000	-	-	60,527	-	-	-	-	8.3	CGL
2,086	204	584	25,000	-	-	44,295	-	-	-	-	8.4	CGL
1,550	271	164	380	-	2,758	2,695	-	-	-	-	9.0	OL
1,730	251	79	5,300	-	10,618	10,792	-	-	-	-	8.5	OL
51,240	13,800	347	66,000	-	188,830	178,213	-	-	-	-	9.7	CGL
4,758	7,680	228	12,600	-	39,220	38,796	-	-	-	-	9.6	CGL
23,326	23,217	744	34,553	22	142,790	119,246	360	0	-	-	9.6	GS
1,000	-	1,990	2,390	4.4	-	7,770	209	0	83	11,200	7.8	CGL
1,000	-	1,774	2,300	-	-	7,276	-	-	-	-	7.8	GS
3,221	228	72	2,560	-	-	7,521	-	-	-	-	8.7	CGL
0	9,015	77	3,400	-	22,961	22,915	-	-	-	-	10.2	CGL
5,120	675	58	2,400	-	9,632	9,674	-	-	-	-	8.8	CGL

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*No. 2. Water production from oil wells in Utah, by Jerry Tuttle, Utah State Engineer's Office, 1960.

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*No. 18. The effect of pumping large-discharge wells on the ground-water reservoir in southern Utah Valley, Utah County, Utah, by R. M. Cordova and R. W. Mower, U.S. Geological Survey, 1967.

No. 19. Ground-water hydrology of southern Cache Valley, Utah, by L. P. Beer, 1967.

No. 20. Fluvial sediment in Utah, 1905-65, A data compilation by J. C. Mundorff, U.S. Geological Survey, 1968.

No. 21. Hydrogeology of the eastern portion of the south slopes of the Uinta Mountains, Utah, by L. G. Moore and D. A. Barker, U.S. Bureau of Reclamation, and James D. Maxwell and Bob L. Bridges, Soil Conservation Service, 1971.

No. 22. Bibliography of U.S. Geological Survey water-resources reports for Utah, compiled by Barbara A. LaPray, U.S. Geological Survey, 1972.

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STATE OF UTAH
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TECHNICAL PUBLICATION NO. 49
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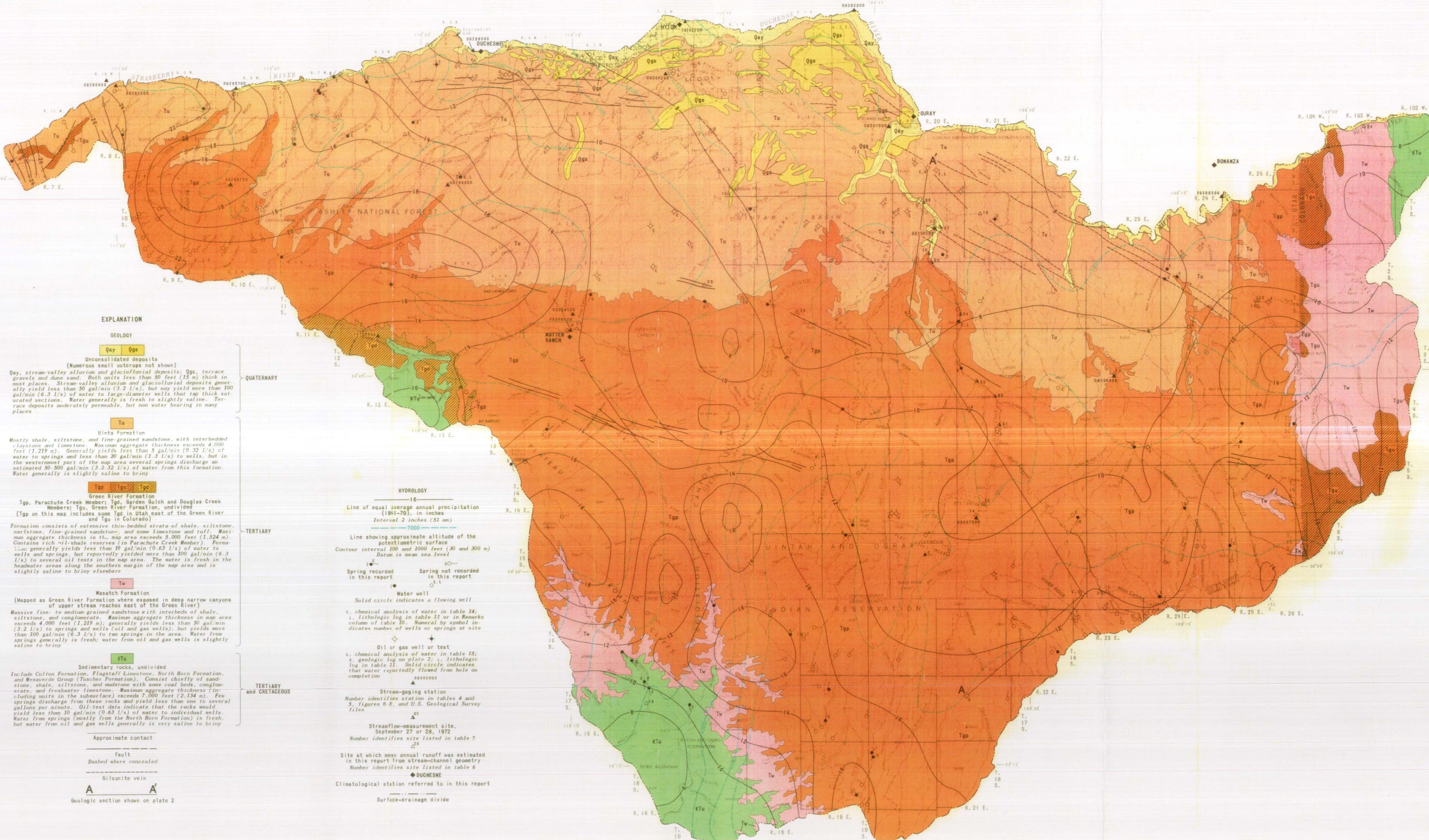


EXPLANATION

GEOLOGY

Qay | Qgs

Unconsolidated deposits
(Numerous small outcrops not shown)

Qay, stream-valley alluvium and glaciofluvial deposits; Qgs, terrace gravels and dune sand. Both units less than 50 feet (15 m) thick in most places. Stream-valley alluvium and glaciofluvial deposits generally yield less than 50 gal/min (3.2 l/s), but may yield more than 100 gal/min (6.3 l/s) of water to large-diameter wells that tap thick saturated sections. Water generally is fresh to slightly saline. Terrace deposits moderately permeable, but non water bearing in many places

QUATERNARY

Tu

Uinta Formation

Mostly shale, siltstone, and fine-grained sandstone, with interbedded claystone and limestone. Maximum aggregate thickness exceeds 4,000 feet (1,219 m). Generally yields less than 5 gal/min (0.32 l/s) of water to springs and less than 20 gal/min (1.3 l/s) to wells, but in the westernmost part of the map area several springs discharge an estimated 50-500 gal/min (3.2-32 l/s) of water from this formation. Water generally is slightly saline to briny

Tgp | Tgu | Tgd

Green River Formation
Tgp, Parachute Creek Member; Tgd, Garden Gulch and Douglas Creek Members; Tgu, Green River Formation, undivided
(Tgp on this map includes some Tgd in Utah east of the Green River and Tgu in Colorado)

Formation consists of extensive thin-bedded strata of shale, siltstone, marlstone, fine-grained sandstone, and some limestone and tuff. Maximum aggregate thickness in the map area exceeds 5,000 feet (1,524 m). Contains rich oil-shale reserves (in Parachute Creek Member). Formation generally yields less than 10 gal/min (0.63 l/s) of water to wells and springs, but reportedly yielded more than 100 gal/min (6.3 l/s) to several oil tests in the map area. The water is fresh in the headwater areas along the southern margin of the map area and is slightly saline to briny elsewhere

Tw

Wasatch Formation
(Mapped as Green River Formation where exposed in deep narrow canyons of upper stream reaches east of the Green River)

Massive fine- to medium-grained sandstone with interbeds of shale, siltstone, and conglomerate. Maximum aggregate thickness in map area exceeds 4,000 feet (1,219 m); generally yields less than 50 gal/min (3.2 l/s) to springs and wells (oil and gas wells), but yields more than 100 gal/min (6.3 l/s) to two springs in the area. Water from springs generally is fresh; water from oil and gas wells is slightly saline to briny

TERTIARY

KTu

Sedimentary rocks, undivided

Include Colton Formation, Flagstaff Limestone, North Horn Formation, and Mesaverde Group (Tuscher Formation). Consist chiefly of sandstone, shale, siltstone, and mudstone with some coal beds, conglomerate, and freshwater limestone. Maximum aggregate thickness (including units in the subsurface) exceeds 7,000 feet (2,134 m). Few springs discharge from these rocks and yield less than one to several gallons per minute. Oil-test data indicate that the rocks would yield less than 10 gal/min (0.63 l/s) of water to individual wells. Water from springs (mostly from the North Horn Formation) is fresh, but water from oil and gas wells generally is very saline to briny

TERTIARY and CRETACEOUS

Approximate contact

Fault
Dashed where concealed

Gilsonite vein

A A'
Geologic section shown on plate 2

HYDROLOGY

16

Line of equal average annual precipitation (1941-70), in inches
Interval 2 inches (51 mm)

7000

Line showing approximate altitude of the potentiometric surface
Contour interval 100 and 1000 feet (30 and 300 m)
Datum is mean sea level

Spring recorded in this report

Spring not recorded in this report

Water well
Solid circle indicates a flowing well

C, chemical analysis of water in table 14; L, lithologic log in table 11 or in Remarks column of table 10. Numeral by symbol indicates number of wells or springs at site

Oil or gas well or test
C, chemical analysis of water in table 15; G, geologic log on plate 2; L, lithologic log in table 11. Solid circle indicates that water reportedly flowed from hole on completion

09302000
Stream-gaging station
Number identifies station in tables 4 and 5, figures 6-8, and U.S. Geological Survey files

35
Streamflow-measurement site, September 27 or 28, 1972
Number identifies site listed in table 7

28
Site at which mean annual runoff was estimated in this report from stream-channel geometry
Number identifies site listed in table 6

DUCHESNE
Climatological station referred to in this report

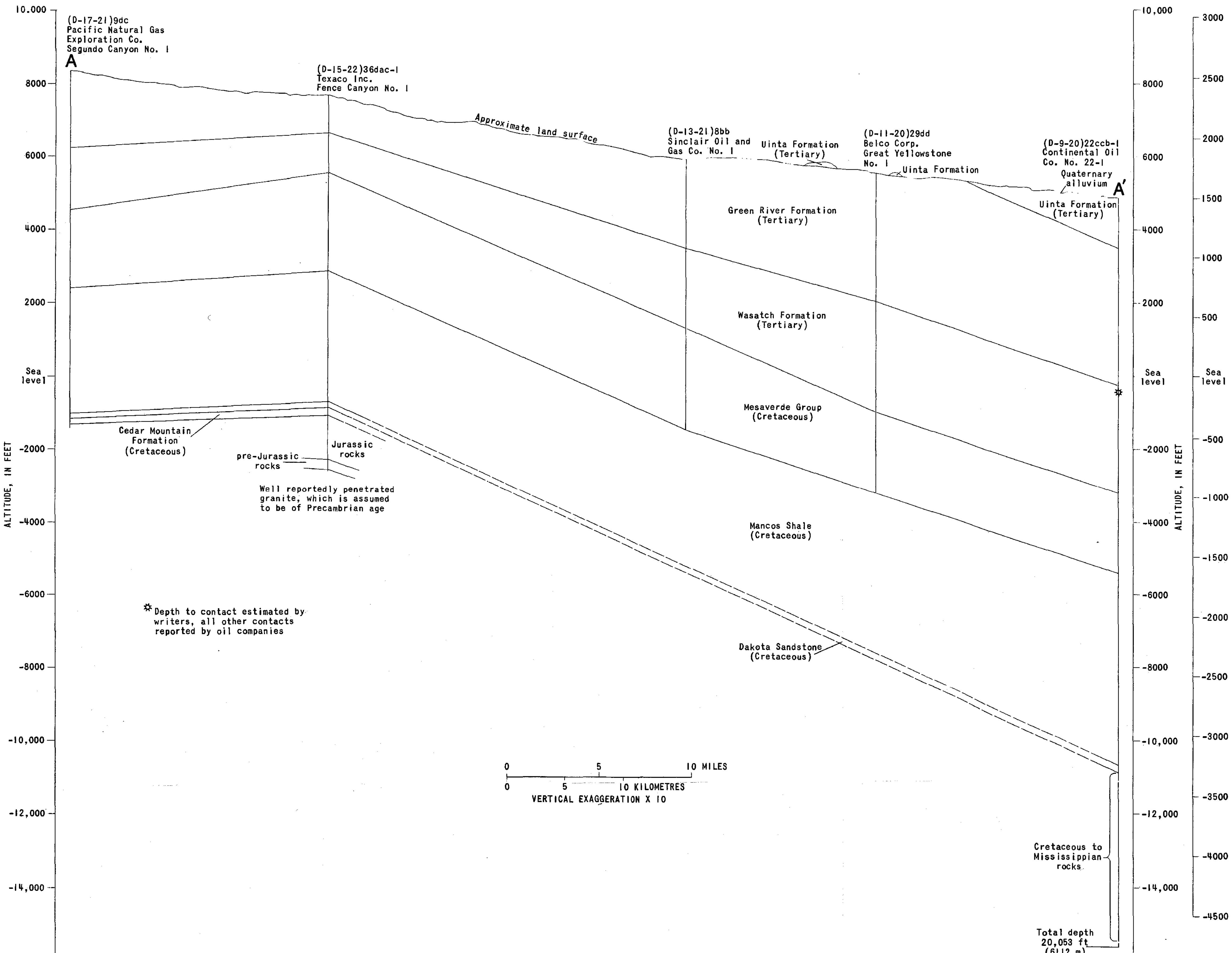
Surface-drainage divide

Base from U.S. Geological Survey 1:250,000 series: Grand Junction, 1962; Price, 1962; Salt Lake City, 1963; and Vernal, 1965

5 0 5 10 15 20 MILES
5 0 5 10 15 20 25 30 KILOMETRES

Hydrology by Don Price and Louise L. Miller, 1973. Geology in Utah after Stokes (1964), modified from data in Cashion and Donnell (1974); in Colorado after Burbank and others (1935). Average annual precipitation from Fields and Adams (1975)

Hydrogeologic map of the southern Uinta Basin, Utah and Colorado



Generalized geologic section A-A' of part of the southern Uinta Basin, Utah and Colorado
(See pl. 1 for location of section.)

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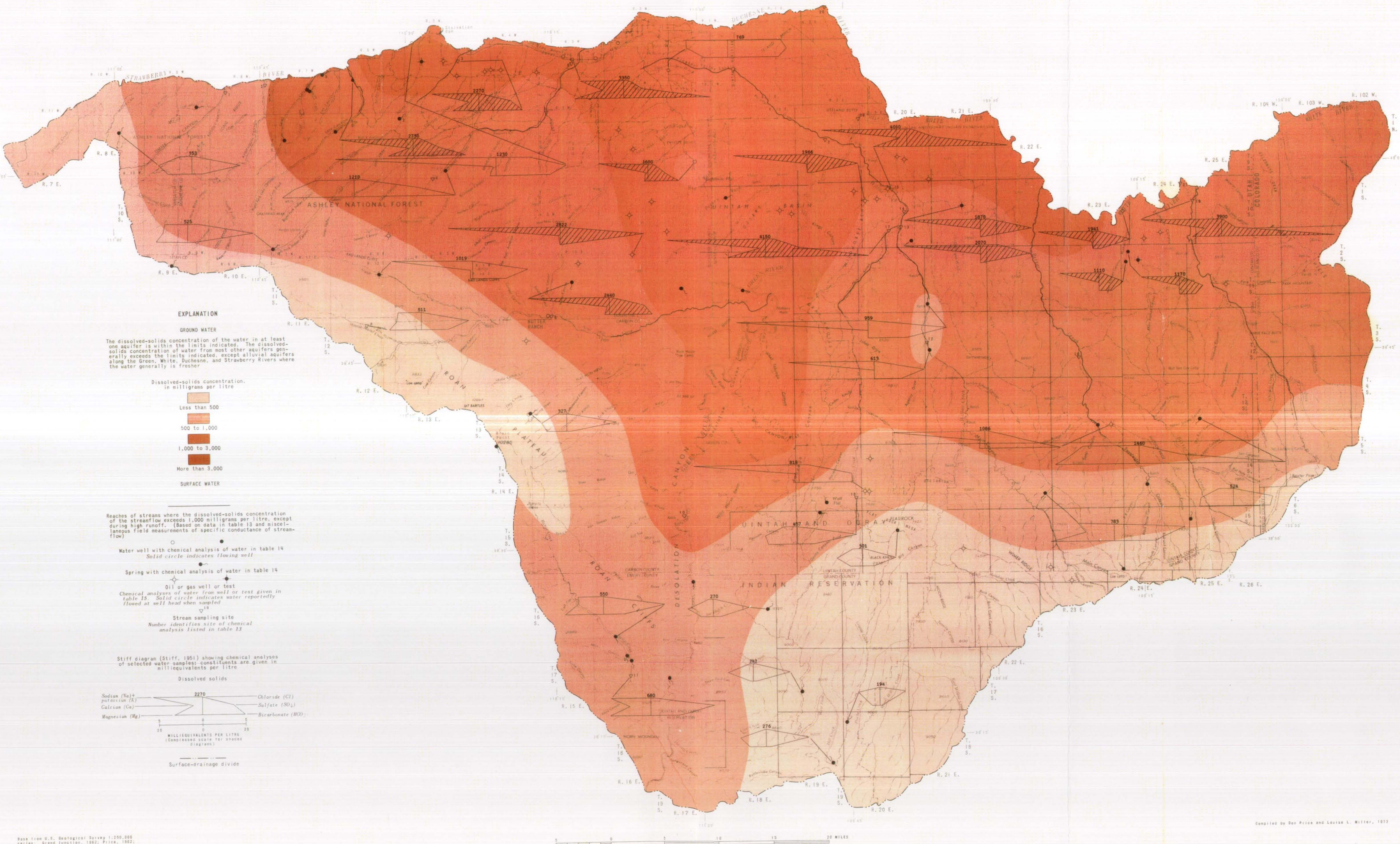

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Map showing general chemical quality of water and location of sampling sites in the southern Uinta Basin, Utah and Colorado

Chapter 26

CHARACTERISTICS OF THE PR SPRING TAR SAND DEPOSIT, UINTA BASIN, UTAH, USA

George F. Dana and Donna J. Sinks* 1984

Abstract

The Laramie Energy Technology Center (LETC) conducted a seven-corehole drilling program in the PR Spring tar sand deposit, southeastern Uinta Basin, Utah, during the summer of 1980. Three main tar sand zones in the southwestern and west-central portion of the deposit were correlated by cross sections, using six of the seven LETC coreholes. The saturated beds and zones are lenticular and discontinuous over both large and small areas. As determined by the LETC cores and twenty eight previously drilled cores in the deposit, from one to twenty seven separate tar sand beds at least one foot thick of continuous saturation exist in the deposit, the thickest of which is 10.7 m (35 ft) thick. Analytical results from the LETC cores and the twenty eight other cores were integrated to further evaluate tar sand characteristics of the deposit. The following general trends were noted: extracted permeability and extracted porosity decrease downdip (northwest); oil saturation decreases to the west-southwest; and water saturation decreases to the east.

INTRODUCTION

The recent search for conventional sources of oil in the United States has resulted in some new discoveries being made, but interest in utilizing alternative sources of fuel has increased sharply, with emphasis on shale oil and tar sands. Drilling in several states, primarily Oklahoma, Texas, California, New Mexico and Utah, has helped in determining the extent of tar sand resources in the United States (figure 26-1).

Utah contains an estimated 81% (20 billion barrels) of the nation's tar sand resources (figure 26-2). Six principal deposits account for 97% of that total. The PR Spring deposit, located in the southeastern portion of the Uinta Basin, encompasses an area of about 435 sq km (270 sq mi) in Uintah and Grand Counties. The PR Spring resources are estimated at 4.5 billion barrels (Minutes, 1980; Ritzma, 1973).

Tar sand deposits in the Uinta Basin have been utilized in the past principally for road paving (Marchant et al., 1974). Some small-scale experimental efforts involving mining and extraction in surface plants have been conducted, but none have been commercially successful. As a result of decontrol of oil prices and recent availability of leases for tar sands, several companies have planned or are designing methods to develop technology for in situ or surface extraction of oil from tar sands. Since most of the tar sand leases containing petroleum in "tar" form are under considerable overburden, future emphasis will be on in situ production or underground mining with subsequent surface extraction.

During the summer of 1980 the Laramie Energy Technology Center (LETC) conducted a drilling and coring program on the PR Spring deposit (core-holes UTS-1 through UTS-6). The LETC-generated information was integrated with other available data to evaluate the deposit. Seven corehole drill sites were selected at varying distances from other coreholes which are sources of data (figure 23-3). Lithologic columns and stratigraphic cross sections are included to illustrate the nature of the saturated strata, including depth of burial, thickness, lateral continuity, porosity, permeability, and oil saturation. These data will hopefully offer encouragement toward the development of the deposit as a source of economically-producible petroleum products.

GEOGRAPHIC AND GEOLOGIC SETTING

The PR Spring deposit encompasses all or parts of Townships 12 S - 17 S and Ranges 21 E - 25 E (figure 26-4). It is centered 241 km (150 mi) southeast of Salt Lake City, Utah, 96 km (60 mi) south of Vernal, Utah, 113 km (70 mi) north of Moab, Utah, and 92 km (57 mi) southwest of Grand Junction, Colorado (Minutes, 1980).

The Uinta Basin was formed during the Eocene Epoch of the Tertiary Period and presently occupies an area 129 km (80 mi) north-south and 209 km (130 mi) east-west. The sediments in which the tar sands are presently found were deposited in semi-fluvial to semi-lacustrine environments, closely followed by and fluctuating with a lacustrine environment. The rate of sedimentation in Lake Uinta was influenced by climatic changes. The major stratigraphic

**Laramie Energy Technology Center, U.S. Department of Energy.*

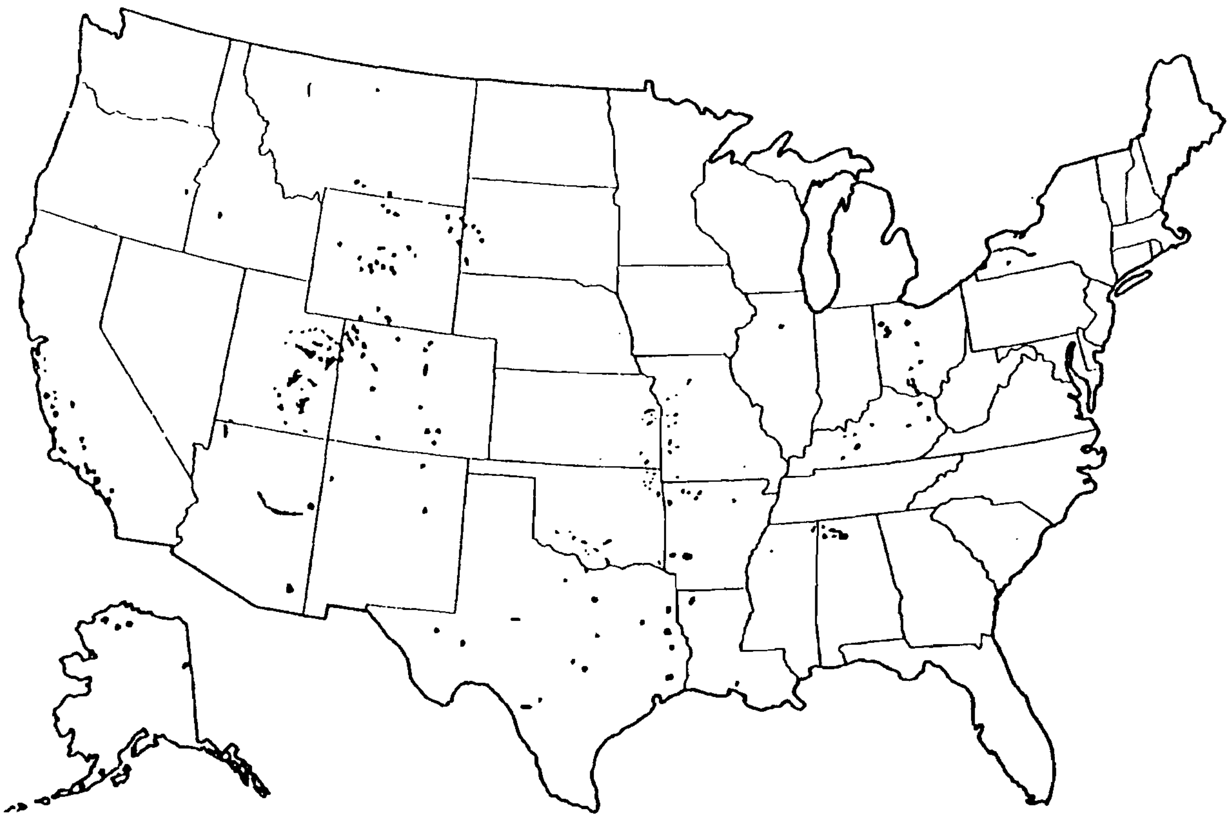

Figure 26-1. *Tar sand occurrences in the U.S.*

units deposited at this time were the Green River and Wasatch Formations. The oil-impregnated zones are found in the sandstones of the upper Douglas Creek Member of the Green River Formation (figure 26-5; Gwynn, 1977). The coarser sediments were derived from the surrounding drainage areas and the finer sediments by mechanical abrusion and from chemical precipitation. Great amounts of plankton, algae, etc., existed in this shallow, freshwater to slightly brackish lake, providing the organic sources of the kerogen in the oil shales of the basin. Oil shale and tar sands are occasionally interbedded in the PR Spring deposit, but the most common situation is for the tar sands to be found underlying the oil shales at intervals up to approximately 200 feet.

The source of the oil in the sandstone beds is from the overlying organic-bearing oil shales of the Parachute Creek Member of the Green River Formation (Campbell and Ritzma, 1980). Oil migration has probably been over comparatively short distances because of the close proximity of the source and the reservoir rocks. Varying degrees of saturation are found in thirteen principal sandstone zones, which are lensing and discontinuous from area to area. The thickest and most numerous tar sand zones are found in the south-central portion of the deposit where the impregnated beds range from several centimeters to 10.7 m (35 ft) in thickness.

The Uinta Basin is a structurally asymmetric basin with the steeply sloping side to the north-northeast and the gently sloping side to the south-southeast (Cashion, 1967). The west and southwest flanks have varying dips up to 12 degrees east and northeast. Dips on the south flank of the basin are north-northwest 1.5°-3°, providing the gentle dip slopes along which hydrocarbons migrated. Subsequent erosion has exposed the tar sands in the walls of the principal canyons in the area. This erosion also permitted the more volatile components of the hydrocarbons to escape (Ritzma, 1973).

CROSS SECTIONS

Thirty four coreholes penetrated tar sand zones within the boundaries of the PR Spring deposit (table 26-1, figure 26-3). Table 26-2 contains pertinent general information on Utah tar sand deposits (Marchant et al., 1980), and table 26-3 includes analyses of six of the LETC cores. The seventh corehole, UTS-7, contained no tar sand.

Two cross sections (figures 26-6 and 26-7) have been constructed incorporating data on six of the seven LETC coreholes and information available on twenty eight other

Table 26-1. *Coreholes penetrating tar sands in the PR Spring deposit*

Map no.	Company and well name	Location and section	Township and range	Elevation in feet (meters)	Total depth in feet (meters)	Tar sand zones depth in feet (meters)	Oil impregnated beds thickness in feet (meters)		Analyses available
							Ind. beds	Total	
1	Utah Geol. &	NE SW NE		6420 Gr.	274	151-156 (46-47.6)	4 (1.2)		yes
	Min. Survey,	34	12S, 24E	(1957)	(83.5)	159-162 (48.5-49.4)	3 (0.9)		
	PR-5					168-172 (51.2-52.4)	4 (1.2)		
						218-222 (66.5-67.7)	4 (1.2)		
						225-228 (68.6-69.5)	3 (0.9)		
						240-242 (73.2-73.8)	2 (0.6)	20 (6.1)	
2	Gulf Oil—	NE SE NE		6540 Gr.		381-392 (116.2-119.5)		11 (3.4)	yes
	Bonanza,	7	12S, 25E	(1994)					
	Corehole #3								
3	Utah Geol. &	SE SW NE		6512 Gr.	417	369-384 (112.5-117.1)		10 (3.0)	yes
	Min. Survey,	7	12S, 25E	(1985)	(127.1)				
	PR-3D								
4	Do	NW NE SW		6302 Gr.	95	39- 65 (11.89-19.8)		26 (7.9)	yes
	PR-3A	8	12S, 25E	(1921)	(29)				
5	Do	NE NW SW		6361 Gr.	158	119-149 (36.3-45.4)		30 (9.1)	yes
	PR-3B	8	12S, 25E	(1939)	(48.2)				
6	Do	SW SW NW		6430 Gr.	317	221-249 (67.4-75.9)		28 (8.5)	yes
	PR-3C	8	12S, 25E	(1960)	(96.6)				
7	DOE/LETC	SW SW SE		6489 Gr.	400	46- 48 (14.0-14.6)	2 (0.6)		yes
	UTS-1	29	13S, 21E	(1978)	(122)	238-246 (72.6-75.0)	8 (2.4)		
						252-253 (76.8-77.1)	1 (0.3)		
						256-257 (78.0-78.4)	1 (0.3)		
						258-263 (78.7-80.2)	5 (1.5)		
						301-303 (91.8-92.4)	1 (0.3)		
						304-306 (92.7-93.3)	1 (0.3)		
						307-310 (93.6-94.5)	2 (0.6)		
						312-313 (95.1-95.4)	1 (0.3)		
						314-315 (95.7-96.0)	1 (0.3)		
						317-318 (96.6-96.9)	1 (0.3)		
						321-324 (97.9-98.8)	3 (0.9)	26 (7.9)	
8	Utah Geol. &	SE SW SW		6707 Gr.	423	162-165 (49.4-50.3)	3 (0.9)		yes
	Min. Survey,	33	13S, 22E	(2045)	(129)	169-173 (51.5-52.7)	4 (1.2)		
	PR-6					176-187 (53.7-57.0)	12 (3.7)		
						192-197 (58.5-60.1)	5 (1.5)		
						230-254 (70.1-77.4)	24 (7.3)		
						262-263 (79.9-80.2)	1 (0.3)		
						267-268 (81.4-81.7)	1 (0.3)		
						277-280 (84.5-85.4)	3 (0.9)		
						295-296 (89.9-90.2)	1 (0.3)		
						299-302 (91.1-92.1)	3 (0.9)		
						323-324 (98.5-98.8)	1 (0.3)		
						326-327 (99.4-99.7)	1 (0.3)		

						330-332 (100.6-101.2)	2 (0.6)		
						338-345 (103.0-105.2)	7 (2.1)		
						350-360 (106.7-109.8)	10 (3.0)		
						373-380 (113.7-115.9)	7 (2.1)		
						383-391 (116.8-119.2)	8 (2.4)		
						411-414 (125.3-126.2)	3 (0.9)	96 (29.3)	
9	Skyline Oil Co., Sweetwater Cr. 26-33	SW SE 26	13S, 23E	6441 Gr. (1964)	254 (77.4)	90-159 (27.4-48.5)		17 (5.18)	yes
10	Utah Geol. & Min. Survey, PR-2	SE SE 29	13S, 23E	6346 Gr. (1935)	202 (61.6)	21- 22 (6.4-6.7)	1 (0.3)		yes
						44- 47 (13.4-14.3)	3 (0.9)		
						51- 56 (15.5-17.1)	5 (1.5)		
						63- 65 (19.2-19.8)	2 (0.6)		
						67- 68 (20.4-20.7)	1 (0.3)		
						78- 95 (23.8-29.0)	13 (3.9)	25 (7.6)	
11	Do PR-1	SW NE SW 6	13S, 24E	6210 Gr. (1893)	326 (77.4)	176-186 (53.7-56.7)	10 (3.0)		yes
						192-195 (58.5-59.5)	3 (0.9)		
						198-199 (60.4-60.7)	1 (0.3)		
						241-247 (73.5-75.3)	6 (1.8)		
						250-264 (76.2-80.5)	14 (4.3)	34 (10.4)	
12	Do PR-4	N/2 SE SW 5	13S, 25E	7187 Gr. (2191)	195 (59.5)	58- 78 (17.7-23.8)		20 (6.1)	yes
13	DOE/LETC UTS-2	SE SE SW 26	14S, 21E	7003 Gr. (2135)	310 (94.5)	93-101 (28.4-30.8)	8 (2.4)		yes
						223-224 (68.0-68.3)	1 (0.3)		
						235-237 (71.6-72.3)	2 (0.6)		
						238-239 (72.6-72.9)	1 (0.3)		
						241-244 (73.5-74.4)	1 (0.3)	13 (3.9)	
14	Geokinetics Corehole W-14	NW NE NE 2	14S, 22E	6721 Gr. (2049)	300 (91.5)	108-111 (32.9-33.8)	3 (0.9)		no
						133-168 (40.5-51.2)	35 (10.7)		
						172-300 (52.4-91.5)		38+ (11.6+)	
15	Skyline Oil Co., Sweetwater Cr. 14-34	SW SE 14	14S, 22E	7101 Gr. (2135)	244 (74.4)	33- 23 (10.1-71.0)		63 (19.2)	yes
16	Skyline Oil Co., Sweetwater Cr. 24-24	SE SW 24	14S, 22E	7130 Gr. (2174)	3010 (917.7)	55-170 (16.8-51.8)		40 (12.2)	yes
17	Skyline Oil Co., Sweetwater Cr. 25-32	SW NE 25	14S, 22E	7162 Gr. (2184)	255 (77.7)	43-255 (13.1-77.7)		71 (21.6)	yes

Table 26-1. *(continued)*

Map no.	Company and well name	Location and section	Township and range	Elevation in feet (meters)	Total depth in feet (meters)	Tar sand zones depth in feet (meters)	Oil impregnated beds thickness in feet (meters) Ind. beds	Total	Analyses available
18	DOE/LETC	NW NW NE		6693 Gr.	230	19- 21 (5.79-6.4)			yes
	UTS-3	8	14S, 23E	(2041)	(70.1)	25- 26 (7.6-7.9)	1 (0.3)		
						27- 30 (8.2-9.1)	3 (0.9)		
						31- 36 (9.5-11.0)	5 (1.5)		
						37- 40 (11.3-12.2)	3 (0.9)		
						49- 50 (14.9-15.2)	1 (0.3)		
						51- 52 (15.5-15.9)	1 (0.3)		
						78- 80 (23.8-24.4)	2 (0.6)		
						81- 82 (24.7-25.0)	1 (0.3)		
						83- 86 (25.3-26.2)	3 (0.9)		
						114- 11 (34.8-35.7)	3 (0.9)		
						119-120 (36.3-36.6)	1 (0.3)		
						122-124 (37.2-37.8)	2 (0.6)		
						127-129 (38.7-39.3)	2 (0.6)	30 (9.1)	
19	Utah Geol. &	SW NW NE		6798 Gr.	212	9- 12 (2.7-3.7)	3 (0.9)		yes
	Min. Survey	14	14S, 23E	(2073)	(64.6)	15- 17 (4.6-5.2)	2 (0.6)		
	PR-7					21- 22 (6.4-6.7)	1 (0.3)		
						24- 43 (7.3-13.1)	19 (5.8)		
						83- 84 (25.3-25.6)	1 (0.3)		
						94-102 (28.7-31.1)	3 (0.9)		
						118-120 (36.0-36.6)	2 (0.6)		
						184-186 (56.1-56.7)	2 (0.6)	33 (10.1)	
20	Do	SW SE		7387 Gr.	242	23- 49 (7.0-14.9)	26 (7.9)		yes
	PRS-3	32	14S, 23E	(2252)	(73.8)	62- 65 (18.9-19.8)	3 (0.9)		
						85- 94 (25.9-28.7)	9 (2.7)		
						96- 98 (29.3-29.9)	2 (0.6)		
						107-110 (32.6-33.5)	3 (0.9)		
						113-114 (34.5-34.8)	1 (0.3)		
						118-120 (36.0-36.6)	2 (0.6)		
						128-134 (39.0-40.9)	6 (1.8)		
						140-142 (42.7-43.3)	2 (0.6)		
						152-157 (46.3-47.9)	5 (1.5)		
						215-216 (65.6-65.9)	1 (0.3)		
						218-220 (66.5-67.1)	2 (0.6)		
						234-235 (71.30-71.7)	1 (0.3)	63 (19.2)	
21	Texaco, Inc.	N/2 SE SW		7500 Gr.	234	20-219 (6.1-66.8)		78 (23.8)	yes
	F.C. Staines #1	35	14S, 23E	(2287)	(71.3)				
22	U.S.G.S.	NW SW NW		7178 Gr.	98	95- 98 (29.0-29.9)		3 (0.9)	no
	Corehole WR-#7	12	15S, 21E	(2188)	(29.9)				
23	DOE/LETC	SE NW NE		7383 Gr.	445	46- 55 (14.0-16.8)	8 (2.4)		yes
	UTS-4	21	15S, 21E	(2251)	(135.7)	56- 62 (17.1-18.9)	6 (1.8)		
						64- 70 (19.5-21.3)	6 (1.8)		

						142-146 (43.4-44.5)	4 (1.2)		
						149-162 (45.4-49.4)	13 (4.0)		
						164-179 (50.0-54.6)	15 (4.6)		
						184-185 (56.1-56.4)	1 (0.3)		
						186-188 (56.7-57.3)	2 (0.6)		
						200-203 (61.0-61.9)	3 (0.9)		
						252-255 (76.8-77.7)	3 (0.9)		
						265-267 (80.8-81.4)	2 (0.6)		
						290-292 (88.4-89.0)	2 (0.6)		
						298-300 (90.9-91.5)	2 (0.6)		
						305-311 (93.0-94.8)	6 (1.8)		
						357-358 (108.8-109.2)	1 (0.3)		
						360-362 (109.8-110.4)	2 (0.6)		
						377-378 (114.9-115.2)	1 (0.3)		
						380-381 (115.9-116.2)	1 (0.3)	78 (23.8)	
24	Texaco, Inc. R.E. Colbert #2	SW NW NE 26	15S, 22E	7505 Gr. (2288)	335 (102)	20-335 (6.1-102.1)		69 (21.0)	yes
25	DOE/LETC UTS-5	SW SW SE 29	15S, 22E	7472 Gr. (2278)	315 (96)	16- 22 (4.9-6.7)	6 (1.8)		yes
						30- 32 (9.1-9.8)	2 (0.6)		
						38- 40 (11.6-12.2)	2 (0.6)		
						74- 84 (22.6-25.6)	10 (3.0)		
						213-217 (64.9-66.2)	3 (0.9)		
						225-234 (68.6-71.3)	8 (2.4)		
						235-238 (71.6-72.6)	3 (0.9)		
						239-252 (72.9-76.8)	13 (4.0)		
						253-254 (77.1-77.4)	1 (0.3)	48 (14.6)	
26	U.S.G.S. Corehole WR-#5	SW SW SW 34	15S, 22E	7542 Gr. (2299)	103 (31.4)	70- 72 (21.3-22.0)	2 (0.6)		no
						73- 88 (22.3-26.8)	15 (4.6)		
						90- 98 (27.4-29.9)	8 (2.4)	25 (7.6)	
27	Texaco, Inc. R.E. Colbert #1	NW NW SE 35	15S, 22E	7580 Gr. (2311)	250 (76.2)	64- 16 (19.5-49.4)		73 (22.3)	yes
28	Texaco, Inc. E #1	SW NE NE		7650 Gr. (2332)	368 (112.2)	23- 36 (7.0-112.2)		106 (32.3)	yes
29	Texaco, Inc. F.C. Minkler #1	SW SE NW 11	15S, 23E	7750 Gr. (2363)	162 (49.4)	22-162 (6.7-49.4)		45 (13.7)	yes
30	Utah Geol. & Min. Survey PRS-2	NE SE NW 16	15S, 23E	7702 Gr. (2348)	282 (86)	57- 58 (17.4-17.7)	1 (0.3)		yes
						61- 65 (18.6-19.8)	4 (1.2)		
						68- 70 (20.7-21.3)	2 (0.6)		
						76- 82 (23.2-25.0)	6 (1.8)		
						123-124 (37.5-37.8)	1 (0.3)		
						126-129 (38.4-39.3)	3 (0.9)		
						132-133 (40.2-40.5)	1 (0.3)		
						135-138 (41.2-42.1)	3 (0.9)		
						172-180 (52.4-54.9)	8 (2.4)		
						193-217 (58.8-66.2)	24 (7.3)		
						233-234 (71.0-71.3)	1 (0.3)		
						246-247 (75.0-75.3)	1 (0.3)		
						252-255 (76.8-77.7)	3 (0.9)	58 (17.7)	

Table 26-1. *(continued)*

Map no.	Company and well name	Location and section	Township and range	Elevation in feet (meters)	Total depth in feet (meters)	Tar sand zones depth in feet (meters)	Oil impregnated beds thickness in feet (meters) Ind. beds	Total	Analyses available
31	Utah Geol. &	SE NE NE		8010 Gr.	247	27- 33 (8.2-10.1)	6 (1.9)		
	Min. Survey	27	15S, 23E	(2442)	(75)	36- 40 (11.0-12.2)	4 (1.2)		
	PRS-1					42- 52 (12.8-15.9)	10 (3.1)		
						66- 70 (20.1-21.3)	4 (1.2)		
						74- 82 (22.6-25.0)	8 (2.4)		
						90-118 (27.4-36.0)	28 (8.6)		
						159-182 (48.5-55.5)	23 (7.0)		
						199-222 (60.7-67.7)	23 (7.0)	106 (32.4)	
32	Texaco, Inc.	NE SW NE		8023 Gr.	451	76-451 (23.2-137.5)		104 (31.7)	yes
	E.D. White #1	32	15S, 23E	(2446)	(137.5)				
33	Texaco, Inc.	SE SE SW		7660 Gr.	207	39-307 (11.9-63.1)		109 (33.2)	yes
	State of UT	32	15½S, 23E	(2335)	(63.1)				
34	B #1	NW SE SW		8925 Gr.	415	24- 27 (7.3-8.2)	3 (0.9)		yes
	DOE/LETC	33	15½S, 24E	(2529)	(126.5)	38- 49 (11.6-14.0)	11 (3.4)		
	UTS-6					88- 98 (26.8-29.9)	10 (3.0)		
						131-146 (39.9-44.5)	15 (4.6)		
						175-178 (53.4-54.3)	3 (0.9)		
						184-187 (56.1-57.0)	3 (0.9)		
						272-279 (83.9-85.1)	7 (2.1)		
						287-296 (87.5-90.2)	9 (2.7)		
						302-307 (92.1-93.6)	5 (1.5)		
						314-315 (95.7-96.0)	1 (0.3)		
						318-319 (97.0-97.3)	1 (0.3)		
						320-321 (97.6-97.9)	1 (0.3)		
						322-324 (98.2-98.8)	2 (0.6)		
						326-331 (99.4-100.9)	5 (1.5)		
						341-348 (104.0-106.1)	7 (2.1)		
						353-354 (107.6-107.9)	1 (0.3)		
						355-363 (108.2-110.7)	8 (2.4)	92 (28.0)	

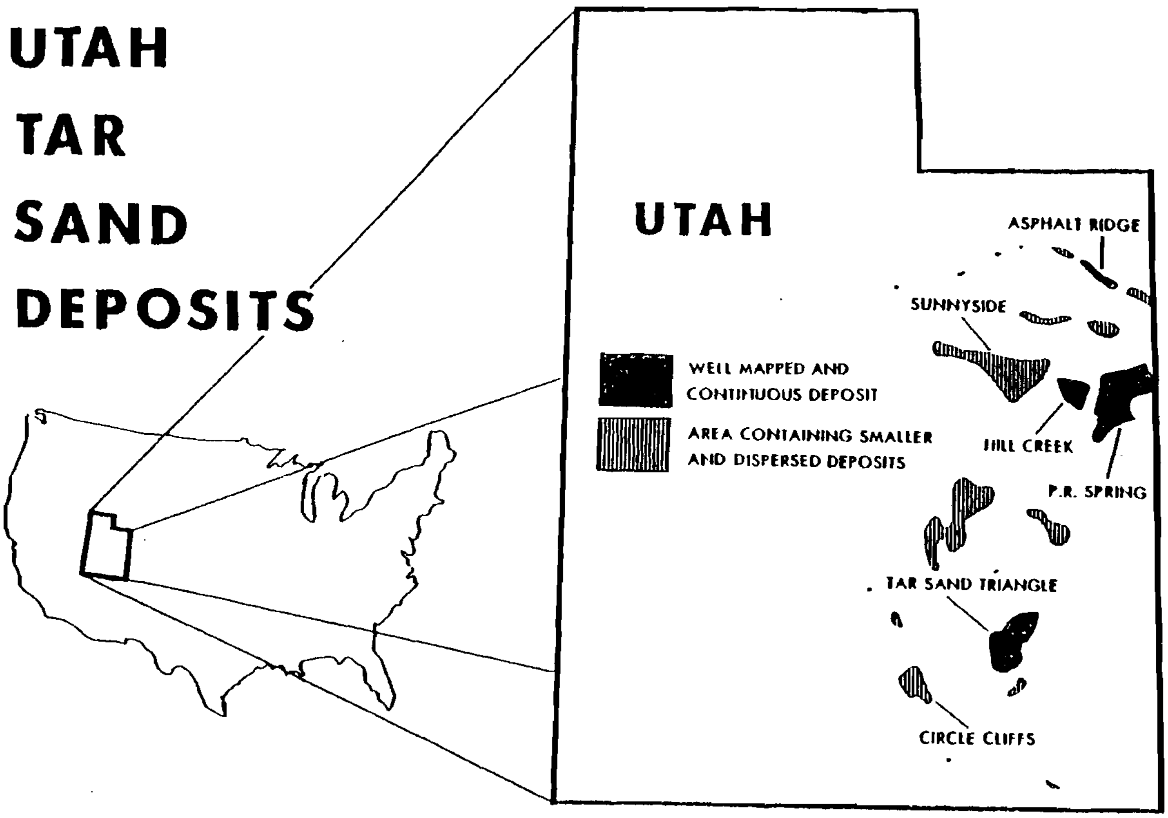

Figure 26-2. *Utah tar sand deposits*

Table 26-2. *Characteristics of some major Utah tar sand deposits*

Porosity	High
Permeability (oil extracted)	High
Permeability (oil saturated)	Low
Oil saturation range	0-100%
Water saturation	Low (oil wet)
Oil gravity range	> 966 kg/m³ (14° API)
Overburden range	0-610 m (0-2000 ft)
Surface mineable	< 15%

coreholes (Cashion, 1981; Peterson, 1975; Peterson and Ritzma, 1974; LETC files). Because it is difficult to graphically represent the coreholes laterally by elevations, these cross sections were constructed to correlate three main tar sand zones. The apparent dip of the tar sand zones in these two figures is not representative of the actual dip of the beds. Although a number of deep oil and gas test wells have been drilled in the area, data from them is insufficient for use in lithologic interpretation.

Variation in the number of individual saturated beds is evident from these cross sections. Correlations of three principal zones are indicated in figures 26-6 and 26-7, providing additional evidence of the discontinuous nature of the reservoir beds. In contrast to work in previous publications (Johnson et al., 1975b, 1975c), the correlation of zones one-three does not include all thinner saturated beds. The correlations herein are based on thicker saturated zones, which could actually be redesignated by the name "bed." However, the lithology of the saturated beds is not homogeneous, thus the term "zone" is used. Corehole UTS-2 contains the least number of saturated beds of those holes drilled by LETC, except for the barren seventh corehole (UTS-7). Located in section 25, T16S, R22E, corehole UTS-7 contained no apparent hydrocarbon staining. The southeastern limit of saturation in the PR Spring deposit is therefore thought to be north and east of this well location. The greatest total thickness of saturation occurs in corehole UTS-6 (map number 34, figure 26-3), the corehole farthest updip among these drilled. This indicates that greater volumes of oil migrated updip when porosity and continuous permeability were sufficient in the host rock.

Table 26-1 contains general information on the thirty four coreholes. It also lists specific beds and zones of saturation, some generalized and some identified by detailed footages, depending upon the availability of data. The raw data on coreholes UTS-1-UTS-6, summarized in table 26-3, is available from LETC upon request.

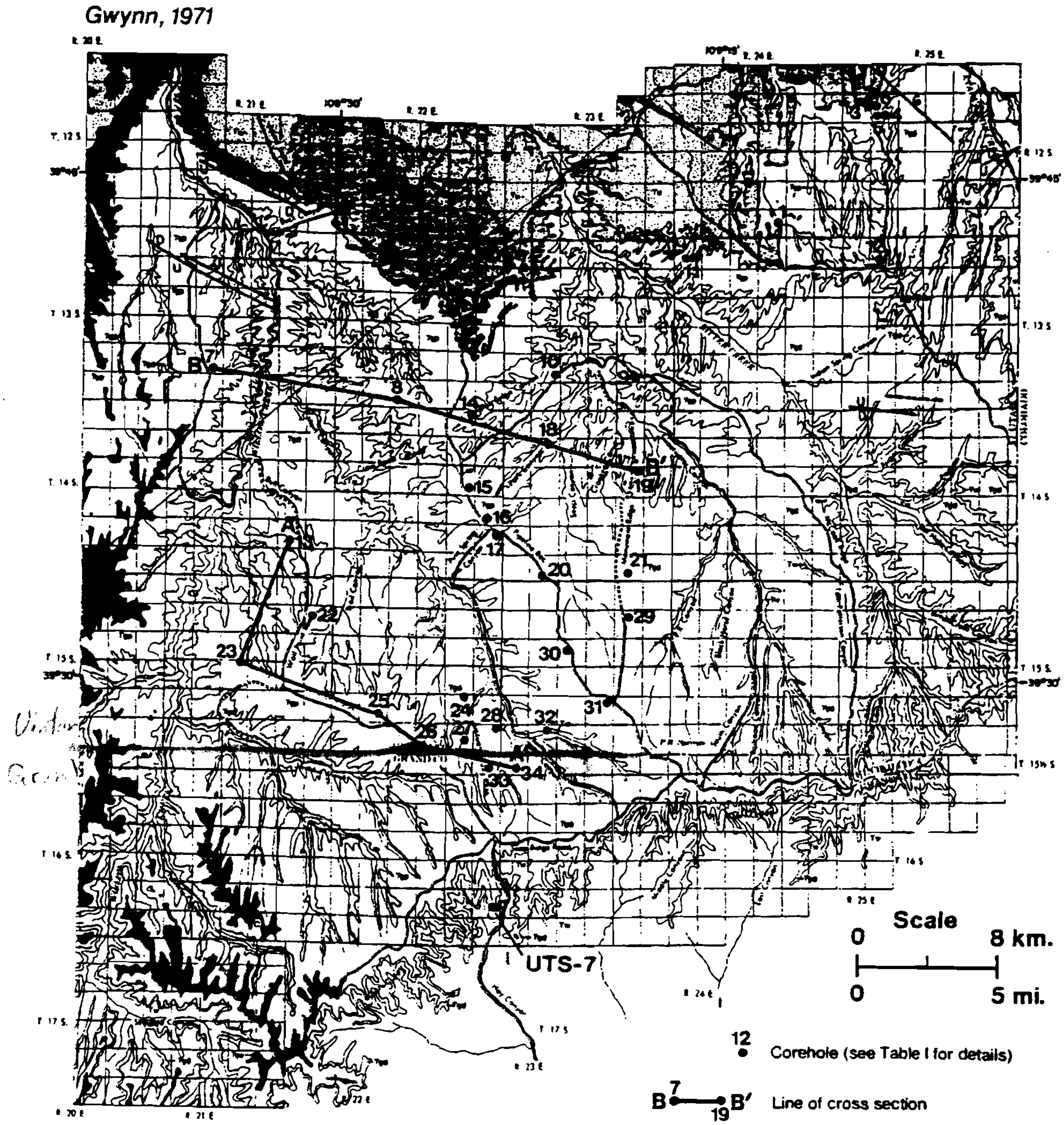

Figure 26-3. *Corehole and cross section locations in the PR Spring deposit*

TAR SAND CHARACTERISTICS

Figures 26-8 and 26-9 are lithologic columns of six of the coreholes drilled by LETC during the exploration phase of the research. Laboratory analyses were completed on these six coreholes (table 26-3). Oil saturations on each of the tar sand zones is represented to the right of the lithologic columns. Every foot of core lithologically described as a tar sand was not necessarily analyzed, explaining the missing actual saturation values in figures 26-8 and 26-9. The zones in figures 26-6 and 26-7 were based on lithologic descriptions and oil saturation analyses. Additional data on various parameters of the analyses are also found in table 26-3.

Table 26-3. *PR Spring tar sand characteristics*

	Corehole UTS-1			Corehole UTS-2			Corehole UTS-3			Corehole UTS-4			Corehole UTS-5			Corehole UTS-6		
	Min	Max	Av	Min	Max	Av	Min	Max	Av	Min	Max	Av	Min	Max	Av	Min	Max	Av
		*37			*13			*41			*82			*50			*92	
Porosity, saturated . . . . . .pct	2.7	16.2	9.13	4.9	16.1	11.36	3.1	19.6	9.95	5.0	24.9	18.11	3.8	23.1	13.29	0.9	22.5	11.36
Porosity, extracted . . . . . .pct	10.4	28.7	18.22	10.0	25.5	19.12	8.1	29.2	21.60	6.3	27.2	22.14	11.7	30.6	23.56	7.7	33.1	24.83
Permeability, saturated. . . .Md	<0.01	298	23.98	0.03	1.8	0.58	<0.01	255	33.88	<0.01	1800	253.19	<0.01	401	57.42	<0.01	6150	351.16
			*36												*49			
Permeability, extracted. . . .Md	<0.01	376	56.6	0.28	660	79.13	0.08	2050	300.41	<0.01	2300	453.67	0.05	8000	1216.86	<0.01	8450	858.48
			*33												*49			
Oil saturation . . . .pct pore vol	3.7	69.6	14.30	2.3	51.9	20.51	3.8	80.9	37.85	0.6	43.7	9.02	0.9	79.7	31.29	1.3	88.4	27.93
Water saturation. . . pct por vol	7.0	62.6	21.9	12.7	39.7	19.85	6.2	29.5	14.8	2.3	33.7	10.05	5.0	28.7	10.66	3.5	34.4	11.38
Bulk density, saturated. . g/cm³	2.61	2.81	2.69	2.12	2.47	2.27	2.03	2.50	2.18	1.96	2.45	2.11	2.02	2.42	2.15	1.89	2.56	2.12
Bulk density, extracted. . g/cm³	2.10	2.50	2.28	1.98	2.41	2.16	1.89	2.48	2.08	1.91	2.39	2.05	1.83	2.40	2.05	1.01	2.56	1.98
Grain density . . . . g/cm³	1.97	2.40	2.20	2.65	2.70	2.68	2.61	2.77	2.66	2.59	2.76	2.66	2.62	2.84	2.73	2.58	2.75	2.63

*Number of samples analyzed.

Table 26-4. *Summary of corehole analyses*

	Min	Max	Av
Saturated permeability (md)	<0.01	6150	120.03
Extracted permeability (md)	<0.01	8450	494.18
Saturated porosity (pct)	0.9	24.9	12.2
Extracted porosity (pct)	6.3	33.1	21.58
Oil saturation (pct pore vol)	0.6	88.4	23.48
Water saturation (pct pore vol)	2.3	62.6	14.76
Saturated bulk density (g/cm³)	1.89	2.81	2.25
Extracted bulk density (g/cm³)	1.01	2.56	2.1
Sand grain density (g/cm³)	1.97	2.84	2.60

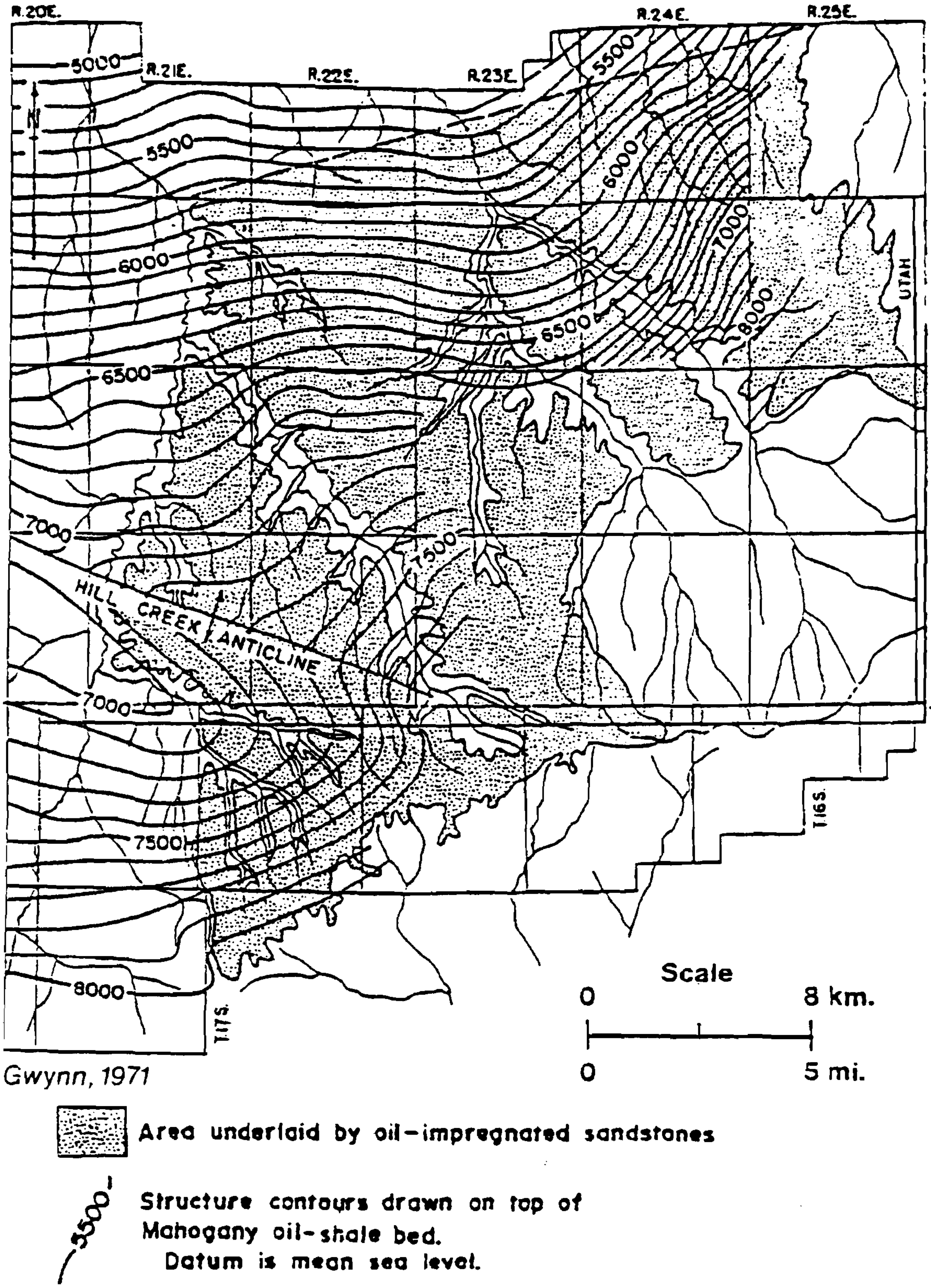

Figure 26-4. *Areal extent of the PR Spring deposit with structural contours on overlying Mahogany oil shale bed*

A number of properties of the saturated zones have been determined before and after extraction of the oil. A summary of the analytical data on the six LETC coreholes is presented in table 26-4.

SUMMARY AND CONCLUSIONS

Numerous tar sand beds are found in cores of the PR Spring deposit. Of the seven coreholes drilled by LETC in 1980, six contained oil-bearing strata in the form of tar sand. The number of individual beds in the six coreholes ranged from two in UTS-2 to eight in UTS-6. Other cores from various parts of the deposit contain from one to 27 individual beds. The most prominent beds are correlated into three principal zones, traceable on cross sections constructed from core data obtained by LETC, the U.S. Geological Survey, and the Utah Geological and Mineral survey.

Table 26-5 contains four analytical parameters of four major Utah tar sand deposits: PR Spring, Hill Creek, Sunnyside, and Tar Sand Triangle. The PR Spring deposit averages highest in extracted permeability of these four deposits, however oil saturation is still low to moderate (about 45%). Extracted porosity is similar for all four deposits, averaging 22.4%. The average oil saturation for these major deposits is 41%. The PR Spring tar sand is considered a "dry" sand; that is, there is very little water occupying pore space in the sandstone.

These same four parameters are compared for nineteen coreholes in the PR Spring deposit (table 26-6). The six

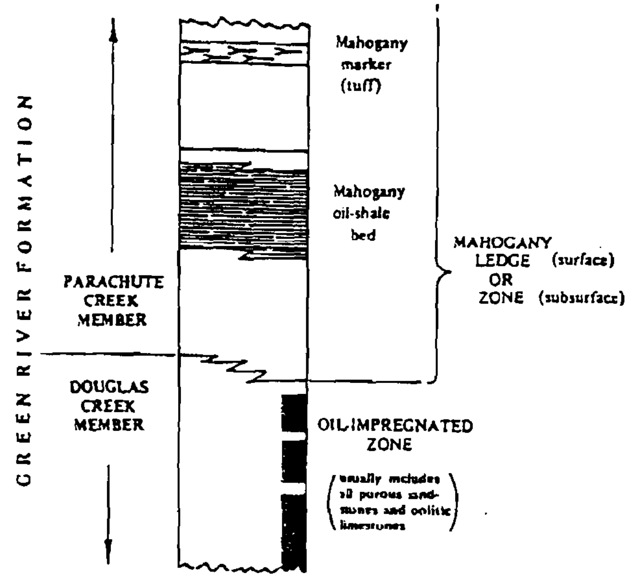

Figure 26-5. *Nomenclature of beds and members of the Green River Formation above and below the contact of Parachute Creek and Douglas Creek Members (Peterson, 1975)*

Table 26-5. *Average analytical data for Utah tar sand deposits*

	PR Spring[a]	Hill Creek[b]	Sunnyside[c]	Tar Sand Triangle[c]
Extracted permeability. . . . . . . md	1309	323	570	340
Extracted porosity. . . . . pct	24.4	22.4	23.1	19.8
Oil saturation . . . . .pct pore vol	44.8	36.6	51.8	32.2
Water saturation . . . . . .pct pore vol	7.3	16.8	20.9	4.67

[a]LETC files; Johnson et al., 1975a, 1975b, 1975c; Marchant et al., 1974
[b]Peterson and Ritzma, 1974
[c]Campbell and Ritzma, 1980

Table 26-6. *Average analytical data for coreholes drilled in PR Spring area*

	LETC UTS Coreholes (7, 13, 18, 23, 25, 34)	Threemile Canyon[a] (3, 4, 5, 6)	Asphalt Wash[b] (1, 11, 12)	North Seep Ridge[c] (8, 10, 19)	South Seep Ridge[d] (20, 30, 31)
Extracted permeability. . . . . . . md	494.2	2855	596	384	2218
Extracted porosity. . . . . pct	21.6	29.2	24.7	20.9	25.6
Oil saturation . . . . .pct pore vol	23.5	67.4	58.1	38.6	36.5
Water saturation . . . . . .pct pore vol	14.8	6.0	9.1	2.8	3.7

[a]Marchant et al., 1974
[b]Johnson et al., 1975a
[c]Johnson et al., 1975b
[d]Johnson et al., 1975c
Note: The material within parentheses are map numbers on figure 26-3.

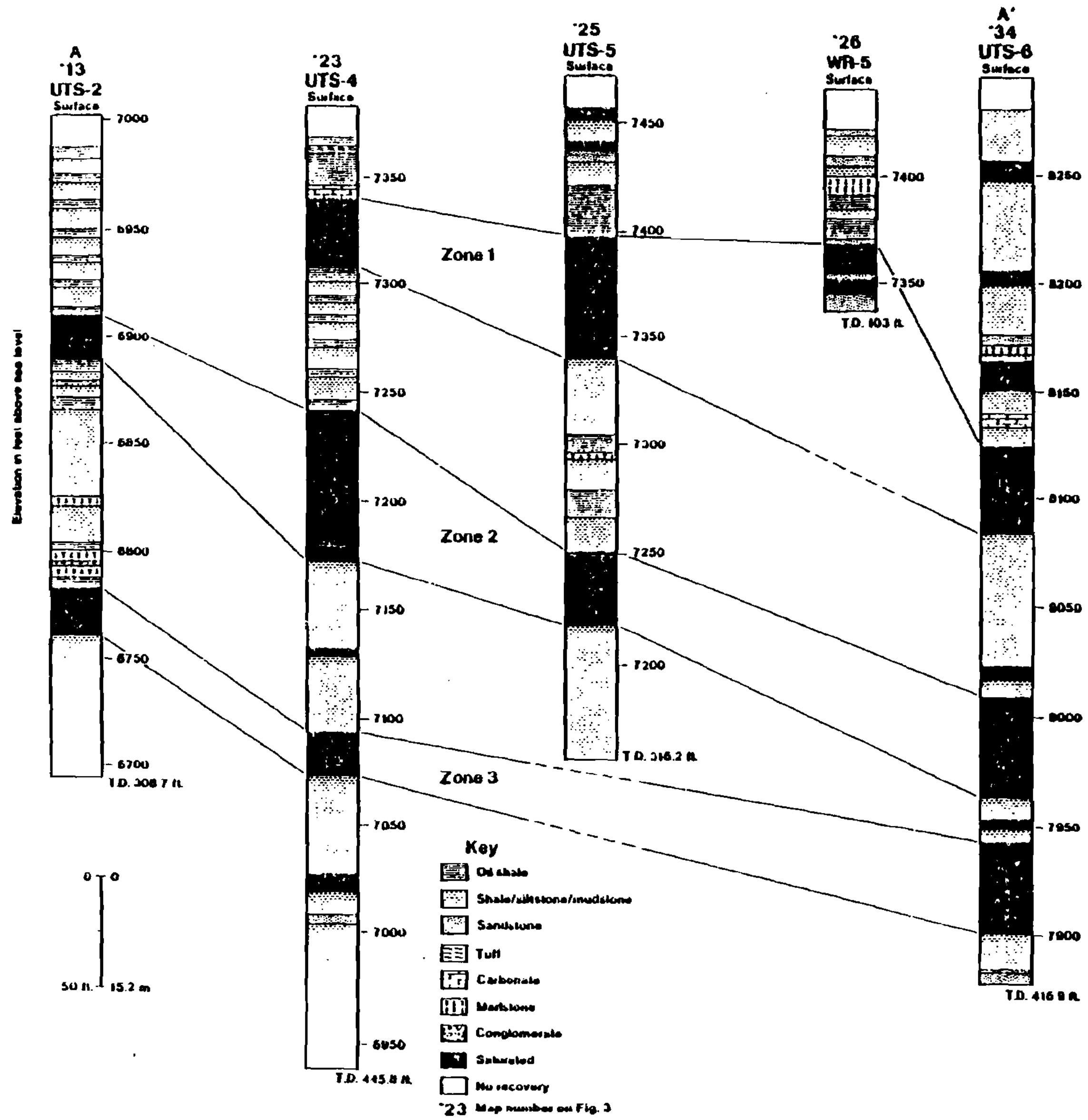

Figure 26-6. *NW-SE cross section A-A'. Cross sectional distance approximately 24 km (14.9 mi)*

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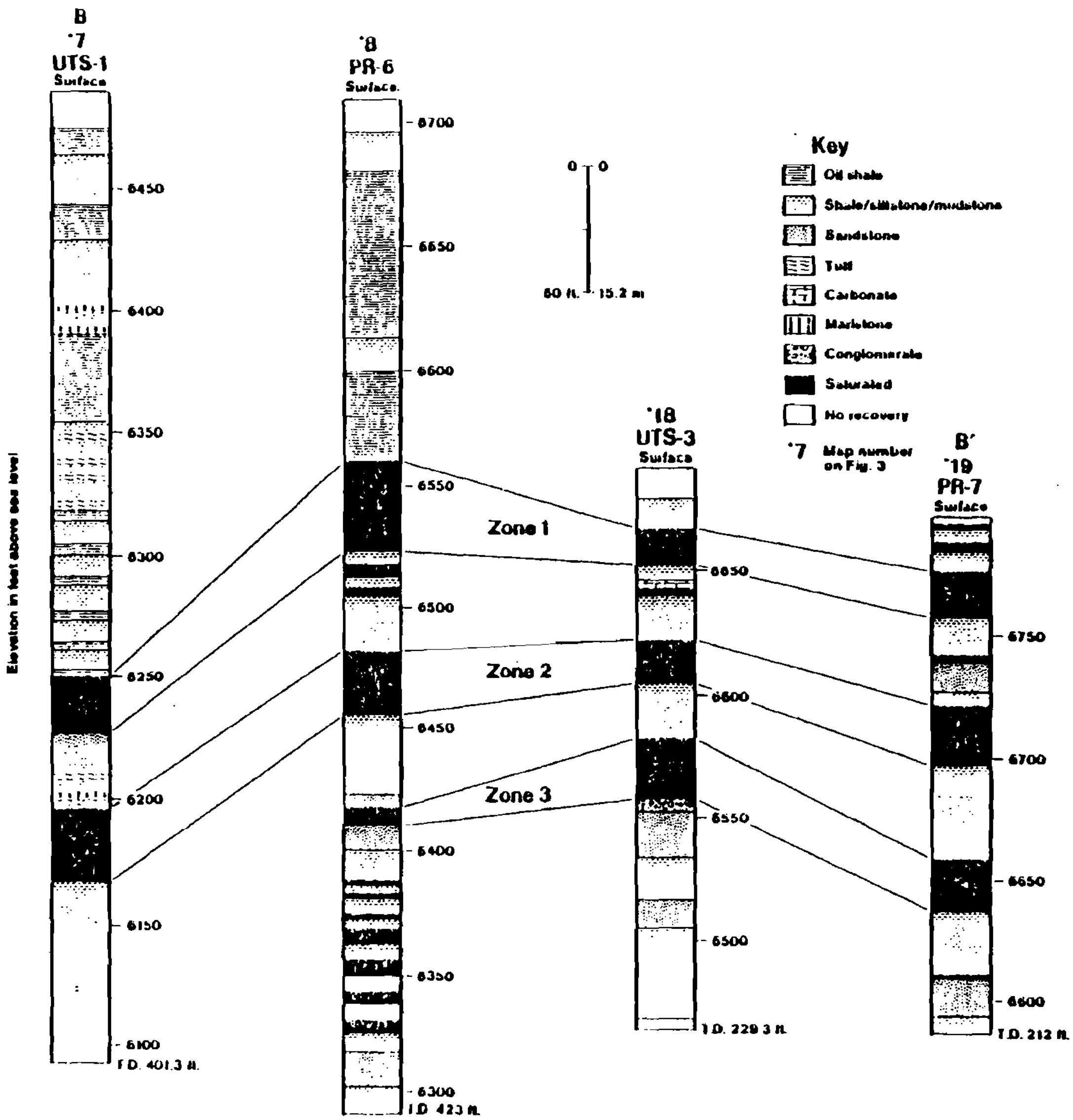

Figure 26-7. *W-E cross section B-B'. Cross sectional distance approximately 23 km (14.3 mi)*

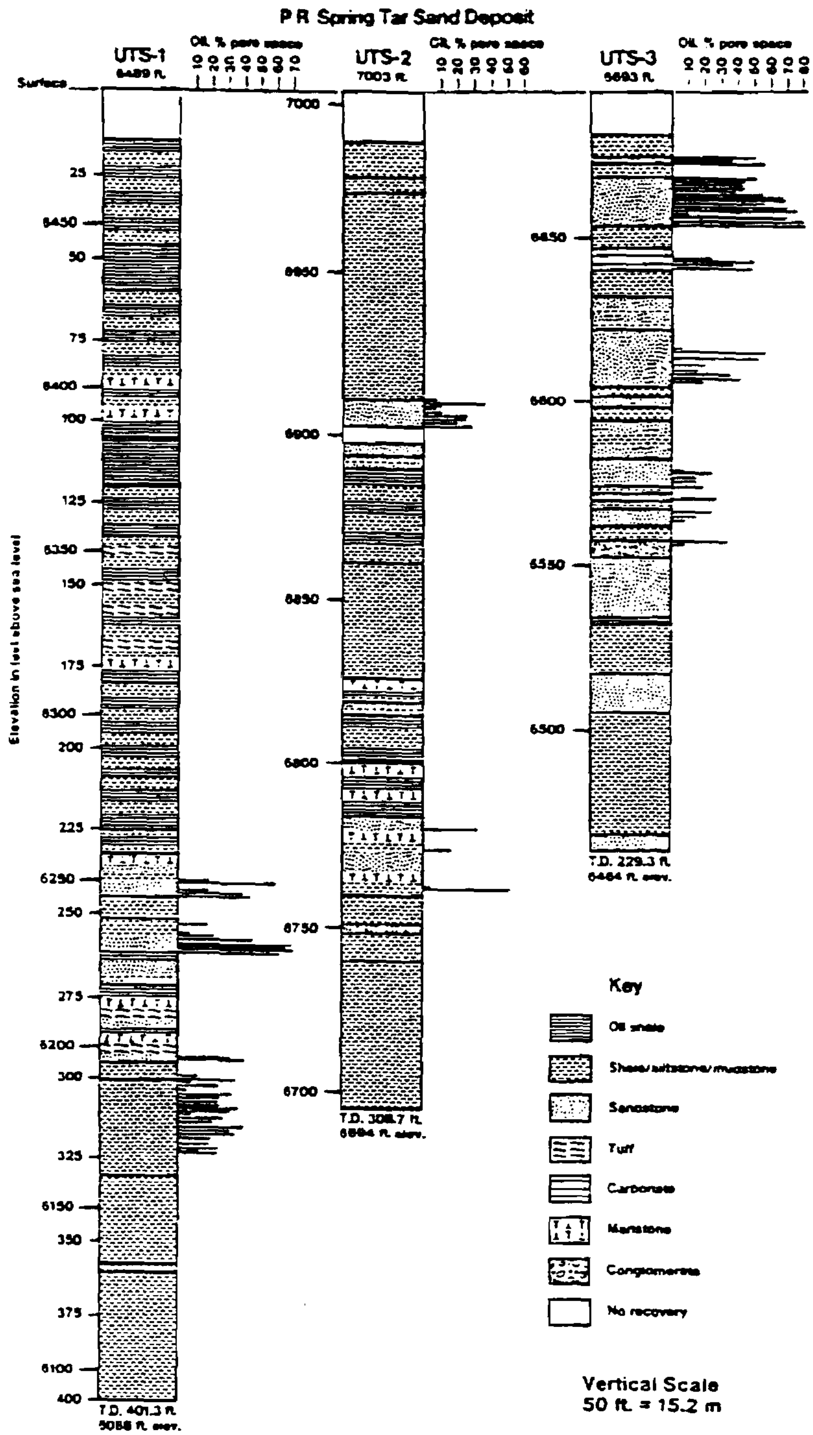

Figure 26-8. *Lithologic columns of UTS-1 through UTS-3 coreholes with oil saturation zones*

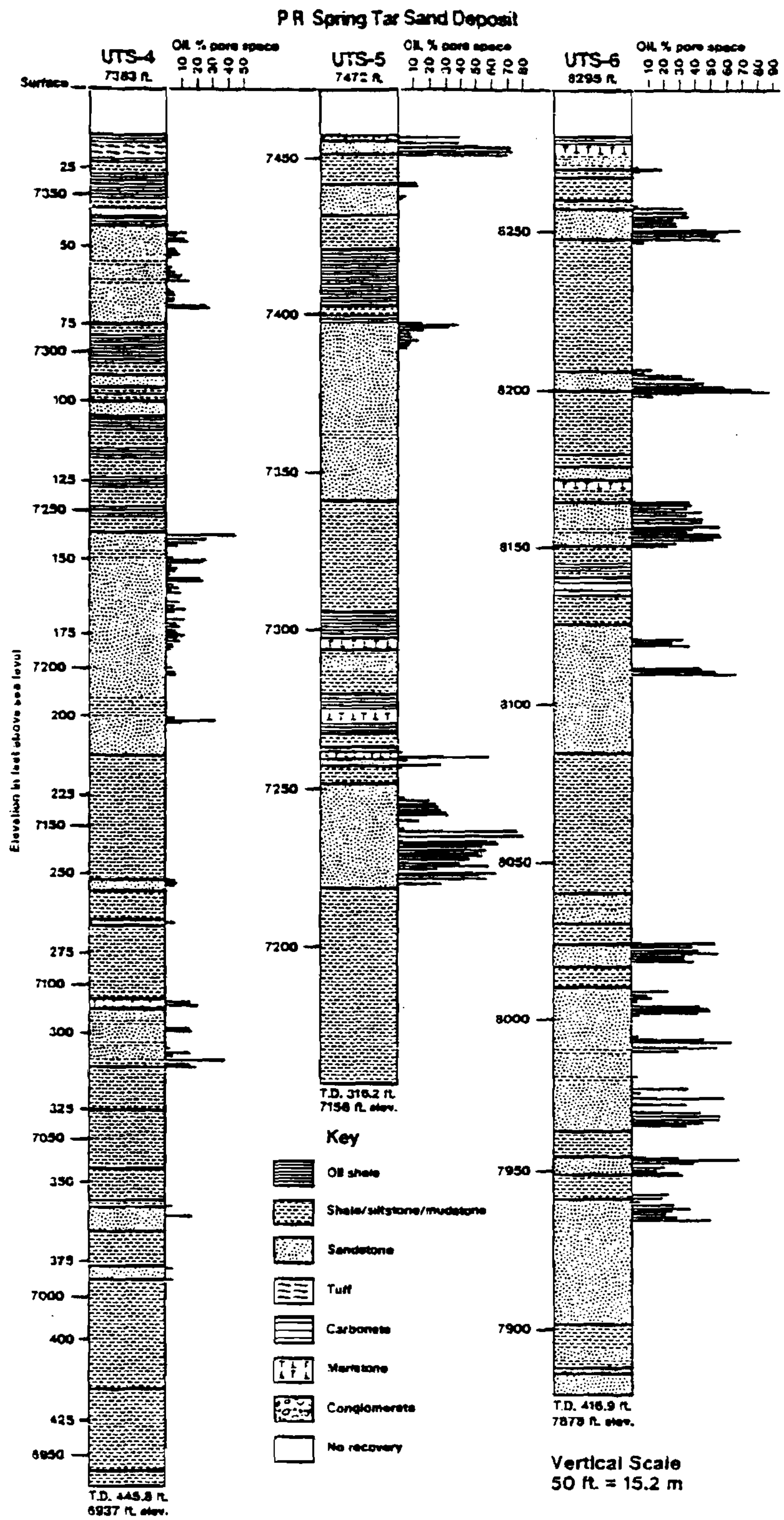

Figure 26-9. *Lithologic columns of UTS-4 through UTS-6 coreholes with oil saturation zones*

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LETC coreholes, along with coreholes from four areas of the deposit, are included in this table: Threemile Canyon–extreme northeast; Asphalt Wash–northeast; North Steep Ridge–north central; and South Steep Ridge–south central. By comparing the analytical data on these coreholes, the following general trends are evident for the PR Spring deposit: 1) extracted permeability decreases downdip (northwest), with an anomalous high occurring at the Threemile Canyon area; 2) extracted porosity decreases downdip (northwest); 3) oil saturation greatly decreases to the west-southwest; and 4) water saturation decreases to the east. These are general trends; abnormally high or low values do occur within the deposit and are considered to be from anomalous saturated beds.

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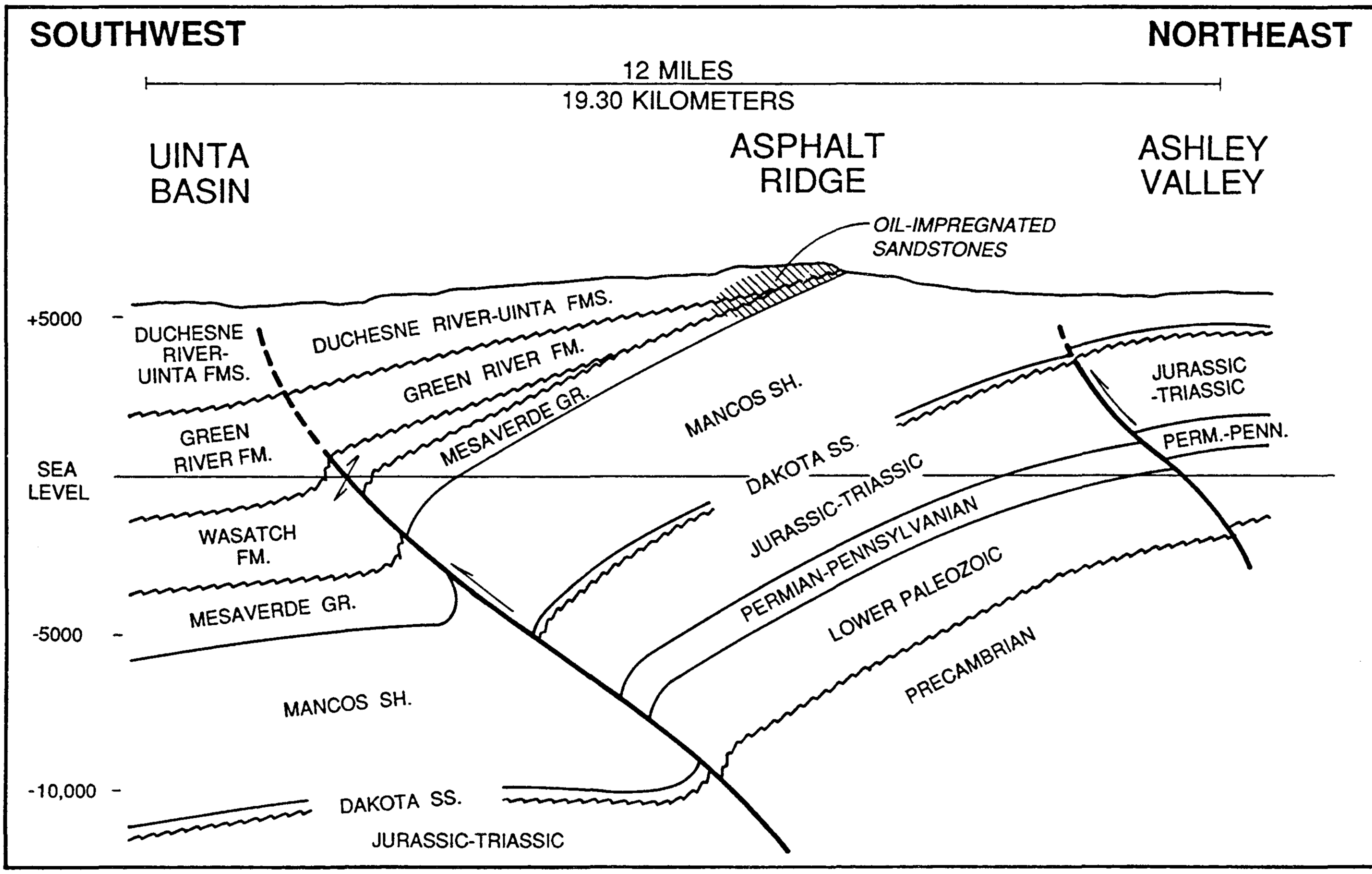

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UTAH GEOLOGICAL SURVEY

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Robert E. Blackett
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Prepared for:
State of Utah
Department of Community and Economic Development
Permanent Community Impact Board

Prepared by:
Utah Geological Survey
and
Utah Engineering Experiment Station
University of Utah

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ABSTRACT

Tar-sand, or oil-impregnated sandstone, deposits and occurrences of the Uinta Basin, Utah are summarized and presented. Twenty five tar-sand deposits/occurrences are reviewed with respect to geology, locations of bitumen-saturated outcrops, land ownership, physiography, bitumen-analyses, development histories, and other aspects. Background information on the physical setting and regional geology of the Uinta Basin is presented along with discussions of theories on the sources of the bitumen. Four areas--Asphalt Ridge, P.R. Spring, Hill Creek, and Sunnyside are presented as the principal areas containing most of the tar-sand resource. The Asphalt Ridge tar-sand deposit, located on the north flank of the Uinta Basin and enclosed in steeply dipping rocks of the Mesaverde Group (Cretaceous) and Duchesne River Formation (Eocene-Oligocene), is estimated to contain more than 1 billion barrels of oil. The P.R. Spring and Hill Creek deposits, located along the southeast margin of the basin and enclosed by gently dipping rocks of the Green River Formation (Eocene), are estimated to comprise a resource in excess of 4 billion barrels of oil. The Sunnyside deposit, located along the south margin of the basin enclosed by rocks of the Wasatch and Green River Formations (Eocene) is the largest of the deposits, estimated to contain more than 5 billion barrels of oil.

The remaining 21 areas discussed are scattered along the northern and southwestern margins of the basin. Along the northeastern side of the basin lies the Raven Ridge, Cow Wash, Rimrock, Spring Hollow, and Upper Kane Hollow deposits. The Chapita Wells and Pariette deposits, located in the central part of the basin are contained in rocks of the Uinta Formation (Eocene), but may be related to near-vertical faults and fractures. Deposits along the southwestern side of the Uinta Basin that may be genetically related to the Sunnyside deposit include Argyle Canyon, Minnie Maud Creek, Ninemile Canyon, and Willow Creek. The Whiterocks deposit, along the north basin margin is unique because it occurs in the Navajo Sandstone of Jurassic age. The Daniels Canyon deposit, located just outside of the western margin of the basin, is associated with fractures in Paleozoic rocks. The Thistle and Oil Hollow deposits, located at the extreme western end of the basin, are contained in oolitic limestone of the Paleocene Flagstaff Limestone and the Green River Formation, respectively.

INTRODUCTION

Background

As part of an effort to assess the commercial potential of Utah's solid hydrocarbon deposits, the University of Utah Engineering Experiment Station initiated a project in 1985 with support from the Department of Community and Economic Development, Community Impact Board, to analyze aspects of tar-sand deposits of the Uinta Basin of northeastern Utah (figure 1). The Utah Geological Survey (UGS) later became involved in the effort in order to summarize available geological information on Uinta Basin tar-sand deposits. Often referred to as "bituminous sandstones" or "oil-impregnated rock," tar sands are found throughout the Uinta Basin in rocks ranging in age from Permian to Tertiary. It has been estimated that the tar-sand deposits of Utah contain roughly 25 billion barrels of bitumen in-place (Ball Associates Ltd., 1964). When compared to estimates of proven United States crude-oil reserves of 25.9 billion barrels, this represent a significant fossil energy resource (U. S. Department of Energy, 1993).

Tar-sand deposits in 24 states, which contain a resource estimated at 54 billion barrels (figure 2), have been documented by Ball Associates Ltd. (1964) and Kuuskraa and others (1984). Moreover, Kuuskraa and others (1984) and Campbell (1975a) estimated that tar-sand deposits in Utah contain between 40 and 95 percent of the total tar-sand resource in the United States. The Uinta Basin contains roughly half of Utah's tar-sand resource, consisting of 27 tar-sand deposits (figure 3; table 1).

The Uinta Basin is among the nations' most hydrocarbon-rich basins, it has produced over 377 million barrels of oil and more than 988 billion cubic feet of nonassociated gas (Utah Division of Energy, 1991). Rocks of Paleozoic, Mesozoic, and Cenozoic age in the basin have produced commercial quantities of oil and gas. In addition to tar sand, some unique, solid hydrocarbons, such as gilsonite, oil shale, ozokerite, wurtzilite, tabbyite, albertite, and native asphalt are found within the Uinta Basin (Barb, 1944). Gilsonite had been recognized and was in production in the eastern Uinta Basin by the late 1800s. By the early 1900s, several attempts had been made to produce oil shale, and ozokerite was produced from the Soldier Summit area (Robinson, 1916). Early oil exploration in the basin was concentrated in the vicinity of well-exposed outcrops of tar sand (Covington, 1964).

Development of Uinta Basin tar sands on a large scale has never proceeded past the demonstration stage, although advancement of recovery technologies has continued. As new technologies evolved that were applicable to tar-sand development, they were generally tested in the Uinta basin. As a result, much literature on tar-sand recovery from government, academic, and private company research has been published over the last 20 years (Campbell and Ritzma, 1979; Dana, 1983). The technology base for the tar-sand industry has improved based on the experience of Canadian tar-sand operators. With the success of the Canadian tar-sand industry, renewed interest has occurred in the Utah deposits. The availability of adequate and secure supplies of comparatively cheap conventional petroleum has been related to interest in possible tar-sand development in Utah since the early 1950s.

Previous Work

Due to its extensive hydrocarbon resources, the Uinta Basin has been the subject of numerous geological investigations. Literature on the tar-sand deposits of the Uinta Basin, however, has been somewhat descriptive and repetitious of earlier work. Some earliest reconnaissance surveys of the Uinta Basin tar-sand deposits are Covington (1963) where he reviewed the known bituminous sandstone and limestone deposits in Utah and Covington (1964) where he described the bituminous sandstones in the Uinta Basin. Ritzma (1979) prepared the most comprehensive compilation of tar-sand deposits in Utah. This work presented the general extent of each deposit and included a map with location, stratigraphic position, lithology, size, and indicated grade of each deposit. This publication superseded two earlier maps by Ritzma (1968 and 1973). Campbell and Ritzma (1979) provided more detailed descriptions of some major tar-sand deposits in Utah; however, this also was essentially a presentation of previously published work.

Although known of for nearly a century, workers for the most part have done only reconnaissance studies on most tar-sand deposits of the Uinta Basin. Spieker (1930) prepared the first detailed study of the geology of the Uinta Basin that addressed aspects of the tar-sand deposits. Spieker described in detail the bituminous sandstones at Asphalt Ridge, near Vernal. Bradley (1931), referred to tar-sand deposits and associated geological features in

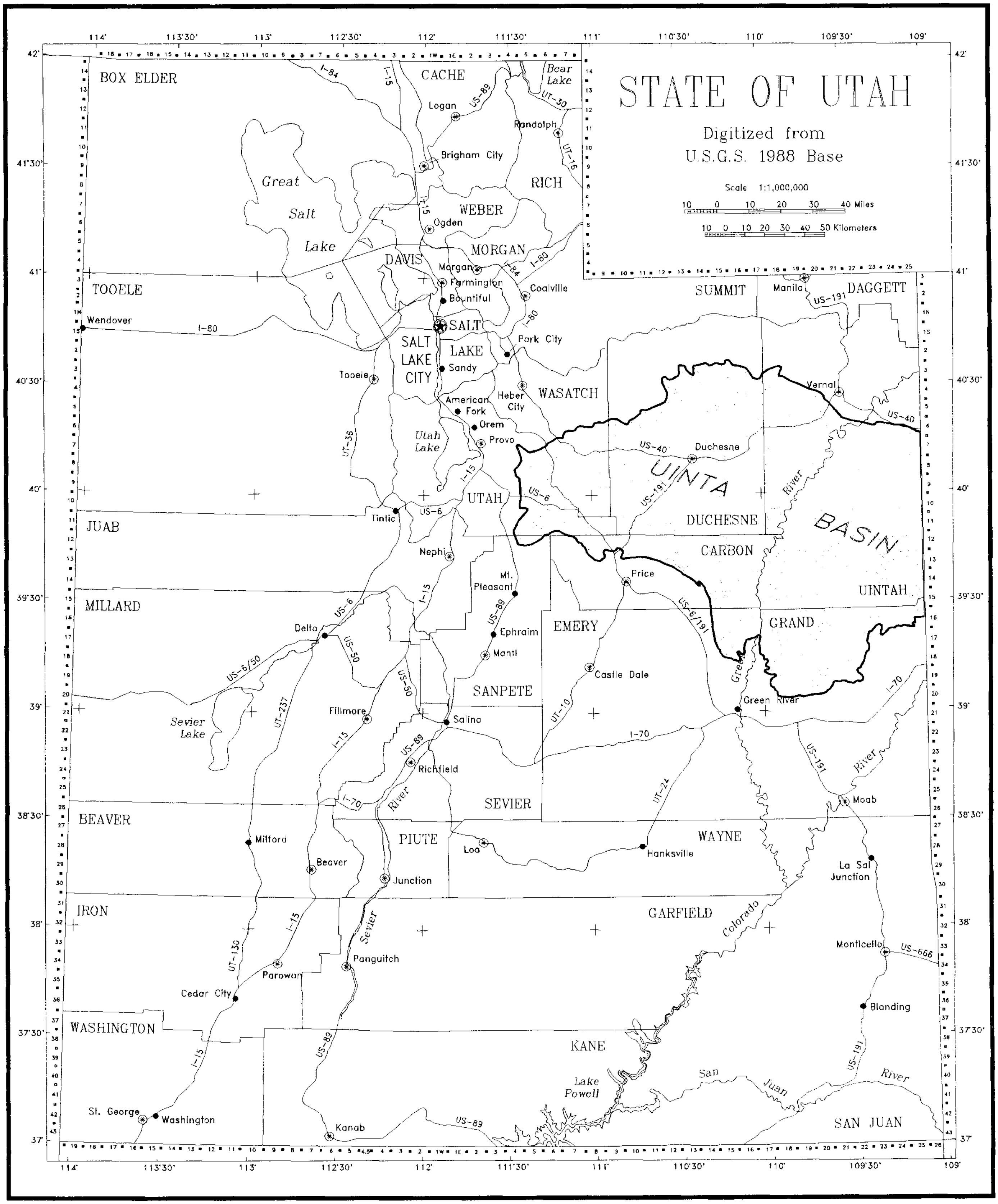

Figure 1. *Index map of Utah, showing the location of the Uinta Basin.*

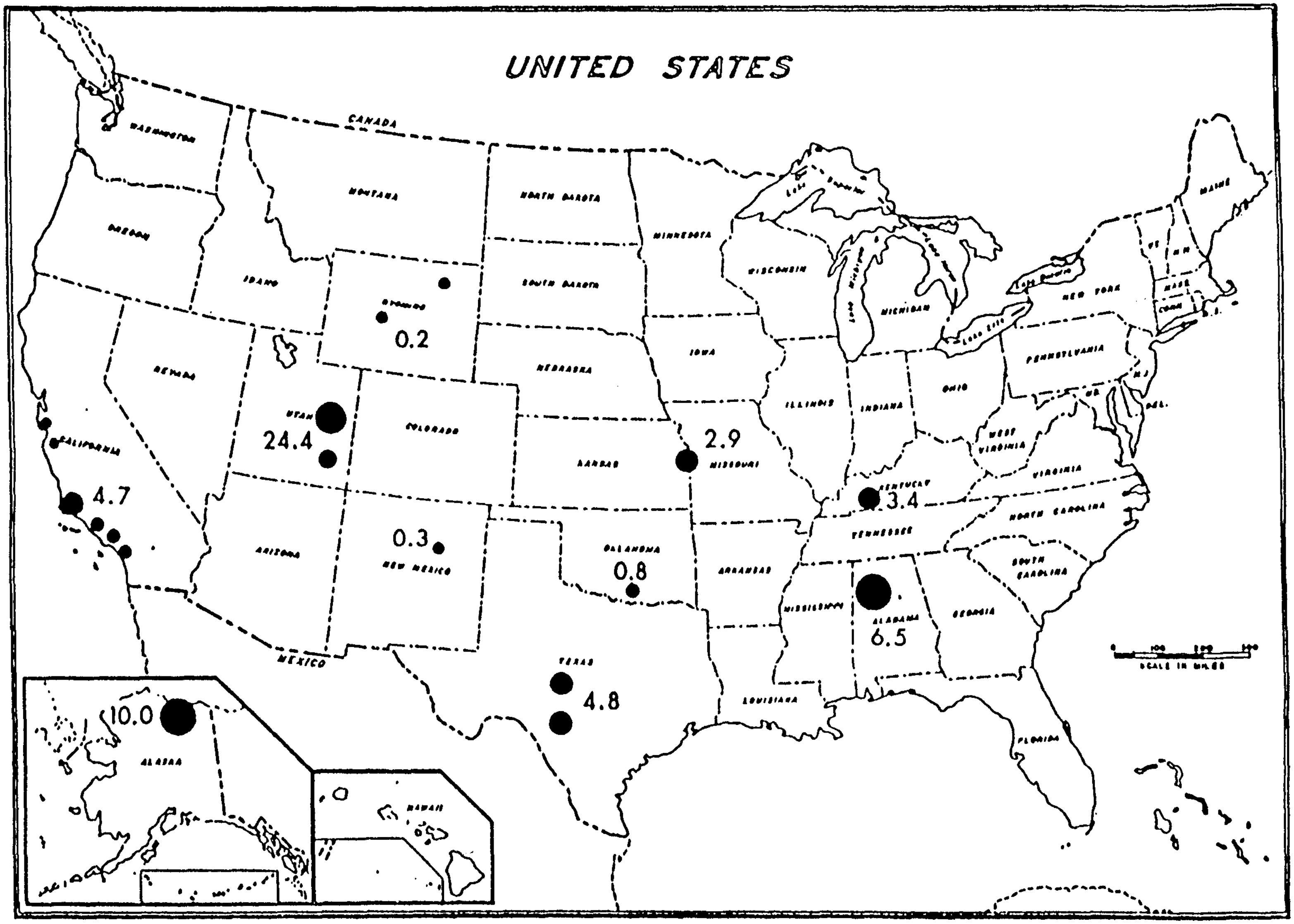

Figure 2. *Location of tar-sand deposits in the United States, with estimated reserves/resources in billions of barrels (from Lewin and Associates, 1984).*

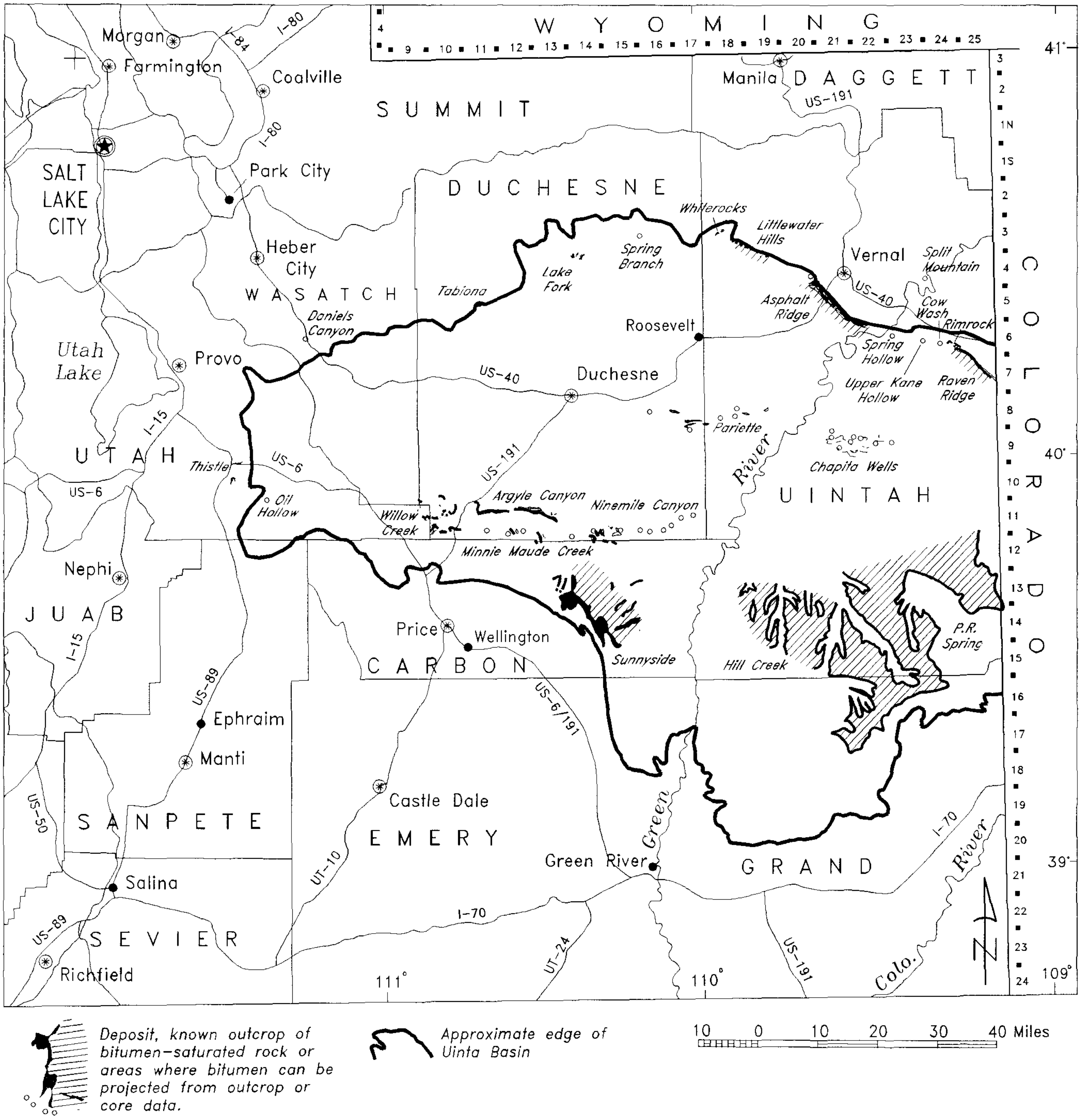

Figure 3. Distribution of tar-sand deposits within the Uinta Basin (from Ritzma, 1971).

Table 1. Summary of tar-sand resources of the Uinta Basin (after Ritzma, 1979 and 1987)

DEPOSIT	FORMATION(S) IN WHICH DEPOSIT OCCURS	DOMINANT LITHOLOGIES	RANGE OF RESOURCE ESTIMATE (millions of barrels)
ARGYLE CANYON	Green River Fm.	Sandstone, Siltstone, Limestone	100 - 125 *
ASPHALT RIDGE	Mesaverde Fm. - Duchesne River Fm.	Sandstone, Siltstone	1,148 - 1,173 **
CHAPITA WELLS	Uinta Fm.	Sandstone	7.5 - 8 *
COTTONWOOD-JACKS CANYON	Green River Fm.	Sandstone, Siltstone	80 - 100
COW WASH	Green River Fm.	Sandstone, Conglomerate	
DANIELS CANYON	Oquirrh Fm.	Limestone	100 - 125 *
HILL CREEK	Green River Fm.	Sandstone, Siltstone	6.5 - 10 *
LAKE FORK	Duchesne River Fm.	Sandstone	
LITTLEWATER HILLS	Duchesne River Fm.	Sandstone, Conglomerate	10 - 20 *
NINE MILE CANYON	Green River Fm.	Sandstone, Siltstone	5 - 10 *
P.R. SPRING	Green River Fm.	Sandstone, Siltstone	4,250 **
PARIETTE	Uinta Fm.	Sandstone, Siltstone	12 - 15 *
RAVEN RIDGE	Green River Fm.	Sandstone, Siltstone	125 - 150 *
RIM ROCK	Wasatch Fm. - Green River Fm.	Sandstone	30 - 35 *
SPRING BRANCH	Duchesne River Fm.	Sandstone, Conglomerate	1.5 - 2 *
SUNNYSIDE	Wasatch Fm. - Green River Fm.	Sandstone, Siltstone	5,200 - 5,850 **
TABIONA	Currant Creek Fm. - Duchesne River Fm.	Sandstone	4.6 *
THISTLE	Green River Fm.	Sandstone, Limestone	
WHITEROCKS	Navajo Ss.	Sandstone	125 - 140 **
WILLOW CREEK	Green River Fm.	Sandstone, Siltstone, Limestone	20 - 25 *

* Ritzma, H.R., 1979, Oil-impregnated rock deposits of Utah, Utah Geological and Mineral Survey Map 47, scale 1:100,000, 2 sheets

** Ritzma, H.R., 1987, Utah Tar Sands in Hollander, J.M., editor, Annual Review of Energy Annual Reviews Inc., p. 286-355 the Uinta Basin. Holmes and others (1948) studied the Sunnyside deposit in detail, and mapped bitumen-saturated outcrops within the Wasatch and Green River Formations. Their interpretations were general, but their work provided a framework that could be used in later studies. Crawford (1949) was one of the first to describe or speculate on the origin of the bituminous material in the Uinta Basin. Bass (1964), and Covington (1964) studied the solid hydrocarbons and bituminous sandstones of the Uinta Basin. Wiley (1967) studied the petrology of the oil-impregnated sandstone at P. R. Spring. Byrd (1967) studied the geology and its relationship to the oil-impregnated sandstones at P. R. Spring, and Clem (1984) investigated the development potential of the P. R. Spring deposit. Cashion (1967) studied the geology and fuel resources of the P. R. Spring area. Jacob (1969) measured some stratigraphic sections at the Sunnyside deposit as part of a study of delta facies in the Green River Formation.

Barb (1944) discussed bituminous deposits in the basin and possible future uses. Kayser (1966) produced physical and chemical data on tars from the basin. Wood and Ritzma (1972) determined the elemental composition of Utah tar sands from many of the deposits in the Uinta Basin. Reservoir characteristics and reserves for many of the deposits have been published by various authors. Some of these are Marchant and others (1974), Byrd (1970), Peterson (1975), Peterson and Ritzma (1974), Johnson and others (1975a), Johnson and others (1975b), Kayser (1966), and Holmes and Page (1956).

PHYSICAL ENVIRONMENT

Physiography

The Uinta Basin is an elongated east-west trending asymmetrical basin, roughly elliptical in shape. It measures about 130 miles (209 km) long by about 100 miles (161 km) wide, and the surface area covers more than 9,000 square miles (23,310 km^2). The topographic axis of the basin lies 10 to 15 miles (16-24 km) south of its structural axis (Hansen, 1963). Fluvial processes have been predominant in the basin during the Quaternary and are responsible for its present configuration.

Stokes (1977) defined the physiographic basin based on its topographic form and shape. This included the flatter, less eroded central parts of the basin and divided the rest of the geographic basin into two physiographic provinces, which he called the Book Cliffs-Roan Plateau and the Marginal Benches subsection of the Uinta Mountains (figure 4). The Book Cliffs-Roan Plateau province is an area with rugged topography, with strata of Cretaceous and Tertiary age that rise gradually southward to elevations of 8,000 to 10,000 feet (2,438-3,048 m) then terminate abruptly at south-facing cliffs. Drainages are deeply incised forming benchlike mesas and steep-walled canyons 500 to 1,000 feet (152-304 m) deep and as much as a 1 mile (1.6 km) wide. The Marginal Benches of the Uinta Mountains are benchlike remnants of old erosional surfaces that merge with the more rugged mountains to the north and the adjacent lowlands of the basin to the south. For purposes of this report, the Uinta Basin is defined to include the Uinta Basin proper, the Book Cliffs, Roan Plateau, and the southern part of Stokes's Marginal Benches subsection.

The Uinta Basin is a topographic basin in the sense that the surrounding regions are higher. The altitude of the land surface at the basin's lowest point on the Green River is about 4,300 feet (1,310 m) above sea level. The central portion of the present-day basin ranges in elevation generally between 5,000 and 6,000 feet (1,524-1,829 m). The Marginal Benches to the north commonly achieve elevations as much as 7,000 feet (2,133 m), while elevations along the southern margin range from 5,700 to over 9,000 feet (1,737-2,743 m). Because of the deep dissection by the drainage systems, differences in elevation of 1,000 feet (300 m) or more can occur over short distances.

The network of channels and tributaries that drain the basin define its physiographic boundary. Smaller rivers drain into the Green River. These streams, with headwaters on the highest parts of the dissected uplands to the north and east, cross the basin to enter either the Duchesne River or the White River. The Duchesne River, with headwaters in the Uinta and Wasatch Mountains, flows eastward and enters the Green River near Ouray, Utah. Its tributaries, the Uinta River, and the Whiterocks River drain the western parts of the Basin. The White River flows west, draining the eastern parts of the basin and also enters the Green River near Ouray, Utah.

Trellis drainage patterns are common; some areas of the basin have intense canyon-development and entrenched meanders. Each drainage varies widely in discharge and is flash-flood prone. In the southern part of

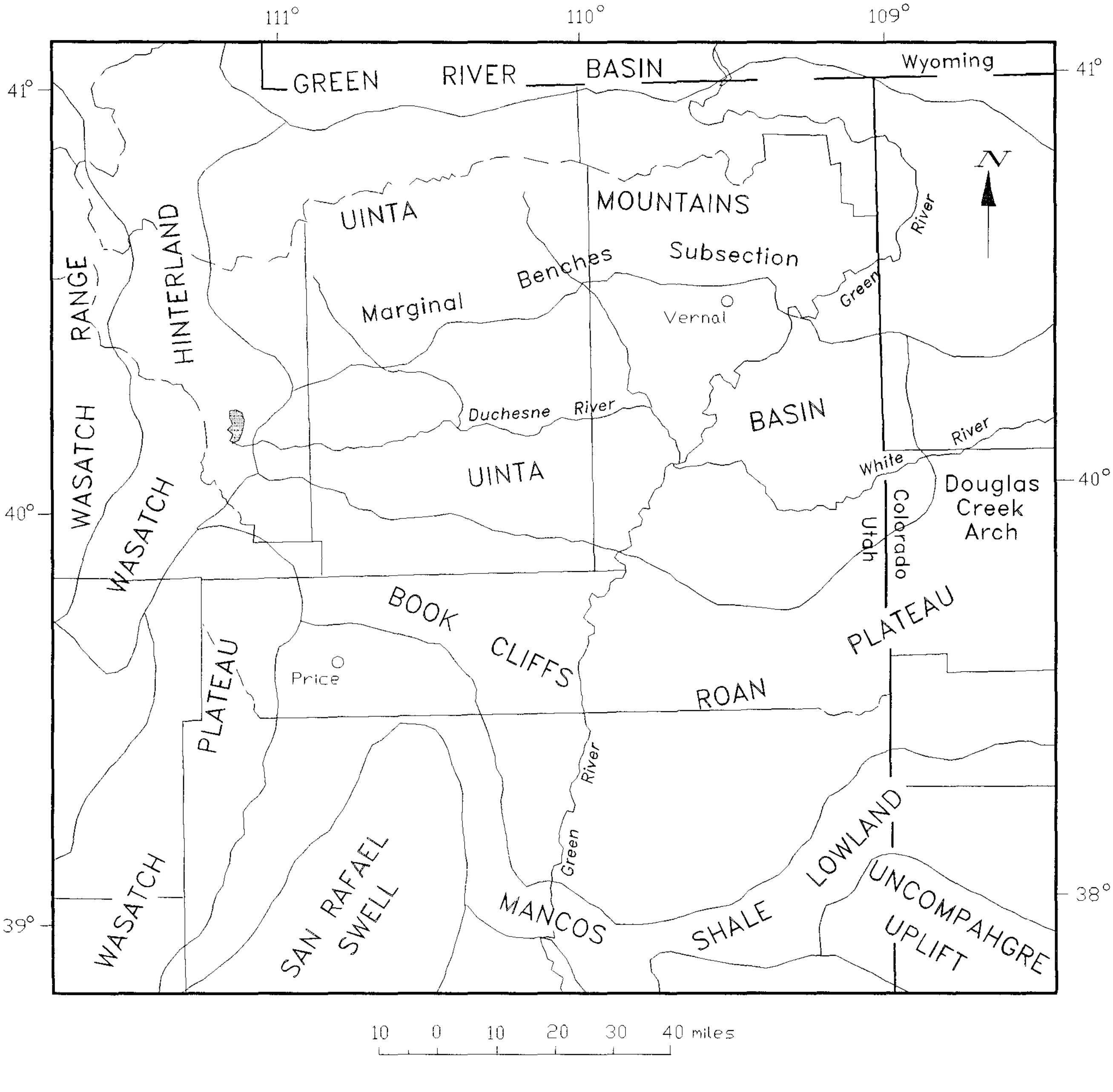

Figure 4. Physiographic provinces and principal rivers of the Uinta Basin (from Stokes, 1977).

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the basin, some streams (such as Hill Creek and Willow Creek) are direct tributaries to the Green River. These tributaries flow into the Green River, the main drainage of the basin, which flows southward through a deep gorge named Desolation Canyon.

Climate

The overall climate of the Uinta Basin is moderate with respect to temperature, and arid to semiarid with respect to precipitation. Much of the basin is arid with precipitation less than ten inches (25 cm) annually. The higher-altitude margins of the basin receive from 12 to 16 inches (30-41 cm) of precipitation annually, while the nearby Uinta and Wasatch Mountains often receive more than 40 inches (102 cm) annually (Richardson and others, 1981). The marginal lands of the basin are semiarid and support pinyon-juniper forests. Lower lands are arid supporting primarily desert-shrubs. The basin proper is characterized by warm summers, cold winters, and relatively low precipitation. Average precipitation for the watershed as a whole is probably about 25 inches (63 cm), which falls mainly as snow at higher altitudes (Clark, 1957; Marsell, 1964; Richardson and others, 1981).

In the middle of the Uinta Basin, daily and seasonal temperature range is wide, relative humidity is low, and evaporation is rapid. Summers are extremely hot and dry with occasional short-duration, localized thunderstorms. Winter is generally cold and dry with little snowfall. Typical of deserts, diurnal temperatures have a wide range, due to the rapid radiation at night from the dry earth to the atmosphere. Daily July temperatures average near 70°F (21°C), with a maximum of 108°F (42°C) reported. Daily January temperatures average about 14°F (-10°C) with minimums as low as -40°F (-40°C) (Marsell, 1964).

GEOLOGY

Regional Setting

The Uinta Basin is a geographic and a structural basin that is a subdivision of the Colorado Plateau Province (figure 4). The basin is bounded on the west and northwest by the High Plateaus Province and eastern slopes of the Wasatch Mountains. The Uinta Mountains form the north boundary. The eastern boundary is generally taken to be the Douglas Creek arch, which separates the Uinta Basin from the Piceance Creek basin of western Colorado. The basin is bounded to the south by the Book Cliffs and Roan Plateau.

Geologic History

A number of workers have described Uinta Basin geology and energy potential in detail. Comprehensive discussions are found in Bruhn and others (1986), Fouch (1975), Hansen (1963), Johnson (1992), Osmond (1965), Osmond and others (1968), Picard (1955), Porter (1963), Ritzma (1972), Ryder and others (1976), Tissot and others (1978), and Wells (1958). The complex history of the Uinta Basin region records seven episodes of development as defined by major changes in depositional processes, subsidence patterns, structural controls, and basin geometry. These episodes have allowed the region to accumulate a sequence of Precambrian to Recent sediments, resting upon Precambrian crystalline basement (Osmond, 1965). Johnson (1992) summarized these seven episodes as: (1) Precambrian basement development, (2) Cambrian through Middle Devonian passive margin development, (3) Late Devonian through early Late Mississippian western orogenic influences, (4) mid-Late Mississippian through early Early Permian Rocky Mountain orogenic influences, (5) late Early Permian through Early Jurassic orogenic influences, (6) a Middle Jurassic through early Early Cretaceous western thrusting episode, and (7) late Early Cretaceous through late Eocene basin evolution. The present-day basin developed during the last period.

Most of the present structural features of the area are of Laramide age (Late Cretaceous to Early Tertiary) or younger. In general terms the Paleozoic and Mesozoic rocks of the area are predominantly marine and continental-margin sequences, with tectonic- and eustatic-induced transgressive-regressive cycles. During the Late Cretaceous the Sevier orogenic belt was active and sediment transport was primarily to the east and south (Bruhn and others, 1983). In latest Cretaceous the dominant east-west tectonic and sedimentation patterns shifted to north-south in response to the rapid uplift of the Uinta Mountains. The sea had retreated from central Utah and the thrusting to the west had resulted in deposition of coalescing alluvial fans and marginal marine sediments. The area had low to moderate relief for an interval of time during late Late Cretaceous, preceding Uinta Basin development (Franczyk and others, 1992). Formation and subsidence of the basin were contemporaneous with the uplift of adjacent highlands, the San Rafael Swell, Uinta Mountains, and Wasatch Range of Utah, the Sierra Madre Park uplift in Colorado and Wyoming, the Park, Sawatch, Douglas Creek arch, and White River uplifts in Colorado, and the reactivation of the Uncompaghre uplift in Utah and Colorado. Subsidence curves by Johnson (1992) suggest that the Uinta Basin formed as a consequence of tectonic and sedimentary loading. Rapid subsidence and sedimentation in the basin began in the Early Tertiary. The fluvial-alluvial sandstone architecture of lenticular sandstone and shale sequence suggests relatively high subsidence rate. These deposition patterns were dominant in the Early Tertiary but gave way to lacustrine sedimentation by Eocene time.

The Uinta Basin was occupied by a series of lakes of varying sizes during the Paleocene and most of the Eocene. Formations accumulated in and around ancestral Lake Uinta. These lakes existed for about 35 million years and underwent many fluctuations leading to a complex interfingering of fluvial, deltaic, and lacustrine deposits (Picard and High, 1972). The depositional axis of the Uinta Basin occurs a few miles south of the structural axis, along which is the most continuous section of lacustrine rocks (Osmond, 1965; Ryder and others, 1976). Alluvial and lacustrine sediments in the deeper parts of the basin, adjacent to the Uinta Mountains, were as much as 21,000 feet (6,000 m) thick. Up to 12,000 feet (3,600 m) of these sediments are of Paleocene and Eocene age. In Eocene and Early Oligocene time an additional 1,200 feet (360 m) of sediment was deposited adjacent to early sediments. This brings the thickness of early Tertiary sediments in the deepest part of the basin to about 22,000 feet (5,500 m) (Osmond, 1965). Tertiary through Upper Cretaceous rocks (exposed on the flanks of the basin) characterize the surface geology of the basin (figure 5).

Development of the Uinta Basin proper essentially ended in the late Eocene or early Oligocene. Some additional uplifting of the region has occurred since the middle Miocene (Gable and Hatton, 1983; Nelson and Weisser, 1985).

Structure

Structurally the basin is a simple asymmetric syncline, and is not highly deformed. Figure 6 is a structure map contoured on the Colton/Wasatch Formation (or equivalent units), showing the asymmetry of the basin (Osmond, 1965). Dips on the southwest and southeast flanks range from a few degrees to 15°; dips on the north flank are between 10° and 35°. A northwest structural trend is common throughout the southeastern and eastern parts of the basin, possibly reflecting the buried older Uncompahgre and Paradox trends (figure 7). This is manifested in northwest plunging anticlinal folds and the gilsonite dikes found in the basin. A dominant west-east structural trend is found in the central part of the basin, possibly showing a relationship to the Uinta Mountains. A regional fracture system, the Duchesne fault system trends east-west and roughly parallels the trend of the Uinta Mountains. Numerous faults compose the Duchesne fault system, displacement across the zone is not large. The north flank is highly complex with major faulting, steep to overturned beds, and multiple successive unconformities that allow youngest Eocene sediments to lie unconformable on Precambrian sediments (Ritzma, 1971).

Stratigraphy

The uppermost Cretaceous and Tertiary strata in the Uinta Basin have been the subject of extensive investigations ranging from detailed studies of specific strata to regional treatises on sedimentation. Summaries of pre-Uinta Basin stratigraphy are found in Osmond (1965), Picard (1985), Clem (1985), Hintze (1988), and Sanborn (1977). A sedimentary succession of Paleozoic and Mesozoic rocks (figure 8) is found on the northern and western flanks of the Uinta Basin and exposed in areas surrounding the basin. It is reasonable to project these under the basin. This study will deal largely with the sediments deposited in the Uinta Basin proper.

Cretaceous sedimentary rocks crop out along the margins of the Uinta Basin. Cretaceous units found in the region are the Mancos Shale and the Mesaverde Group. The Mancos Shale intertongues from east to west with the overlying Mesaverde Group. The Mesaverde Group was deposited in fluvial, deltaic, and shallow marine environments during the final marine regression of the Createaous sea. A basin-wide unconformity marks the

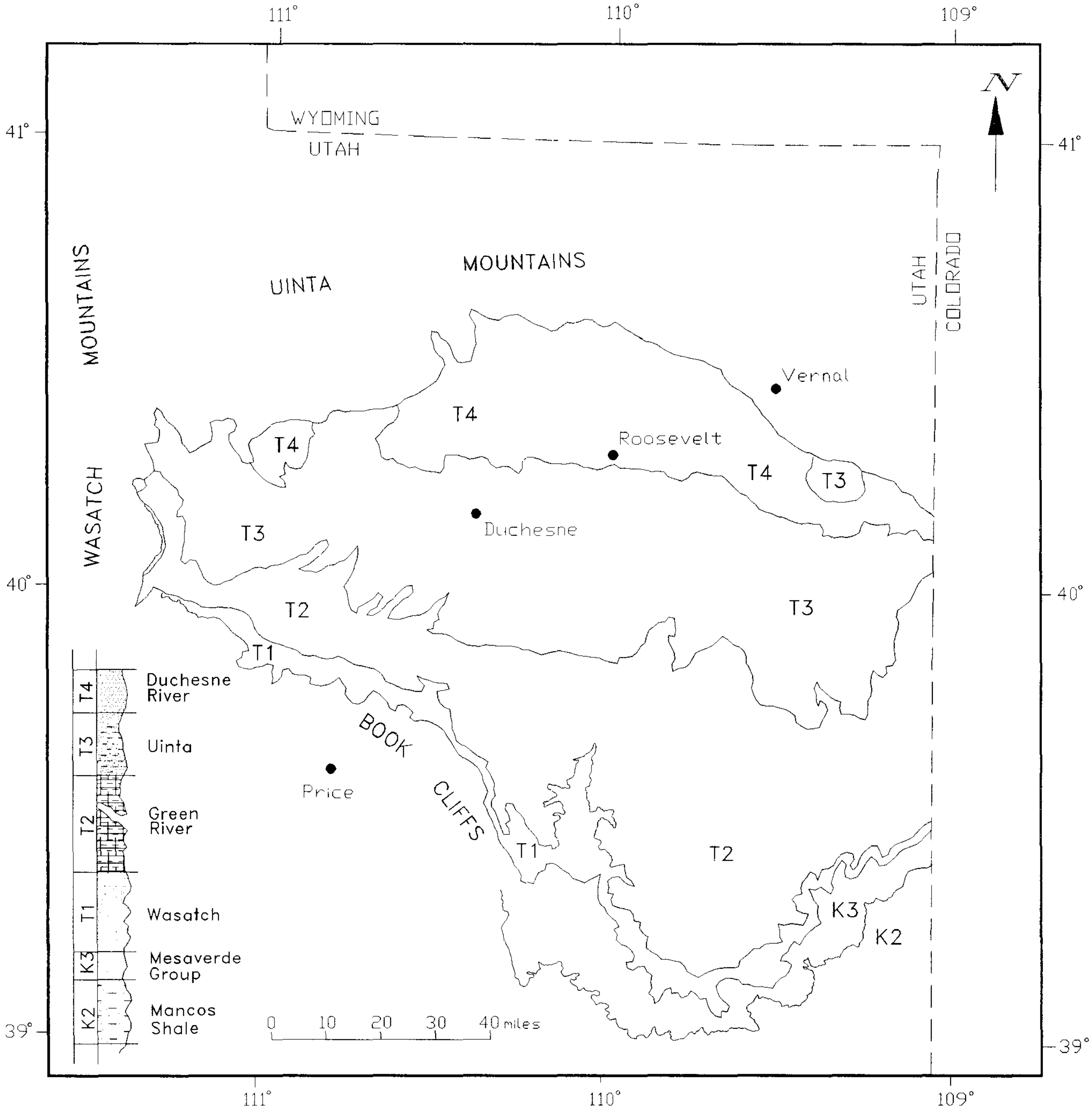

Figure 5. Generalized geologic map of the Uinta Basin region (from Hintze, 1980).

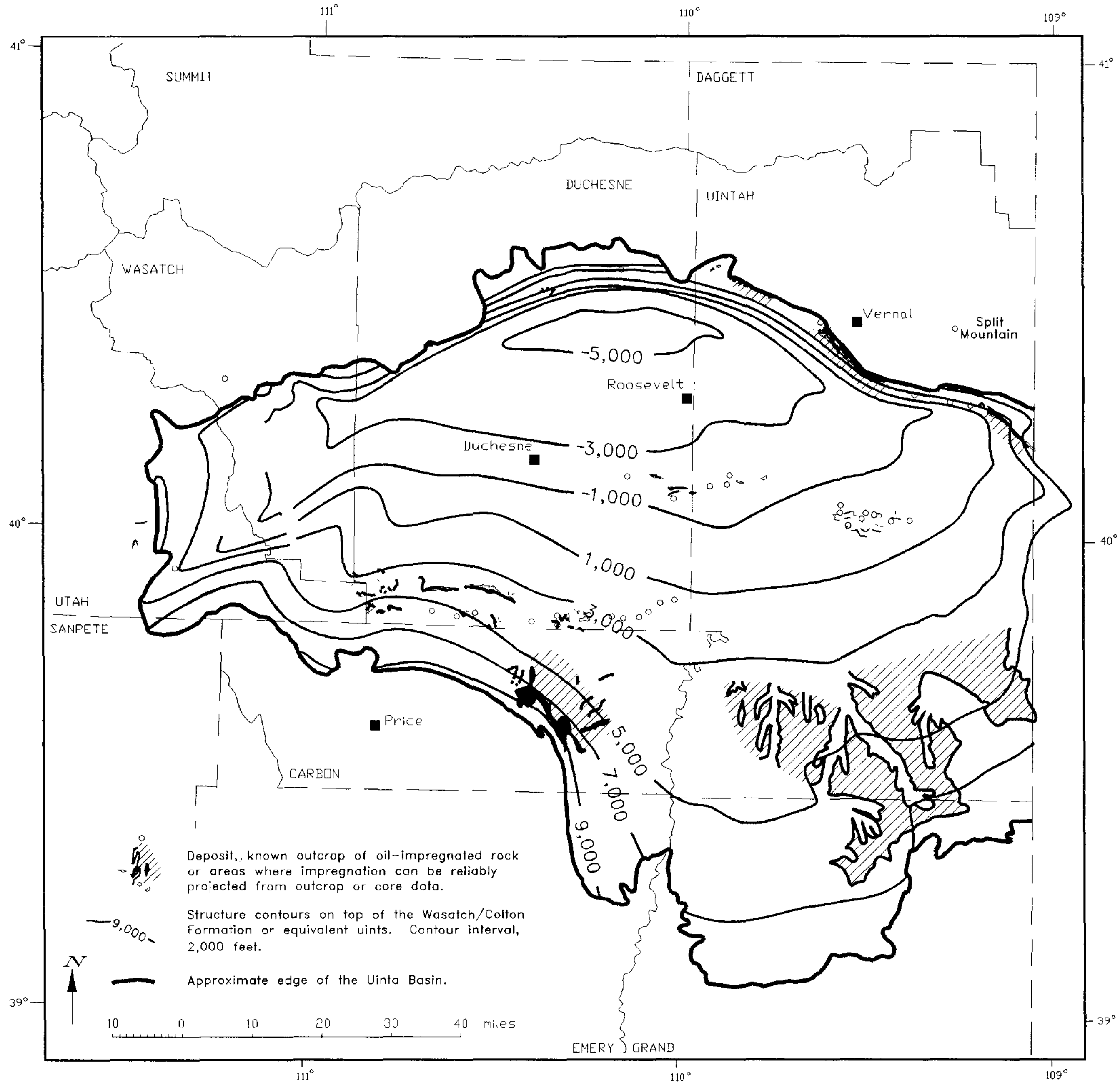

Figure 6. *Structure contour map of the Uinta Basin. Contours are elevations, in feet above msl, of the top of the Wasatch/Colton Formation or equivalent units.*

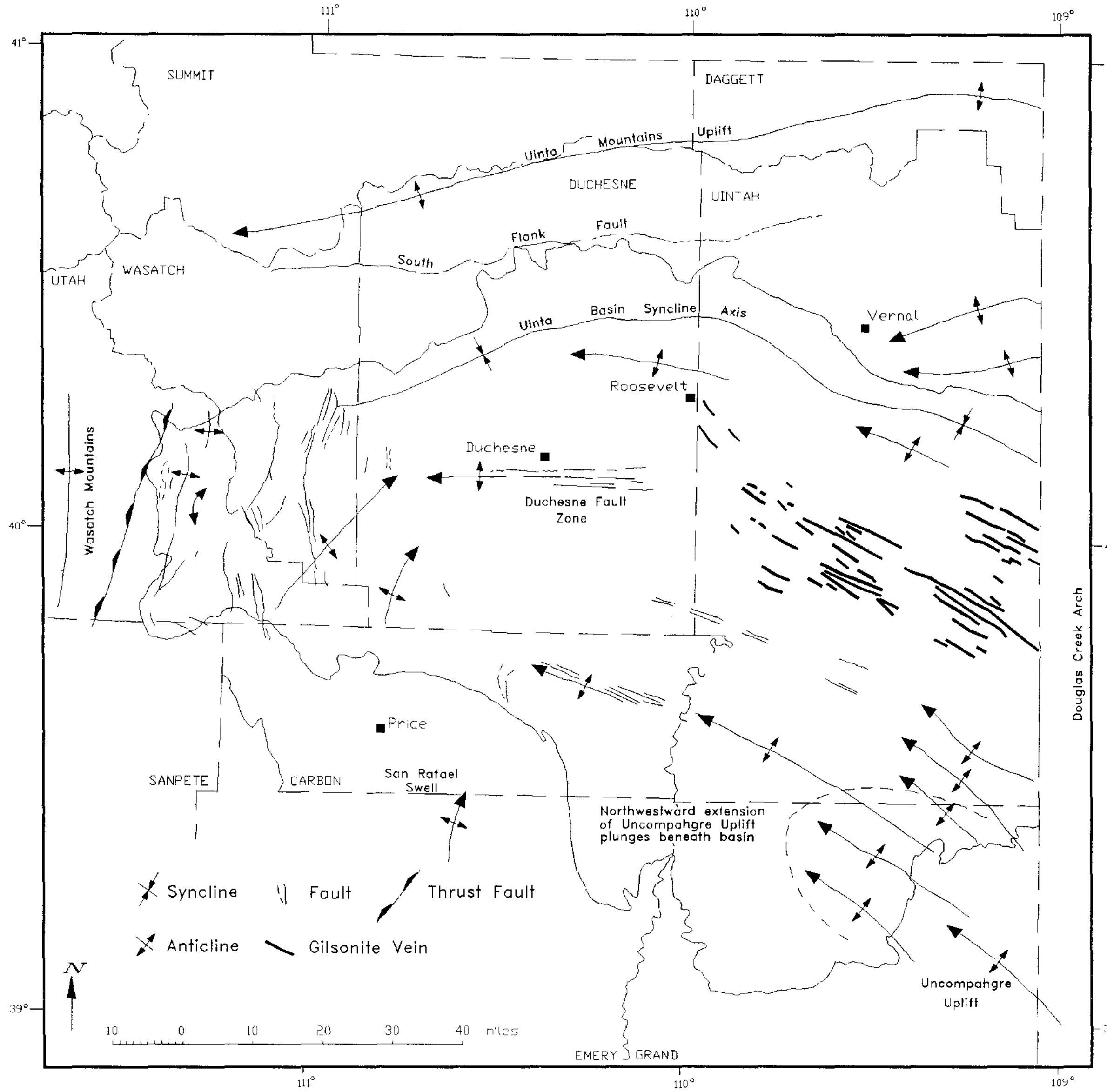

Figure 7. *Tectonic features of the Uinta Basin (from Osmond, 1965).*

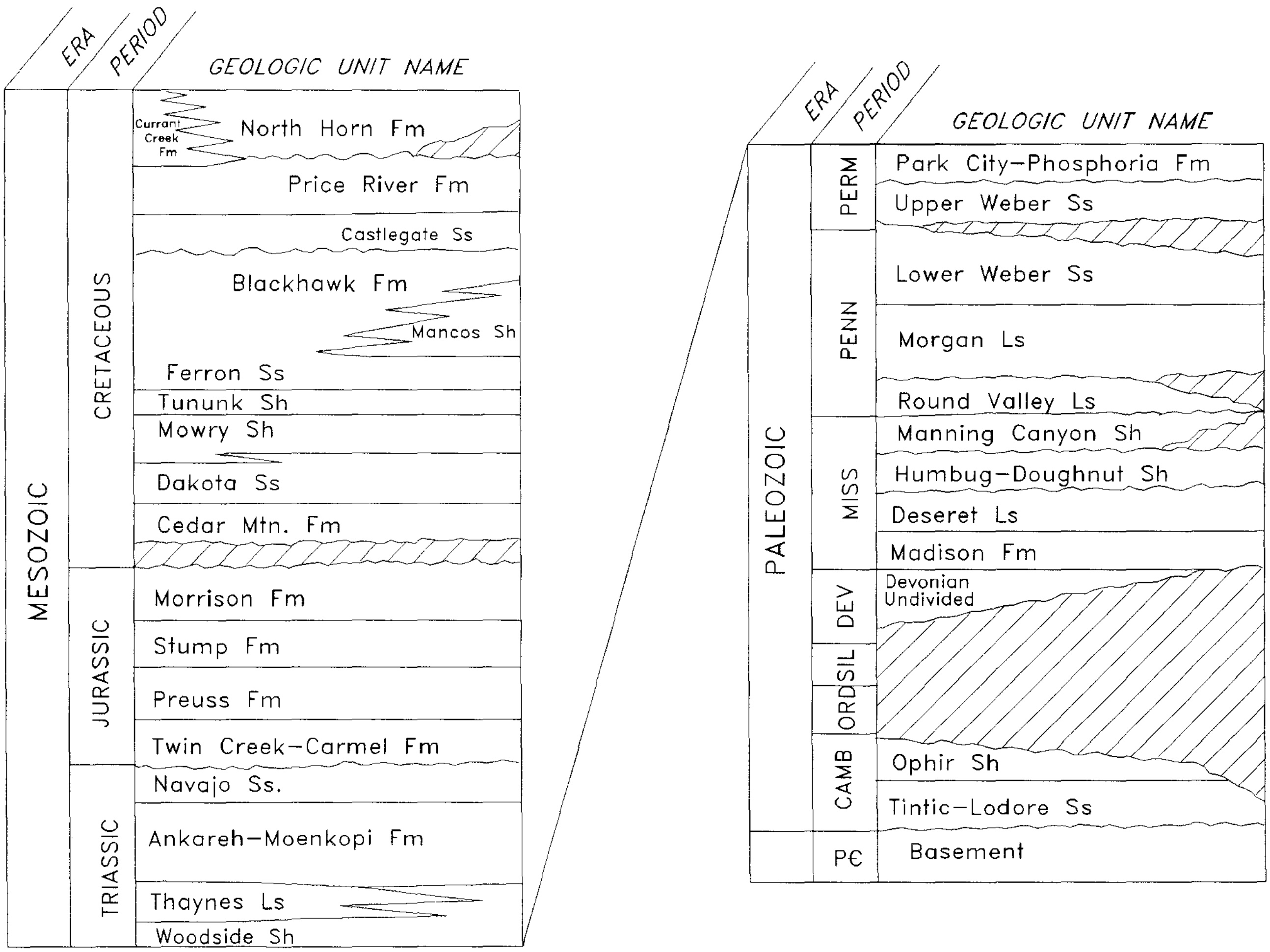

Figure 8. *Generalized stratigraphic framework of Paleozoic and Mesozoic rocks in the Uinta Basin (from Sandborn, 1977).*

transition from deposition associated with the Cretaceous sea to deposition associated with the Uinta Basin. The unconformity is represented by slight angular discordance and basal conglomerates. Alluvial and fluvial deposition followed this hiatus on a basin-wide scale. The continual thrusting to the west had resulted in the deposition of extensive coalescing alluvial fans that prograded eastward. These alluvial fan facies broadly graded into an extensive alluvial braid-plain depositing the Current Creek Formation, North Horn Formation, and Wasatch Formation. The rising Uinta Mountains, San Rafael Swell, and Uncompahgre uplift supplied the alluvial sediments. These formations can be characterized as clastic wedges of alluvium derived from source areas undergoing rapid uplift and erosion (Ryder and others, 1976; Isby and Picard, 1985). These upper Cretaceous to lower Eocene formations consist of variegated sandstone, mudstone, and minor limestone.

The Tertiary stratigraphy of the Uinta Basin is complex; numerous lithostratigraphic units have been defined and correlated within the basin. The treatment of the stratigraphy follows a more or less conventional systematic description of the named units, this in itself is difficult since the lateral relationships between units are as much a factor as are the vertical relationships. The general stratigraphy of the Uinta Basin based on Ryder and others (1976) is diagrammatically shown in figure 9. Terminology usage involves the designated facies and members of the Green River Formation and conventional names for other formations (Bradley, 1931; Dane, 1954; Dane, 1955; Picard, 1959; Cashion and Donnell, 1974). Ryder and others (1976) and Fouch and others (1992) dispensed with conventional names for the Green River Formation, using a terminology based on a depositional environment classification for the siliciclastic and carbonate sediments that accumulated in the basin.

In early Tertiary to late early Tertiary time the Uinta Basin became a topographic basin and lakes occupied the depositional basin (Isby and Picard, 1985). A complicated nomenclature has developed for the lakes that occupied the basin, but generally the name Lake Uinta is appropriate. Beginning of Green River Formation deposition was marked by a relatively rapid growth of Lake Uinta to its maximum size. Clastic deposition around the periphery of this lake continued, depositing the Wasatch Formation (Ryder and others, 1976). The lacustrine environment usually was restricted to the interior of the basin, where accommodation exceeded sedimentation. Frequent lake expansions and contractions resulted in large variations in the lake size. Repeated fluctuation of the lake level produced extensive shore deposits. On the northern side, where regional slopes were high, there was an abrupt transition from fluvial to lacustrine deposition. On the southern side of the lake, where the regional slopes were low, extensive deltaic facies developed (Picard and High, 1968). Lacustrine morphological features included wide zones of intertonguing deltaic and fluvial facies. Subsidence rates were most likely greater during deposition of the delta facies, and appears to have varied across the basin. The size of the delta front sequences represents progradation into the relatively shallow lake water. Lacustrine facies within the Uinta Basin fluctuated laterally in response to changes in the lake's base level (Franczyk and others, 1992). The Green River Formation reaches maximum thickness in the western and west-central Uinta Basin (Cashion, 1967).

The Uinta Formation was deposited in the final phase of Lake Uinta, consisting mostly of fluvial deposits. Lake Uinta was isolated and had become more saline, depositing evaporite minerals (Dyni and others, 1985). An influx of volcaniclastic in the late Eocene contributed to a shift of the depocenter of the lake westward. The Uinta Formation consists of marlstone, claystone, cross-stratified sandstone, siltstone and minor, poorly stratified oil shale. Contact between the Uinta and Green River Formation is gradational and irregular. During latest Eocene or earliest Oligocene time, Lake Uinta disappeared leaving scattered wet lands. The Duchesne River Formation is a fluvial sedimentary rocks consisting of laterally discontinuous sandstone lens with varying amount of conglomerate and poorly stratified fine-grained rocks (Anderson and Picard, 1972).

UINTA BASIN TAR-SAND DEPOSITS

Definition, Origin, and Classification

Not precisely defined in a physical, chemical, or geological manner the term "tar sand" is a commonly used name to describe a sedimentary rock reservoir impregnated with a very heavy viscous crude oil which cannot be produced by conventional production techniques (Tissot and Welte, 1984). Tar sand infers a sandy sedimentary rock as the host, but this is not always the case and other porous rocks such as siltstone and fractured carbonates have also

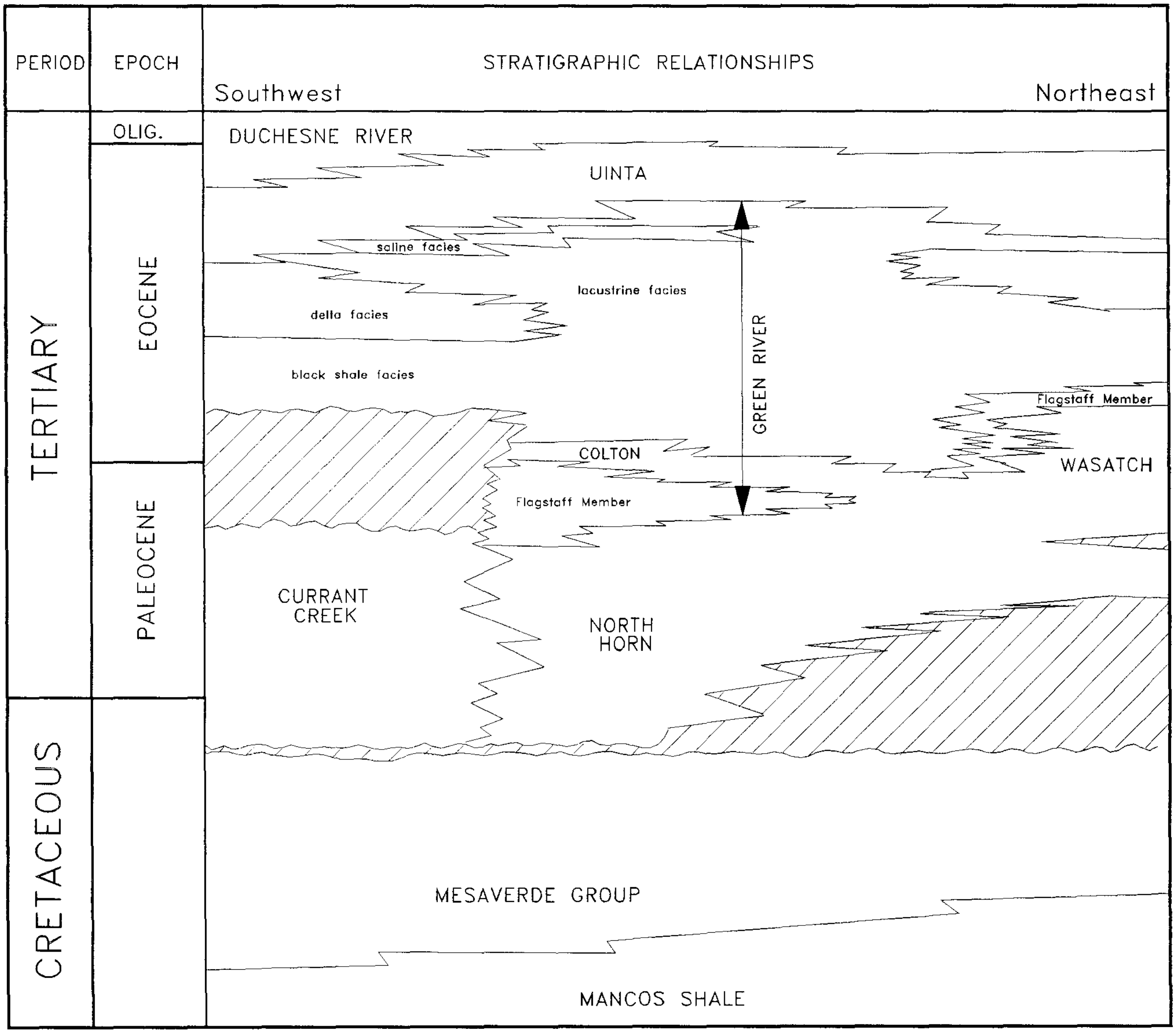

Figure 9. *Stratigraphic relationships and nomenclature of late Cretaceous and early Tertiary (Paleogene) rocks in the Uinta Basin (from Ryder and others, 1976).*

been classified as tar sand. For the purposes of this report tar-sand deposits have zero economic primary production, and an external source of energy is required to mobilize the oil.

While "tar sand" refers to the type of resource, the heavy oil substance impregnating the rock mass is more accurately called "bitumen," a dense viscous substance exhibiting chemical characteristics similar to petroleum and other hydrocarbons. Natural bitumens comprise a very large family of hydrocarbon substances, of which crude oil is only one example. Their chemical composition is characterized by a low carbon to hydrogen ratio compared with conventional petroleum.

The bitumen in tar sand is thought to be derived from crude oil that accumulated in conventional petroleum reservoirs near the land surface. These reservoirs were breached by streams or other erosion processes which cut through the reservoir cap-rocks, thereby allowing the volatile components of the crude oil to escape. The viscous bitumens from the crude oil, which remained in the deposit, were then altered by the combined action of ground water, air, and bacteria. Other terms such as "bituminous sands," "oil sands," and "oil-impregnated sandstone" have also been used interchangeably in the description of such deposits. Despite the ambiguity of the term "tar sand," it is firmly entrenched in the technical and industrial literature and in legislative documents. The U.S. Department of Energy defined tar sand in 1980 as any consolidated or unconsolidated rock, excepting coal, oil shale, and gilsonite which contains hydrocarbons (bitumen) and has a gas-free viscosity greater than 10 pascal seconds, or 10,000 centipoise, at original reservoir temperature. Following passage of the 1981 Federal Combined Hydrocarbon Leasing Act, the U.S. Bureau of Land Management added the phrase "or is produced by mining or quarrying" to the definition.

Classification schemes for bitumens have traditionally depended on differences in solubility, fusibility, and the hydrogen to carbon ratios. An example of such a classification scheme is shown in figure 10. Hydrocarbons are composed of hydrogen and carbon atoms and form a continuous series of organic compounds; natural bitumens are just one of these compounds. Precise boundaries do not exist between hydrocarbons and natural bitumens. However, viscosity is normally the first classification criterion. Hydrocarbons with viscosity more than 10,000 centipoise are called natural bitumens. Natural bitumens are semisolid or solid mixtures of hydrocarbons and may be divided into two groups on the basis of their solubility in various organic solvents, such as carbon disulfide (CS_2) (Hunt, 1979). These two groups are (1) the soluble "true bitumens" (oils, asphalts, mineral waxes, and asphaltites) and (2) the insoluble "pyrobitumens." Pyrobitumens are divided into two subgroups based on hydrogen to carbon ratio. The soluble natural bitumens generally contain various amounts of mineral matter. The true bitumens occur in three groups based on their relative fusibility, with the mineral waxes being the most readily fusible and the asphaltites being the least fusible. Tar sands are natural asphalts and are moderately fusible (Meyer and De Witt, 1990).

Distribution of Deposits

The Uinta Basin tar-sand deposits practically encircle the more than 9,000 square miles (23,310 km^2) of the Uinta Basin, as well as occur within it. Deposits range in size from giant (containing more than 500 million barrels of in-place bitumen) to minor (containing less than 0.5 million barrels of in-place bitumen) (Ritzma, 1979). Tar sands are found in strata that range in age from Pennsylvanian to Oligocene. Most of the tar sands are in Tertiary stratigraphic and structural sandstone traps. Tar-sand deposits are not homogeneous; bitumen distribution in a deposit varies depending on the permeability and porosity of the host rocks. Large accumulations of tar sands occur in sandstone of Eocene age, deposited in a fluvial-deltaic environment. Other tar-sands are found in alluvial and fluvial sandstone throughout the basin. The tar-sands resource of the Uinta Basin is thought to exceed eight billion barrels of oil (Ritzma, 1979). Data on the size of most of these deposits are sparse and, therefore subject to revision. At least four of the deposits are giant deposits, each containing in excess of one billion barrels of bitumen in-place. Another thirteen deposits contain more than 10 million barrels, with six deposits having more than 100 million barrels of bitumen in-place.

Chemical Properties and Thermal Maturity

Wood and Ritzma (1972) studied analyses of Uinta Basin tar sands and concluded that hydrocarbon varied considerably in some basic physical properties among deposits (table 2). The most variable characteristic they

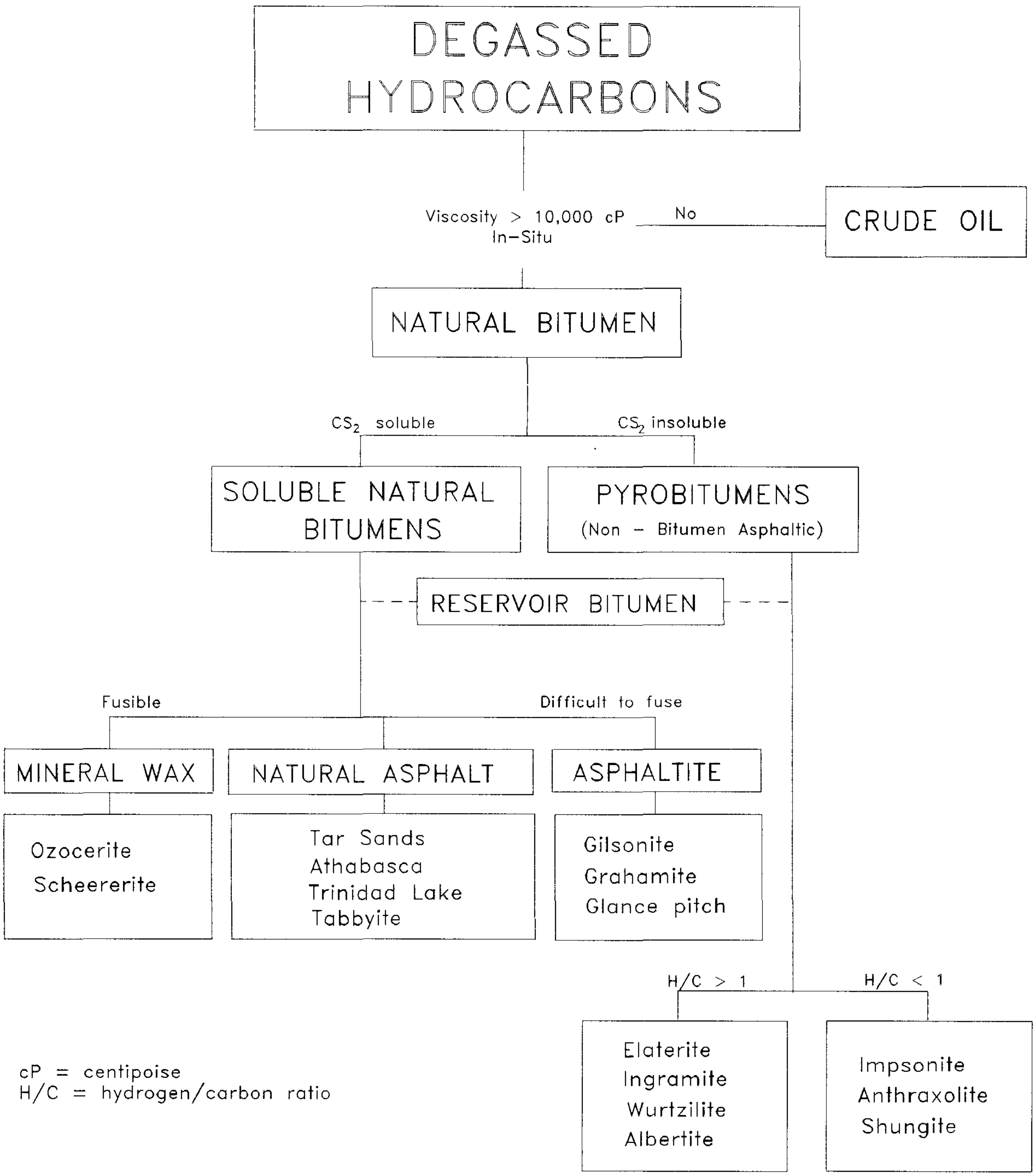

Figure 10. *Physical classification scheme for natural bitumens (from Hunt, 1979; and Meyer and DeWitt, 1990).*

Table 2. Analytical data for tar-sand deposits of the Uinta Basin (after Wood and Ritzma, 1972; and Mauger and others, 1973).

SAMPLE NO.	DEPOSIT	FORMATION (AGE)	PERCENT					SP. GR. G/CC.	GRAVITY •API	$\delta^{34}S$
			TAR	C	H_2	N_2	S			
69-19E	Asphalt Ridge	Rim Rock Mbr., Mesaverde Gp. (Upper Cretaceous)	17.0	71.0	10.3	0.9	0.19	0.980	12.9	
PC-65-5	Asphalt Ridge	Rim Rock Mbr. of Mesaverde Gp. (Upper Cretaceous)	85.3	11.2	1.01	0.28	0.99		12.0	
PC-65-6	Asphalt Ridge	Duchesne River Fm. (Eocene)	83.6	11.0	0.96	0.62	1.01		8.2	
RK-I-3	Asphalt Ridge	Rim Rock Mbr., Mesaverde Gp. (Upper Cretaceous)					1.0			+19.8
RK-I-4	Asphalt Ridge	Rim Rock Mbr., Mesaverde Gp. (Upper Cretaceous)					1.0			+21.6
RK-II-4	Asphalt Ridge	Duchesne River Fm. (Eocene)					0.2			+14.0
RK-III-2	Asphalt Ridge	Duchesne River Fm. (Eocene)					0.9			+13.5
RK-IV-1	Asphalt Ridge	Duchesne River Fm. (Eocene)					0.2			+21.2
RK-IV-4	Asphlat Ridge	Duchesne River Fm. (Eocene)					0.2			+14.1
RK-IV-5	Asphalt Ridge	Duchesne River Fm. (Eocene)					0.4			+17.8
RK-V-4	Asphalt Ridge	Uinta Fm. (Eocene)					0.5			+15.6
RK-V-5	Asphalt Ridge	Uinta Fm. (Eocene)					0.9			+7.0
1836	Asphalt Ridge	Rim Rock Mbr., Mesaverde Gp. (Upper Cretaceous)					0.3			+21.0
1835	Asphalt Ridge	Uinta Fm. (Eocene)					0.6			+20.1
69-18E	Asphalt Ridge, Northwest	Asphalt Ridge Mbr. of Mesaverde Gp. (Upper Cretaceous)	13.4	84.0	10.2	1.4	0.40	0.970	14.3	
69-15E	Chapita Wells	Uinta Fm. (Eocene)	1.7	82.0	10.6	1.2	0.28	1.013	8.2	
69-1A	Cow Wash	Parachute Creek Mbr., Green River Fm. (Eocene)	2.7	85.1	10.3	1.1	0.39	1.025	6.6	
70-22D	Daniels Canyon	Oquirrh Fm. (Penn-Perm)	2.79	67.3	11.0		0.62	0.985	12.2	
74-1A	Daniels Canyon	Oquirrh Fm. (Penn-Perm)	2.1	78.3	9.46		0.25	1.027	6.3	
74-2A	Daniels Canyon	Oquirrh Fm. (Penn-Perm)	0.4	79.5	9.77		0.29	1.031	5.7	
910	Daniels Canyon	Oquirrh Fm. (Penn-Perm)					0.59			
911	Daniels Canyon	Oquirrh Fm. (Penn-Perm)					0.57			
69-11C	Hill Creek	Douglas Creek Mbr., Green River Fm. (Eocene)	11.2	81.5	11.8	1.4	0.40	1.017	7.6	
68-21D	Lake Fork	Duchesne River Fm. (Eocene)	63.9	90.0	3.6	0.7	0.44	0.979	13.0	+8.1
68-22D	Lake Fork	Duchesne River Fm. (Eocene)	13.5	82.4	3.1	0.0	0.46	1.039	4.8	+8.3
68-14C	Littlewater Hills	Duchesne River Fm. (Eocene)	11.1	75.5	10.3	0.6	0.41	1.078	-0.2	+2.7
69-13E	P.R. Spring (Dragon-Asphalt Wash	Douglas Creek Mbr., Green River Fm. (Eocene)	12.4	80.0	9.5	1.0	0.45	1.012	8.3	

Table 2. (continued)

SAMPLE NO.	DEPOSIT	FORMATION (AGE)	PERCENT					SP. GR. G/CC.	GRAVITY •API	$\delta^{34}S$
			TAR	C	H_2	N_2	S			
67-1A	P.R. Spring	Douglas Creek Mbr., Green River Fm. (Eocene)	97.6	86.0	10.9	0.67	0.36	0.969	14.5	
67-5A	Raven Ridge	Parchute Creek Mbr., Green River Fm. (Eocene)	8.6	79.2	9.74	1.07	1.31	1.041	4.4	
67-8A	Raven Ridge	Green River Fm. (Eocene)	7.0	85.0	11.2	0.33	0.27	1.001	9.9	+5.3
67-10A	Raven Ridge	Parachute Creek Mbr., Green River Fm. (Eocene)	7.3	78.2	10.3	0.90	0.43	1.014	8.0	+20.6
67-4A	Rim Rock	Wasatch Fm. (Eocene)	12.6	72.9	9.76	0.55	0.38	1.045	3.9	+4.7
67-6A	Rim Rock	Green River Fm. (Eocene)	10.6	81.5	9.95	0.61	0.43	1.027	6.3	+6.9
67-7A	Rim Rock	Green River Fm. (Eocene)	9.0	78.1	9.62	0.34	0.33	1.037	5.0	+6.5
67-9A	Rim Rock	Wasatch Fm. (Eocene)	11.3	81.8	10.1	0.49	0.43	1.024	6.7	+5.7
68-17D	Split Mountain	Park City Fm. (Permian)	1.12	85.6	3.4	0.0	2.94	1.055	2.7	-2.0
68-23D	Spring Branch	Duchesne River Fm. (Eocene)	10.7	76.2	7.9	0.9	0.47	1.022	7.0	+3.1
68-24D	Spring Branch	Duchesne River Fm. (Eocene)	14.1	83.6	3.2	1.0	0.82	1.061	1.9	+7.4
68-18D	Spring Hollow	Duchesne River Fm. (Eocene)	2.6	87.5	3.3	0.60	0.76	0.968	14.7	+7.0
68-15C	Tabiona	Uinta (?) Fm. (Eocene)	5.45	74.9	10.1	0.40	0.20	1.038	4.9	+5.5
68-16C	Tabiona	Currant Creek Fm. (Paleocene-Eocene)	2.55	81.3	10.8	0.10	0.21	1.025	6.5	+5.9
68-20D	Tabiona	Currant Creek Fm. (Paleocene-Eocene)	8.25	83.0	3.2	0.80	0.29	1.004	9.8	
69-2A	Upper Kane Hollow	Parachute Creek (?) Mbr., Green River Fm. (Eocene)	1.3	86.4	9.9	1.35	0.32	1.017	7.6	
WR-1	Whiterocks	Navajo Ss. (Jurassic)					0.2			+21.2
WR-2	Whiterocks	Navajo Ss. (Jurassic)					0.3			+21.2
WR-3	Whiterocks	Navajo Ss. (Jurassic)								+21.4
68-10A	Whiterocks	Navajo Ss. (Jurassic)	7.8	84.4	11.2	1.3	0.48	0.996	10.6	

observed was sulfur content. Sulfur compounds generally form the largest group of non-hydrocarbons in oil, and Wood and Ritzma (1972) showed that sulfur content of Uinta Basin tar sands commonly varied between 0.19 to 0.62 percent. Five deposits had relatively higher values (figure 11). They observed that sulfur contents of these deposits was low, suggesting they were derived from low-sulfur oil.

Palacas and others (1988) analyzed some of the tar sands in the Uinta Basin to determine the level of maturity and to postulate the source of the hydrocarbons. They observed that these deposits were commonly depleted in some standard compounds called "biomarkers" (steranes, isoprenoids, and alkanes), which they attributed to extensive biodegradation. They studied other biomarkers, more resistant to biodegradation, and concluded that Uinta Basin tar sands are characterized by low triaromatic-enrichment ratios. Other biomarkers reflect low maturity. Together, these observations suggest that Uinta Basin tar sands are likely to have been derived from a shallow,

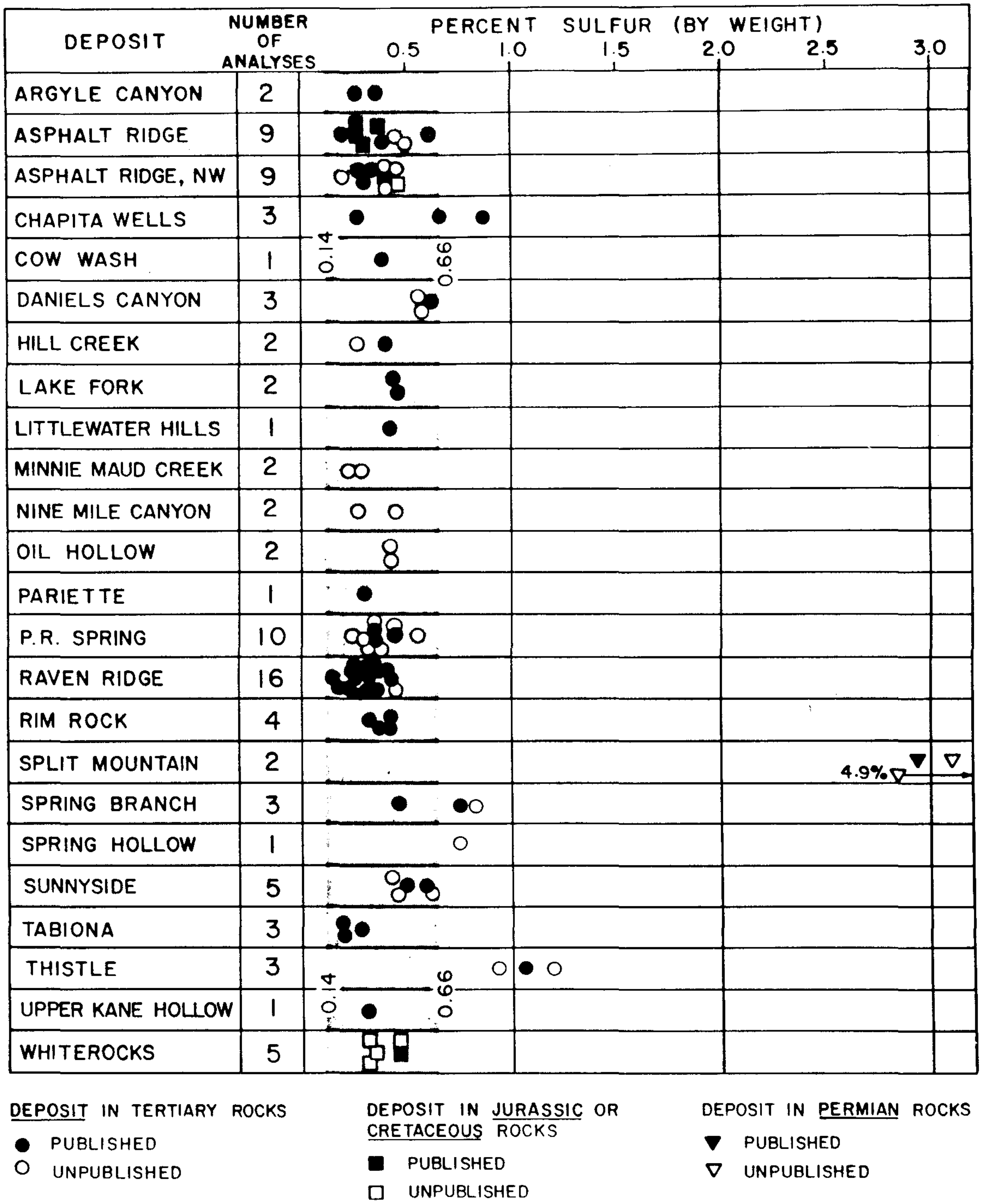

Figure 11. *Percent sulfur (by weight) in bitumen extracted from tar sands in the Uinta Basin (from Wood and Ritzma, 1972).*

immature source. Palacas and others (1988) concluded that the Green River Formation units that acted as the source of hydrocarbons generated and expelled immature to marginally mature oils and heavy oils. Biodegradation of the heavy oils led to formation of the tar sand and deposits of other solid hydrocarbons, such as gilsonite. According to biomarker signatures, the Sunnyside, P. R. Spring, and Asphalt Ridge deposits are thermally immature, while the Raven Ridge deposit is thermally mature.

Source, Migration, and Degradation

Lacustrine rocks are the most important petroleum source beds in continental sedimentary sequences. Organic matter on lake bottoms is normally derived from fresh-water algae and bacteria that tend to be oil-prone and waxy. In deep lakes, surface winds do not disturb the lower layers of water and, therefore, stagnant conditions, favorable to the accumulation of organic matter, exist. As a lacustrine basin evolves by sediment accumulation and subsidence, oil generation occurs and migration tends to move oil upward within a homogeneous carrier bed. Bitumen moves out of the fine-grained lacustrine source rocks, through the more permeable carrier beds, and finally into porous traps. There appear to be no distance constrains on migration, as the distances from likely source beds to individual deposits vary. Migration continues until a trap is reached, or until the organic material is destroyed by oxidation and biodegradation.

Tar-sand deposits are a product of biodegradation and water-washing (dissolution of oil by meteoric water) of crude oils after migrating from sources and accumulating in traps. Biodegradation and water washing occur when crude oil contacts bacteria and oxygen-laden meteoric water at low temperatures (below 93°C [199°F]), and usually at shallow depths (Demaison, 1977). The bacteria consume the light-hydrocarbons in the crude oil, resulting in density and viscosity increases in the residual oil. Water-washing removes the water-soluble hydrocarbons, whereas, biodegradation removes paraffins and isoprenoids. These processes have caused the tar sands to be partially to totally depleted in some standard hydrocarbon compounds such as n-alkanes, isoprenoids, alkylcyclohexanes, and alkylbenzenes.

Land Status

State, private, tribal, and federal lands are found in the Uinta Basin (Bureau of Land Management, 1977). Oil and gas, tar sands, and other solid hydrocarbons are generally part of mineral rights associated with the land. Utah State lands normally include state-owned mineral rights and are subject to lease. Private lands commonly include rights to minerals, but there are exceptions. Mineral rights on privately held lands and valid mining claims are sold or leased in any way the owner feels appropriate. Minerals on tribal lands are held in trust by the federal government and are the property of the tribes and managed by them. Federal lands require a lease to develop minerals. Acquisition or leasing of mineral rights in the Uinta Basin involve the following:

(1) Most of Utah State Lands within the Uinta Basin are managed by the Utah School and Institutional Trust Lands Administration (SITLA). The Division of Sovereign Lands and forestry administers the mineral rights within Utah sovereign lands.

(2) Mineral rights for private Lands (Fee Lands) are normally conveyed through sale or leasing by the individual land owners or their agents. Sometimes with land transfers, mineral rights are reserved by federal, state, or tribal agencies.

(3) The Ute tribe and the Bureau of Indian affairs, which has the right to negotiate and issue leases on mineral commodities including tar sand, administers land within the Ute and Ouray Reservation.

(4) Federal lands include mainly public domain administered by the Bureau of Land Management and National Forests administered by the U.S. Forest Service.

History of Leasing and Land Ownership

Prior to 1926 tar sands on Federal lands could be located as placer mining claims under the General Mining Law of 1872, although the mining law was awkward for these types of deposit. The Petroleum Placer Act of 1897 confirmed the applicability of the mining law in the locating of mining claims for petroleum deposits on vacant Federal lands (Pruitt, 1964). Tar-sand claims could also be patented or they could be held as unpatented mining claims (until the Combined Hydrocarbon Act of 1981). Tar-sand mining claims generally covered 160 acres per claim. The federal government first attempted to remove tar sands (along with oil and gas) from the mining law in 1909-1910, when a presidential order closed large areas of the western U. S. (known or believed to contain petroleum) to mining claims. The Uinta Basin was not considered a petroleum province and not adversely affected by this action (Pruitt, 1964).

The federal government first distinguished between oil and gas fields and tar-sand deposits beginning on July 17, 1914 with an Act of Congress. Congress authorized the reservation to the United States of all deposits of "phosphate, nitrate, potash, oil, gas, or asphaltic minerals" in agricultural land patents. The Mineral Leasing Act of 1920 did not specifically identify tar sands, but provided that deposits of oil, oil shale, and gas on federal lands be disposed of exclusively by separate mineral leases. The Mineral Leasing Act was directed toward certain well-known commodities, where it was felt that greater government control for their orderly development was needed. The Department of the Interior interpreted the Mineral Leasing Act to exclude tar sands which remained subject to the General Mining Law of 1872.

Lands known to contain deposits of tar sands and other like substances were withdrawn from consideration for location as placer mining claims under the General Mining Law, by Executive Order No. 4371 in 1926 (Pruitt, 1964). Congress amended the Mineral Leasing Act in 1960 to allow leasing of tar-sand deposits on Federal lands. This amendment provided for separate oil and gas and tar-sand leases. Conversion of mining claims to tar-sand leases within a one-year period was provided for by the act, but delays in publishing the regulations effectively did away with this conversion period (Pruitt, 1964). The 1960 amendment made reference to "materials from which oil is recoverable only by special treatment after the deposit is mined or quarried". A conflict soon developed over in-situ recovery of hydrocarbons from the tar-sand deposits and other wording in the amendment. This conflict caused the Department of the Interior to cease tar-sand leasing in 1965, thereby creating an obstacle to tar-sand development. Even the tumultuous events in the oil market during the 1970s did not result in any serious change in the situation. Companies were prevented from establishing significant land plays due to the lack of federal leasing policy.

The U.S. Congress enacted the Combined Hydrocarbon Leasing Act (Public Law 97-78) in 1981 (Kerns, 1984). The Act provides for combined hydrocarbon leases applicable only in specified areas purportedly containing the bulk of the federally owned tar sands. In Utah, 11 areas were specified for combined-hydrocarbon leases. Congress's intent was to "facilitate and encourage the production of oil from tar sand and other hydrocarbon deposits." Passage of the Combined Hydrocarbon Leasing Act accomplished the following:

(1) Redefined oil to include tar sand.

(2) Provided for conversion of existing oil and gas leases and certain valid mining claims to Combined Hydrocarbon Leases.

(3) Provided for issuance of new Combined Hydrocarbon Leases, on a competitive basis.

Combined Hydrocarbon Leases are offered in areas designated by Congress as Special Tar-Sand Areas (STSAs). All current STSAs are located in Utah (figure 12). Table 3 shows the distribution of land ownership within the STSAs. Despite the apparent intent of Congress to encourage tar-sand development, neither extensive leasing nor commercial development has taken place. Although beyond the scope of this report, a combination of factors--economic, technical, legal, and policy--appear to be responsible for lack of development. Interest in possible tar-sand development has fluctuated widely since the early 1950's and has generally been related to availability of adequate, secure supplies of comparatively cheap conventional petroleum.

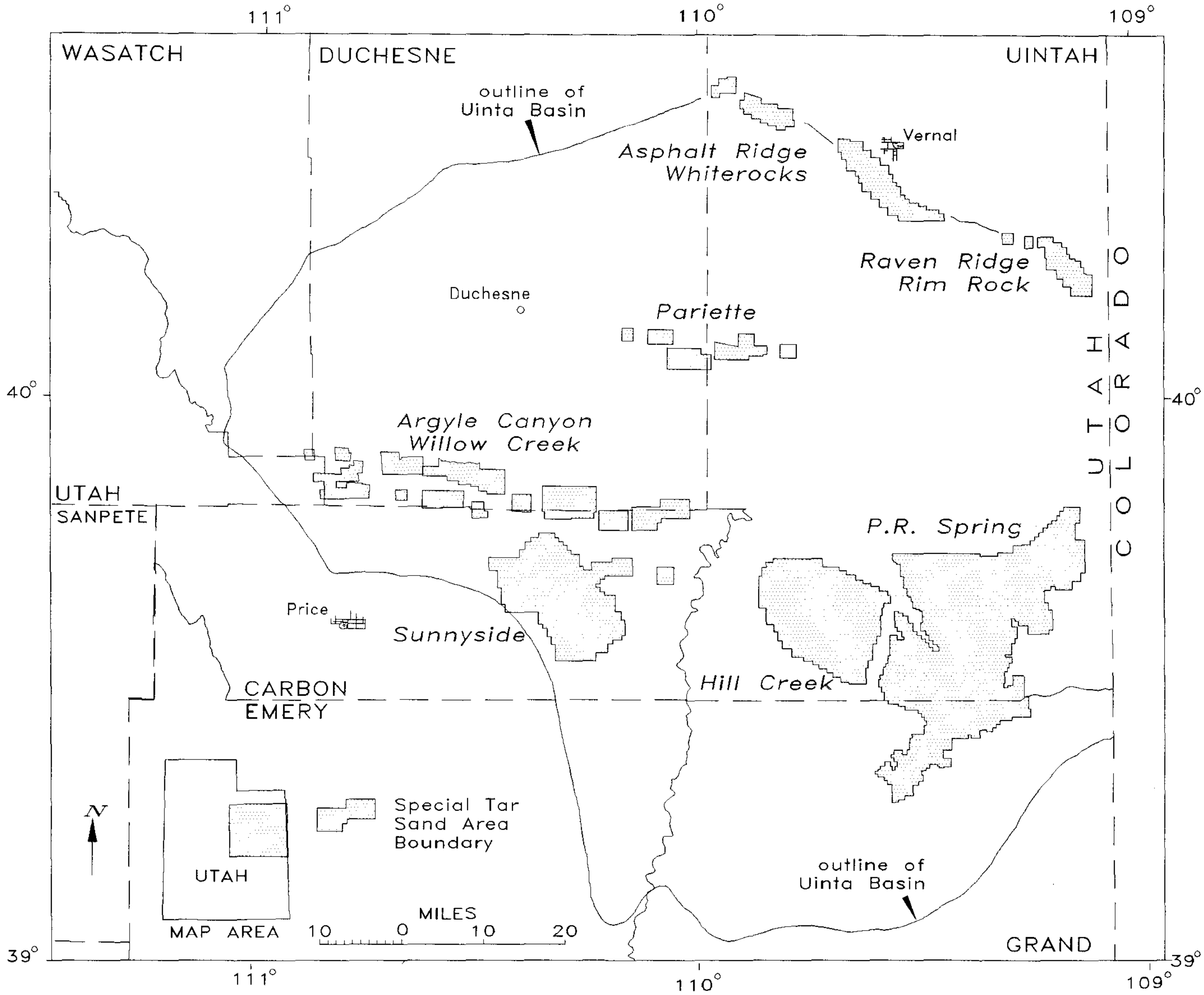

Figure 12. *Geographic distribution of Special Tar Sand Areas (STSAs) in the Uinta Basin (after Bureau of Land Management, 1984).*

Table 3. Distribution of Lands in Special Tar Sand Areas in the Uinta Basin (from U.S. Bureau of Land Management, 1980).

STSA	Public	Forest	State	Private	Indian
Asphalt Ridge-Whiterocks	5,120	1,920	17,976	1,600	9,920
Hill Creek	32,256		2,560	8,160	63,664
P.R. Spring	196,480		63,696	14,384	
Sunnyside	83,872		9,600	53,000	
Pariette	12,480		1,440		2,240
Argyle Canyon-Willow Creek	640	5,312	2,240	6,400	13,760
Raven Ridge-Rim Rock	13,960		2,080		
Total	**344,808**	**7,232**	**99,592**	**83,544**	**89,584**

The State of Utah has long encouraged a tar-sand industry in Utah. It has actively pursued land selection and exchange opportunities to establish a major presence in tar-sand localities in eastern Utah. Prior to 1952 the State of Utah issued leases covering asphalt, oil, and gas on state lands. After 1952, tar sands (asphalt or bituminous sand) were leased separately. A version of the federal combined-hydrocarbon lease is presently used to lease tar sands on state lands. In a few instances, where the State owns tar sands, but not oil and gas rights, leasing is accomplished with an "asphaltic sands" lease.

SUMMARIES OF PRINCIPAL TAR-SAND DEPOSITS

The following sections briefly describe the four principal tar-sand deposits of the Uinta Basin. These include Asphalt Ridge, P.R. Spring, Hill Creek, and Sunnyside. More complete descriptions and information are included in the references to these deposits. The reader is urged to consult these publications and articles for more details. Figure 13 shows the locations of the principal tar-sand areas with respect to primary roads and communities.

Asphalt Ridge and Asphalt Ridge Northwest

Location and Access

The Asphalt Ridge and Asphalt Ridge Northwest tar-sand deposits are located on the north-northeast flank of the Uinta Basin, about 3.5 miles (5.6 km) southwest of the town of Vernal, Uinta County, Utah (figure 13). The deposits crop out on the northeast side of Asphalt Ridge from the Maeser-Lapoint road to the north to the Green River to the south. Bitumen-saturated outcrops are exposed along broad, northeast-facing cliffs of Asphalt Ridge and lie in T.4-6S., R.20-22E. (SLM).

U.S. Highway 40 crosses the north part of Asphalt Ridge. Several unimproved roads provide vehicle access from U.S. 40 to various parts of the deposit.

Physiography and Land-Use

Asphalt Ridge is situated along the northeast edge of the Uinta Basin physiographic subprovince (Stokes, 1977). The Marginal Benches/Uinta Mountains subprovince of the Middle Rocky Mountains lies less than 10 miles (16 km) to the north. The ridge forms the southwest limit to the low-lying farm lands of Ashley Valley. The Green River, which flows southwestward through the Uinta Basin, meanders around the southeast extension of Asphalt Ridge. The ridge is a northwest-southeast trending cuesta, where Cretaceous and Tertiary formations dip to the southwest (Kayser, 1966). Bitumen-saturated outcrops extend for about 12 miles (19 km) northwest-southeast along the strike of the outcrops.

The town of Vernal is less than 4 miles (6.4 km) to the northeast in Ashley Valley where elevations range generally between 5,200 and 5,500 feet (1,585 and 1,676 m). Asphalt Ridge rises from 500 to 1,000 feet (152 to 305 m) above Ashley Valley, forming a prominent escarpment. The highest point on the ridge, located near the northwest end, is slightly more than 6,400 feet (1,951 m) in elevation. The Ashley Valley oil field, a Permian-Pennsylvanian oil reservoir, lies 8 to 10 miles (13 to 16 km) to the southeast.

The Uintah and Ouray Indian Reservation boundary lies about 8 miles (15 km) west of the Asphalt Ridge deposit. Ashley Valley, northeast of the ridge, is mostly privately owned, while Asphalt Ridge is federal and state owned (figure 14). Most of area comprising the tar-sand outcrops is administered by the Bureau of Land Management. Lands making up the "down-dip" (southwest) portion of the deposit are primarily Utah State lands managed by SITLA.

Geologic Setting

Exposed strata consist of the Asphalt Ridge Sandstone and the overlying Rim Rock Sandstone, both of the Mesaverde Group (Cretaceous), and the Duchesne River Formation (Eocene-Oligocene) (figures 15 and 16). The Asphalt Ridge Sandstone and the Rim Rock Sandstone are separated by a thin tongue of Mancos Shale. All Cretaceous units are of marine origin. At Asphalt Ridge the Duchesne River Formation, containing interbedded fluvial sandstones with associated shales and conglomerates, lies unconformably atop the Rim Rock Sandstone (Campbell and Ritzma, 1979). The Rim Rock Sandstone (Mesaverde) ranges from about 100 feet (30 m) to more than 300 feet (90 m) in thickness, due to erosion of the unit prior to deposition of the overlying Duchesne River Formation (Kayser, 1966). Elsewhere, the Duchesne River Formation successively overlies the Uinta, Green River, and Wasatch Formations. The Green River and Wasatch Formations are not present in the section at Asphalt Ridge

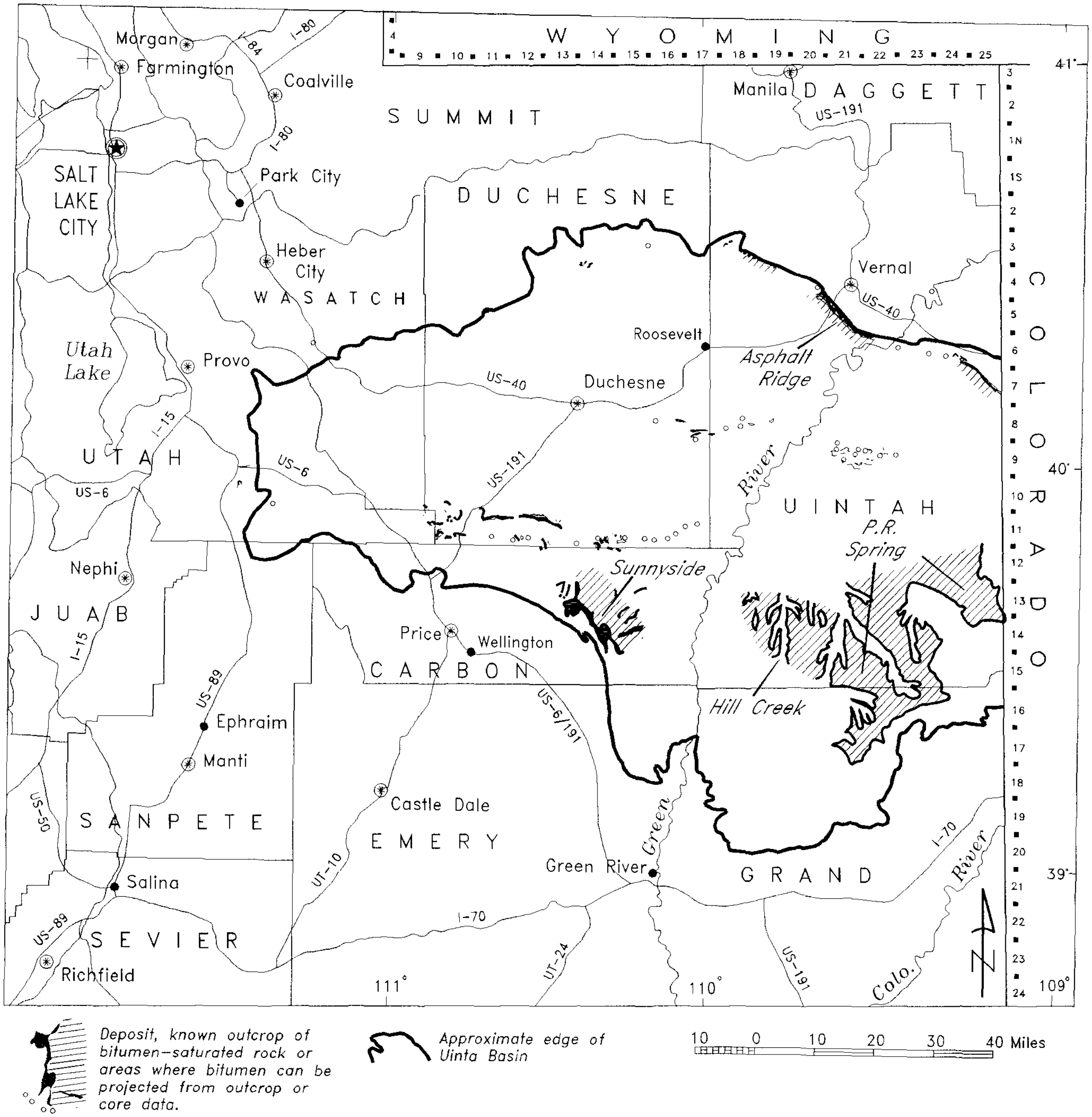

Figure 13. Locations of primary tar-sand deposits of the Uinta Basin.

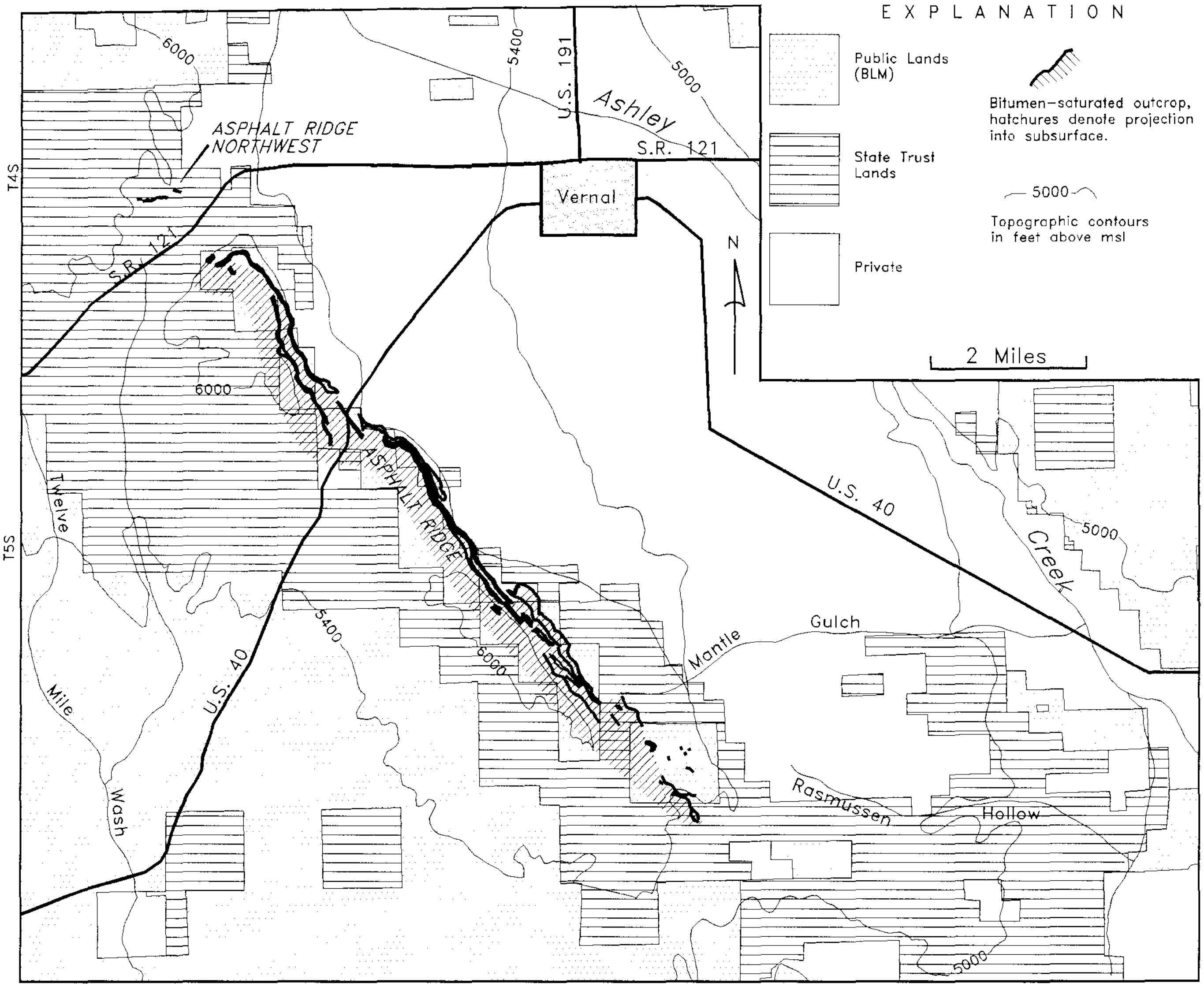

Figure 14. Land-ownership map of the Asphalt Ridge tar-sand deposit area.

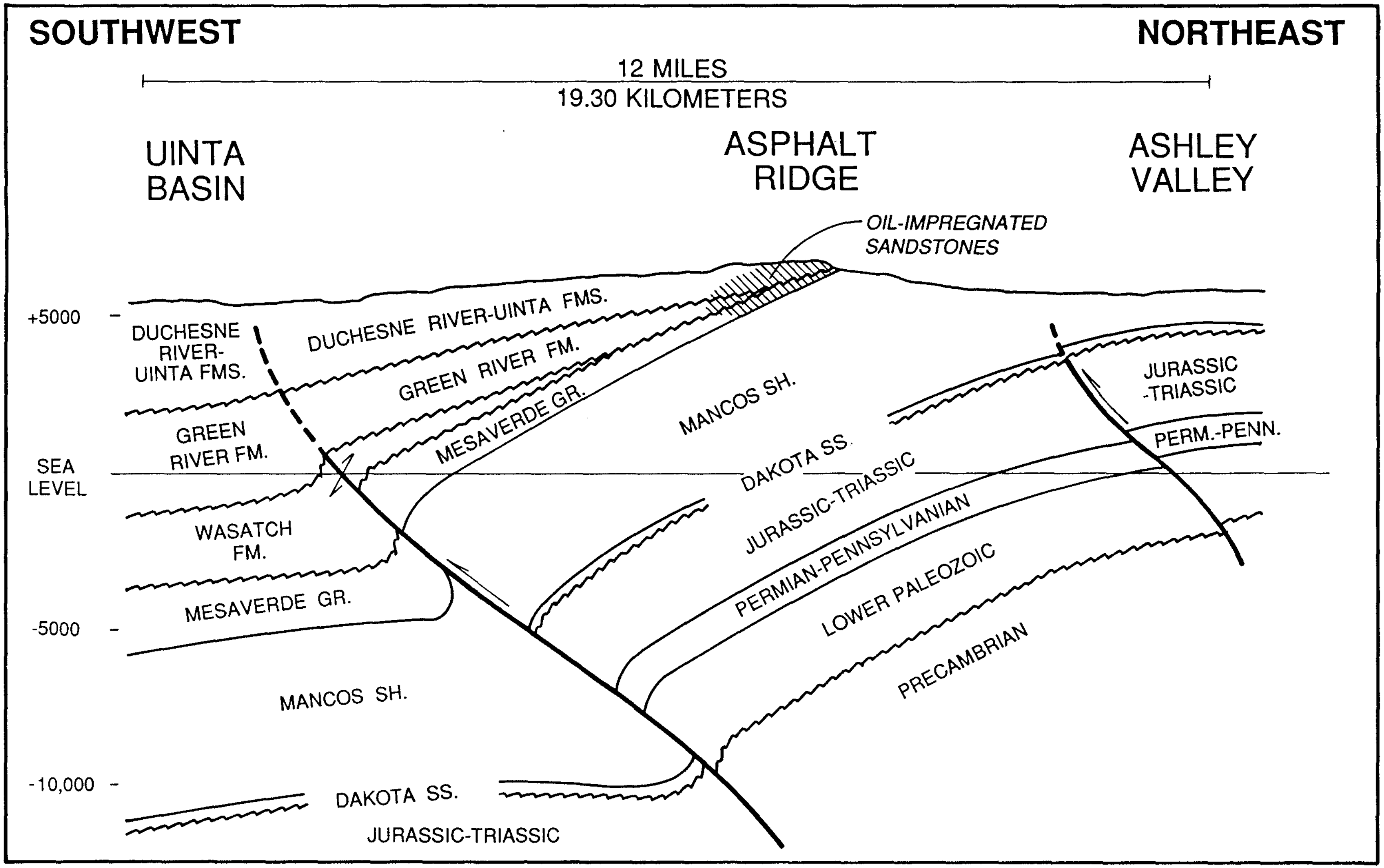

Figure 15. Geologic cross section of the Asphalt Ridge tar-sand area (after Campbell and Ritzma, 1979).

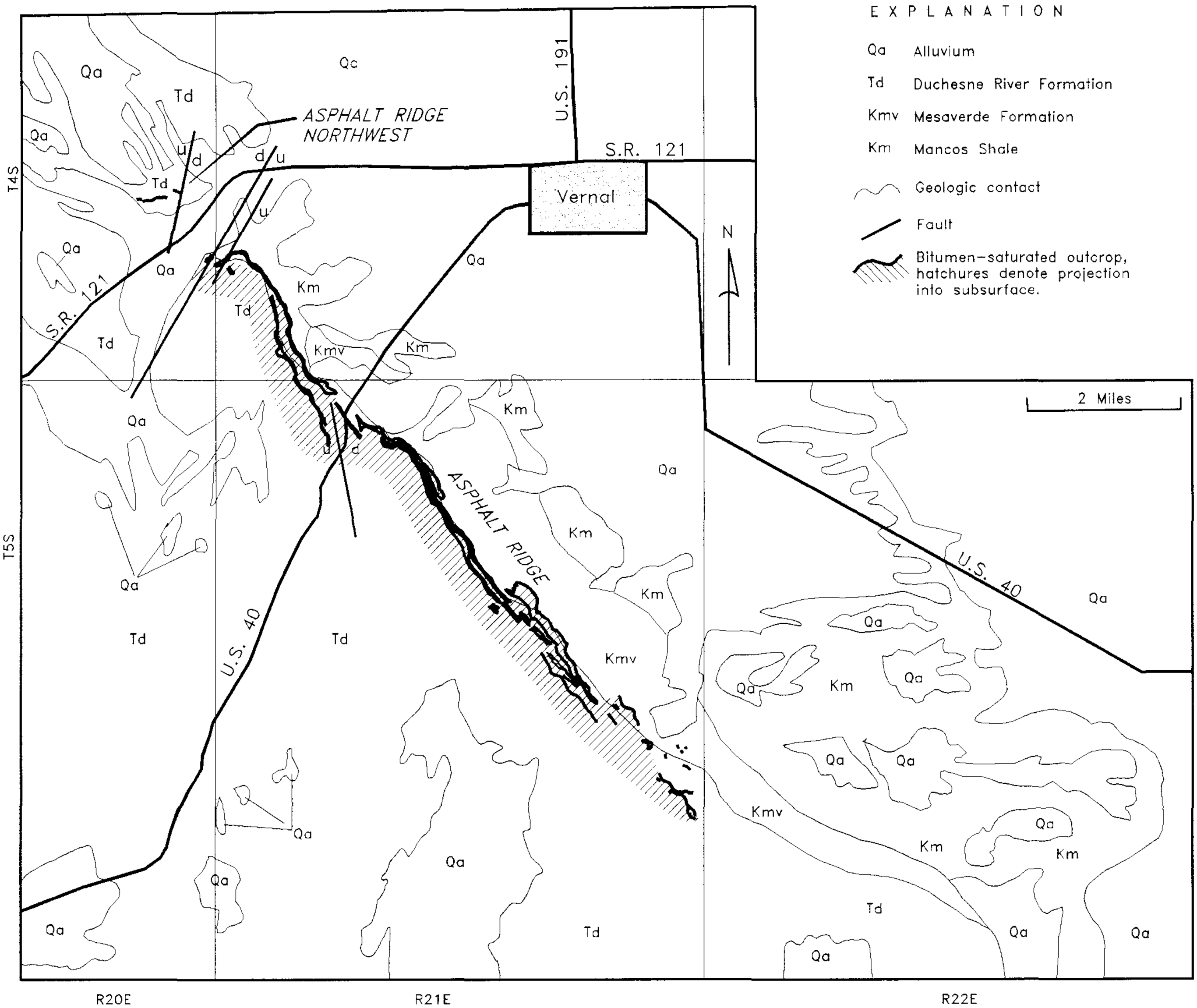

Figure 16. General geology of the Asphalt Ridge tar-sand area (after Hintze, 1980; tar-sand outcrops from unpublished UGS file data).

either due to erosion or nondeposition. The Uinta Formation may be present, but the Uinta Formation-Duchesne River Formation contact is gradational and difficult to recognize (Spieker, 1930).

Attitudes measured on outcrops of the Rim Rock Sandstone indicate dips ranging from 8 to 30 degrees south-southwest, while beds of the Duchesne River Formation dip 9 to 20 degrees south-southwest. The angular unconformity between these two rock-units probably represents several thousand feet of the Wasatch, Green River, and Uinta Formations either eroded or never deposited in this area. Asphalt Ridge is one of several hogback ridges trending northwest-southeast and extending southeast to Raven Ridge.

Minor faults within the deposit area are confined to rocks of the Mesaverde Group and do not pass upward into the Tertiary units. A prominent fault, exposed at an asphalt pit in sections 30 and 31, T.4S., R.21E., strikes N.24°W. The fault surface is nearly vertical and the displacement is 150 feet (46 m) down on the west side. A fault at the north end of the ridge in section 25, T.4S., R.20E., trends north and drops the Rim Rock Sandstone to the west. This fault intersects and offsets another fault, which separates the Asphalt Ridge Northwest deposit from the Asphalt Ridge deposit and trends north-northeast with the down-thrown side to the northwest. Numerous minor faults and joints occur along the length of the ridge and trend from N.50°W. to N.70°W. (Kayser, 1966).

The Asphalt Ridge deposit is separated from the Asphalt Ridge Northwest deposit by a northeast-trending fault. This high-angle fault, located in section 24, T.4S., R.20E. (SLM), strikes N5°E and crosscuts the outcrops perpendicular to the bedding strike. This fault has apparently acted as a barrier to oil migration. While both deposits are essentially continuous, the Asphalt Ridge Sandstone is saturated in the Northwest deposit and unsaturated in the Asphalt Ridge deposit.

Bitumen-saturated strata south and west of the Asphalt Ridge are covered by Tertiary sedimentary units. Drilling has revealed bitumen-saturated sections of up to 2,000 feet (610 m) in thickness (Campbell and Ritzma, 1979).

Bitumen occurs along the strike of Asphalt Ridge, within the Rim Rock Sandstone of the Mesaverde Group (Cretaceous), the Uinta Formation (Eocene), and the Duchesne River Formation (Oligocene). Kayser (1966) describes the Rim Rock Sandstone as cropping out along the entire length of Asphalt Ridge and mostly saturated by bitumen, thereby masking lithologies. In bitumen-free areas, the Rim Rock Sandstone is light gray, fine to medium-grained, and speckled with numerous black chert grains.

The Uinta Formation consists of fluvial, interbedded sandstone, mudstone, and shale, with lenses of grit and conglomerate. Bitumen in the Uinta Formation occurs mostly in the southern part of Asphalt Ridge in thin sand beds (Kayser, 1966).

Bitumen-saturation within clastic beds of the Duchesne River and Uinta Formations varies both laterally and vertically. Rock-type ranges from shale to conglomerate, but in general, the most saturated zones are in medium- to coarse-grained sandstone. Sandstone is mostly comprised of detrital, poorly sorted quartz and chert, and cemented with calcite, hematite, and silica (Kayser, 1966). Covington (1964) suggested that the oil probably originated from the Green River Formation and migrated updip along the Tertiary-Cretaceous unconformity. Sulfur isotope studies by Mauger and others (1973) support this theory.

Spieker (1930) estimated total tar-sand resources at Asphalt Ridge of nearly 2 billion cubic yards extending from the outcrop downdip 1.5 miles (2.4 km) into the subsurface. He calculated that proven reserves were nearly 900 million barrels of bitumen, of which 400 million barrels were in the Rim Rock Sandstone and 500 million barrels were in the Duchesne River Formation. Kayser (1966) estimated that nearly 700 million barrels of bitumen were contained in the Rim Rock Sandstone within two tracts comprising 5,250 acres within the deposit. Ritzma (1979) classified the deposit as "giant," and estimated that 1,048 million barrels of bitumen were contained in-place. Of this total, he categorized 435 million barrels as measured and 438 million barrels as indicated, with the remaining 175 million barrels as inferred.

Bitumen Analyses

Analyses of bitumen extracted from samples of the deposit were reported by Kayser (1966), Wood and Ritzma (1972), and Mauger and others (1973). These analyses show that bitumen here is low-sulfur and high-gravity (table 2). Asphalt Ridge Northwest sample 69-18E was collected from an adit located in SE¼SE¼ section 23, T.4S., R.20E. in the Asphalt Ridge Sandstone.

Development History

Mining of the Asphalt Ridge deposit for paving streets and sidewalks in the town of Vernal dates back to at least the 1920s (Spieker, 1930). A number of unsuccessful shallow wells were drilled into the bitumen-saturated outcrops between 1910 and 1950 in an apparent attempt to locate liquid petroleum below the asphaltic seal (Kayser, 1966; Campbell and Ritzma, 1979). During the 1930s a tar-sand extraction plant utilizing a hot water separation process was built at the present site of the Uinta County asphalt pit. In the early 1950s, Knickerbocker Investment Company and W.M. Barnes Engineering Company acquired a large block of patented and unpatented oil placer mining claims and began the first comprehensive evaluation program (drilling and mapping) on the ridge. Bituminous sand was shipped to a pilot extraction plant in California. The claims were then leased to Sohio Petroleum Company, which completed its own extensive mapping and drilling program.

In the early 1970s, Major Oil Company obtained a working agreement with Sohio Natural Resources Company to strip mine the tar sands and build and operate an extraction plant on a tract at the southeast end of Asphalt Ridge. The material was crushed and packed into flotation cells where a hot-water-solvent process was used to strip the bitumen from the sand. The bitumen was shipped to a refinery located in Roosevelt, Utah. Aminoil Company provided technical assistance for this project, which was acquired in 1972 by Arizona Fuels Corporation and Fairbrim Company (Anonymous, 1974; Covington and Young, 1985).

Sun Oil Company drilled a series of test wells on the south end of the ridge, while Texaco and the Phillips Petroleum Company performed exploratory drilling in the central part. Shell Oil Company and others drilled test wells on the north end of the ridge during the early 1970s (Campbell and Ritzma, 1979).

The Laramie Energy Technology Center of the U.S. Department of Energy conducted extensive field experiments in the Asphalt Ridge Northwest deposit between 1971 and 1982. A series of in-situ reverse combustion field experiments were conducted on a ten-acre site provided by Sohio Petroleum company. Uinta County presently excavates the material from an asphalt pit and uses it for road surfacing (Covington and Young, 1985).

P.R. Spring

Location and Access

The P.R. Spring tar-sand deposit is located on the southeast flank of the Uinta Basin, about 50 miles (80 km) northwest of Grand Junction, Colorado, and about 50 miles south of the town of Vernal (figure 13). The deposit area is remote, whereby vehicle access is gained from two primary routes. The area may be approached from the north by driving east from Vernal on U.S. Highway 40 for about 20 miles (32 km) to the junction with State Route 45, then south on SR-45, passing the town of Bonanza, and continuing south and southwest for about 25 miles (40 km). Two roads provide access to the area from the south. The San Arroyo Canyon road and the Hay Canyon road join Interstate Highway 70 near the Utah-Colorado state line. The roads within the area are unimproved and mostly follow stream-courses in canyons and along ridge-tops. Numerous oil-well maintenance roads connect canyons and ridges.

Physiography and Land-Use

The P.R. Spring tar-sand deposit extends along the length of the eastern Book Cliffs from Willow Creek on the west to the Utah-Colorado border on the east. The deposit is within the Book Cliffs-Roan Plateau physiographic subdivision of the Uinta Basin, and encompasses an area of 240 to 270 mi^2 (614 to 691 km^2) in southern Uintah and northern Grand Counties (Ritzma, 1979).

Tar-sands crop out at elevations ranging from 6,500 feet to 8,800 feet (1,981-2,682 m). The land surface is relatively flat, with pediments that slope gradually northwestward toward the center of the Uinta Basin. Gently sloping, narrow plateaus and mesas are incised by intermittent and perennial streams forming dendritic drainage patterns. Canyons are steep and trend generally northwest. Several prominent northwest-southeast trending ridges persist within the area. Vegetation, typical of the arid and semiarid climate, consists of grasses and shrubs on mesas and canyon bottomlands and mixed conifer forests on north-facing mountain slopes and ridges.

Most of the land in the area is public land administered by the Bureau of Land Management. A large block of Utah State land, known as the Book Cliffs Planning Unit, plus scattered sections, are administered by SITLA. The Hill Creek Extension of the Uinta and Ouray Reservation covers much of the Hill Creek tar-sand area to the west. Smaller tracts of private lands are also present (figure 17).

The Book Cliffs Conservation Initiative (BCCI), an initiative to improve wildlife habitat in the southeastern Uinta Basin, is a cooperative effort between the BLM, the Rocky Mountain Elk Foundation (RMEF), The Nature Conservancy (TNC), and the Utah Division of Wildlife Resources (DWR). The portion of the Book Cliffs covered by the BCCI encompasses about 450,000 acres in the P.R. Spring area: about 319,000 acres (71 percent) are administered by the BLM; 114,000 acres (25 percent) are School Trust Lands administered by SITLA; and about 20,000 acres are privately owned (information pamphlet on the BCCI prepared by BLM, RMEF, TNC, and DWR; Utah Division of State Lands and Forestry, 1992). The effects of the BCCI on future development-potential of tar-sand resources is unclear.

Geologic Setting

The P.R. Spring deposit is located on the southeastern limb of the Uinta Basin and contained within the Green River Formation (Eocene) (figure 18). The Green River Formation in this area is composed of oil shale beds, marlstones, shales, siltstone, sandstones, limestones, and tuff, deposited primarily in a lacustrine environment. Clastic sediments of the Green River and Wasatch Formations in this area are thought to be derived from the Uncompahgre Uplift to the south (Picard, 1971).

Stratigraphic nomenclature for the Green River Formation, proposed initially by Bradley (1931) and modified by subsequent investigators, is complicated. Cashion (1967) defined the current terminology used in the P.R. Spring area (southeastern Uinta Basin). Ryder and others (1976) redefined the terminology generally used in the Uinta Basin, but did not work in the P.R. Spring area. Cashion's terminology is, therefore, generally used in describing the P.R. Spring deposit. Cashion (1967) named three mappable units, in ascending order, as the Douglas Creek, Parachute Creek, and Evacuation Creek Members of the Green River Formation (figure 19). The Mahogany Bed, a kerogen-rich unit recognized as an "oil-shale" resource, separates the Douglas Creek and Parachute Creek Members. Campbell and Ritzma (1979) recognized as many as 13 fluvial-deltaic sandstone bodies in the deposit area.

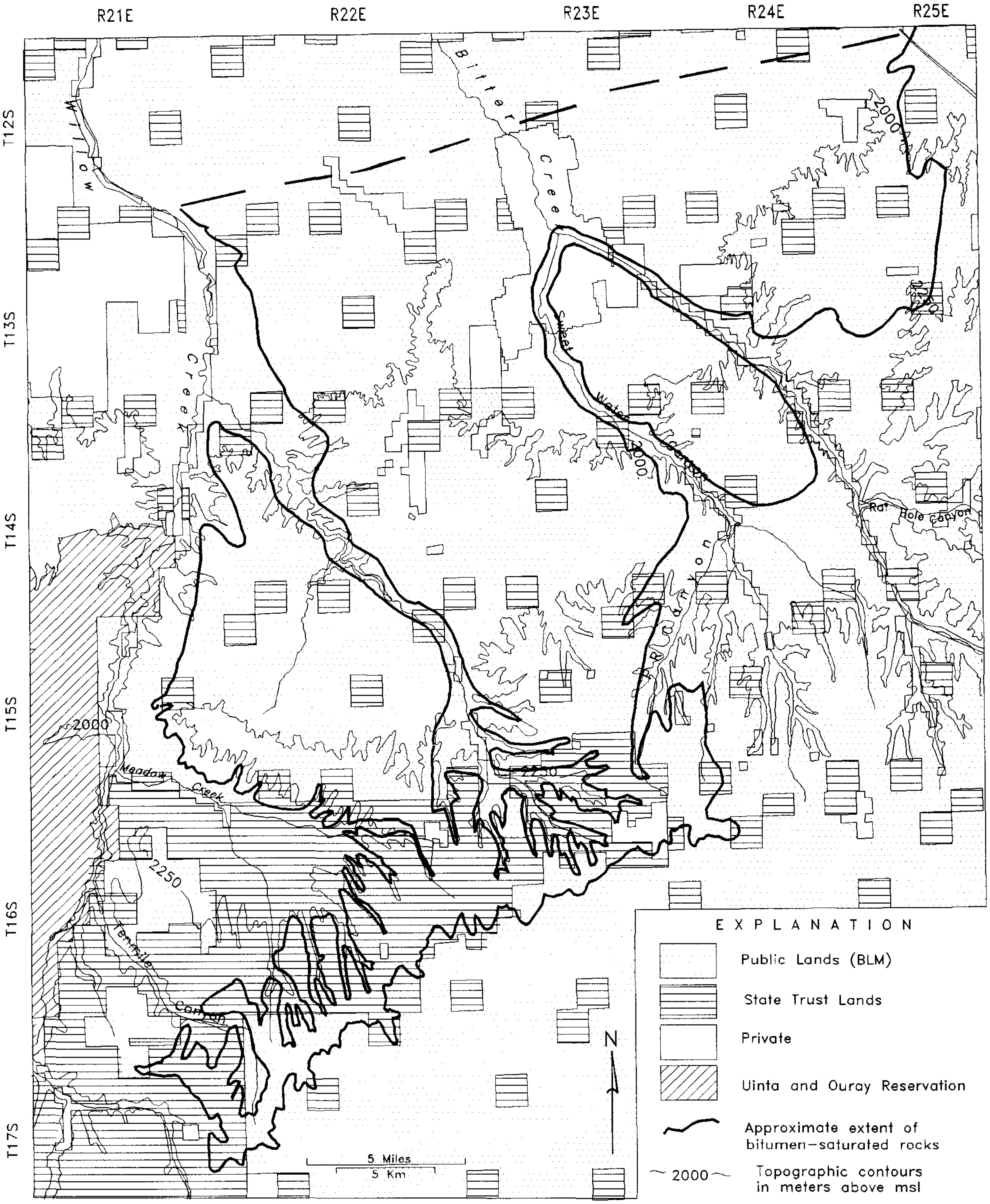

Figure 17. Land-ownership map of the P.R. Spring tar-sand area.

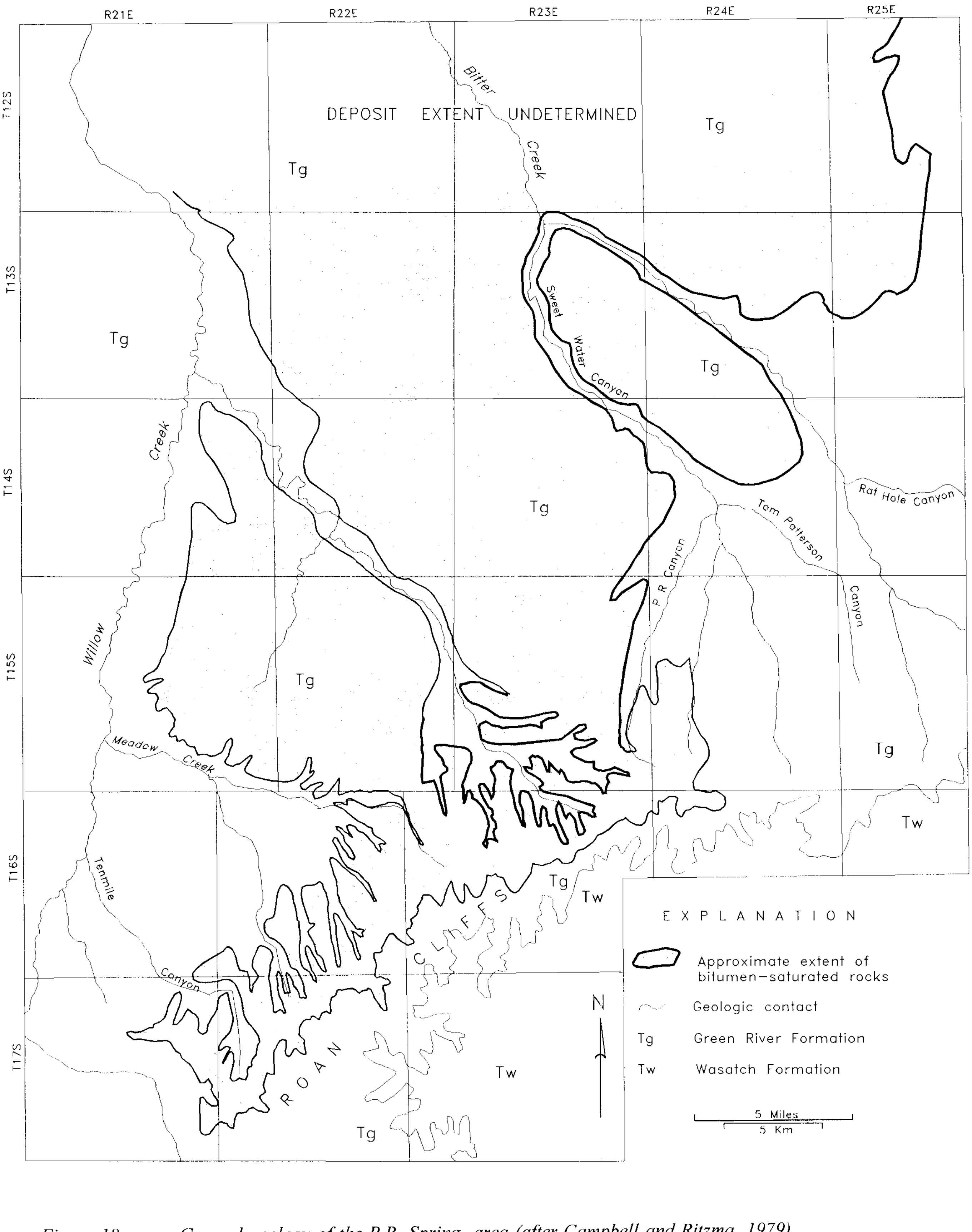

Figure 18. *General geology of the P.R. Spring area (after Campbell and Ritzma, 1979).*

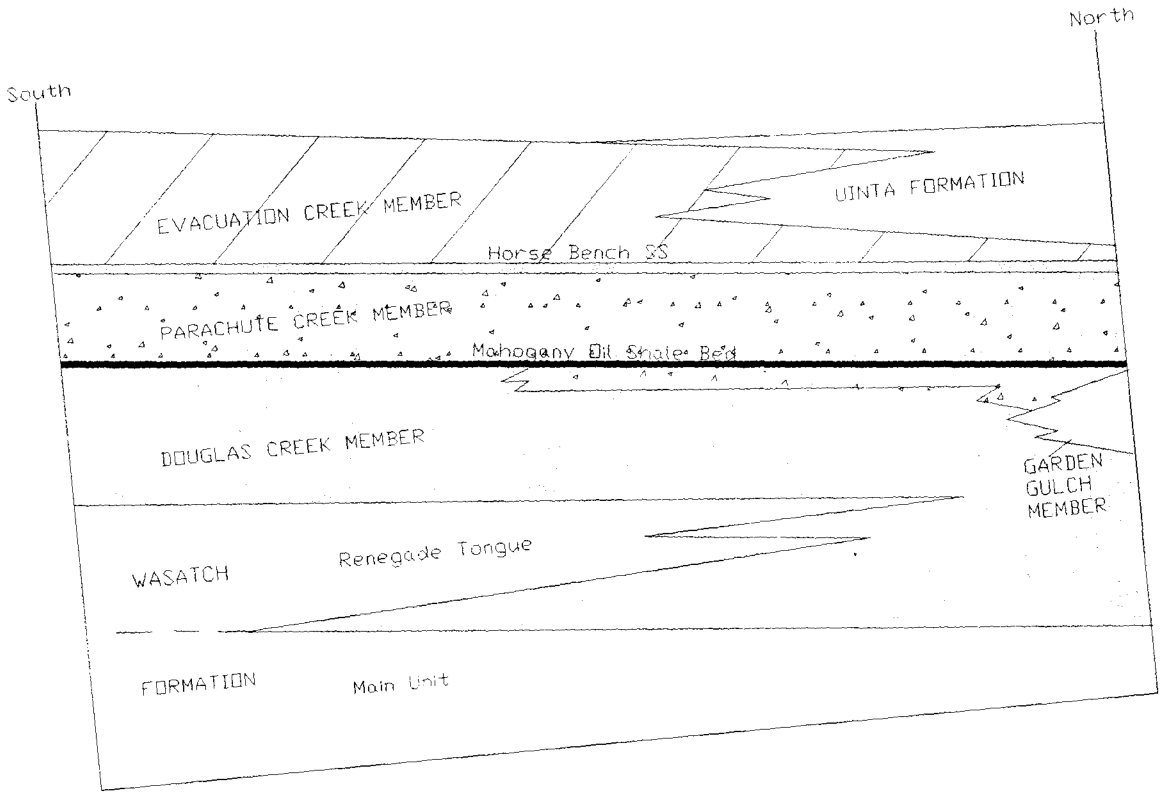

Figure 19. *Generalized geologic relationships of the Wasatch Formation and members of the Green River Formation in the southeastern Uinta Basin (after Cashion, 1967; and Gwynn, 1971).*

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The deposit overlies the northwest flank of the Uncompahgre Uplift, a regional northwest-trending basement uplift. Regional dip is toward the northwest at 2 to 6 degrees. Although shallow folds related to the Uncompahgre Uplift are present on the surface, they apparently have not affected the emplacement or migration of bitumen. Byrd (1970) recognized six northwest plunging anticlinal noses and some minor faulting in the area.

Bitumen has impregnated five zones--four in the upper portion of the Douglas Creek Member and one in the lower portion of the Parachute Creek Member (figure 20). In ascending order, these zones have been designated A, B, C, D, and E and can be correlated throughout the deposit (Gwynn, 1971). Degree of bitumen saturation varies laterally and vertically in each of the zones. The deposit becomes progressively deeper northward and may extend in the subsurface farther than indicated by previous work (Campbell and Ritzma, 1979). Lateral correlation of individual rock units, even over short distances, is difficult. Individual sandstone beds range from 6 inches (15 cm) to 30 feet (9 m) in thickness. The P.R. Spring tar-sand deposit occupies the same stratigraphic position as the Hill Creek deposit to the west. The Willow Creek drainage is the arbitrary boundary between the two deposits (figure 18).

The sandstone units enclosing the tar-sand deposits in the P.R. Spring area are heterogeneous with extremely variable gross textures and lithologies (Wiley, 1967). The most common variations are grain-size and shape, type and degree of cementing, bitumen content, degree of sorting, and porosity. The sandstones are primarily arkosic, with primary constituents of quartz (60 percent) and orthoclase (32 percent), and minor amounts of heavy minerals (tourmaline, zircon, sphene, chlorite, hornblende, and garnet). Picard (1971) classified most of the sandstone as arkose, with some subarkose and lithic arkose.

Bitumen impregnation appears controlled by lateral extent, porosity, and permeability of individual sandstone beds. The degree of bitumen-saturation varies laterally and vertically. Vertically, all degrees of saturation are visible in an individual bed at any one locality. Horizontally, variations from slight to rich may occur within a distance of a few hundred feet along the outcrop.

Numerous tar seeps occur in the P.R. Spring deposit. Hydrologic head-gradients from the Roan Cliffs cause bitumen to move downdip toward canyons incised in dip-slopes. During wet seasons, these seeps become active, and large amounts of water flow from the seeps as well as bitumen. During dry seasons, both bitumen and water cease to flow.

Resource Estimates

Investigators have estimated that the P.R. Spring tar-sand deposit contains from 3.3 to 4.5 billion barrels of oil. Byrd (1970) calculated that the P.R. Spring area contains about 3.7 billion barrels of oil in-place. Ritzma (1979) estimated that the deposit contains between 4.0 and 4.5 billion barrels of oil. And, Clem (1984) calculated that the P.R. Spring deposit contains about 3.3 billion barrels of oil.

Bitumen Analyses

Wood and Ritzma (1972) reported the results of analyses on three samples collected from the P.R. Spring deposit. Results of the analyses are shown on table 2, and the location and sample descriptions are as follows:

Sample 69-13E -- Douglas Creek Member, Green River Formation, SW¼NE¼ section 8, T.12S., R.25E.
Sample 69-14E -- Parachute Creek Member, Green River Formation, NW¼NW¼ section 5, T.12S., R.25E.
Sample 67-1A -- Main Canyon Seep in the Douglas Creek Member, Green River Formation, center of NE¼ section 5, T.16S., R.24E.

Development History

The earliest known operation for petroleum recovery from the P.R. Spring area was an oil test well drilled in section 35, T.15S., R.23E., by John Pope in 1900. Another early venture consisted of a 50-foot-long adit, located in section 34, T.15S., R.23E., which was driven into a tar-sand outcrop. A steel pipe was run from the adit to a metal trough to collect the gravity-drained oil.

The P.R. Spring tar-sand deposit was the subject of intense activity during the late 1970s and early 1980s. While very few on-site operations were conducted, numerous companies and government agencies studied the

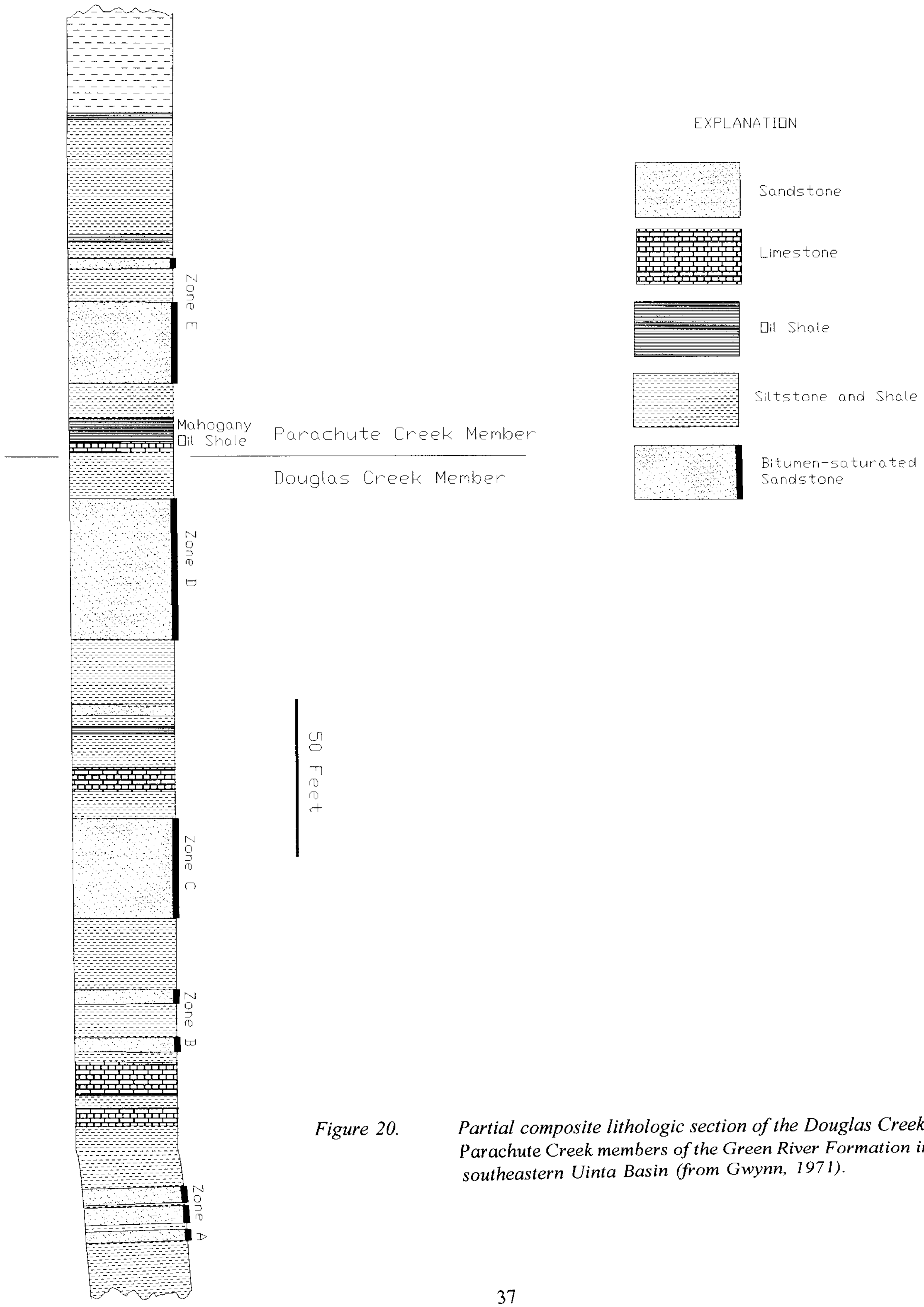


Figure 20. *Partial composite lithologic section of the Douglas Creek and Parachute Creek members of the Green River Formation in the southeastern Uinta Basin (from Gwynn, 1971).*

resource and extraction potential. During 1983, the U-tar Division of Bighorn Oil Company of Salt Lake City, operated a 100 barrels-per-day pilot processing plant. Located in section 5, T.16S., R.24E., the pilot plant used a solvent solution for extraction. Several companies have reportedly proposed development operations for both in-situ extraction and surface mining of tar sand (Covington and Young, 1985). As of 1995, no viable commercial production of tar sand from the P.R. Spring area has taken place.

Hill Creek

Location and Access

The Hill Creek deposit is located on the southern flank of the Uinta Basin, about 55 miles (88 km) east of the town of Price and about 50 miles (80 km) south of the town of Roosevelt in T.13-15S., R.18-21E. (SLM), Uintah County (figure 13). Access is gained via State Highway 88, southward from its junction with U.S. Highway 40 through the town of Ouray. From Ouray, SR-88 continues south for about 4 miles (6.4 km), and branches into secondary oil-field access roads and trails. Numerous oil-well maintenance roads connect the canyons and ridges that expose the deposit.

Physiography and Land-Use

The Hill Creek tar-sand deposit lies near the south-central part of the Uinta Basin. Situated between the Sunnyside deposit to the west and the P.R. Spring deposit to the east, the Hill Creek deposit extends along the Roan Cliffs from Willow Creek on the east to Tabyago Canyon on the west. Willow Creek and Hill Creek, which flow northward, are the only perennial streams in the region. While Willow Creek forms the eastern boundary of the deposit, Hill Creek divides the deposit into east and west halves.

About two-thirds of the deposit is located on the wilderness land reserve of the Hill Creek Extension, Uinta and Ouray Indian Reservation (figure 21). The remainder lies on BLM-administered public lands, and scattered parcels of SITLA-administered state lands. A relatively large (30 mi^2; 77 km^2) contiguous tract of private-owned land is situated on the northern edge of the deposit. The northwest quarter of the deposit extends into the U.S. Naval Oil Shale Reserve No. 2. Surface elevations range from about 7,200 feet (2,195 m) to about 5,800 feet (1,767 m).

Geologic Setting

The deposit is located on the central part of the southern limb of the Uinta Basin where Cenozoic strata dip gently about 2 degrees northward. The Hill Creek anticline, an expression of the underlying Uncompahgre Uplift, trends northwest in the southeast part of the deposit area (figure 22). High-angle faults and joints have been mapped along the southern flank of the Hill Creek anticline (Gwynn, 1985). These structures together form a northwest-trending fractured zone, approximately 10 miles long, that marks the southern limit of the deposit.

Exposed strata in the Hill Creek area include the Green River Formation (Eocene) and Wasatch Formation (Eocene-Paleocene). The Green River Formation in this area is composed of marlstones, kerogen-rich shales, siltstone, sandstones, limestones, and tuffs, deposited in a lacustrine environment. The Wasatch Formation is composed of shales, siltstone, and sandstones deposited in a fluvial environment.

The Green River Formation is divided into, in ascending order, the Douglas Creek, the Parachute Creek, and the Evacuation Creek Members. The Mahogany oil-shale bed lies at the base of the Parachute Creek Member and conformably overlies the Douglas Creek Member (Gwynn, 1985).

Bitumen-saturated sandstone lenses are in the upper portion of the Douglas Creek Member and the lower portion of the Parachute Creek Member, both below and above the Mahogany oil-shale zone, respectively. The degree of saturation and extent of bitumen in these sandstone lenses is controlled largely by porosity, permeability, and lateral extent of individual lenses. Correlation of individual rock units throughout the area is difficult, even over short distances, as individual sandstone beds range from 6 inches (15 cm) to 30 feet (9 m) in thickness. Within these beds, grain size and shape vary widely along with the type and degree of cementing.

Using the Mahogany zone as a datum, Gwynn (1985) reported that apparent overburden (overlying, non-saturated rock) thickness varies from less than 100 feet (30 m) to more than 1,000 feet (300 m). Locally, however, actual overburden thicknesses can be much less than apparent thicknesses due to the highly variable nature of bitumen saturation. The degree of saturation varies both laterally and vertically. Vertically, all degrees of saturation are visible in an individual bed. Horizontally, variations from slight to rich may occur within a distance of a few hundred feet along the outcrop. Ritzma (1979) classified the Hill Creek deposit as giant sized, and estimated that 1.6 billion barrels of bitumen are in-place.

The Hill Creek deposit is contained in rocks that are stratigraphically equivalent to those of the P.R. Spring deposit. The two deposits are separated arbitrarily along the Willow Creek Canyon drainage.

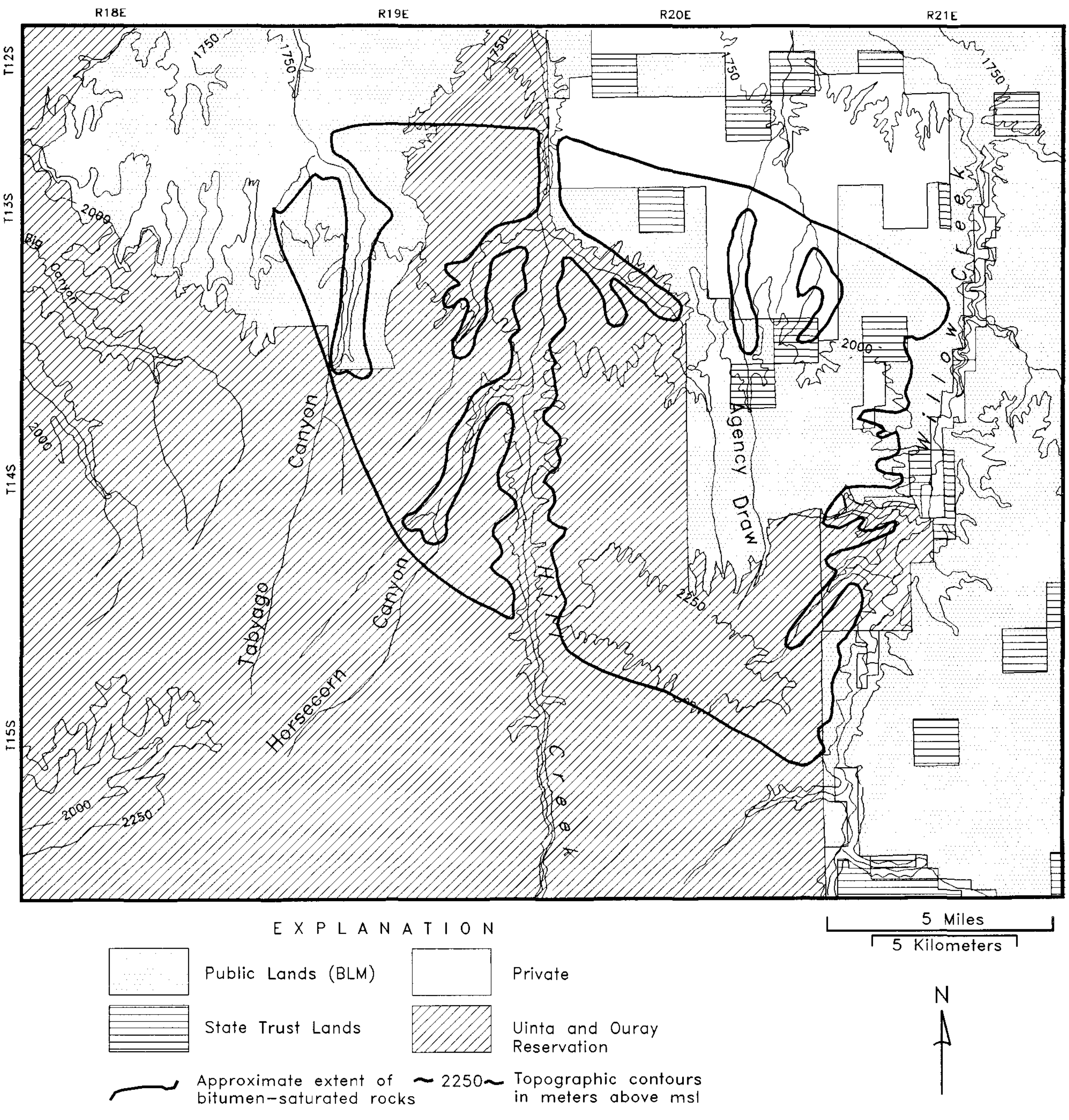


Figure 21. Land-ownership map of the Hill Creek tar-sand deposit area.

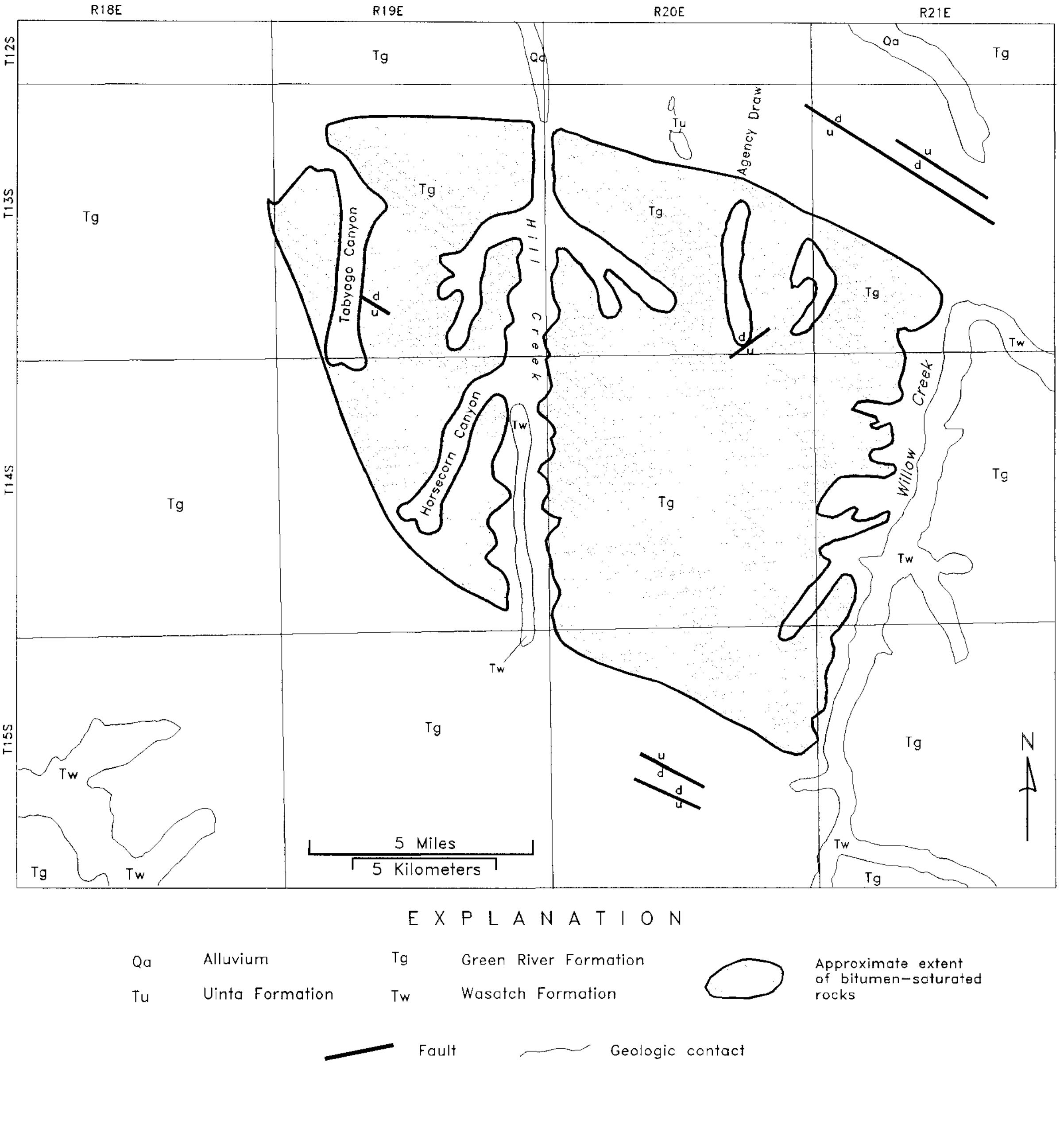


Figure 22. General geology of the Hill Creek area (after Cashion, 1973).

Bitumen Analyses

Wood and Ritzma (1972) reported results of bitumen analyses on one sample collected from the Douglas Creek Member within the Hill Creek deposit (table 2). Sample 69-11C from the upper part of the Douglas Creek Member, was taken along Oil Sand Canyon, located in the SW¼SW¼ section 30, T.14S., R.20E.

Johnson and others (1976) presented results of analyses of three drill cores from the Flat Rock Mesa area in the Hill Creek tar-sand deposit (table 4). They described two major tar-sand zones with a net thickness of 55 to 81 feet (17 to 25 m). Other information from this study included porosity (average 20.2 percent of bulk volume); permeability before and after oil extraction (averaging 150 and 325 md respectively); low oil-saturation (average of 29.7 percent of pore volume); and sulfur and nitrogen contents (average 0.45 and 0.73 percent respectively). The analyses of bitumen from core holes HC-1, HC-2, and HC-3 are composites from both members. HC-1 was located in the SE¼NW¼NE¼ section 31, T.14S., R.20E. HC-2 was located in the SE¼NW¼SW¼ section 33, T.14S., R.20E. HC-3 was located in the NE¼NE¼NE¼ section 3, T.15S., R.20E.

Development History

Because the majority of the Hill Creek tar-sand deposit lies within an area set aside for preservation by the Ute Tribe, no development has taken place. Moreover, it is unlikely that any development of tar sands will take place in the foreseeable future. The Flat Rock oil field, located in T.14S., R.20E., is the only known petroleum development in the area.

Table 4. Technical data from core holes HC-1, HC-2, and HC-3 of the Hill Creek tar-sand deposit (after Johnson and others, 1976).

Corehole	Units	HC-1	HC-2	HC-3	Overall Avg.
Location*	---	(D-14-20)31abd	(D-14-20)cbd	(D-20-15)aaa	---
Surface elevation	ft.(above sea level)	7260	7485	7410	---
Top of tar sand (depth)	ft.	41	327	307	---
Bottom of tar sand (depth)	ft.	230	461	461	---
Net thickness of tar sand	ft.	81	55	67	68
Porosity, saturated	pct.	10.9	13.3	16.6	13.4
Porosity, extracted	pct.	19.7	20.1	21	20.2
Permeability, saturated	md	59	120	286	150
Permeability, extracted	md	325	264	375	325
Oil saturation	pct. of pore vol	42.2	29.7	15.5	29.7
Oil saturation	pct. of sample wt.	3.9	2.8	1.4	2.8
Water saturation	pct. of pore vol.	2.8	1.6	1.7	2.1
Bulk density, saturated	g/cm3	2.209	2.173	2.133	2.174
Bulk density, extracted	g/cm3	2.12	2.107	1.087	2.106
Sand grain density	g/cm3	2.641	2.636	2.641	2.64
Compressive strength, saturated	psi	5826	8438	5949	6555
Compressive strength, extracted	psi	4579	6454	4681	5130
Oil Specific gravity at 60°	g/cm3	1.004	1.025	0.994	1.004
Oil gravity	°API	9.4	6.6	10.9	9.4
Sulfur	wt. pct. oil	0.48	0.42	0.42	0.45
Nitrogen	wt. pct. oil	0.75	0.81	0.8	0.73

* Well and Spring Numbering System for Utah. The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U.S. Government. The number designates a location and describes its position in the land net. The land-survey system divides the state into four quadrants by the Salt Lake Base Line and Meridian, and these quadrants are designated by uppercase letters as follows: A, northeast; B, northwest: C, southwest; and D, southeast. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section and is followed by the three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section (generally 0.04 km2 or 10 acres). The quarters of each subdivision are designated by lowercase letters as follows: a, northeast; b, northwest; c, southwest; and d, southeast.

Sunnyside

Location and Access

The Sunnyside deposit is located on the southwest flank of the Uinta Basin, about 18 miles (29 km) east of the town of Price, Utah in T.12-13S., R.13-15E. and T.14S., R.14-15E. (SLM), Carbon County (figure 13). Access from the west is via U.S. Highway 6 heading southeast from Price, then east on State Highway 123 past the town of Sunnyside. Numerous ranching and oil-well maintenance roads provide access to canyons and ridges where the deposit is exposed. The deposit is located less than 10 miles (< 16 km) from a spur of the Rio Grande Railroad.

Physiography and Land Use

The Sunnyside deposit is situated in the Book Cliffs-Roan Cliffs physiographic subprovince of the Uinta Basin. The deposit is exposed along the western side of the Roan Cliffs, from Rock Creek on the south to Nine Mile Creek on the north. Elevations of bitumen-saturated outcrops range from about 8,900 feet to about 9,700 feet (2,713-2,957 m). Topography is characterized by high-relief and rugged terrain. The deposit covers an area of approximately 122 mi^2 (316 km^2).

Land ownership for the Sunnyside deposit is mostly private with some federal and state land (figure 23). Land use is limited to primarily cattle and sheep grazing. The Sunnyside underground coal mines near East Carbon City used to produced large tonnages of metallurgical-grade coal, but are now shut down.

Geologic Setting

The Sunnyside tar-sand deposit lies on the western part of the southeast lobe of the Uinta Basin. Regional dip is northeastward at 3 to 12 degrees. Small-scale structures (minor faulting and fracturing) found in the area do not appear to have affected bitumen emplacement. The Sunnyside tar sands occur within the lower part of the Green River Formation (Eocene) in the marginal lacustrine facies, and in the upper part of the Colton Formation (Paleocene/Eocene) (figure 24). The deposit represents deposition of several stacked channels, downcutting, and subsequent in-filling (Schenk and Pollastro, 1987). Sandstone of the Sunnyside deposit was deposited in meandering-stream, fluvial environments on the southern margin of Lake Uinta (Banks, 1981).

At Sunnyside, bitumen-saturated units occur within both the Green River and Colton Formations (Schenk and Pollastro, 1987). Distinction between the two formations is difficult due to intertonguing and similar lithologic types. The Green River Formation consists of shale, marlstone, siltstone, sandstone, limestone, and tuff, deposited in lacustrine environments. Beds of shale, siltstone, and sandstone, deposited in a fluvial-deltaic environment, compose the Colton Formation. Bitumen-bearing sandstone bodies in both formations are interbedded with mudstone, shale, siltstone, and carbonate that do not contain significant bitumen (Schenk and Pollastro, 1987).

The Peters Point-Stone Cabin gas fields, located in a northwest to southeast trend from T.12S., R.14E. to T.13S., R.17E., produce primarily gas and some oil from the Green River and Wasatch Formations at depths of 2,800 to 4,300 feet (853 to 1,311 m). This interval is stratigraphically equivalent to the saturated interval at Sunnyside. Some workers believe that the Jacks Canyon anticline and associated faults trapped hydrocarbons thereby preventing their movement updip to Sunnyside.

Bitumen-saturated sandstone bodies occur within the lower part (marginal lacustrine facies) of the Green River Formation and in the upper part of the Colton Formation. These bodies are more prevalent in the western part of the deposit, nearest to the delta complexes. Holmes and Page (1956) reported that porosities of these sandstones range between 25 and 30 percent, and permeabilities range between 154 and 677 md (based on four determinations).

Up to 32 saturated beds have been identified from surface mapping of outcrops. Lateral extent, porosity, and permeability control the degree of saturation of the individual beds. Vertically, all degrees of saturation are visible in a bed at any one locality. Horizontally, variation from barren to highly rich may occur within a distance of a few hundred feet. Channeling, irregular thickness, pinchout, and interfingering with neighboring beds make correlations of individual beds very difficult (Clem, 1985).

Two zones of saturation have been identified in the subsurface. The upper zone crops out in several drainages and may have a gross thickness of up to 1,000 feet (305 m). The lower zone, 800 to 900 feet (244-274

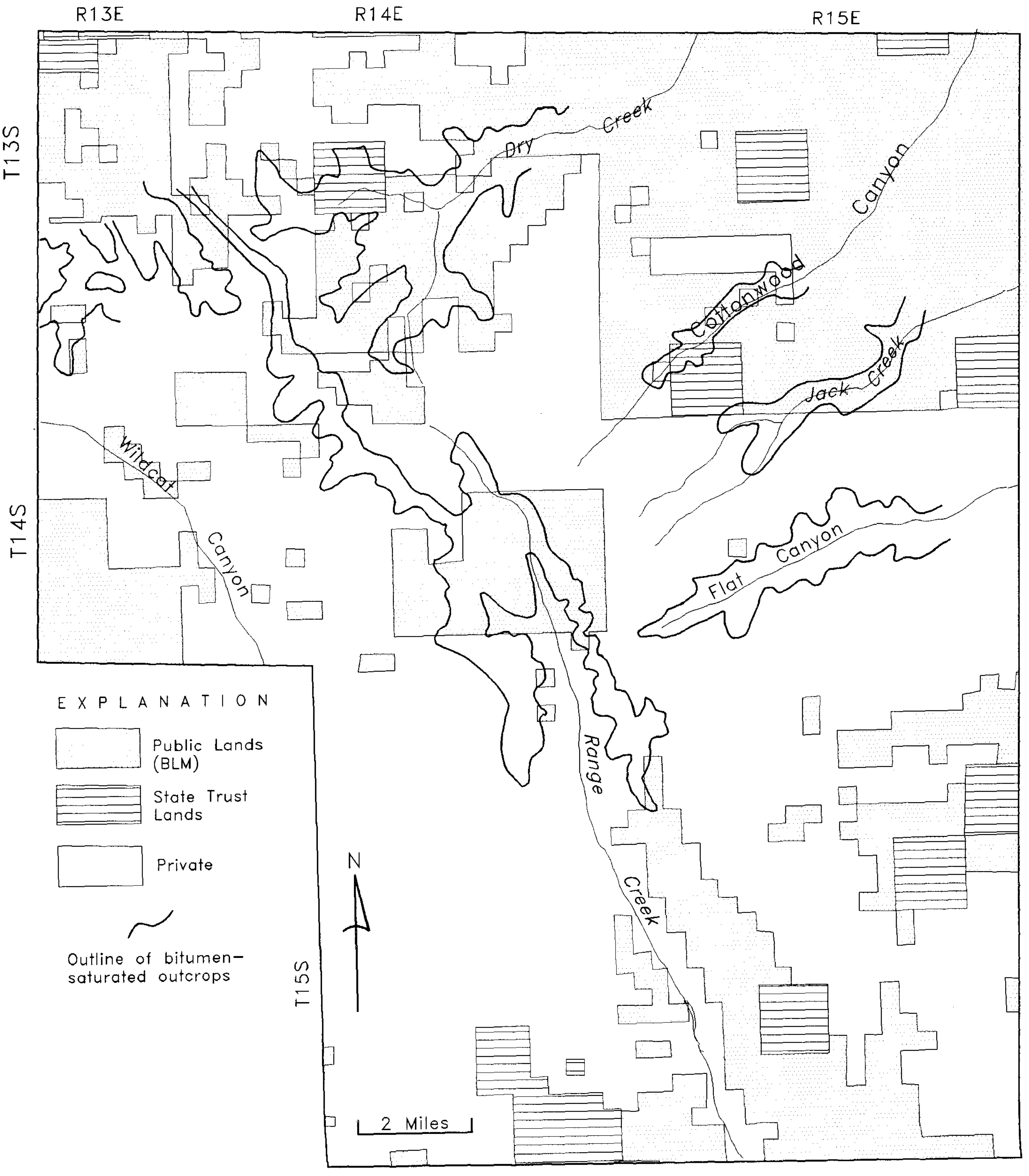


Figure 23. Land-ownership map of the Sunnyside tar-sand deposit area.

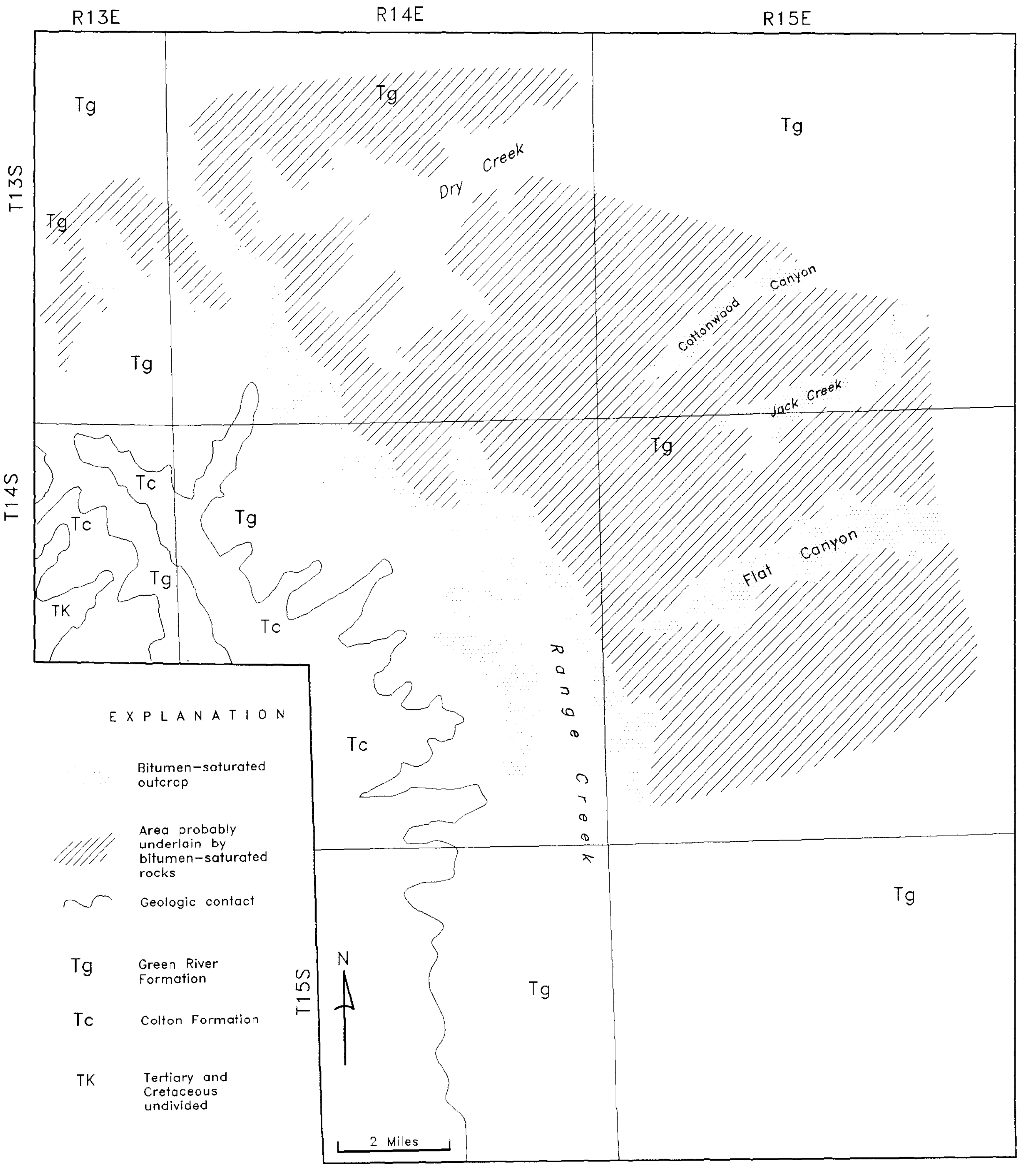


Figure 24. General geology of the Sunnyside tar-sand area (after Campbell and Ritzma, 1979).

m) below the upper zone, is between 1,300 and 1,900 feet (396-579 m) thick. In the outcrops along the cliff side of Bruin Point, there is no distinction between these two zones (Gwynn, 1986).

The individual sandstone beds range from 0.5 to more than 100 feet (0.15 m - 30.5 m) in thickness. Characteristics such as size and shape of sand grains, sorting, porosity, and type and degree of cement all vary from one bed to another (Clem, 1985).

In 1945, the U.S. Geological Survey (USGS) estimated that the Sunnyside bituminous-sandstone resource consisted of about 1.6 billion cubic yards (1.22 billion m^3) of material. Of this, they estimated that 0.9 billion cubic yards (0.69 billion m^3) included measured plus indicated resources, with 0.7 billion cubic yards (0.54 billion m^3) as inferred resources (Holmes and others, 1948; Holmes and Page, 1956). The U.S. Bureau of Mines translated this estimate into 728 million barrels of oil equivalent, of which 409.5 million barrels included measured plus indicated resources, and 318.5 million barrels were inferred resources (Ball Associates, Ltd., 1964).

Ritzma (1979), using additional data, classified the deposit as "giant," and estimated that between 3.5 and 4.0 billion barrels of oil were contained in-place. Of this estimate he classified 1.25 billion as measured, 1.75 billion as indicated, and the remaining 0.5 to 1.0 billion as inferred.

Bitumen Analyses

Wenger and others (1952) reported complete analyses using fractional distillation for "extracted" and "recovered" bitumen from Sunnyside. Specific gravity was 0.922 and 1.024, API gravity was 22.0 and 6.7, and sulfur content was 0.47 and 0.50 percent, respectively. Nitrogen content was reported as 0.96 percent. Presentation of their analyses of distilled fractions is beyond the scope of this report.

Development History

The Sunnyside deposit was mined intermittently from 1892 to the late 1940s, mostly for roadbase construction. Holmes and others (1948), stated that 335,000 tons (304,000 mt) of rock had been quarried by the time of their study. Between 1931 and 1945, the material was used for road paving in Utah and five other western states. The ore was carried from the quarry by a 3-mile (4.8-km) long aerial tramway and then trucked to the railhead at Sunnyside.

Several companies performed resource assessments, and tested tar-sand pilot projects at the Sunnyside deposit. In 1963 to 1964, Shell Oil Company collected cores from numerous boreholes as part of an evaluation program that eventually lead to an experimental (five spot) in-situ steamflood in 1966. Shell continued evaluation of the deposit and drilled additional core holes in 1967 (Thurber and Welbourn, 1977). Signal Oil and Gas Company, in 1966 and 1967 tried an in-situ steam process using horizontal holes to recover oil. Pan-American Petroleum Corporation also performed an in-situ steamflood at the Sunnyside deposit in 1966. Texaco and Gulf later conducted coring operations within the deposit. During 1982, Enercor did preliminary mining feasibility studies on leases they had acquired. Phillips Petroleum, Sabine Resources, Cities Service, and Amoco all considered development of tar-sand resources at Sunnyside. Gulf Oil Corporation had a land interest in the area and drilled one test hole. Mono Power Company's Utah Tar Sand Project entered into an agreement with Amoco to evaluate the Sunnyside deposit in the early 1980s (Charles Bishop, 1996, verbal communication--various news releases).

Chevron Resource Company signed an operating agreement with Great National Corporation (GNC) for the development of 2,000 acres of the Sunnyside deposit in 1982. GNC had been involved in development of the Sunnyside deposit since the late 1970s and had also proposed to build a pilot plant. Under the Chevron/GNC agreement, bitumen-saturated material was mined and test-processed at Chevron's pilot plant located next to Chevron's refinery north of Salt Lake City (Covington and Young, 1985).

SUMMARIES OF SECONDARY TAR-SAND DEPOSITS

The following section briefly describes 20 tar-sand deposits in the Uinta Basin that we classify as secondary due to their relatively small size, inaccessible nature, or because they are not well defined. More complete descriptions are included in the many references to these deposits. The reader is urged to consult these publications and articles for more details. Figure 25 shows the locations of these areas with respect to primary roads, geographic features, and communities.

Argyle Canyon

Location and Access

The Argyle Canyon tar-sand deposit is situated along the southwest side of the Uinta Basin (figure 25) in an area known as the Bad Land Cliffs. The deposit is located in sections 11 and 12, T.11S., R.12E. and in sections 7 through 26, T.11S., R.13E. (SLM), Duchesne County. The area lies about 20 miles (32 km) northeast of the town of Price, Utah. Access is via State Highway 33 from its junction with U.S. Highway 6 in Price River Canyon. Utah-33 intersects a gravel road about 14 miles (22 km) northeast from the junction with US-6, opposite the Avintaquin Campground road, and leading east to Argyle Canyon. From this intersection, the gravel road winds east-southeast along Argyle Creek. The westernmost outcrops of the Argyle Canyon tar-sand deposit are encountered about 12 miles (19 km) eastward along this road. From here, the deposit outcrops extend east-southeast along the north side of the canyon for another 14 miles (23 km), parallel to the road. At the east end of the deposit, the Argyle Canyon road intersects the Nine Mile Canyon road, which also intersects US-6 about 21 miles (34 km) to the southwest near the town of Wellington.

Physiography and Land-Use

The Argyle Canyon deposit lies along the southwest margin of the Uinta Basin along a geographic feature known as the Bad Land Cliffs. The Bad Land Cliffs are an east-west trending set of cliffs, highly dissected by north-south trellis-type drainage. Although in stratigraphically younger rocks, outcrop patterns in the Bad Land Cliffs somewhat mimic those of the Roan and Book Cliffs located a few miles to the south. Argyle Creek flows eastward and converges with Minnie Maud Creek and Nine Mile Creek, which together form the main-stem of Nine Mile Creek. Elevations of bitumen-saturated outcrops range generally between 7,100 and 8,000 feet (2,164-2,500 m).

Land ownership in the Argyle Canyon area is mainly public land and private land with a few scattered parcels of School Trust Lands (figure 26). Part of the Ashley National Forest lies less than two miles north of the tar-sand outcrops. Most mineral ownership of the private land, however, has been reserved by the Federal Government. The land is used mainly for grazing and for summer home sites.

Geologic Setting

The Argyle Canyon deposit occurs within interbedded open lacustrine and marginal lacustrine rocks of the Green River Formation (Eocene) (Ryder and others, 1976). Sandstone (marginal lacustrine facies) of the Delta facies and interfingering, fine-grained source beds (open lacustrine facies) of the Parachute Creek Member dip gently northward toward the center of the Uinta Basin (figure 27). The Green River Formation is overlain by mainly fluvial deposits of the Uinta Formation (Eocene).

The Delta facies consists of irregularly bedded, lenticular micaceous sandstone with interbedded mudstone. In the eastern part of Argyle Canyon, this unit is dominantly sandstone and is about 1,500 feet (457 m) thick. To the west the Delta facies becomes somewhat thicker but more dominated by mudstone and siltstone (Tripp, 1986c).

The Parachute Creek Member is regularly bedded and contains siltstone, mudstone, and kerogen-rich shale sequences with several prominent tuff beds. In the Argyle Canyon area there are numerous lenticular sandstones with unconformable channeling along their bases. The Parachute Creek Member is about 500 feet (152 m) thick (Tripp, 1986c).

Most of the bitumen is contained in delta facies sandstone tongues which pinch-out within the Parachute Creek Member. Deposits with the highest bitumen saturation appear to be in the central part of Argyle Canyon

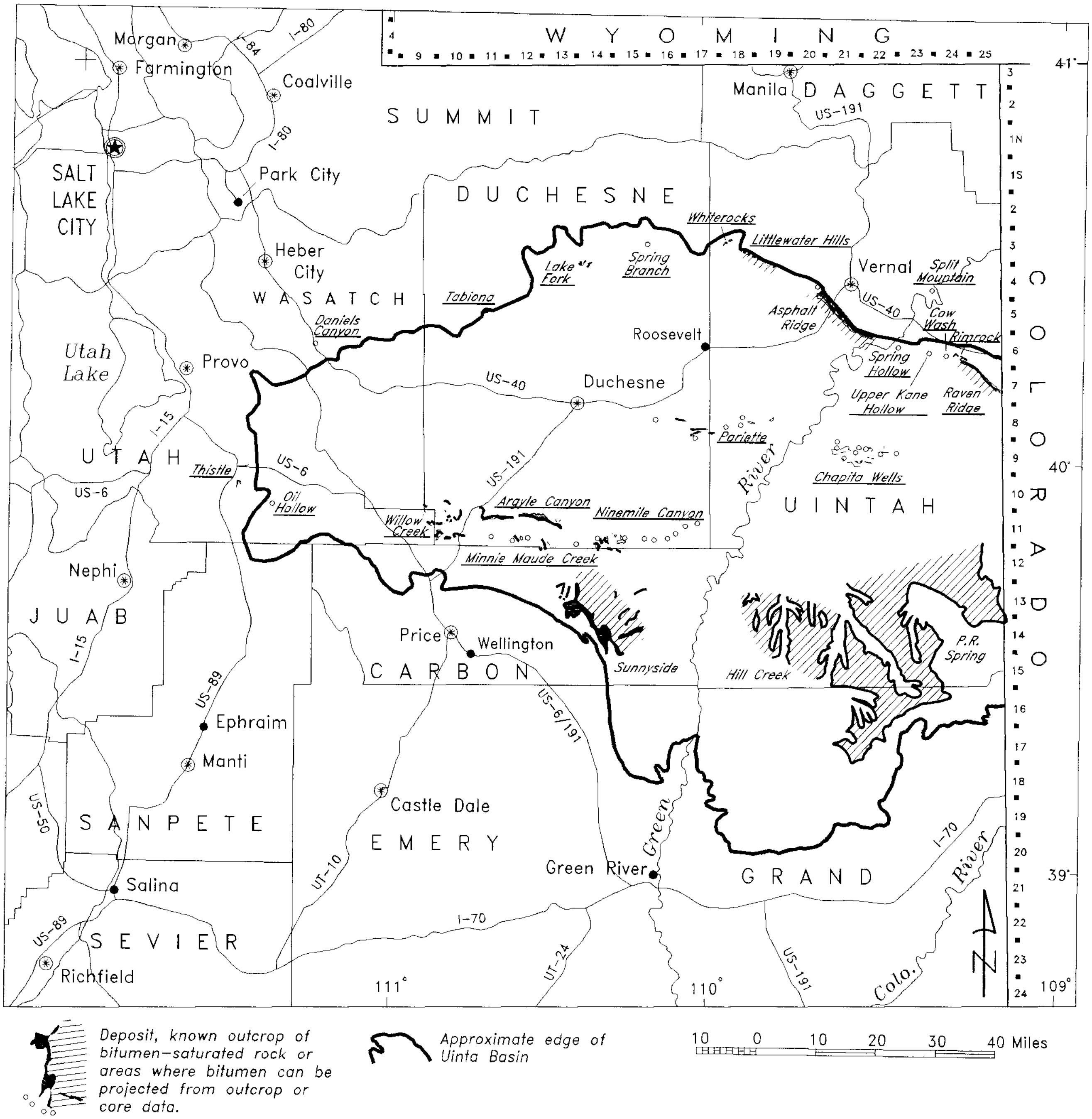


Figure 25. Locations of secondary tar-sand deposits of the Uinta Basin (underlined).

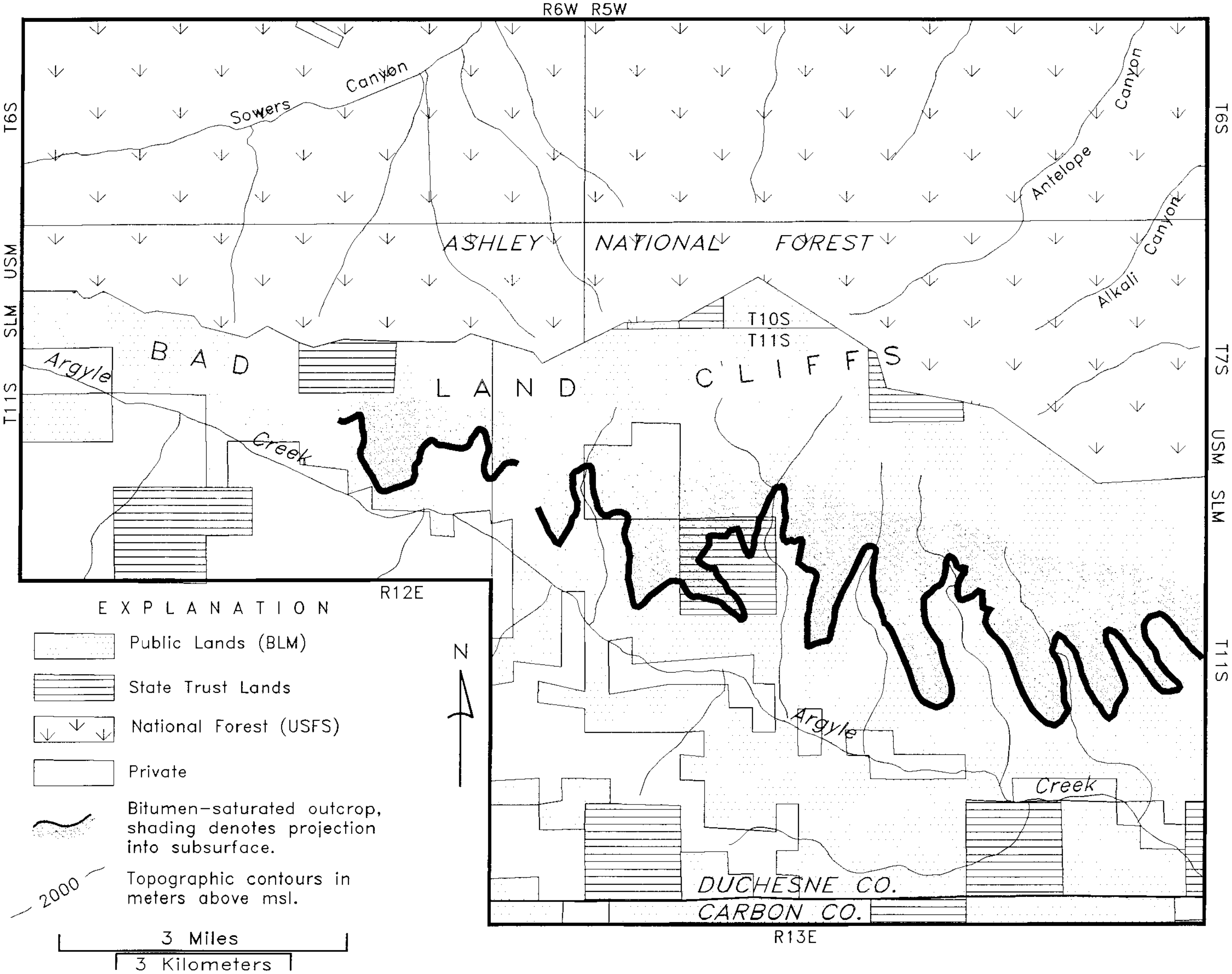


Figure 26. Land-ownership map of the Argyle Canyon tar-sand deposit area.

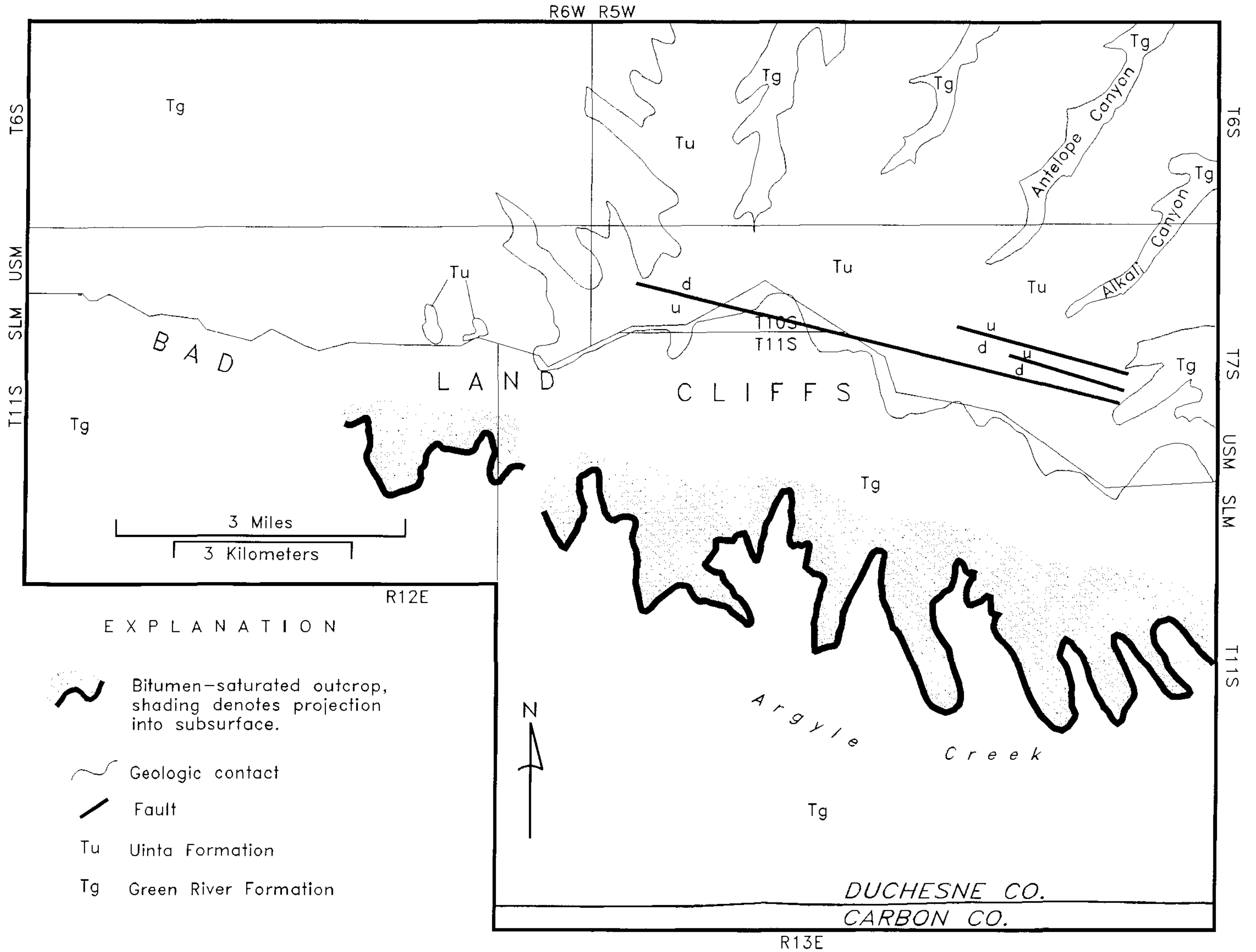


Figure 27. *General geology of the Argyle Canyon tar-sand area (after Weiss and others, 1990; tar-sand outcrops from Tripp, 1986).*

where intertonguing is more prevalent. Tripp (1986a) estimated the thickness of the saturated zone in the central part of the canyon at about 400 feet (122 m).

The only structural feature in the deposit area is a set of west-northwest trending, high-angle faults that cross-cut Green River and Uinta Formation beds 2 to 3 miles (3.2-4.8 km) north of the bitumen-saturated outcrops of Argyle Canyon (Doelling and Graham, 1972). The longest mapped fault-trace extends for about 6 miles (9.6 km).

Development History

The Argyle Canyon deposit was reportedly mined for local use as asphalt for road pavement (Tripp, 1986c). No large-scale mining of this deposit has been reported. Isopach and overburden maps, prepared by Tripp (1986a, 1986b) showed that overburden would likely be a determining factor in the viability of any future mining operation. Because of the highly dissected, steep-walled canyons, the terrain does not lend itself to surface mining operations.

Chapita Wells

Location and Access

The Chapita Wells deposit is located on the south flank of the Uinta Basin, about 28 miles (45 km) south of the town of Vernal and 11 miles (18 km) west of the town of Bonanza in T.8-9S., R.22-23E. (SLM), Uinta County (figure 25). The eastern edge of the deposit area is near the confluence of Kennedy and Coyote Washes and the western boundary is the White River. Elevations of bitumen-saturated outcrops range from about 4,800 feet to about 5,200 feet (1,463-1,585 m). Access to the area is gained along State Highway 45, south from the town of Vernal, then west via oil-well maintenance roads. The deposit consists of many scattered, bitumen-saturated outcrops extending intermittently for 10 miles (16 km) along Coyote Wash.

Physiography and Land-Use

The deposit is near the center of the Uinta Basin among generally low-lying hills and meandering washes. Land ownership is comprised mostly of Public Land administered by the BLM with scattered sections of School Trust Land administered by SITLA (figure 28). The western part of the deposit is within the Uinta and Ouray Reservation. A number of gas fields are located in the vicinity, and several gas pipelines cross the deposit area. Gilsonite mining has taken place on the east and southeast edges of the deposit area.

Geologic Setting

The Chapita Wells area is situated on the southern limb of the Uinta Basin in a belt of gently, west-dipping and northwest-dipping beds. Gilsonite veins occur on the east and southeast edges of the deposit area (figure 29). Bitumen impregnates fluvial sandstone channels within the Uinta Formation (Eocene). The host sandstone units are coarse-grained and poorly sorted and are gray at the outcrop. The degree of saturation of individual sandstone beds varies. Although the degree of saturation depends, in part, upon porosity and permeability, the proximity of the beds to fault and fracture zones appears to be the primary control (Covington, 1964). Ritzma (1979) classified the deposit as medium-small, with a gross resource of 7.5 to 8 million barrels of bitumen.

The bitumen-saturated rocks at Chapita Wells, similar to rocks at the Pariette deposit, appear to be spatially related to gilsonite veins in the area suggesting a common origin. The Pariette deposit is located about 20 miles (32 km) west of Chapita Wells.

In the Chapita Wells area, Fantasy Canyon (NW corner, section 12, T.9S., R.22E.) contains some of the most intricately carved erosion forms in Utah. Wind and rain have etched out the softer parts of a sandstone lens, leaving an array of pillars, pinnacles, arches, knobs and projections. These sandstone "goblins" are cemented with the yellow-brown bitumen.

Bitumen Analyses

Wood and Ritzma (1972) reported an analysis of bitumen extracted from the deposit. Sample 69-15E (table 2) was collected from a channel sandstone in the Uinta Formation near a gilsonite vein. The sample location was in the NE¼NW¼ section 12, T.9S, R.23E. The sandstone was reportedly stained yellow-brown and contained a waxy, volatile oil.

Development History

Bituminous sandstones of the Chapita Wells area were first mentioned in geologic literature in 1963, although they were well known to early settlers and to the Ute Indians (Covington, 1964). The only known development of the deposit was undertaken by NESCO Corporation and Oil Sands Exploration Company, both of Salt Lake City, Utah. In 1975, these companies leased ten, pre-1920 placer claims, which covered 1,600 acres in sections 15, 21, and 22 of T.9S., R.22E. They reportedly developed plans to construct processing equipment to extract oil and perform core drilling. In early 1976, the venture was abandoned (UGS internal files).

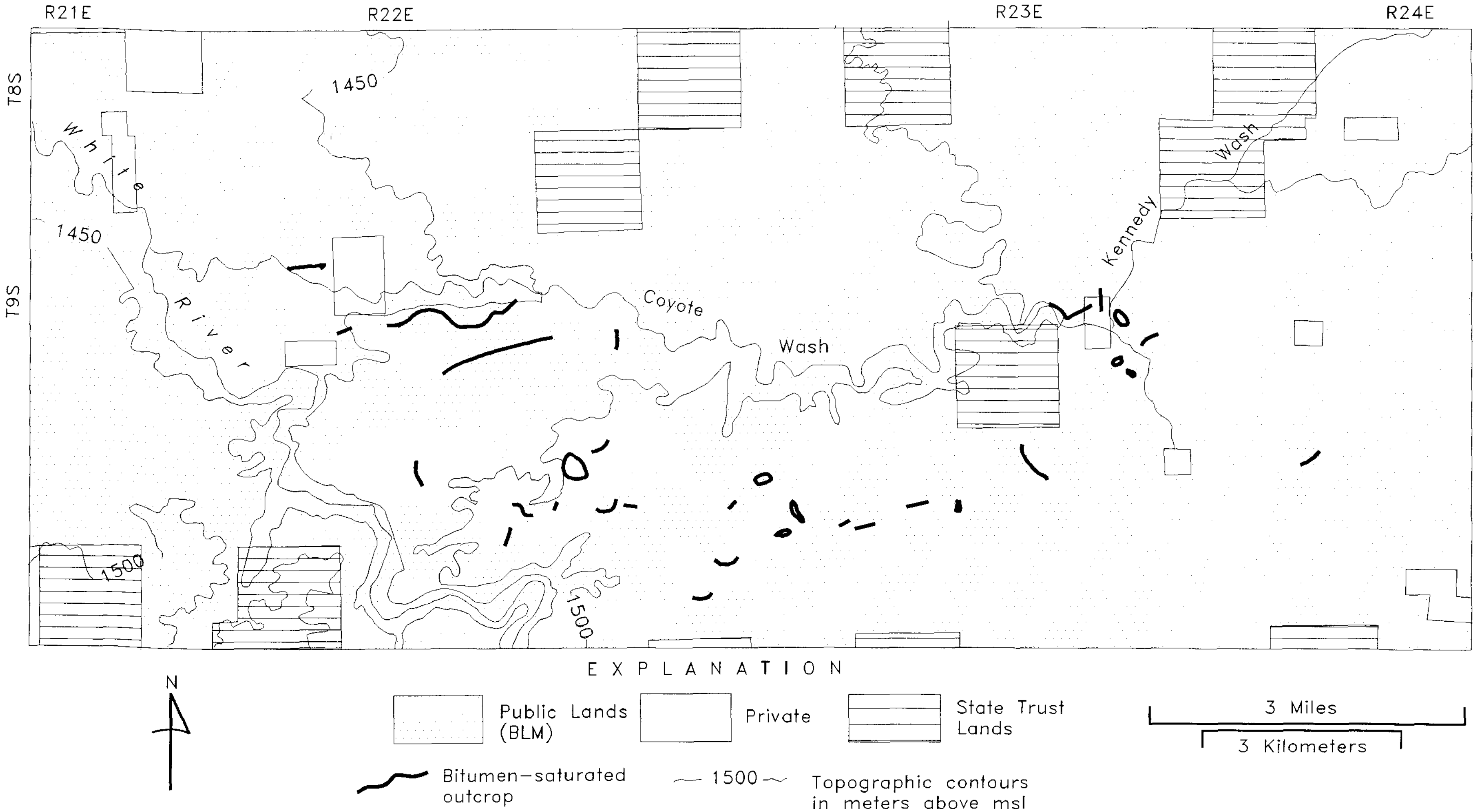


Figure 28. *Land-ownership map of the Chapita Wells tar-sand deposit area.*

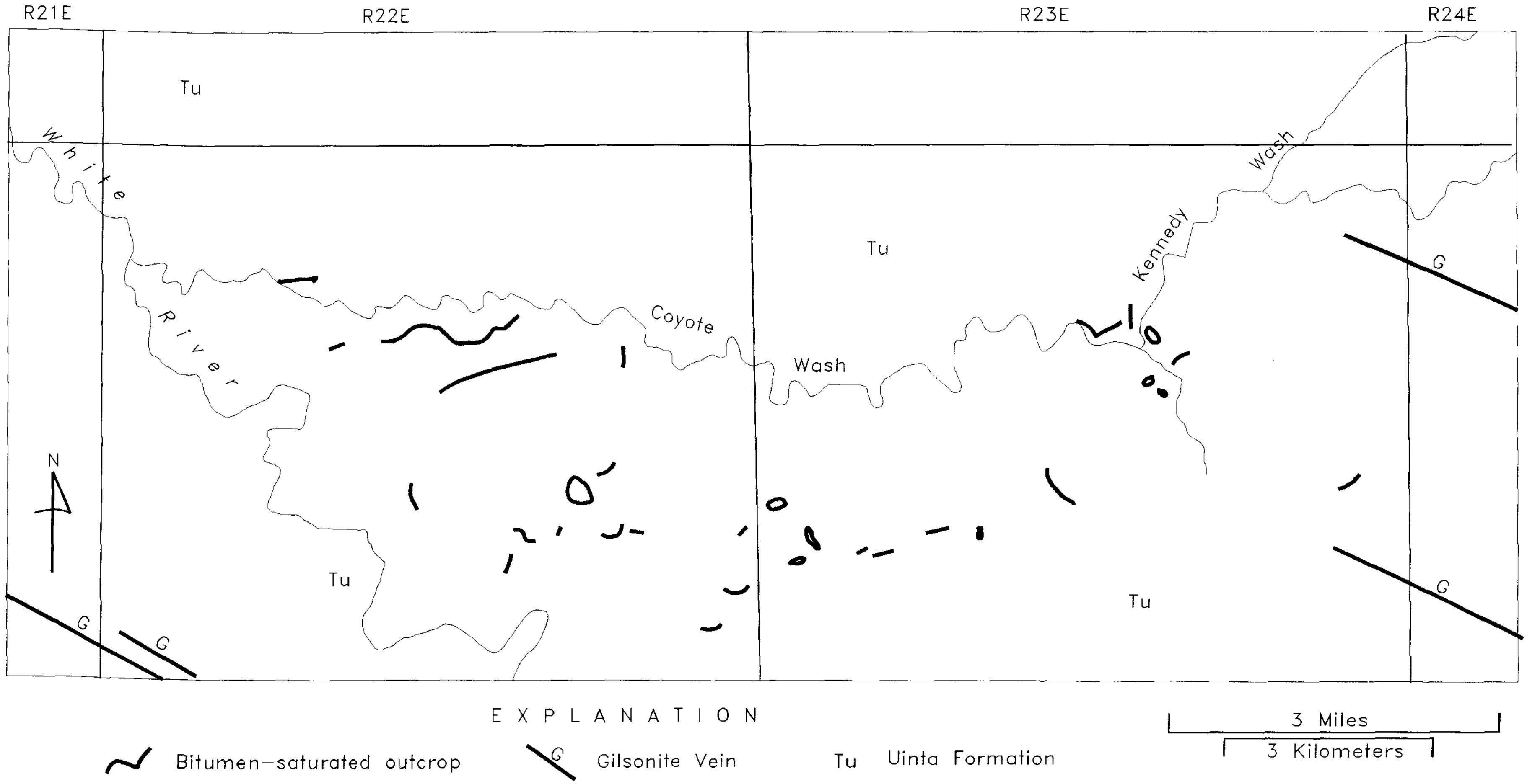


Figure 29. General geology of the Chapita Wells tar-sand area (after Rowley and others, 1985; tar-sand outcrops from K. Clem, unpublished data).

Cow Wash

Location and Access

The Cow Wash tar-sand deposit is located just northwest of the Raven Ridge and Rimrock deposits in sections 20 and 21, T.6S., R.24E. (SLM), Uinta County (figure 25). Access to the area is by U.S. Highway 40, southeast from Vernal for about 20 miles (32 km), and then southwest for about 2 miles (3.2 km) by unimproved pipeline-access roads. The deposit consists of two beds of bitumen-saturated sandstone which crop out for about 1 mile (1.6 km) along an east-southeast alignment between a pipeline road and Cow Wash. The Utah-Colorado border is about 10 miles (16 km) to the south-southeast along U.S. 40.

Physiography and Land-Use

The Cow Wash deposit is located on the northeast margin of the Uinta Basin in an area characterized by low-lying hogback ridges (The Rim Rock) and bad-land type topography. Dinosaur National Monument and Split Mountain, comprised of deeply eroded Mesozoic and Paleozoic sedimentary rocks, lie about 15 miles (24 km) to the north. The Walker Hollow, Red Wash, White River, and Wonsits Valley oil and gas fields lie between 6 and 18 miles (10-29 km) southwest of the area. The Powder Springs gas field and the Coyote Basin oil field lie about 10 miles (16 km) to the southeast.

Land ownership is mostly Public (BLM-administered) Lands with isolated state sections, outside of the deposit area, administered by (figure 30). Land use is mainly livestock grazing and activities related to oil-field development.

Geologic Setting

The deposit is contained in interbedded sandstones and conglomerates, within the Parachute Creek member of the Green River Formation (figure 31). These bedded units dip 65 degrees south-southwest toward the basin axis. The Green River Formation (Eocene) rests unconformably upon the Wasatch Formation (Paleocene-Eocene) and is overlain by the Uinta Formation (Eocene). Bitumen is trapped in pinchouts of lenticular, medium-grained sandstones and, to a lesser extent, conglomerates. Ritzma (1979) classified the deposit as small, and calculated the total resource at 1.0 to 1.2 million barrels.

Bitumen Analyses

Sample 69-1A (table 2) was collected from an outcrop of the Parachute Creek Member of the Green River Formation west of a pipeline-cut between Cow Wash and the pipeline road in the SW¼NE¼NW¼ section 21, T.6S., R24E. (SLM).

Development History

No exploration or development of this deposit is known. The Cow Wash tar-sand deposit is one of several minor deposits located in the area between the Asphalt Ridge and Raven Ridge deposits. The discovery of these tar sands was reportedly instrumental in triggering exploration that led to the discovery of Green River Formation petroleum (depth of 5,300 feet) in the Red Wash Field to the southwest (Quigley, 1972).

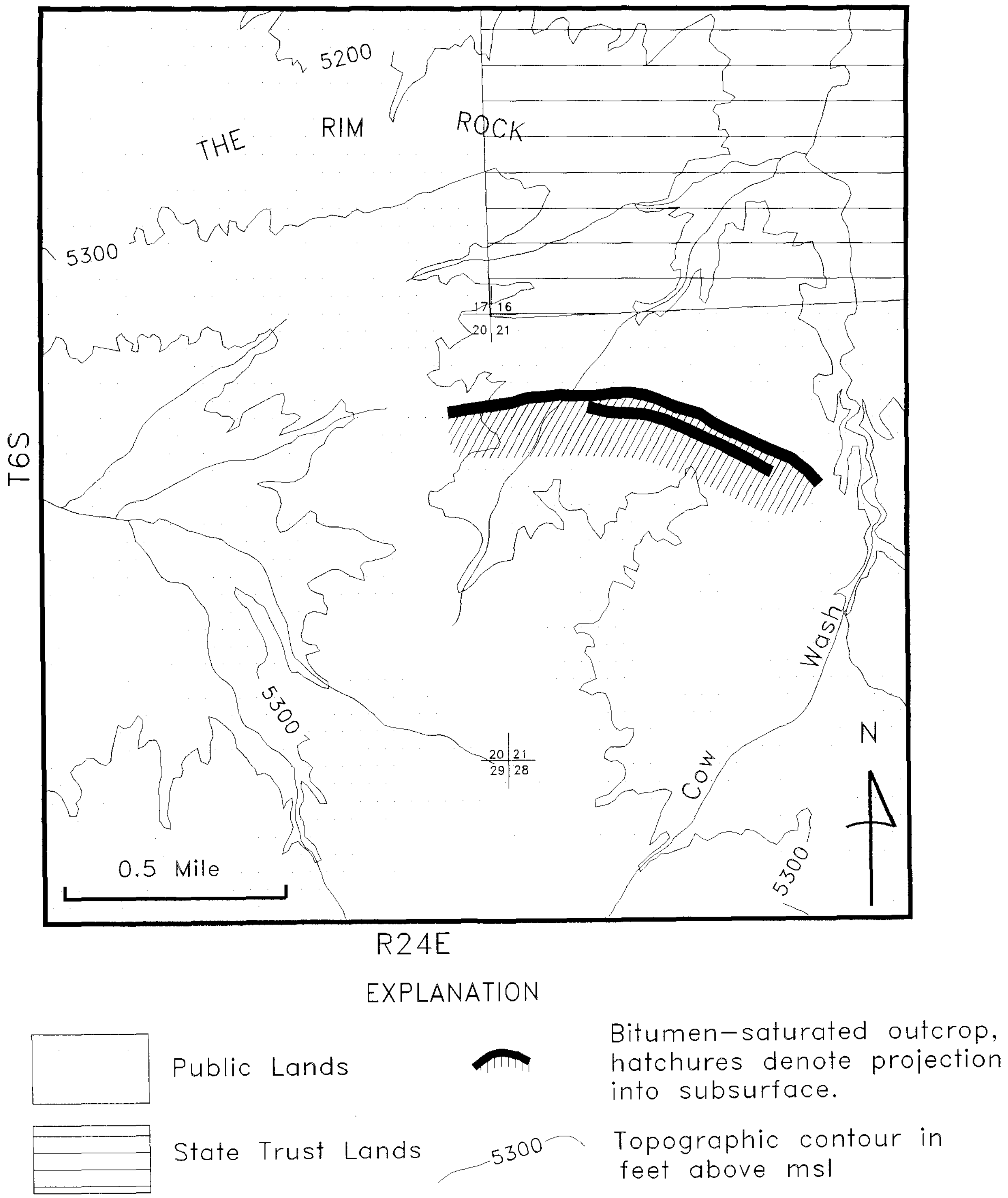
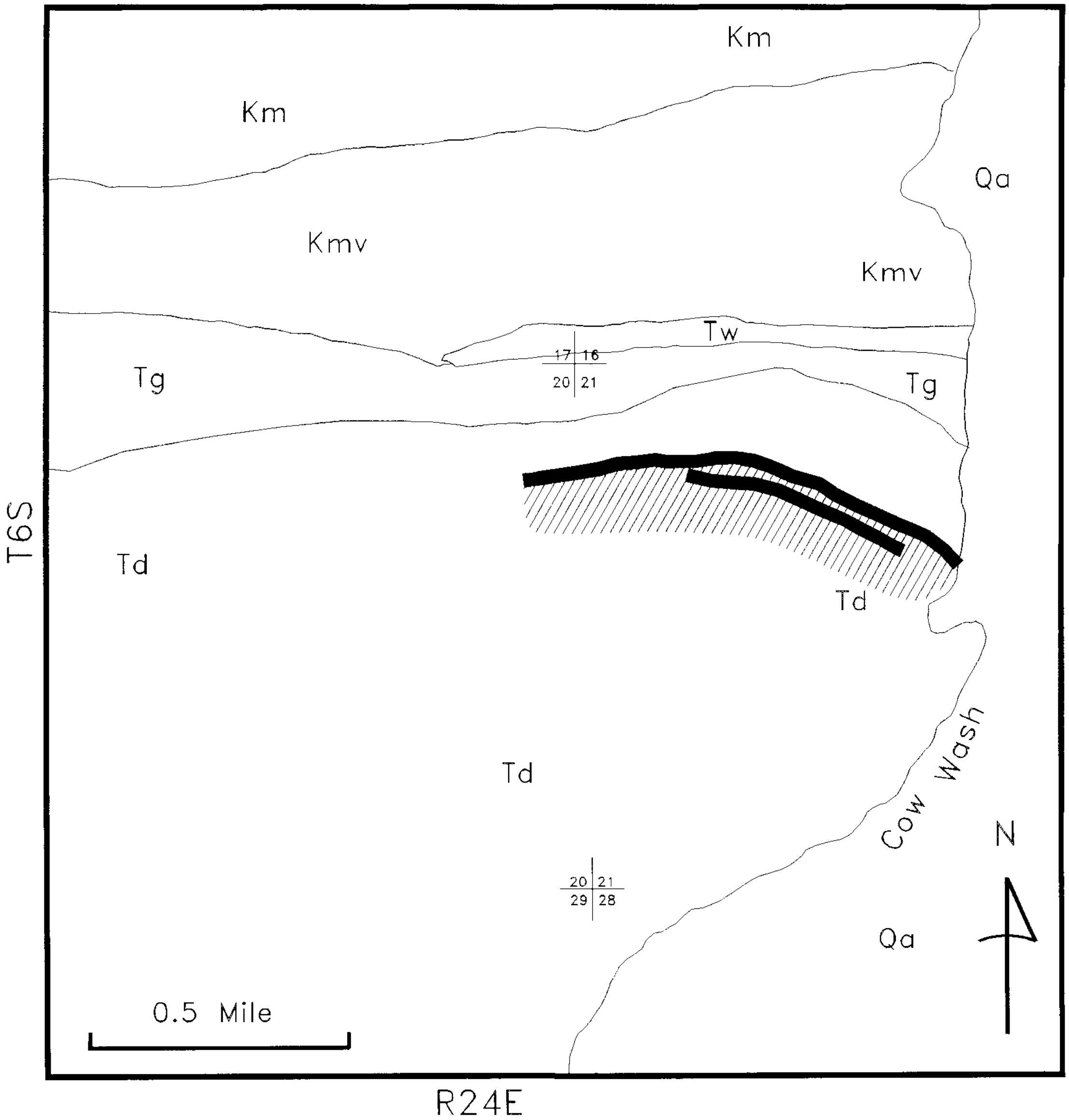


Figure 30. Land-ownership map of the Cow Wash tar-sand area.



EXPLANATION

Qa	Alluvium	Kmv	Mesaverde Group
Td	Duchesne River Formation	Km	Mancos Shale
Tg	Green River Formation		Geologic contact
Tw	Wasatch Formation		Bitumen–saturated outcrop, hatchures denote projection into subsurface.

Figure 31. General geology of the Cow-Wash tar-sand area (after Rowley and others, 1985).

Daniels Canyon

Location and Access

The Daniels Canyon deposit lies slightly west of the western flank of the Uinta Basin, 17 miles (27 km) southeast of Heber City, Utah, near the summit of Daniels Canyon, Wasatch County (figure 25). It is about 200 to 300 feet (60-90 m) east of U.S. Highway 40 and about 1.0 mile (1.6 km) north of Daniels Pass in the SE¼NE¼NE¼SW¼ section 10, T.6S., R.6E. (SLM), Wasatch County, Utah. A short trail starting from U.S. Highway 40 and leading east along the north side of a minor, unnamed tributary of Daniels Canyon provides access to the deposit.

Physiography and Land-Use

The area is in the Wasatch Hinterland physiographic subprovince of the Uinta Basin. The deposit consists of an east-west alignment of bitumen-saturated exposures located in mountainous, forested terrain. The deposit covers about 2,000 square feet (186 m^2) at an elevation of 7,900 feet (2,408 m). The best exposures are at an abandoned mine, called the Chinese Wax Mine (Ritzma, 1975). The deposit is entirely within the Uinta National Forest (figure 32).

Geologic Setting

The deposit occurs in the highly fractured, brecciated Oquirrh Formation (Pennsylvanian-Permian) on the west flank of the Uinta Basin where the Paleozoic and Mesozoic formations of west-central Utah have been thrust along a low-angle plane over the west margin of the basin. The Oquirrh Formation was deposited in the Oquirrh basin, an important depocenter in the mid-Paleozoic foreland basin. The geometry of the Oquirrh basin is obscure because of Cretaceous thrust faulting during the Sevier orogeny. The Strawberry Valley (or Charleston) thrust is exposed 4.7 miles (7.6 km) to the east and dips at a low angle to the west. The sole of the thrust may lie more than 5,000 feet below the Daniels Canyon deposit (Ritzma, 1975). The rocks surrounding the deposit are likely of Permian age (figure 33). They are overturned and dip from 60 to 75 degrees to the north and northeast (Ritzma, 1975).

Bitumen saturates interstices of the intensely fractured and brecciated siliceous limestone and quartzite of the Oquirrh Formation. The strike of this fractured zone, from alignment of the mine entries and dumps, is about N.70°E. The fractures dip about 25 degrees to the north. Clasts of the limestone and quartzite are impermeable and mostly devoid of bitumen.

The oil is a shiny black solid at temperatures up to 100°F (38°C). On surfaces warmed by the sun, it becomes tacky and oozes in tiny rivulets. The material resembles a mineral wax more than a tar.

Bitumen Analyses

Analyses of three samples of bitumen extracted from the mined material are listed in table 2. Sample 70-22D came from the mine dump, while samples 74-1A and B were cut from the walls of the mine entry.

Extensive analyses of the two samples indicate that the bitumen has been moderately degraded by weathering and bacterial action, and is similar in composition to ozocerite. Ozocerite, a mineral of solid hydrocarbon, is found in the Wasatch and Green River Formations elsewhere in the Uinta Basin.

Development History

The Daniels Canyon deposit is the only deposit in Utah exploited solely as a source for petroleum products. It was discovered in about 1900 and the first claims were recorded in early 1909. The mine was operated sporadically for a number of years following discovery until it was shut down in the early 1920s. In the late 1920s interest revived in the mine, and in 1929 and 1930 the Daniel Mining and Refining Company re-opened the mine. The mine came to be known as the Chinese Wax Mine because much of the investment capital came from several residents of Park City who were of Chinese descent (Ritzma, 1975).

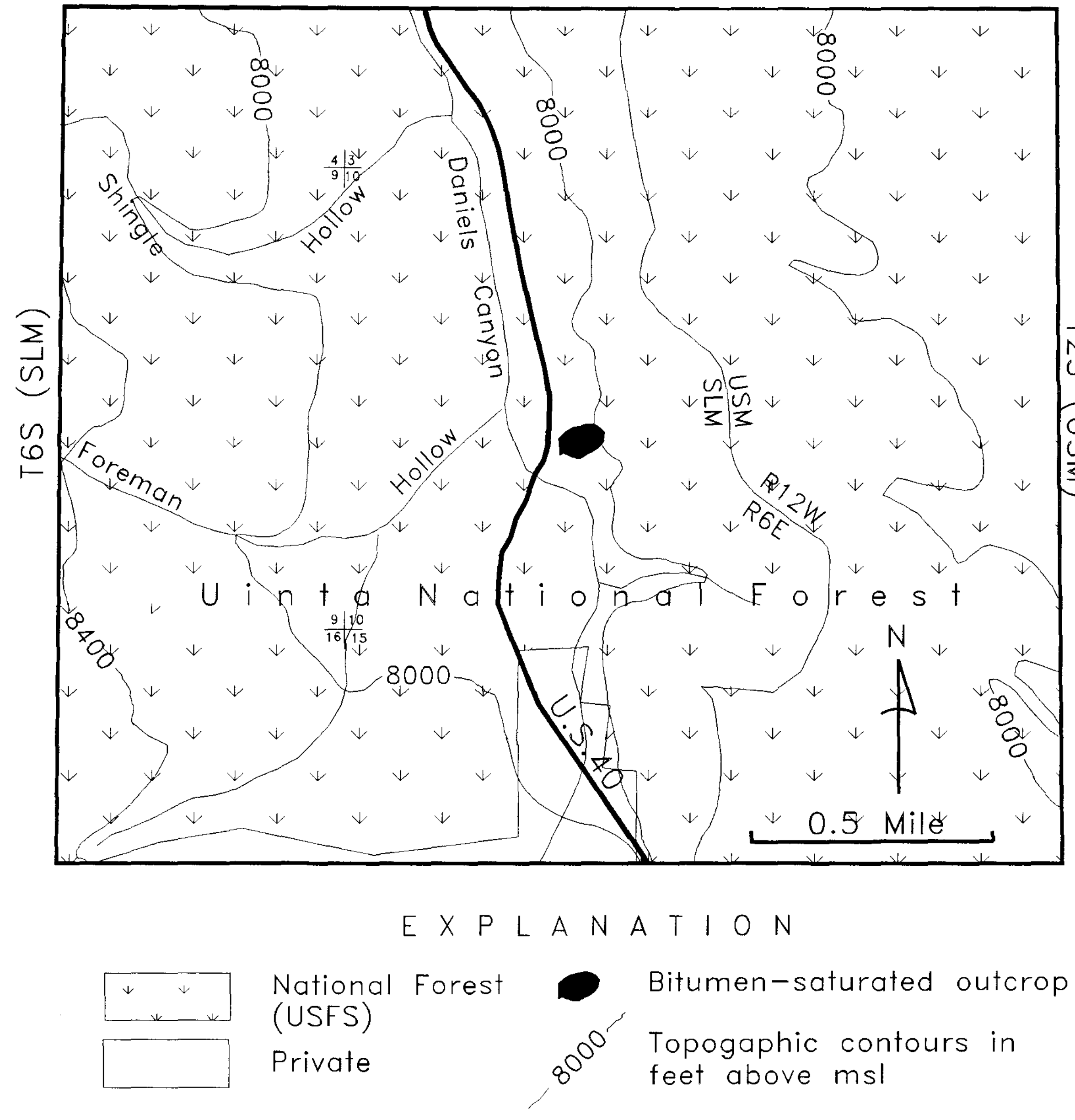


Figure 32. *Land-ownership map of the Daniels Canyon tar-sand area.*

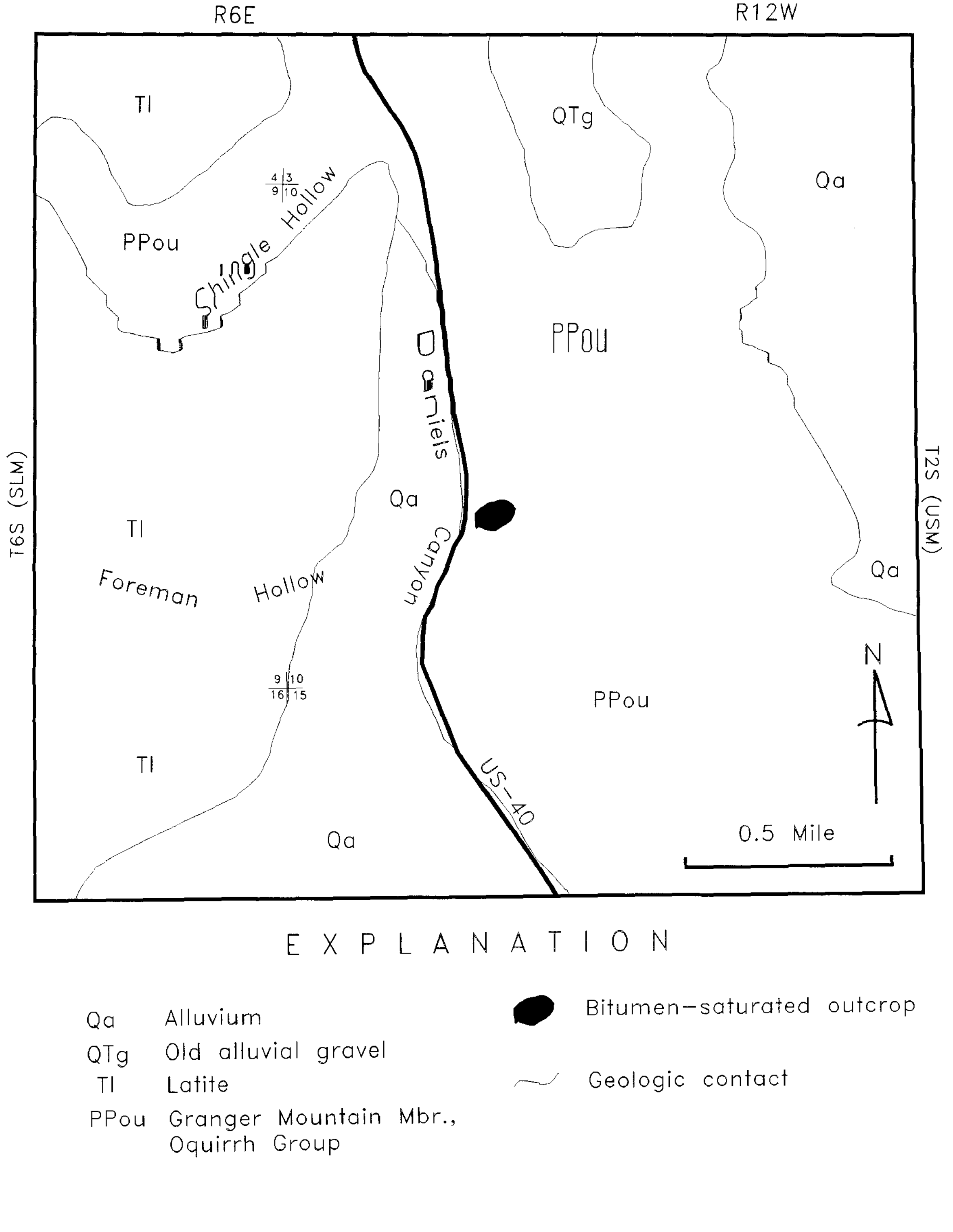


Figure 33. *General geology of the Daniels Canyon tar-sand area (after Bryant, 1992; Ritzma, 1975; tar-sand outcrops from K. Clem, unpublished data).*

Examination of the mine site in the 1970s by UGS geologists showed that the mine was a steeply inclined shaft following the "vein" of bitumen-saturated, fractured and brecciated rock. Several short drifts were driven outward from the shaft until encountering barren rock. Ritzma (1975) reported that one entrance to the shaft was located on top of a hill at the highest bitumen-saturated outcrops, while another entrance was located about 120 feet (37 m) downslope. A retort, reportedly moved from an oil-shale plant near Carlin, Nevada, was erected at the bottom of the shaft next to the lower entry. The crumbly, brecciated rock in the "vein" was retorted and yielded a black waxy substance which was further distilled or refined at the site. Products from the retort included (1) high-grade, pale-yellow oil, used in automobiles and machinery; (2) lamp oil; and (3) candle wax. The market for these products was local, therefore, only a small amount was produced. The mine and plant closed after about two years of operation, and the retort was dismantled and moved to DeBeque, Colorado, during World War II (Ritzma, 1975).

Lake Fork

Location and Access

The Lake Fork deposit is located on the south flank of the Uinta Mountains, about 25 miles (40 km) north of the town of Duchesne in sections 5 and 6, T.1N., R.4W., and section 1, T.1N., R.5W. (USM), Duchesne County (figure 25). Formerly referred to as Lake Fork-Yellowstone, Yellowstone, and Black Diamond, the deposit is situated along low-lying slopes about 1 mile (1.6 km) west of the Yellowstone River. Although not maintained, numerous forest-fire control roads cross the area.

Physiography and Land-Use

The deposit is located on the northwest flank of the Uinta Basin in a belt of south-dipping beds that marks the basin margin. Bitumen-saturated rocks crop out at an elevation of about 8,000 feet (2,438 m) on wooded lands belonging to the Uinta and Ouray Reservation (figure 34).

Geologic Setting

The Duchesne River Formation, the host rocks for the deposit, dips from 4 to 6 degrees southward in this area (figure 35). Within the Duchesne River Formation (Eocene), bitumen is confined to a fluvial-channel interval comprised of four beds with a gross thickness between 15 and 20 feet (5-6 m). These sandstone bodies are cross-bedded, poorly sorted, and weather to grey and white. The complete deposit may be obscured by younger Quaternary gravel and dense brush (K. Clem, unpublished data). Ritzma (1979) classified the deposit as small and calculated the gross resource to be 6.5 to 10 million barrels.

Bitumen Analyses

Wood and Ritzma (1972) collected two samples from the Lake Fork deposit and reported the results of analyses (table 2). Sample 68-21D was collected from an oil seep in the Duchesne River Formation, located in the center of the SW¼ section 5, T.1N., R.4W. Sample 68-22D was collected from a prospect pit in the Duchesne River Formation, located in the center of the SW¼ of section 5.

Development History

In 1957 and 1958, the Duchesne County Road Commission conducted a coring program to assess the Lake Fork deposit for possible use as road-surfacing material. The Commission determined that the deposit was not sufficiently rich for use as paving material. In addition to land and mineral title disputes, the results of the coring program led the commission to abandon the project.

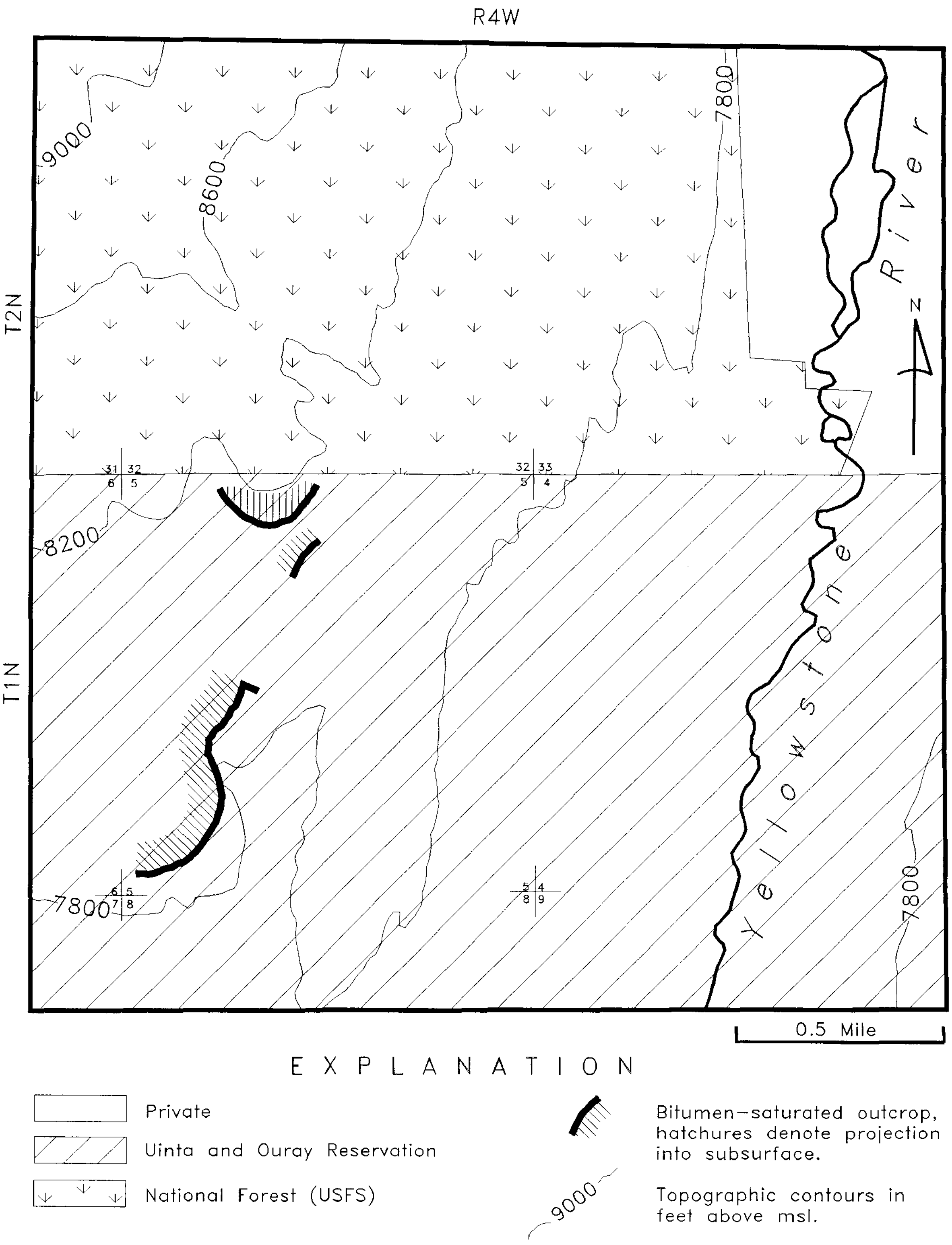


Figure 34. Land-ownership map of the Lake Fork tar-sand area.

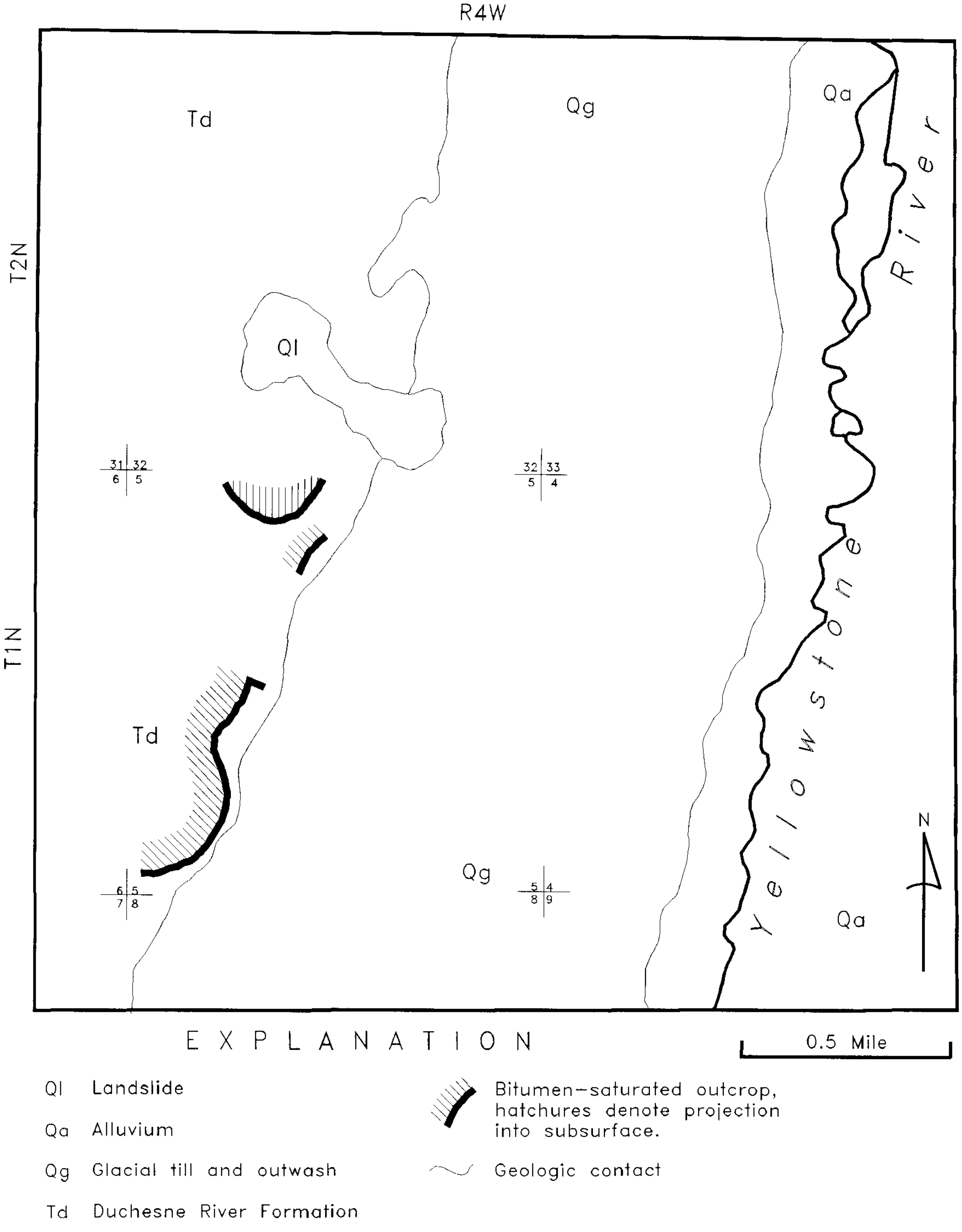


Figure 35. *General geology of the Lake Fork tar-sand area (after Bryant, 1992; tar-sand outcrops from unpublished UGS file data).*

Littlewater Hills

Location and Access

The Littlewater Hills deposit consists of two areas of numerous, small bitumen-saturated sandstone outcrops located in sections 26, 27, 35, and 36 of T.2N., R.1E. (USM); in sections 4 and 5 of T.1N., R.2E. (USM); in section 31 of T.2N., R.2E. (USM); and in section 34, T.3S., R.19E. (SLM), Uintah County (figure 25). Former names of the deposit include Deep Creek and Deep Creek Nose (Ball Associates, Ltd., 1964). Located about 15 miles (24 km) north of the town of Roosevelt, the deposit is accessed by paved county roads and unimproved ranch roads.

Physiography and Land-Use

The western part of the deposit extends about 2 miles (3.2 km) in an east-southeast alignment along the north side of the Littlewater Hills, ending near Grouse Creek (Little Water Creek). The eastern part of the deposit extends about 1 mile (1.6 km) in a southeast alignment also along the north side of the Littlewater Hills, ending near Deep Creek (figure 36). The deposit crops out at an elevation of 6,600 to 7,200 feet (2,012-2,196 m) and is somewhat obscured by vegetation.

Nearly the entire deposit area is contained on lands belonging to the Uinta and Ouray Reservation. Adjacent to the north lie tracts of private, Public, and National Forest lands.

Geologic Setting

The deposit is located on the north flank of the Uinta Basin in the belt of south-dipping beds that mark the basin margin in this area. Upper Cretaceous rocks in the vicinity dip to the south from 15 to 17 degrees (Kinney, 1955). Dips generally decrease through successively younger beds southward toward the basin axis.

In the deposit area (figure 37), the Duchesne River Formation rests unconformably upon the Mancos Shale (Upper Cretaceous). Both units are poorly exposed. The basal strata of the Duchesne River Formation are white to grey, medium-grained sandstones with occasional lenses of conglomerate. The conglomerate lenses contain grit- to cobble-size clasts. Bitumen of varying saturation is primarily within this basal strata. These saturated units are unconformably overlain by massive conglomerates of Duchesne River Formation. The conglomerate contains cobble- to boulder-sized clasts. Bitumen occasionally extends up into the conglomerates.

Covington (1964) stated that the Littlewater Hills deposit had no economic significance, but was of geologic interest. Ritzma (1979) classified the deposit as large, containing 10-12 million barrels.

The Littlewater Hills deposit is geologically important because of its location between the Asphalt Ridge deposit, located 3 miles (4.8 km) to the southeast, and the Whiterocks deposit, located 4 miles (5.4 km) to the west.

Bitumen Analyses

Chemical analyses suggest that the origin of the oil was the Green River Formation (Eocene). Sample 68-14C, shown in table 2, was taken from an outcrop and bulldozer cut on the east bank of Deep Creek (SW¼SW¼SW¼ section 4, T.1N., R.2E.).

Development History

There has been no known exploration or attempt at development of this deposit. A test well for oil and gas was drilled just north of the deposit by Cotton Petroleum Company in 1974. The No. 1 Bruchez, located in the NW¼NW¼NW¼ section 32, T.2N., R.2E. (USM), penetrated the Weber Sandstone (Permian) at a depth of 4,555 feet. Two formation tests, one within the Mancos Shale produced 5 MCF of gas per day; and the other, within the Weber Sandstone, produced water. The well was subsequently plugged and abandoned.

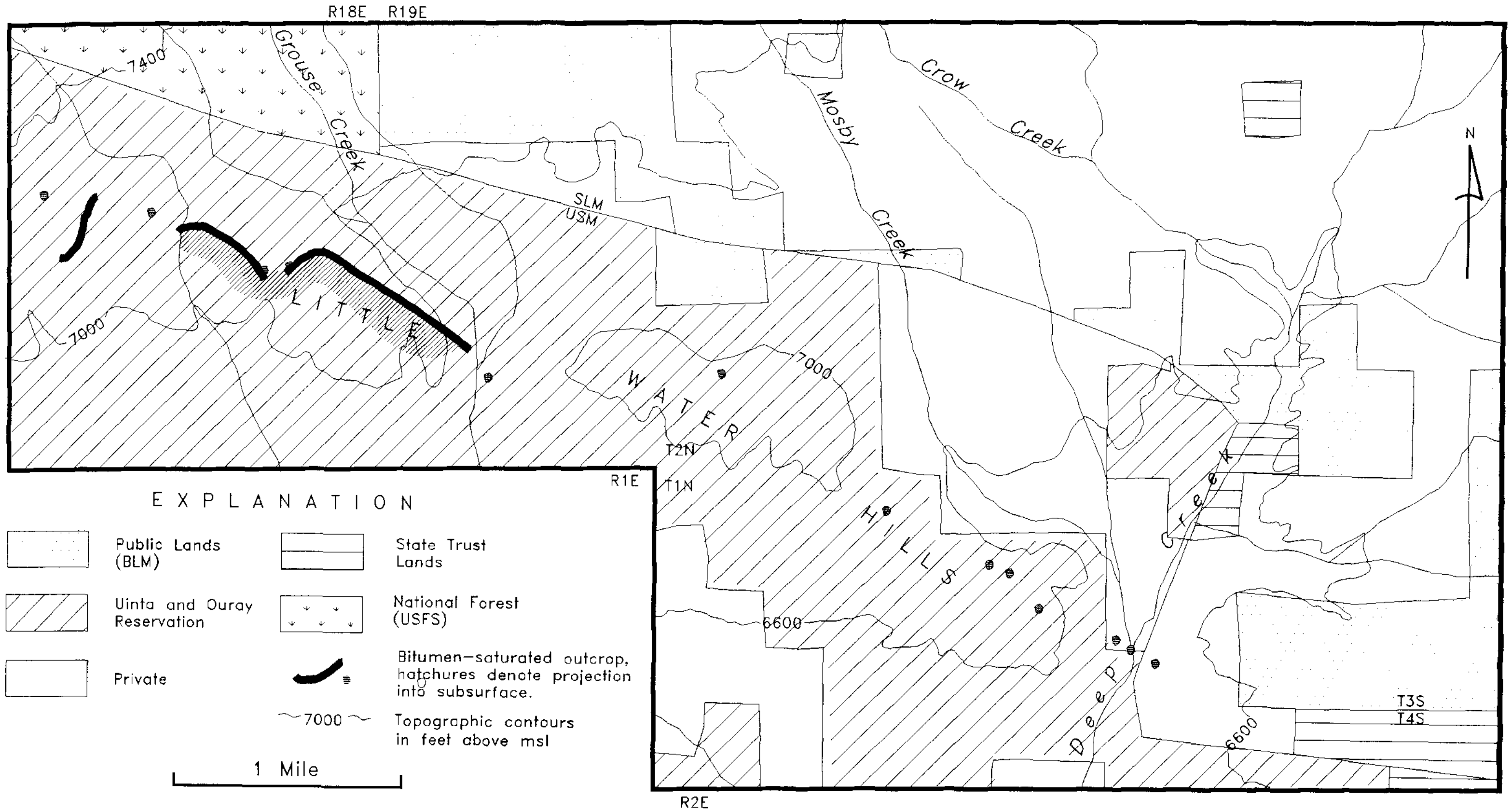


Figure 36. *Land-ownership map of the Littlewater Hills tar-sand deposit.*

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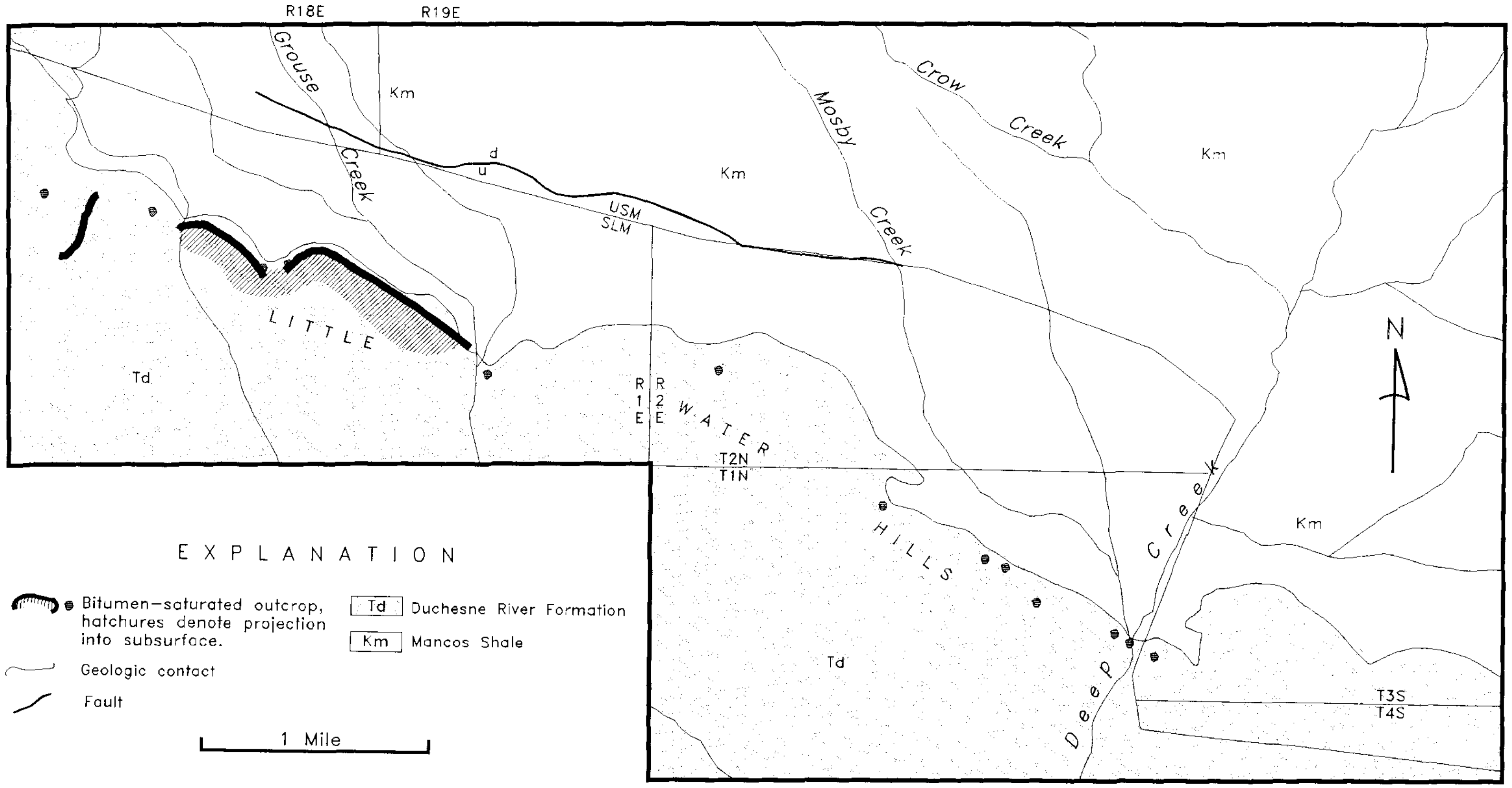


Figure 37. General geology of the Littlewater Hills tar-sand area (after Doelling and Graham, 1972; tar-sand outcrops from K. Clem, unpublished data).

Minnie Maud Creek

Location and Access

The Minnie Maud Creek deposit is located on the southwest flank of the Uinta Basin, about 18 miles (29 km) northeast of the town of Price in T.11-12S., R.12-13E (SLM), Carbon and Duchesne Counties, Utah (figure 25). The deposit extends east-west on the north side of Minnie Maud Creek, a tributary of Nine Mile Creek. Bitumen-saturated beds generally crop out at elevations around 7,300 feet (2,225 m).

Access to the area is via U.S. highway 6 southeast from Price then north on the Nine Mile Canyon Road, just past the town of Wellington. This road follows Soldier Creek northeastward for about 20 miles (32 km) to Nine Mile Canyon. Minnie Maud Creek extends to the northwest from the head of Nine Mile Canyon. Several ranch maintenance roads connect the numerous side canyons and ridges where the deposit is exposed.

Physiography and Land-Use

The deposit area lies just northeast of the Roan Cliffs. Minnie Maud Creek is mostly a homoclinal valley following the geologic strike (east-southeast) of gently dipping sedimentary rocks. Many side canyons trend generally northeast-southwest forming a trellis-type drainage pattern.

Although mineral rights have been reserved by the Federal Government, much of the surface ownership is private (figure 38). Land in the area is used mostly for grazing, for recreational use, and summer homes.

Geologic Setting

The Minnie Maud Creek tar-sand deposit is located on the southwest limb of the Uinta Basin, where strata generally dip northward from 4 to 12 degrees. Sedimentary formations exposed in the canyon include the Garden Gulch and Parachute Creek Members of the Green River Formation, and the Wasatch Formation (figure 39). Bitumen-saturated rocks occur within both the Garden Gulch and Parachute Creek Members of the Green River Formation. Between one and four principal saturated zones are reported, with a gross thickness ranging from 5 to 15 feet (1.5-4.6 km) (Ritzma, 1979). Ritzma (1979) classified the deposit as "large," containing between 10 and 15 million barrels of oil-in-place.

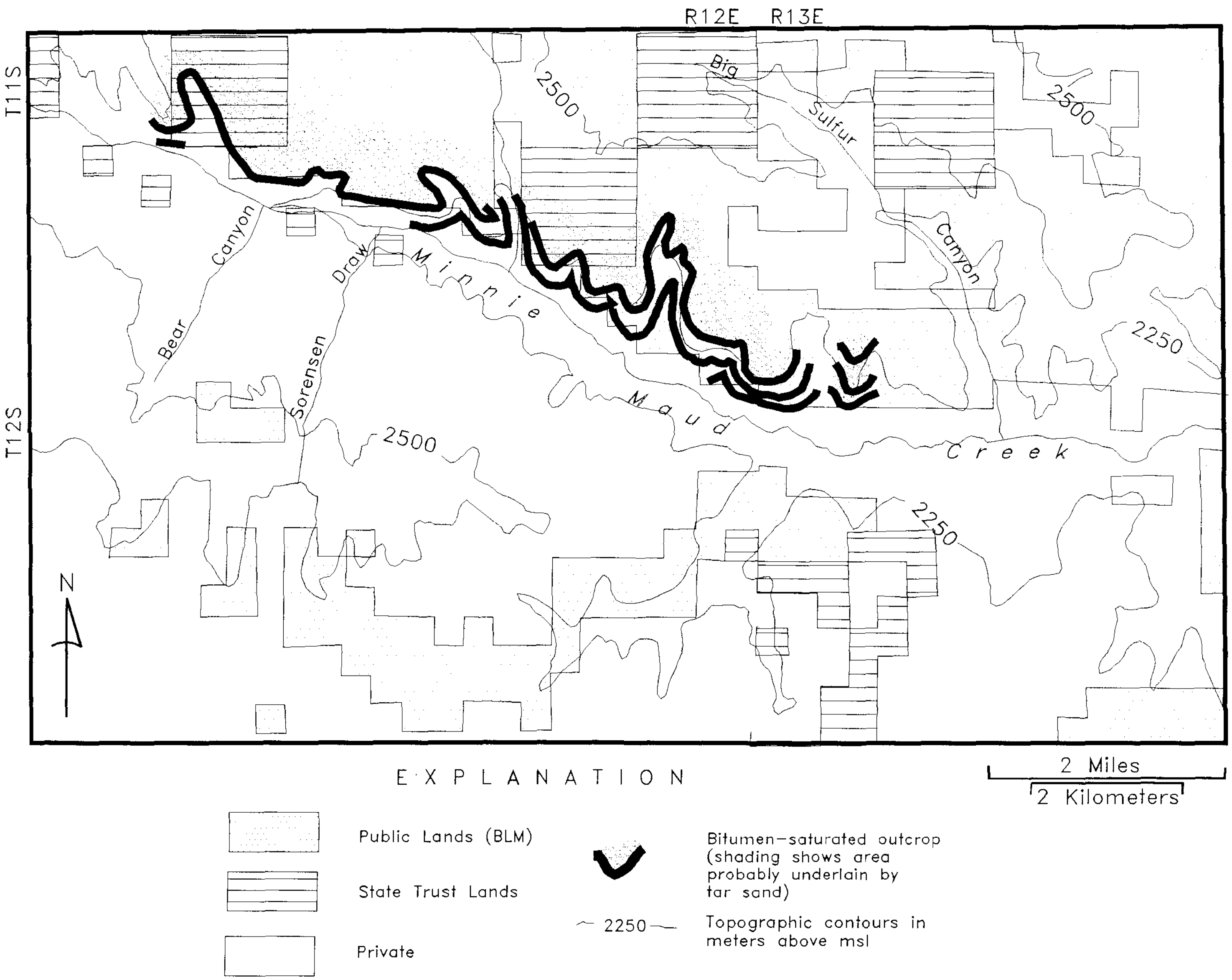


Figure 38. *Land-ownership map of the Minnie Maud Creek tar-sand deposit area.*

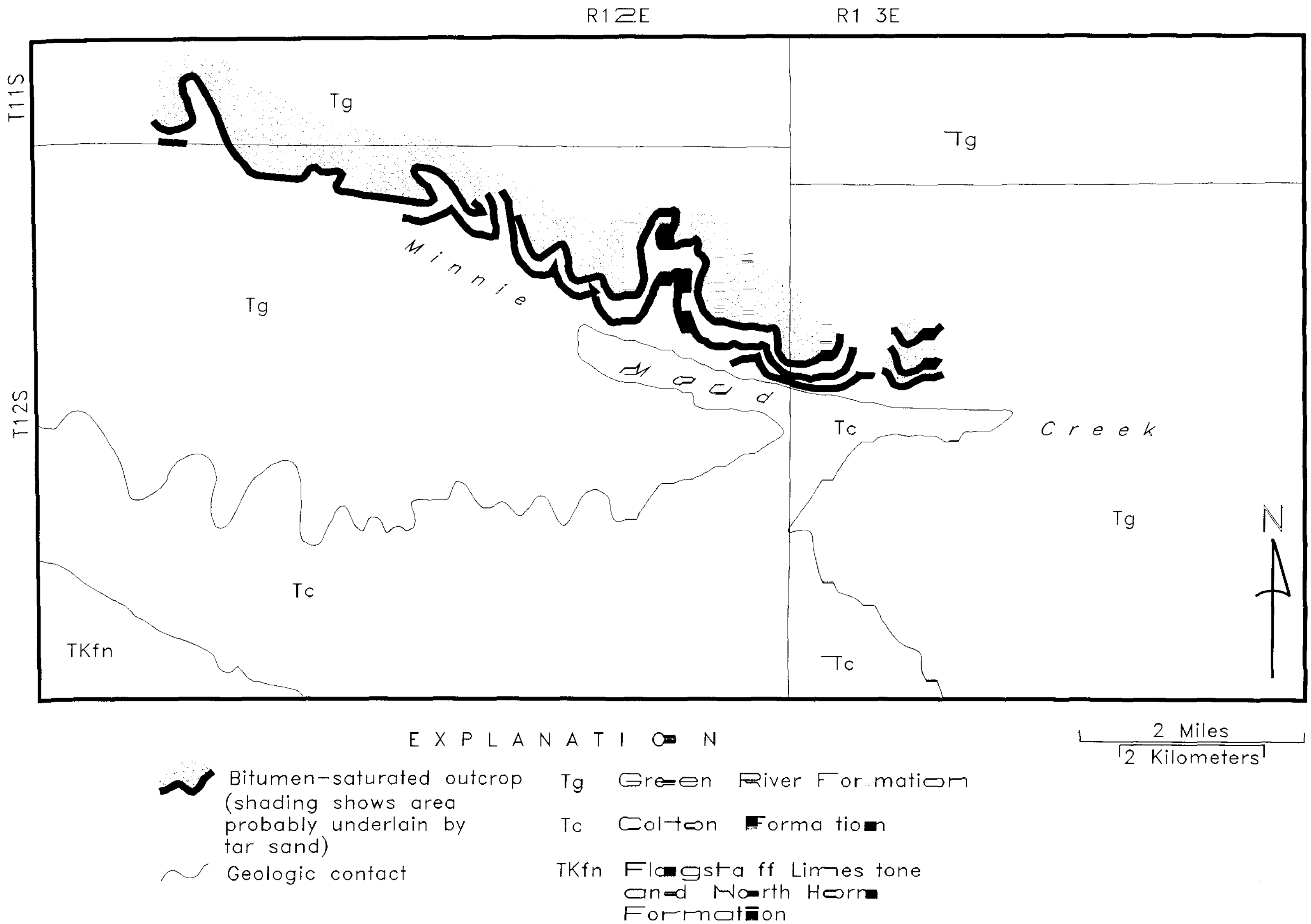


Figure 39. *General geology of the Minnie Maud Creek tar-sand deposit area (after Weiss and others, 1990; tar-sand outcrops from K. Clem, unpublished data).*

Nine Mile Canyon

Location and Access

The Nine Mile Canyon deposit is located on the southwest flank of the Uinta Basin, about 24 miles (39 km) northeast of the town of Price, Utah, in T.11S., R.14-17E. (SLM), Duchesne County (figure 25). The deposit is expressed as scattered outcrops and extends in an east-west direction for about 20 miles (32 km) on the north side of Nine Mile Canyon. Bitumen-saturated rocks crop out at elevations of about 6,500 feet (1,981 m).

Access is via U.S. Highway 6 southeast from Price, then north onto Nine Mile Canyon Road just past the town of Wellington. This road follows Soldier Creek northeastward for about 20 miles (32 km) to Nine Mile Canyon. Several ranch-maintenance roads connect numerous side canyons and ridges where the deposit is exposed.

Physiography and Land-Use

The Nine Mile Canyon tar-sand deposit is situated on the southwest margin of the Uinta Basin in the Bad Land Cliffs area where tributaries to Nine Mile Creek have eroded nearly flat-lying sedimentary rocks. The Bad Land Cliffs extend roughly 35 miles (56 km) from Argyle Canyon to the west across the north side of the Nine Mile Canyon area. Elevations range from about 5,700 feet (1,737 m) to 6,500 feet (1,981 m).

Surface ownership is mostly Public Lands with scattered sections of School Trust Lands. Small tracts of private lands are located mainly along Nine Mile Creek and in the Water Canyon drainage (figure 40). The lands are used mainly for grazing with some private lands serving as summer home sites.

Geologic Setting

The Nine Mile Canyon tar-sand deposit is located on the southwest limb of the Uinta Basin, where strata generally dip northward from 4 to 12 degrees. Sedimentary rock units exposed in the canyon include the Garden Gulch and Parachute Creek Members of the Green River Formation and the Wasatch Formation. Bitumen-saturated rocks occur within both the Garden Gulch and Parachute Creek Members of the Green River Formation. Outcrops of bitumen-saturated rocks are discontinuous and extend for about 17 miles (27 km) along Nine Mile Creek, Gate Canyon, Petes Canyon, Currant Canyon, and Parley Canyon (figure 41).

Ritzma (1979) classified the deposit as "medium" to "small," and estimated that 5 to 10 million barrels of oil were in-place.

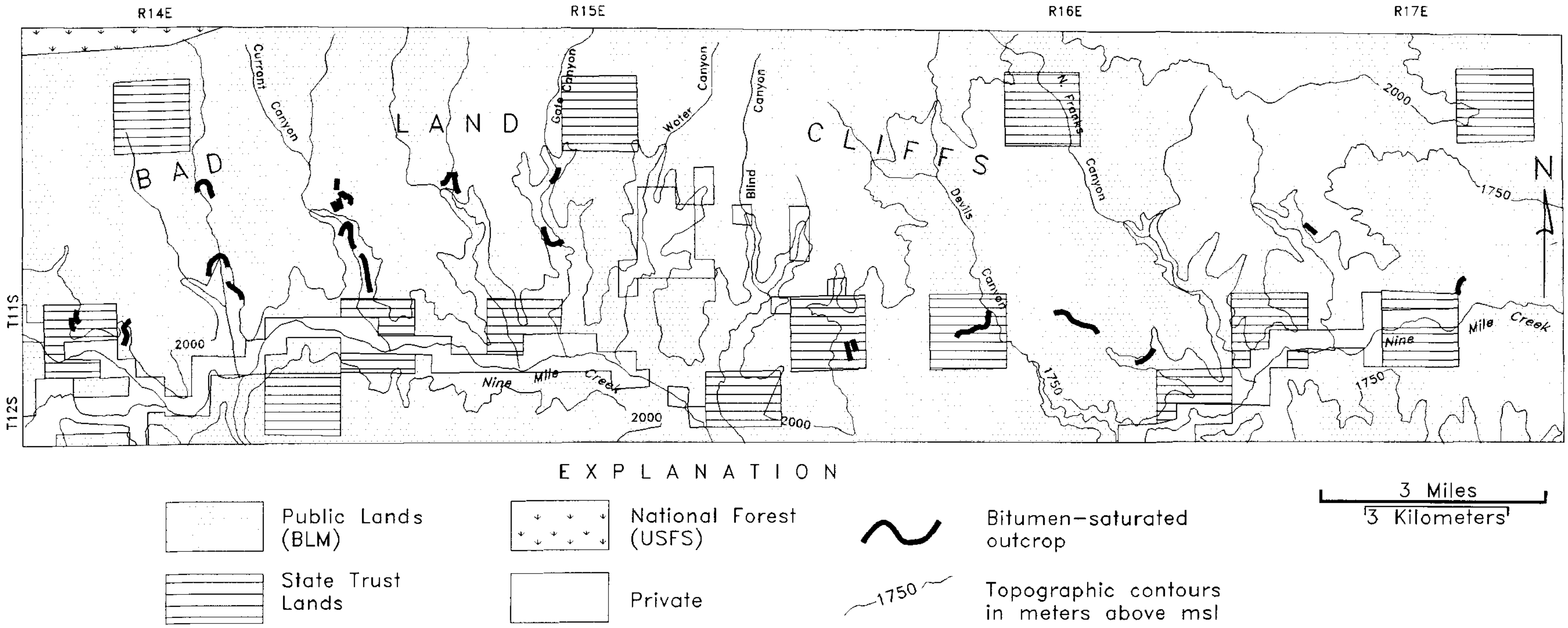


Figure 40. Land-ownership map of the Nine Mile Canyon tar-sand deposit area.

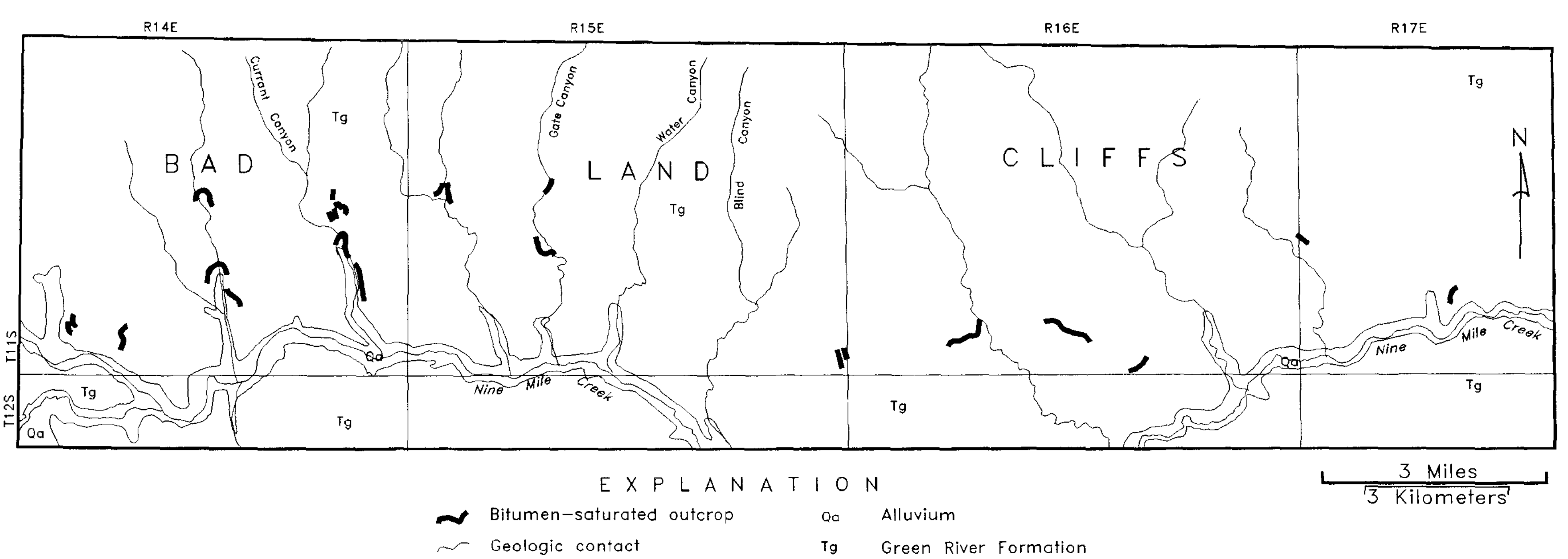


Figure 41. *General geology of the Nine Mile Canyon tar-sand area (after Weiss and others, 1990; tar-sand outcrops from K. Clem, unpublished data).*

Oil Hollow

Location and Access

The Oil Hollow tar-sand deposit is located in the W½W½ section 28, T.10S., R.5E, (SLM), Utah County (figure 25). Numerous small outcrops of oil-impregnated sandstone occur for about 0.6 miles (1 km) in a north-south alignment on the east side of the valley at the head of Oil Hollow and to the south across a sharp divide in the head of an unnamed north fork of Spring Hollow. The area is accessed from U.S. Highway 6 near Thistle Junction in Spanish Fork Canyon. From here a 4-wheel-drive road continues southeastward "up" Lake Fork for about 7 miles (11 km). A 4-wheel-drive road from Dairy Fork to the northeast crosses the deposit and connects with the Lake Fork road about 2 miles (3.2 km) south of the deposit.

Physiography and Land-Use

The Oil Hollow deposit is located at the extreme west margin of the Uinta Basin near the north end of the Wasatch Plateau. The deposit crops out at an elevation of about 7,100 feet (2,164 m) in mountainous, forested terrain. The land surface is administered by the Forest Service, minerals are owned by the Federal Government, but have apparently been withdrawn from leasing. An isolated state section less than 1 mile (1.6 km) south of the occurrence is administered by SITLA. The southernmost exposure is located on private lands, which are probably patented mining claims. Land use is mainly for summer grazing and for harvesting forest products (figure 42).

Geologic Setting

The Oil Hollow deposit occurs in sandstone units of the Green River Formation (Eocene) which dip 10 to 15 degrees northeast (figure 43). In the deposit area, the Green River Formation has been down-dropped more than 500 feet (150 m) along the Martin Mountain fault, and placed adjacent to the Flagstaff (Paleocene) and North Horn (Cretaceous-Paleocene) Formations to the west (Pinnell, 1972).

The host sandstone units, although discontinuous, are grouped within a sequence of green shale and claystone that is about 50 feet (15 m) thick. Some adjacent shale is also saturated with bitumen. The sandstone is fine- to medium-grained, well-sorted, variably calcareous, and weathers to a characteristic light bluish gray color (K. Clem, unpublished data).

Bitumen Analyses

Analyses of two samples from the deposit yielded an average of 10.1 percent of oil by weight. Sulfur content was 0.42 and 0.44 percent (K. Clem, unpublished data). No laboratory report or other reference to these analyses were available, however.

Development History

Peterson and Ritzma (1972) reported that several pits and tunnels (adits) were observed in the deposit area. They also reported that a simple retort was apparently operated at the site.

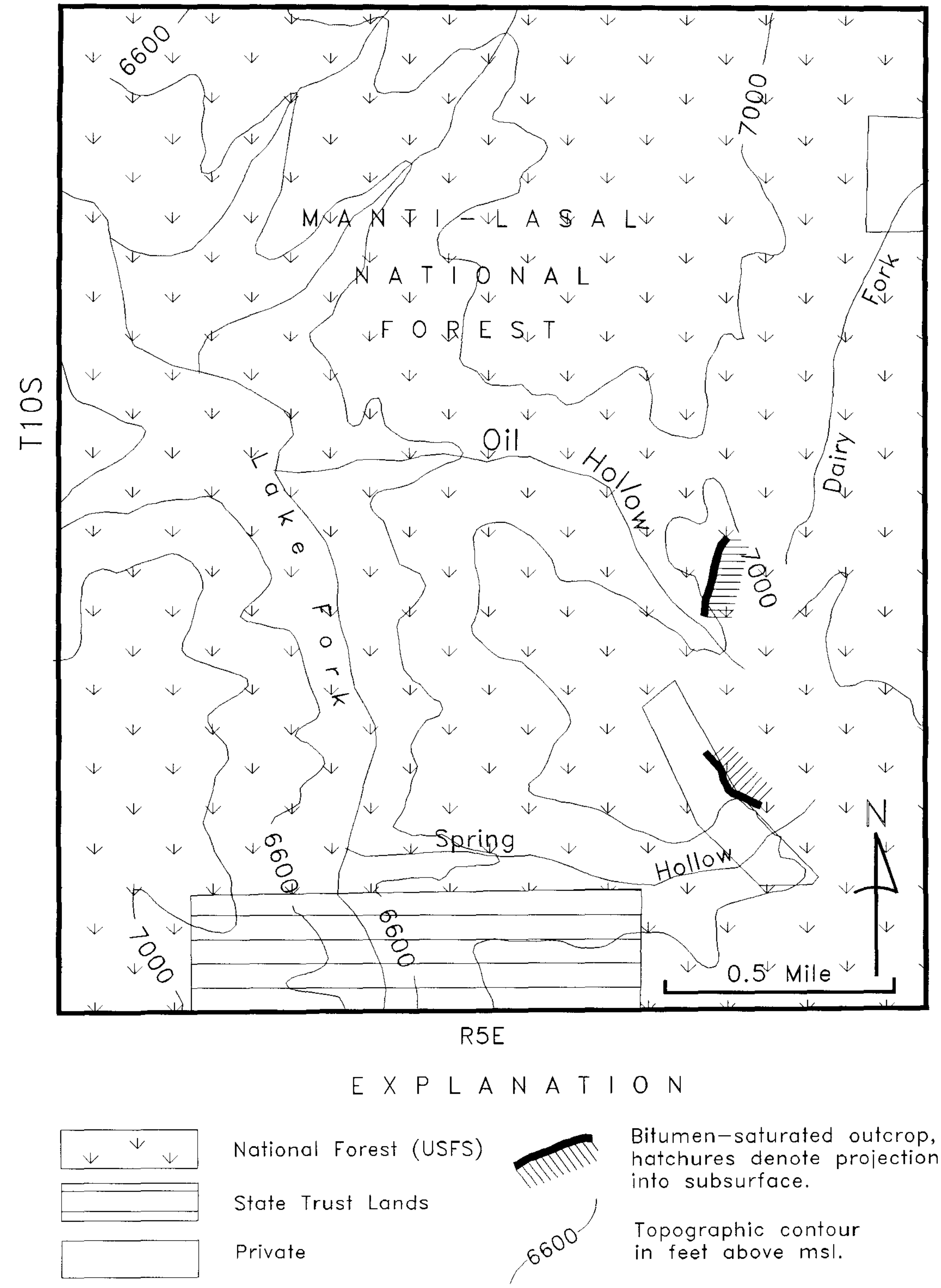


Figure 42. *Land-ownership map of the Oil Hollow tar-sand deposit area.*

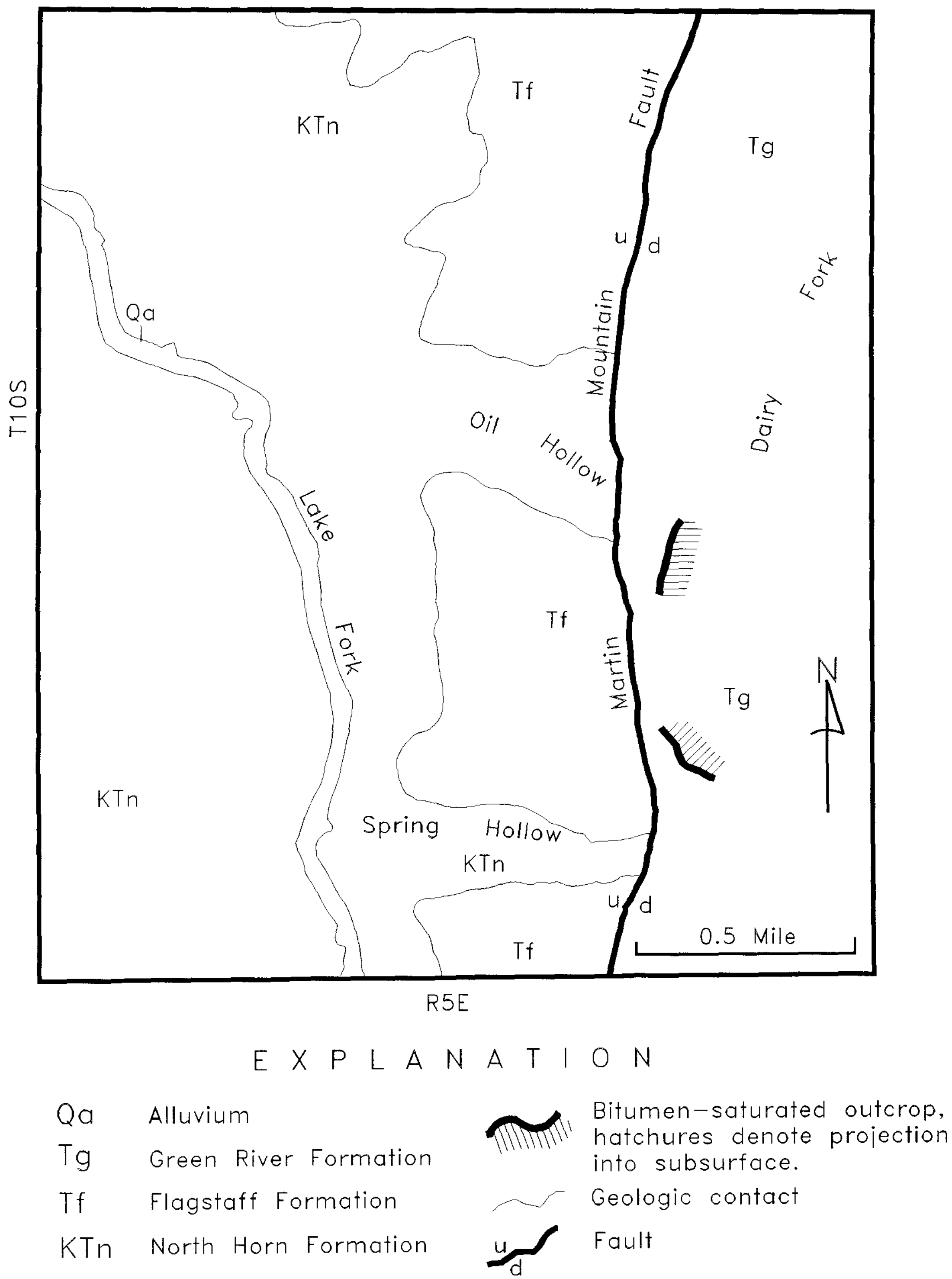


Figure 43. *General geology of the Oil Hollow tar-sand area (after Pinnell, 1972; tar-sand outcrops from unpublished UGS file data).*

Pariette

Location and Access

The Pariette deposit is located on the south flank of the Uinta Basin, about 15 miles south of Roosevelt and Fort Duchesne, in Duchesne and Uintah Counties (figure 25). The deposit consists of numerous scattered outcrops extending about 20 miles (32 km) intermittently along Pariette Bench. The deposit area includes T.4S., R.1-2E., and R.2W. (USM), and T.8S., R.17-18 E. (SLM). Elevations of the outcrops range from about 4,850 feet to about 5,350 feet (1,478-1,631). Access to the area is via state highway 161 and oil-well maintenance roads southward from the town of Myton for about 10 miles (16 km).

Physiography and Land-Use

The deposit is located in an area of low relief near the topographic center of the Uinta Basin. The area lies partly within the Uinta and Ouray Indian Reservation, and includes a combination of Reservation lands, private lands, Public (BLM-administered) Lands, and isolated State sections (figure 44). Land is used mostly for irrigated crops and stock grazing.

Geologic Setting

Geologic units present (figure 45) in the area include the Uinta Formation (Eocene), which dips gently from 1 to 4 degrees northward in this area, and Quaternary surficial deposits (Hintze, 1980). Several scattered, lenticular fluvial-sandstone units of the Uinta Formation in the Pariette area are bitumen-saturated. Individual saturated zones are up to 15 feet (4.6 m) thick, and commonly pinch-out laterally within a few feet. Bitumen-saturated outcrops are normally buff to gray in color, while the surrounding rocks are red to orange. Saturated sandstones are typically medium-grained, crossbedded, and well sorted (UGS, unpublished file data). The Pariette deposit lies about 5 to 10 miles (8-16 km) southeast of the Duchesne fault zone and in the proximity of several gilsonite veins (Gurgel, 1983).

The position of bitumen-saturated zones vary horizontally and vertically, making correlations of individual zones difficult. Bituminous outcrops along Pleasant Valley appear higher in the section compared to bituminous outcrops along Pariette Bench and Uteland Butte. Visual inspections of the Pariette Bench-Uteland Butte outcrop indicate that these tar-sands are generally of a better grade and more extensive than those along Pleasant Valley.

Bitumen saturation varies from weak to rich, with reported "dry" tar occurrences (Covington, 1963). While the areal extent of saturation is large, the majority of the outcrops are of less than a rich grade. Covington (1963) postulated that the origin of bitumen is related to the Duchesne Fault zone, as oil could have migrated upward along the fault zone and into the Uinta Formation from the underlying Green River Formation. Gilsonite veins, which are in close proximity, also cannot be discounted as a source.

Ritzma (1979) classified the Pariette deposit as "large," and estimated that the area contains from 12 to 15 million barrels of bitumen. Covington (1963, 1964) suggested that, due to the lenticular nature of the host sandstone units, the deposit does not have great commercial value.

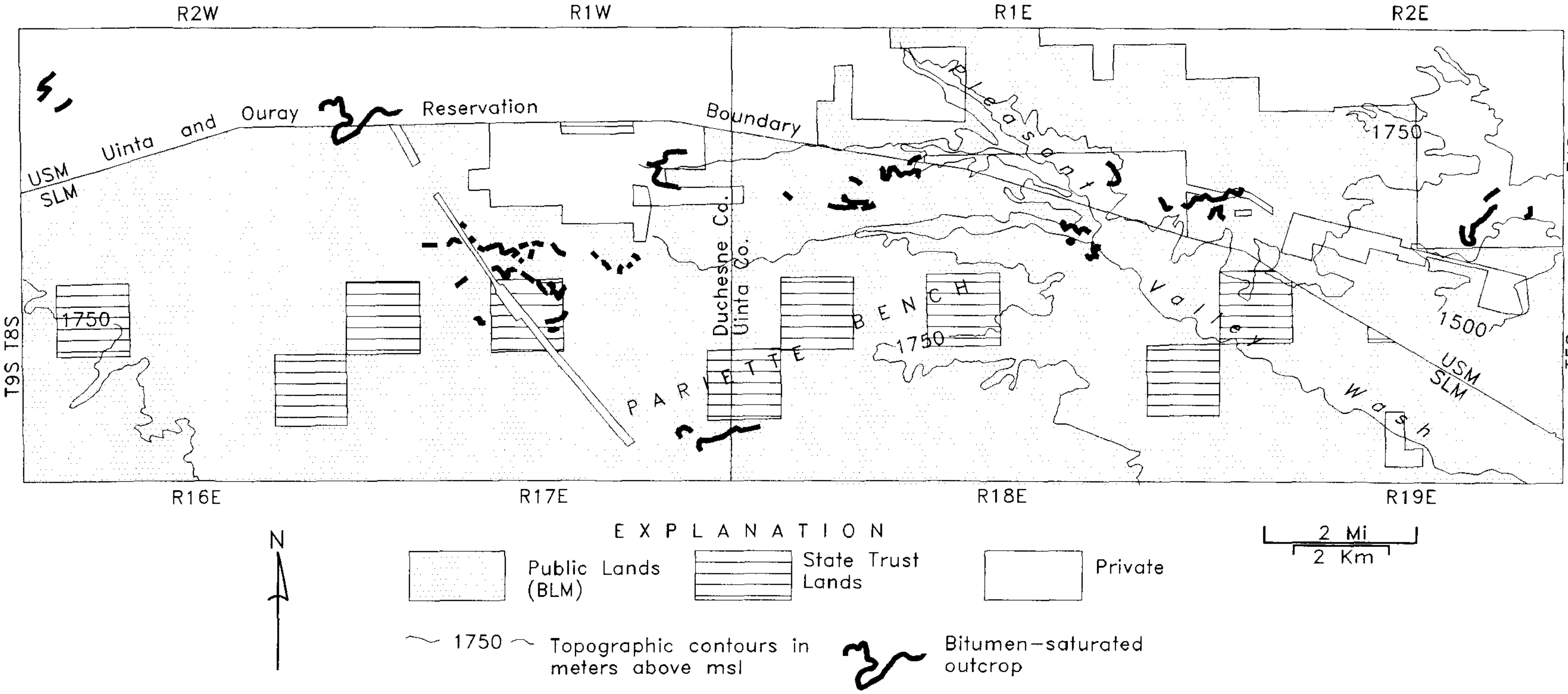


Figure 44. Land-ownership map of the Pariette tar-sand area.

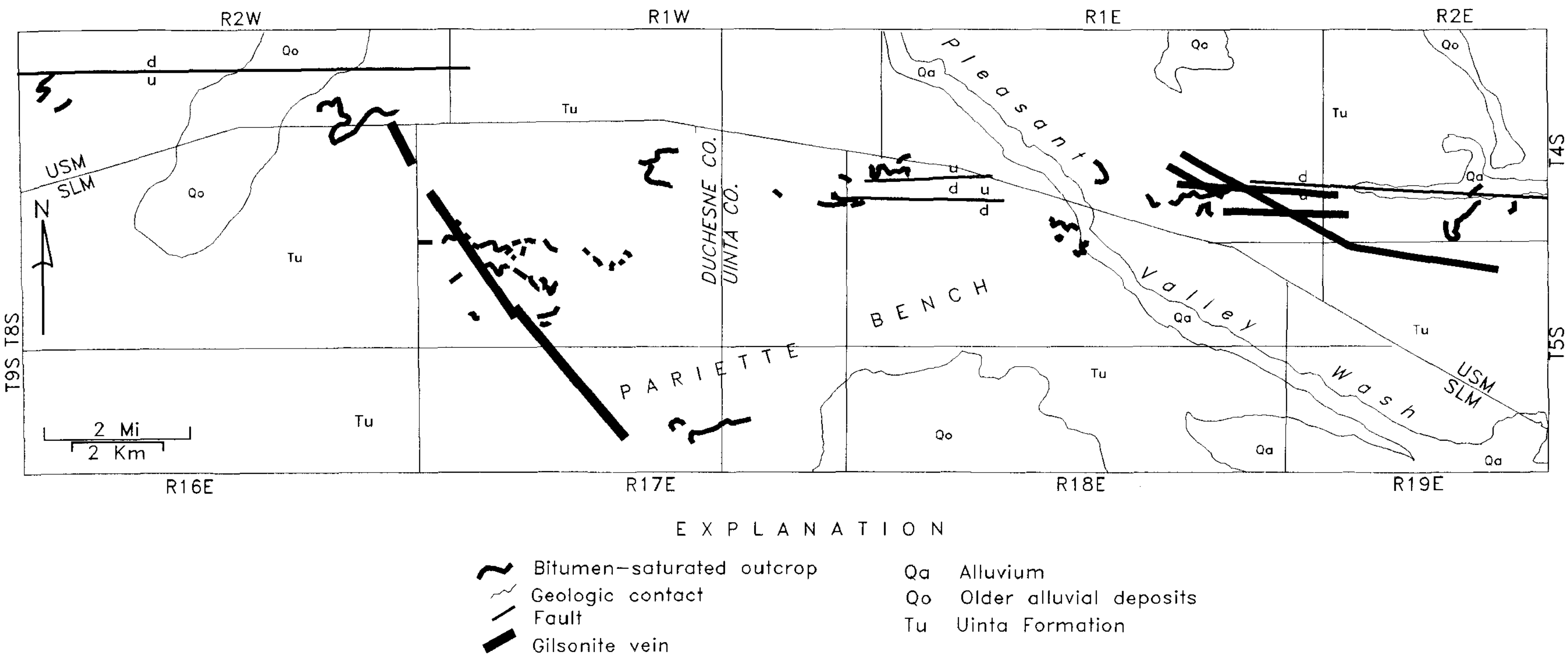


Figure 45. *General geology of the Pariette tar-sand area (after Rowley and others, 1985; tar-sand outcrops from K. Clem, unpublished data), and unpublished UGS file data).*

Raven Ridge

Location and Access

The Raven Ridge deposit is located on the north flank of the Uinta Basin, about 25 miles (40 km) southeast from the town of Vernal, along U.S. Highway 80, in T.6-7S., R.24E. (SLM), Uintah County (figure 25). Access is gained via a secondary road which branches southward from U.S. Highway 40 about 3 miles (4.8 km) east of the intersection of U.S. 40 and State Highway 45. This road provides access to the northern and western portions of the deposit. Several seismic-line roads crisscross the deposit area.

Physiography and Land-Use

The deposit lies along and adjacent to a series of northwest-trending hogbacks known as Raven Ridge and Squaw Ridge that extend from the Colorado-Utah border westward to Powder Springs Wash. Elevations of bitumen-saturated outcrops range from 5,400 to 6,000 feet (1,646 to 1,829 m). The surface ownership in the area is mainly Public Land (BLM administered) with scattered State sections (SITLA administered) (figure 46). Land is used mainly for stock grazing and oil and gas development.

Geologic Setting

The Raven Ridge tar-sand deposit is located on the northern and northeastern flank of the Uinta Basin. Raven Ridge and Squaw Ridge are part of a northwest-southeast trending set of hogbacks, where Tertiary strata dip from 10 to 85 degrees southwest and average about 30 degrees southwest (figure 47). Bitumen-saturated sandstone units are primarily within Douglas Creek, Parachute Creek, and Evacuation Creek Members of the Green River Formation (Eocene) and also within the basal part of the Uinta Formation (Eocene). The Green River Formation in this area is composed of sandstone, limestone, and shale deposited mainly in shoreline and delta facies (marginal lacustrine). The Uinta Formation consists of fluvial-deltaic shales, sandstones, and pebble conglomerates with source areas to the east (Quigley, 1972).

Bitumen-saturated units in the Douglas Creek Member are exposed in the northern part of the deposit along Raven Ridge. Bitumen occurs within a zone about 90 feet (27 m) thick at the base of the Douglas Creek Member. This zone contains many thin, cross-bedded sandstone lenses, most of which are well sorted and fine to medium grained. The degree of saturation ranges from very rich to moderate, with the greatest saturation at the base of the interval.

Bitumen-saturation in the Parachute Creek Member ranges from weak to very rich. Two places are saturated: (1) patchy, weakly saturated occurrences along the Colorado-Utah border, and (2) a zone of rich saturation in the central part of the deposit along Squaw Ridge. Individual sandstone beds range between 30 and 50 feet (9-15 m) thick, while saturated zones occupy only 4 to 16 feet (1.2-5 m) of the beds. The sandstone units are all well sorted with subrounded grains ranging in size from fine to medium grained (Quigley, 1972).

Bitumen-saturated beds in the Evacuation Creek Member are discontinuous and commonly less than 4 feet (1.2 m) thick. Bitumen-saturated zones in this member extend from the central part of Squaw Ridge northeastward for about 3 miles (4.8 km) to the south side of Powder Springs Wash. The beds are fine- to very fine-grained, well-sorted sandstones, ranging from rich to weakly saturated.

Bitumen-saturated zones are rare in the Uinta Formation, but where present, typically occur near the base. These beds are commonly medium to coarse grained, well sorted, and cross stratified. Ritzma (1979) classified the deposit as "large," with 75 to 100 million barrels of bitumen in-place.

Surface mining methods may not be applicable to the Raven Ridge deposit because of steeply dipping strata and the relatively thin nature of bitumen-saturated units.

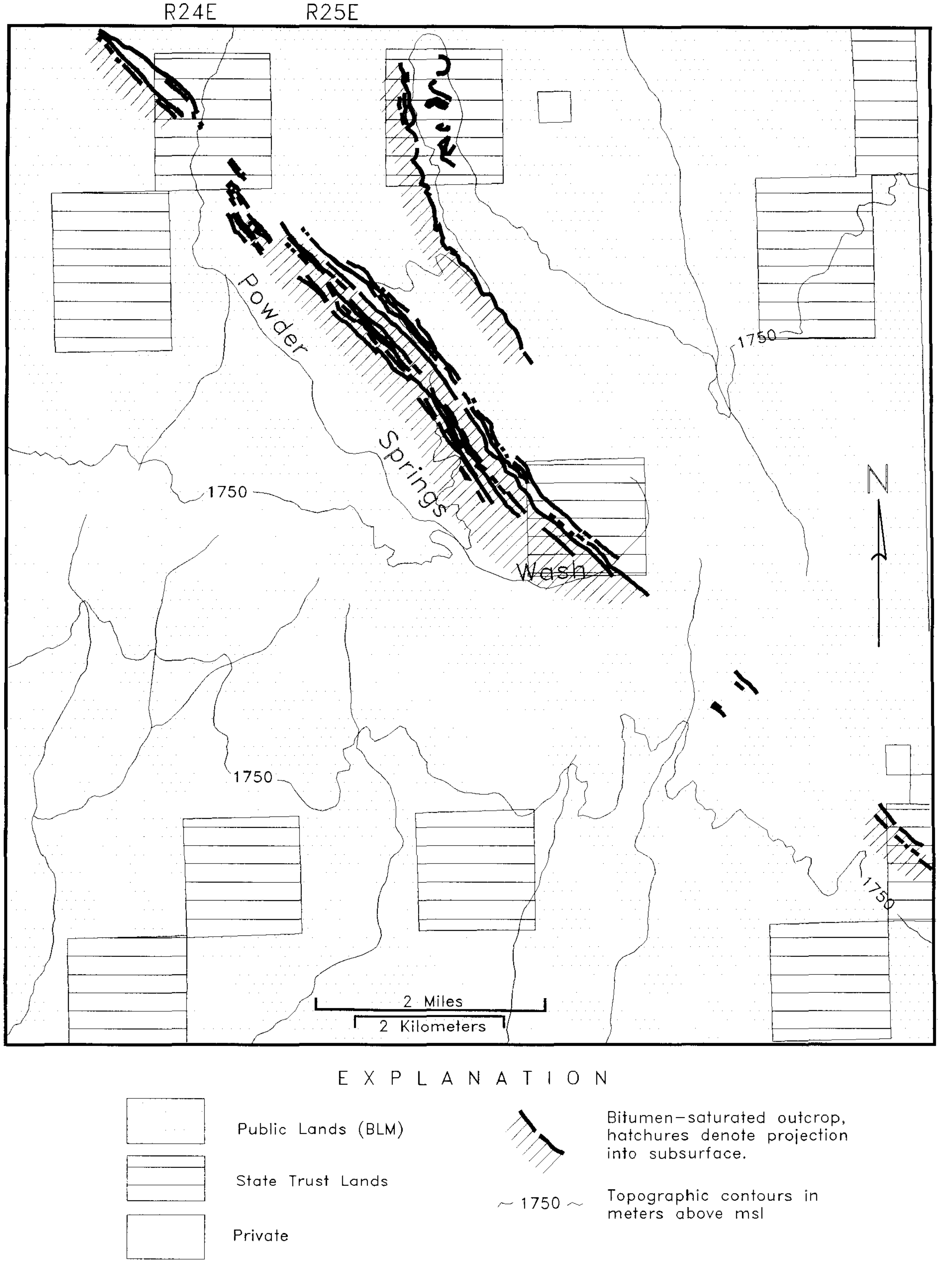
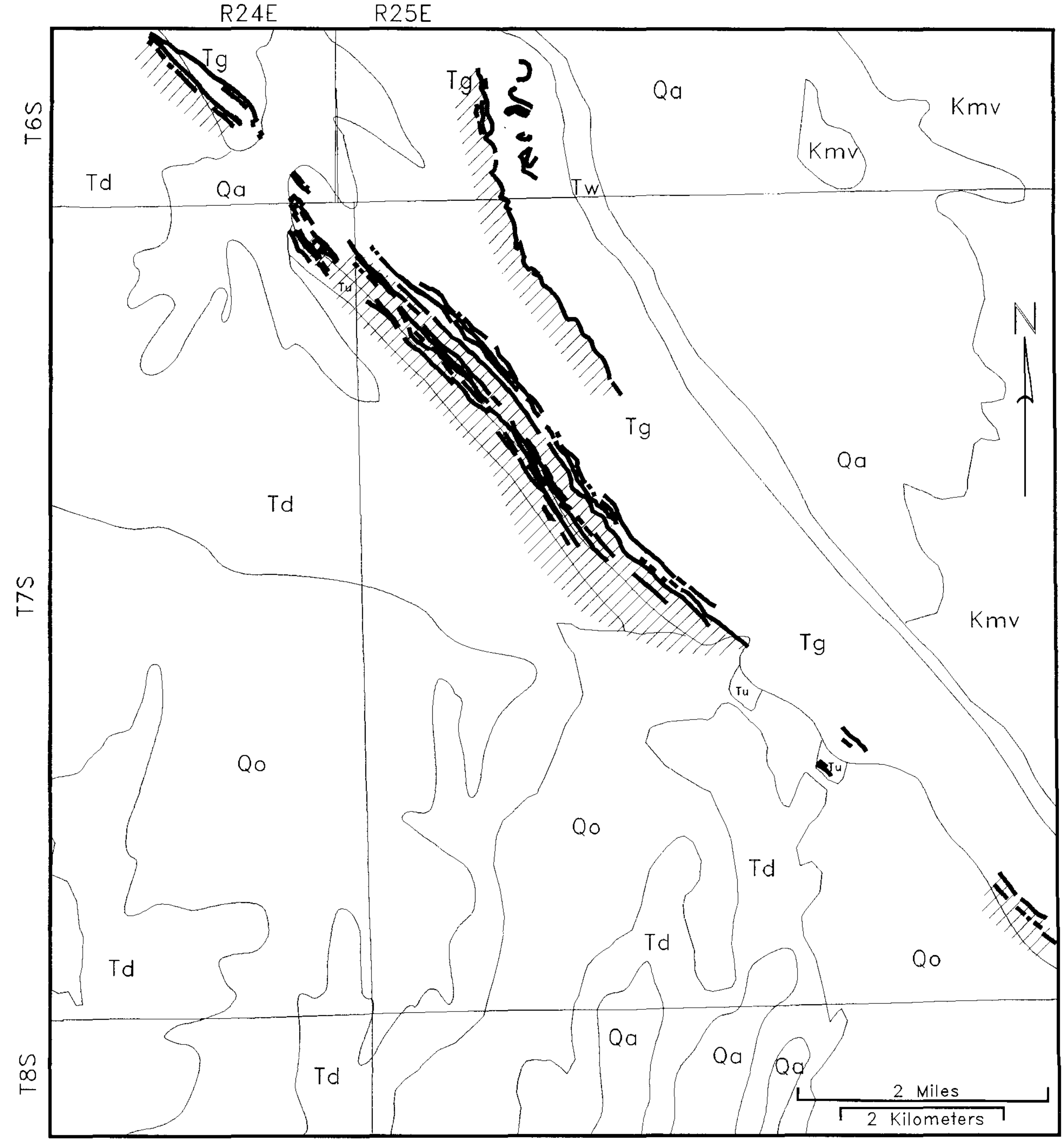


Figure 46. Land-ownership map of the Raven Ridge tar-sand deposit area.



E X P L A N A T I O N

Qa	Alluvium	Tg	Green River Formation
Qo	Older alluvial deposits	Tw	Wasatch Formation
Td	Duchesne River Formation	Kmv	Mesaverde Group
Tu	Uinta Formation		

Geologic contact

Bitumen–saturated outcrop, hatchures denote projection into subsurface.

Figure 47. *General geology of the Raven Ridge tar-sand area (after Rowley and others, 1985; and Quigley, 1972).*

Bitumen Analyses

Wood and Ritzma (1972) reported the results of analyses of three samples of oil extracted from the Raven Ridge tar-sand deposit (table 2). The location and description of the three samples are as follows:

Sample 67-5A is from a sandstone within the Parachute Creek Member, located in the SE¼SW¼ section 8, T.7S., R.25E.

Sample 67-8A is from a basal sandstone within the Green River Formation and in a zone of sharp flexure immediately west of Powder Springs Wash, located in the SW¼NE¼SW¼ section 25, T.6S., R.24E.

Sample 67-10A is from a sandstone from the Parachute Creek Member, located in the NW¼NE¼ section 21, T.7S., R.25E.

Development History

Ball Associates Ltd. (1964) described sporadic attempts to develop the Raven Ridge deposit principally for paving material. In the summer of 1980, Western Tar Sands, Inc. tested strip-mining of a 22-foot, saturated sandstone zone within a 23-acre site in section 15, T.7S., R.24E. Results from this test-mining indicated that bitumen reserves were 348,000 barrels within the test site (Anonymous, 1981). The company planned to build a 100 BPD pilot plant for the extraction of oil from the site using a patented process, but, the plant was never built.

Occurrences of the oil sands in the area from Asphalt Ridge to Raven Ridge were instrumental in triggering exploration that led to the discovery of petroleum in the Green River Formation in the Red Wash oil and gas field located a few miles to the southwest (Koesoemadinata, 1970).

Rimrock

Location and Access

The Rimrock tar-sand deposit is exposed along the Raven Ridge-Asphalt Ridge trend of hogbacks between the Raven Ridge and Cow Wash deposits (figure 25). The deposit is located in T.6S., R.24E., sections 22, 23, 25, and 26 (SLM), Uintah County. The Rimrock deposit has also been referred to as the Northwest Raven Ridge deposit. U.S. Highway 40 and State Route 45 provide access to the area, located about 20 miles (32 km) southeast of the town of Vernal. From the junction of US-40 and SR-45, the area lies south along SR-45 about 1.5 miles (2.4 km) and northwest about 1 mile (1.6 km) along powerline and pipeline access roads.

The Rimrock deposit is one of several "minor" deposits located in the area between the Asphalt Ridge and Raven Ridge deposits. Occurrence of these tar-sand deposits helped lead to the discovery of Green River Formation petroleum in the Red Wash oil and gas field located a few miles to the southwest.

Physiography and Land Use

The deposit lies at the east end of a number of low-lying, west-northwest-trending hogbacks collectively called the Rim Rock that extend from Powder Springs Wash westward to upper Kane Hollow. The Rimrock, Cow Wash, and upper Kane Hollow tar-sand deposits occur along this trend. Elevations of bitumen-saturated outcrops lie at about 5,400 feet (1,646 m). The surface ownership in the area (figure 48) is mainly Public Land (BLM administered) with scattered State school sections (SITLA administered). A contiguous tract of 640 acres of private land is situated within 1 mile (1.6 km) northeast of the deposit. Land is used mainly for stock grazing and oil and gas development.

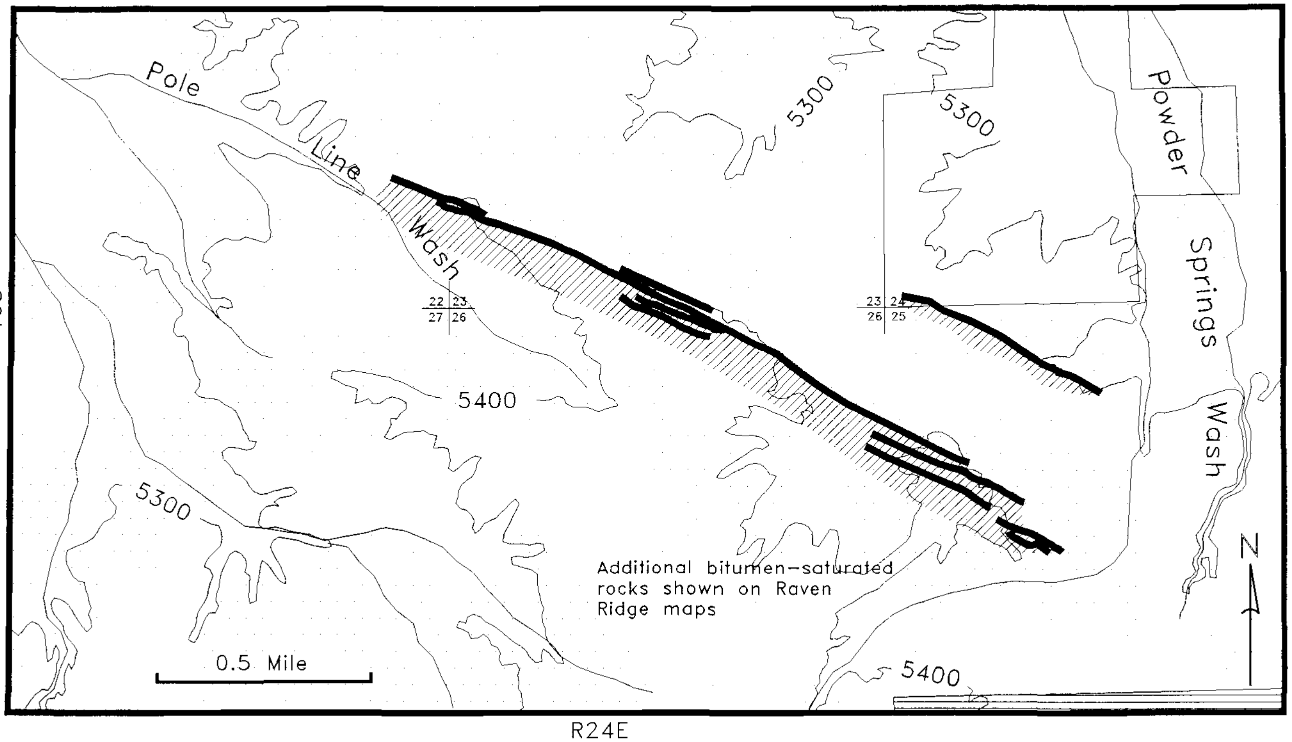
Geologic Setting

The Rimrock tar-sand deposit consists of numerous beds of bitumen-saturated sandstone that crop out for about 2 miles (3.2 km) in a southeast alignment between Pole Line Wash and Powder Springs Wash (figure 49). The area is along the northeast flank of the Uinta Basin in a belt of southwest-dipping beds that mark the basin margin. Beds of the Parachute Creek and Douglas Creek Members of the Green River Formation and the Wasatch Formation dip up to 67 degrees southwest toward the basin axis. The Parachute Creek Member overlaps and truncates the Douglas Creek Member with angular discordance. Similarly, the Douglas Creek Member overlaps and truncates the Wasatch Formation. Wasatch strata dip more steeply toward the center of the basin than the Green River strata.

Bitumen is localized in units of the Wasatch Formation and in Green River sandstones that truncate underlying Wasatch strata. Bitumen is primarily contained in lenticular sandstones within a 90 foot interval above the base of the Douglas Creek Member of the Green River Formation. Degree of saturation ranges from very rich to moderate, and saturated units are exposed for a distance of 0.75 mile (1.2 km). The saturated sandstone units are commonly thin, blocky, and cross-stratified. Grain sizes range from fine to medium, and most of the sandstones in the interval are well sorted (Quigley, 1972). Ritzma (1979) classified the deposit as large, with an estimated total resource of 25 to 30 million barrels.

Bitumen Analyses

Bitumen in the Rimrock deposit has similar chemical characteristics to oil extracted from lacustrine shale of the upper part of the Wasatch Formation. Sulfur isotope data show that Rimrock oil is very similar to other Tertiary-age, north rim deposits, except Raven Ridge, Asphalt Ridge, and Whiterocks (Mauger and others, 1973). Hydrocarbons evidently moved updip within sand units of the Wasatch Formation and then spread laterally through lower Green River units.



E X P L A N A T I O N

Public Lands (BLM)

State Trust Lands

Private

Bitumen-saturated outcrop, hatchures denote projection into subsurface.

~5400~ Topographic contours in feet above msl

Figure 48. Land-ownership map of the Rimrock tar-sand deposit area.

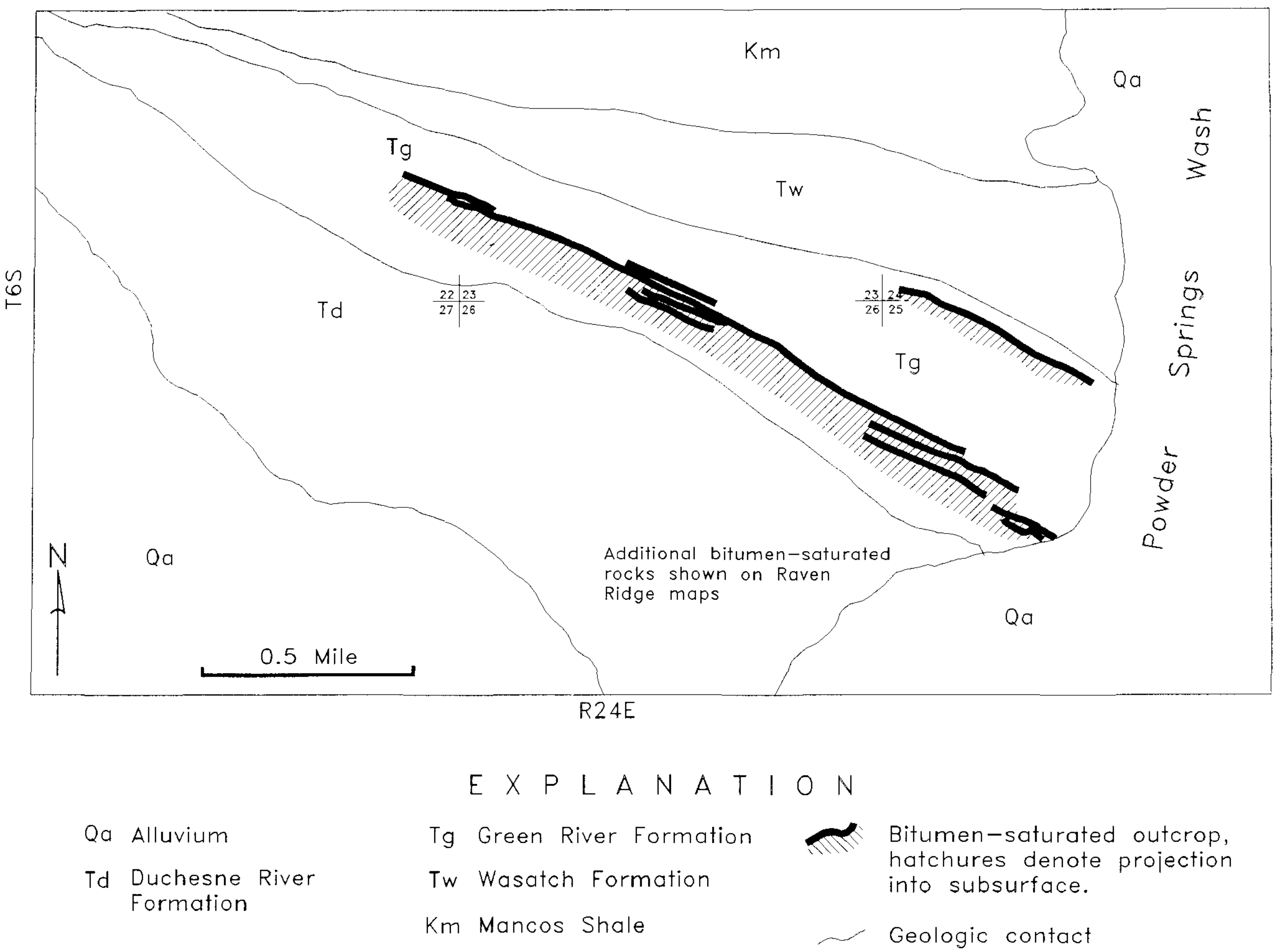


Figure 49. *General geology of the Rimrock tar-sand area (after Rowley and others, 1985; tar-sand outcrops from unpublished UGS file data).*

Extracted oil has been analyzed by fractional distillation methods (Wood and Ritzma, 1972) and for sulfur isotopes (Mauger and others, 1973). Wood and Ritzma (1972) reported analytical results of four samples from the Rimrock area. The analyses are shown on table 2 and the locations of the samples are listed below.

Sample 67-4A is from the Wasatch Formation in the center of NE¼NE¼ of section 26.

Sample 67-6A is from the SE¼SE¼SW¼ of section 23.

Sample 67-7A is from the upper part of the Green River Formation occurrence, and is from the SE¼SE¼SW¼ section 23.

Sample 67-9A is from the Wasatch Formation in the north half of SE¼SE¼NW¼ of section 25.

Split Mountain

Location and Access

The Split Mountain tar-sand occurrences are located 1 to 3 miles (1.6-4.8 km) west-northwest of the Split Mountain Campground in Dinosaur National Monument. Bitumen-saturated outcrops are located in the S½SW¼ section 24; the NW¼NE¼ section 25; and the center and E½SE¼ section 23, T.4S., R.23E.; and in the W½NW¼ section 30, T.4S., R.24E. (SLM), Uintah County (figure 25). Access is by foot trail northwest from the campground along Cottonwood Wash and Red Wash, and then northward along narrow canyon-bottoms that issue off Split Mountain. The dinosaur quarry from which the monument is named is about 1.1 miles (1.8 km) southwest.

Physiography and Land Use

The tar-sand occurrence lies entirely within Dinosaur National Monument on the southwest flank of Split Mountain. The area is characterized by deeply incised canyons and flatirons along the plunging west end of the Split Mountain anticline. The Green River, a major tributary of the Colorado River system, flows through Split Mountain Canyon less than 1 mile (1.6 km) to the east. The tar-sand occurrences lie entirely within Dinosaur National Monument on land administered by the National Park Service.

Geologic Setting

Isolated, bitumen-saturated outcrops are within the Park City Formation (Permian) along rugged flatirons caused by deeply incised canyons that cross-cut the formation (figure 50). The Park City Formation rests conformably upon the Weber Sandstone (Permian-Pennsylvanian).

The Split Mountain tar-sand occurrences are located on the plunging west end, south flank of the Split Mountain anticline, an east-west trending fold lying south of and parallel to the Uinta Mountain arch. On the southwest flank in the occurrence area, the Park City Formation dips from 65 to 72 degrees south-southwest (Untermann and Untermann, 1954).

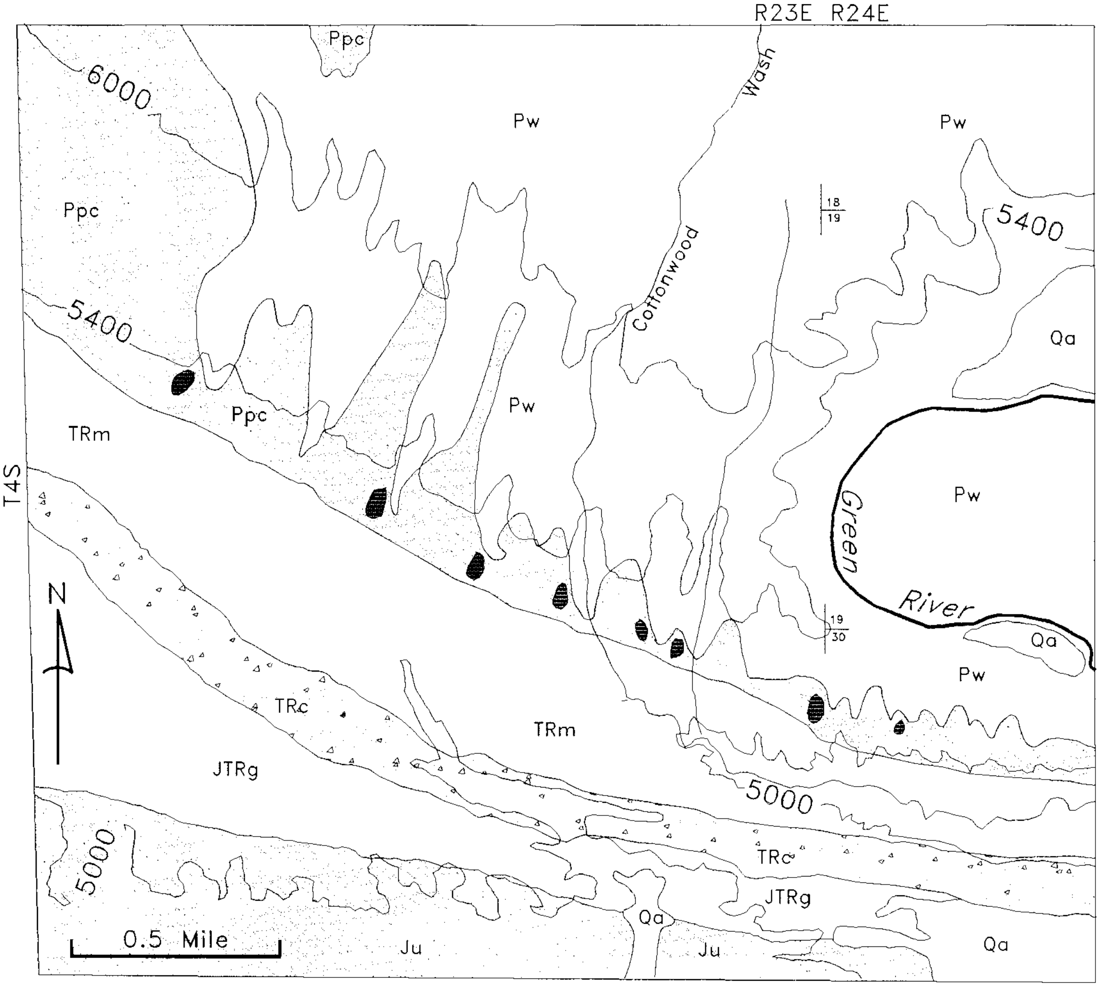
Bitumen-saturated, platy limestone from 2 to 3 feet (0.6-0.9 m) thick occurs immediately beneath the Moenkopi Formation (Triassic). Because of irregularities along the unconformable Park City-Moenkopi contact, the bitumen may occur as much as 10 feet (3 m) below the Moenkopi or may be cut out by erosion.

Bitumen is commonly found saturating pods of coarsely crystalline, vugular limestone developed roughly parallel to the bedding planes of the Park City Formation. Where it is not bitumen-saturated, the Park City Formation emits a petroliferous odor on fresh fractures. Crystalline masses and vugs are heavily stained with viscous, fresh oil with a strong oily, sulfurous odor. Sandstones in the Moenkopi Formation immediately above the Park City are also lightly and spottily stained with oil, and the beds are tan in color suggesting that the hydrocarbons have altered the rock from its normal red color. Spotty impregnation of oil is also found in a few limestone beds in the lower Park City Formation, but the oil is dead and where found in vugs disintegrates to powder (K. Clem, unpublished data).

Total thickness of the Park City in the area of the deposit ranges from 50 to 60 feet (15-18 m) with most of the variation occurring at the irregular upper contact. Regionally the Park City Formation thins from west to east across this area. The unit in which the deposit occurs thins gradually from west to east and pinches out between the deposit area and Split Mountain Canyon to the east. To the west the unit grades into dense, sandy, nonpetroliferous limestone. The lateral extent of the deposit is about 1.8 miles (2.9 km) (K. Clem, unpublished data).

Bitumen Analyses

Wood and Ritzma (1972) reported the results of analysis of one sample of bitumen (table 2; sample no. 68-17D) collected from the Split Mountain tar-sand occurrence. Of particular interest is the high sulfur content (2.94 percent), which contrasts with an average of 0.4 percent sulfur for bitumen extracted from deposits in Tertiary formations or for bitumen migrated from Tertiary rocks to older formations. Moreover, bitumen from this occurrence is much more sulfurous than that produced from the Weber Sandstone (Permian-Pennsylvanian; 0.83 percent) in the



E X P L A N A T I O N

Qa Alluvium
Ju Jurassic undivided
JTRg Glen Canyon Sandstone
TRc Chinle Formation
TRm Moenkopi Formation
Ppc Park City Formation
Pw Weber Sandstone

Bitumen–saturated outcrop
Geologic contact
Topographic contours in feet above msl

Figure 50. *General geology of the Split Mountain tar-sand area (after Rowley and others, 1979; tar-sand outcrops from K. Clem, unpublished data).*

Ashley Valley field located 10 miles (16 km) to the southwest and in the Rangely field in Colorado located 30 miles (48 km) to the southeast (0.72 percent).

The Split Mountain deposit, although of minor importance, was studied and sampled carefully because it appears to contain the only indigenous Permian or (Paleozoic) crude oil of all Uinta Basin tar-sand deposits.

Development History

No attempt has been made to develop this deposit. The presence of oil in outcrops of the Park City Formation here and elsewhere in northeast Utah has encouraged drilling for oil and gas in the Weber Sandstone along the Ashley Valley-Rangely trend.

Spring Branch

Location and Access

The Spring Branch deposit is located on the north flank of the Uinta Basin, about 20 miles (32 km) northeast of the town of Roosevelt in sections 13 and 24, T.2N., R.3W., (USM), Duchesne County. The deposit lies near the headwaters of Spring Branch Creek (figure 25). The elevation of the deposit is about 8,600 feet (2,621 m).

Hiking trails provide the only access, as the closest maintained road is 2 miles (3.2 km) to the south. This county road connects the communities of Altonah and Neola with the turnoff to Spring Branch approximately halfway between the two towns.

Physiography and Land-Use

The Spring Branch deposit is situated along the marginal benches subsection of the Uinta Basin along the southern flank of the Uinta Mountains. The area is entirely enclosed within the Uintah and Ouray Reservation. The Reservation boundary with the Ashley National Forest lies 3 miles (5 km) north of the deposit. The area is mountainous, forested terrain used mainly for summer-range livestock grazing.

Geologic Setting

The Spring Branch deposit is located on the northern flank of the Uinta Basin, and consists of one exposure of bitumen-saturated rocks within the Upper Eocene Duchesne River Formation (figure 51). The Duchesne River Formation in this area is composed of fluvial sandstone and conglomerate.

A small-displacement reverse fault, which crosscuts the deposit, may have controlled the accumulation of bitumen. The fault is oriented northeast-southwest, and is traceable for about 1,000 feet (305 m). Clem (unpublished data) suggested that the fault displaces the Duchesne River Formation probably more than 200 feet (60 m); however, he could trace no mappable units across the fault. The hanging-wall block is on the northwest side of the fault, and the fault plane dips about 80 degrees to the northwest.

Located within the Duchesne River Formation (Eocene), bitumen is in two zones, separated by the reverse fault. The host strata southeast of the fault is sandstone, while the host strata on the northwest side of the fault is mainly conglomerate. The bitumen-saturated zone on the southeast side of the fault is 180 to 200 feet (55-61 m) thick, while the saturated zone on the northwest side is 50 to 60 feet (15-18 m) thick. Saturation along the fault zone is very rich and small seeps along the trace ooze oil (K. Clem, unpublished data).

Ritzma (1979) classified the deposit as "medium-small," and estimated that 1.5 to 2 million barrels of oil are in-place.

Bitumen Analyses

Wood and Ritzma (1972) and Mauger and others (1973) reported analyses of oil extracted from the deposit (table 2). Sample 68-23D was taken from sandstone in the footwall (southeast side) of the fault, located in the NE¼NE¼NW¼ section 24. Sample 69-24D was taken from a conglomeratic sandstone in the hanging-wall of the fault, located in the NE¼NE¼NW¼ section 24.

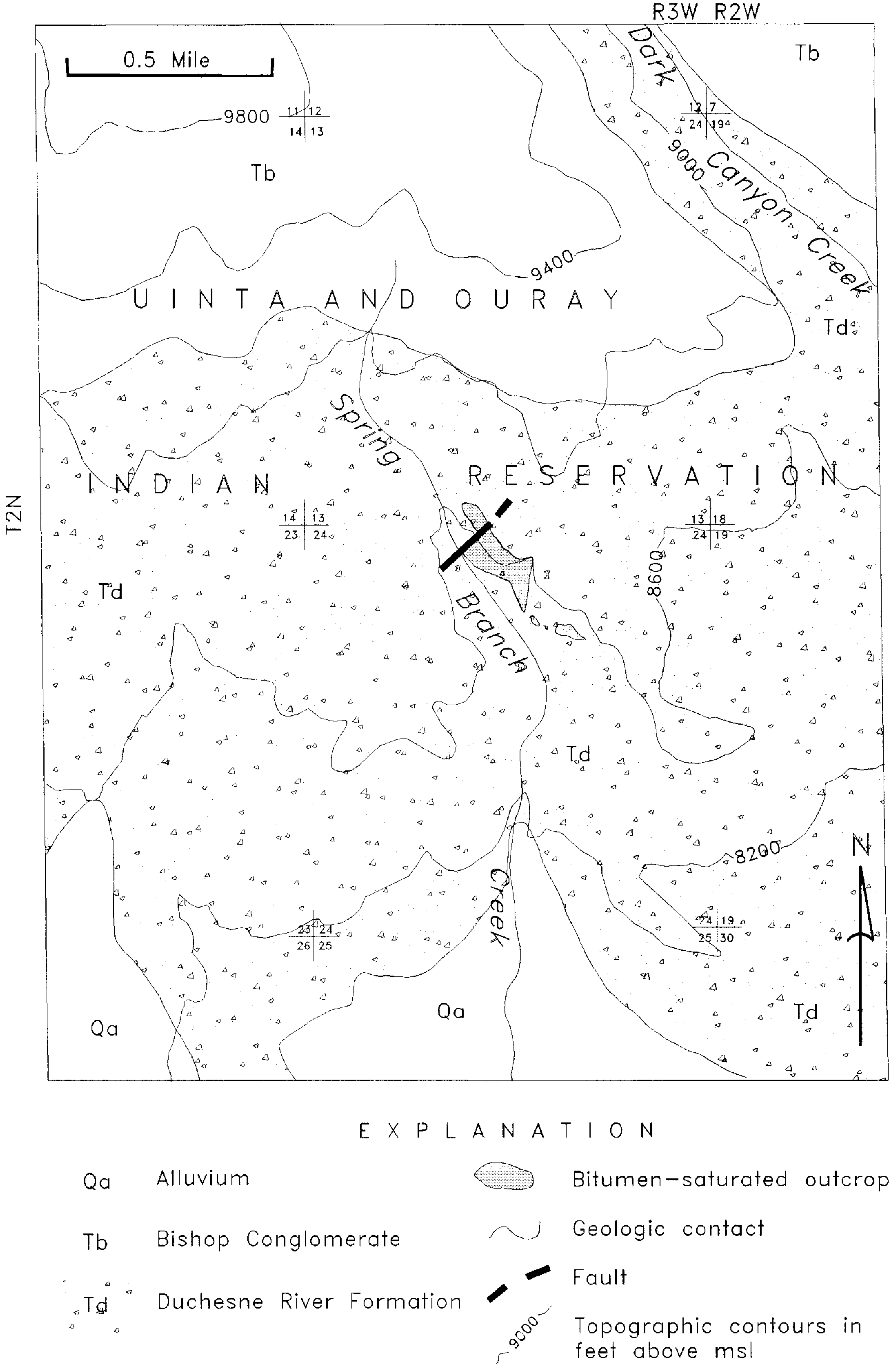


Figure 51. General geology of the Spring Branch tar-sand area (after Bryant, 1992; tar-sand outcrops from K. Clem, unpublished data).

Spring Hollow

Location and Access

The Spring Hollow tar-sand deposit consists of two small isolated outcrops of oil-impregnated sandstone, positioned halfway between the southeastern end of the Asphalt Ridge deposit and the Upper Kane Hollow deposit (figure 25). The deposit is within Spring Hollow, a minor tributary of the Green River, located about five miles south of the town of Jensen in section 18, T.6S., R.26E., and in section 13, T.6S., R.22E. (SLM), Uintah County. Access is by way of a county road southwest from Jensen for about 6 miles (9.6 km), then east along an agricultural road for less than 0.5 mile (0.8 km).

Physiography and Land-Use

The deposit is situated less than 1 mile (1.6 km) east of the Green River, a major tributary of the Colorado River, which meanders generally northeast to southwest along its course. Low-lying hills and valleys compose the landscape elsewhere. Along and adjacent to the course of the Green River, land is mainly irrigated cropland mostly in private ownership. Northwest of the Green River, SITLA administers a large, contiguous tract of state land that adjoins the Asphalt Ridge tar-sand deposit area. East of the Green River, land-ownership is primarily Public Land administered by the BLM and scattered school sections administered by SITLA.

Geologic Setting

Untermann and Untermann (1964) mapped the rocks in the deposit area as the Uinta Formation (Eocene), which overlies the Mesaverde Group (Cretaceous) with angular discordance. Ritzma (1979), however, listed the deposit as hosted by the Duchesne River Formation (Eocene), which is similar in character but overlies the Uinta Formation. Figure 52 illustrates the geologic interpretation of Rowley and others (1985). A few miles east of Spring Hollow, the Uinta Formation rests atop the Green River Formation (Eocene), which unconformably overlies the Mesaverde Group. The deposit area is situated less than a mile northeast of the axis of the Uinta Basin syncline. Untermann and Untermann (1964) projected the Uinta and Green River Formations in this area to be more than 6,000 feet (1,829 m) thick.

Bitumen has saturated either the basal part of the Duchesne River Formation or the Uinta Formation and near the trace of a small-displacement fault (K. Clem, unpublished data). Ritzma (1979) classified this deposit as "minor," and did not estimate resources.

Bitumen Analyses

Wood and Ritzma (1972) and Mauger and others (1973) reported the results of analyses on samples from the Spring Hollow deposit. Although Untermann and Untermann (1964) mapped the area as Uinta Formation, Wood and Ritzma (1972) reported that sample 68-18D (table 2) was collected in a fault zone from sandstone of the Duchesne River Formation in the center of the SE¼ section 18, T.6S., R.23E.

Development History

There has been no known exploration or attempt at development of this deposit. The Spring Hollow deposit is one of several "minor" deposits located in the area between Asphalt Ridge and Raven Ridge deposits. Occurrences of these oil sands were instrumental in triggering exploration that led to the discovery of petroleum in the Green River Formation in the Red Wash field 6 miles (9.6 km) to the southeast.

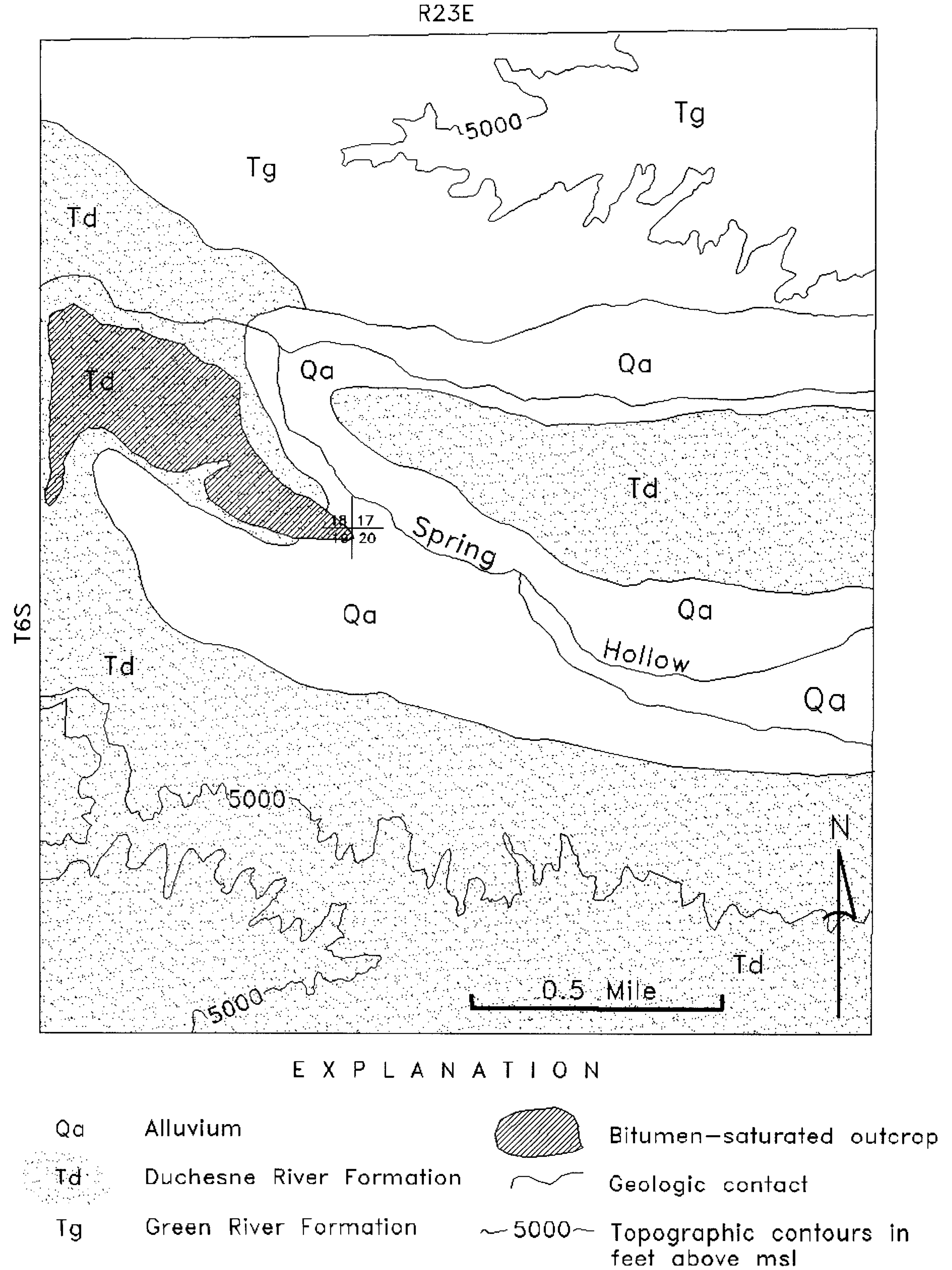


Figure 52. *General geology of the Spring Hollow tar-sand area (after Rowley and others, 1985; tar-sand outcrops from unpublished UGS file data).*

Tabiona

Location and Access

The Tabiona deposit lies on the northern flank of the Uinta Basin, and is about 2.5 miles (4 km) north of the town of Tabiona (figure 25). The deposit consists of two separate areas; one area is located near the head of a small canyon off of Little Valley, and the other near the bottom of Little Valley. The deposit is located in the SE¼ section 16 and S½S½ section 17, T.1S., R.7W., (USM), Duchesne County.

Access to the area is gained from State Highway 35 about 2 miles (3.2 km) northwest of the town of Tabiona. From here, travel is by unimproved roads and trails for 1 to 2 miles (1.6-3.2 km) east from SR-35.

Physiography and Land-Use

Bitumen-saturated outcrops are found in rugged and wooded terrain within the marginal benches subsection of the Uinta Mountains physiographic province. Outcrops in the eastern area are in a narrow, heavily wooded canyon between 7,150 and 7,400 feet (2,179-2,256 m) elevation, and are about 0.7 miles (1.1 km) from the nearest 4-wheel-drive access road. The western outcrops are in open, brush-covered terrain at about 7,000 feet (2,134 m) elevation, and are generally along the north face of an east-west trending ridge along the north side of Little Valley. Lands involved are part of the Indian Lands within the Uinta and Ouray Indian Reservation. Total surface area for both parts of the deposit is less than 0.5 square mile (1.3 km^2).

Geologic Setting

The deposit is located along the northern margin of the Uinta Basin in a belt of south-dipping beds that mark the basin margin. The Mesaverde Group (Upper Cretaceous), which crops out about one mile (1.6 km) north of the deposits, dips 45 to 50 degrees southward (figure 53). The Current Creek Formation (Tertiary-Cretaceous) overlies the Mesaverde Group, and the Duchesne River Formation (Eocene) lies unconformably above the Current Creek Formation. The Current Creek dips 26 degrees southward. Bedding attitudes generally flatten through successively younger formations southward toward the center of the basin.

Bitumen-saturated rocks are in the Current Creek and Duchesne River Formations in the two areas. The eastern part of the deposit is in the Current Creek Formation at the north end of a short lineament traceable on aerial photographs from Tonigut Spring in the NE¼SW¼ section 23, and trending N.60°W. through a spring near the SW corner of section 15. Garvin (1969) noted anomalous steep dips and fracturing in the deposit area. Part of this deposit occurs along the contact between the Current Creek and Duchesne River Formations. Average difference in dip between the Currant Creek and Duchesne River Formations is between 10 and 15 degrees. At the intersection of the lineament with the unconformable contact, however, near-vertical Current Creek rocks are overlapped by Duchesne River rocks that dip southward 30 degrees. Garvin (1969) suggested the lineament appears to be the surface expression of deep-seated faulting.

The eastern part is near the bottom of a narrow, unnamed canyon where steeply dipping sandstones of the Currant Creek Formation are impregnated with yellow-brown, waxy oil. The sandstones are fine to medium grained, friable, porous, and weather to a light gray and tan color. The sandstone is moderately saturated, yellow-brown, and has a strong odor of oil on fresh fractures. Bitumen is spotty and decreases away from fractured zones. Clay-gouge in zones of small-scale faulting is normally unsaturated. Fractures and bedding planes appear to be the principal conduits for migration of the oil.

Bitumen extends upward from Currant Creek sandstones into the basal sandstone of the Duchesne River Formation [previously called the Uinta Formation by Garvin, (1969)]. Bitumen-saturation in the Duchesne River sandstones ranges from moderate to very rich and continues upward to the top of the canyon wall where the Duchesne River Formation is capped by unconformable coarse conglomerate, probably Bishop Conglomerate.

Basal sandstone units of the Duchesne River Formation are saturated for about 1,000 feet (305 m) east to west along the outcrop and for 100 to 150 feet (30-45 m) above the base of the formation. The lateral limits of the deposits are sharp. In contrast to the Currant Creek Formation occurrence, bitumen in the Duchesne River is black, less waxy, volatile, and imparts a tough, rubbery cement to the otherwise friable sandstone. Tar sands in the Duchesne River are medium to coarse grained and contain lenses of coarse sandstone and conglomerate.

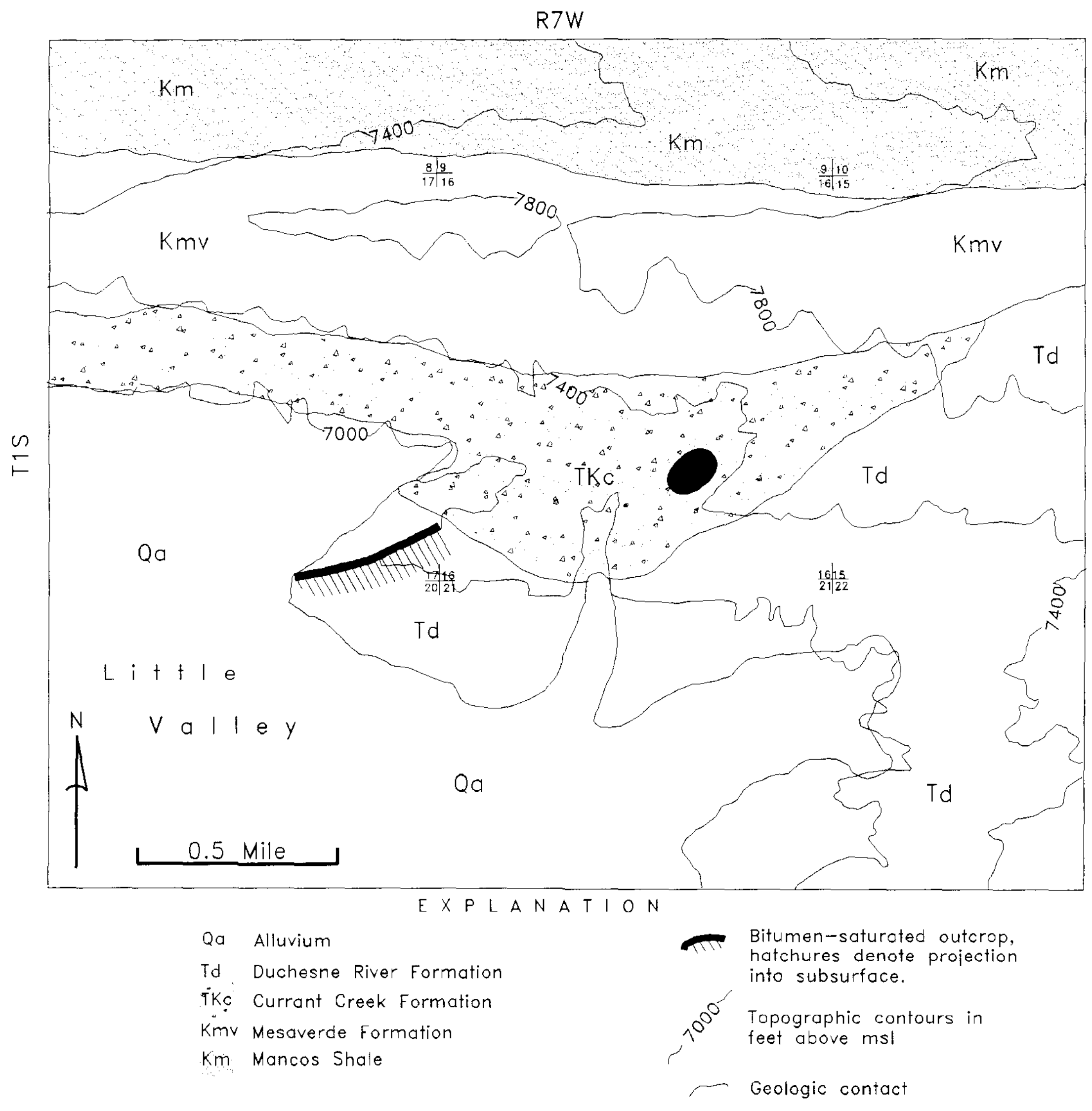


Figure 53. *General geology of the Tabiona tar-sand deposit (after Bryant, 1992; tar-sand outcrops from K. Clem, unpublished data).*

Tar sands crop out in the western part of the deposit along the north face of a ridge of south-dipping Duchesne River sandstone. Bitumen occurs in three zones, about 85 feet thick (26 m), of alternating sandstone, siltstone, and shale. Bitumen is more persistent in the lower two zones, which comprise about 45 feet (14 m) of the section. In friable, porous sandstones the rock is deeply weathered and dry. The lithified zones are more saturated and show sheens of liquid oil on fresh fractures. Conglomerate lenses in the upper zone contain cobbles and pebbles of sandy limestone with vugs filled with bitumen. In the western part of the deposit, no bitumen was found in the Currant Creek Formation where it is exposed below the Duchesne River Formation. The deposit is mostly in fine- to coarse-grained sandstone and conglomerate.

Ritzma (1979) estimated that 1.3 million barrels of oil are contained in both eastern and western deposits.

Bitumen Analyses

Wood and Ritzma (1972) reported the results of analyses of three bitumen samples from different parts of the deposit (table 2). API gravity ranged from 4.9 to 9.8 and sulfur contents ranged from 0.20 to 0.29 percent. Sulfur isotope analysis of one sample yielded a value for $\delta^{34}S$ of +5.9 permil (Mauger and others, 1973).

Development History

The Tabiona deposit is an important occurrence in the context of migration and entrapment of oil. Presence of a possible trap of live oil in the subsurface has also attracted interest as a possible exploration target. No exploration or development, however, has taken place for the tar-sand resource.

Thistle Area

Location and Access

The Thistle tar-sand deposit consists of two areas of bitumen-saturated outcrops, located about 2 miles (3.2 km) apart and separated by Spanish Fork Canyon (figures 25 and 54). The locality is named for a small town in the southern part of Utah County which was destroyed in 1983 by a flood caused by a landslide-dam near the confluence of Thistle and Soldier Creeks. The northern tar-sand outcrop area is in sections 26-28, T.9S., R.4E. The southern tar-sand outcrop area is in sections 3, 4, 9, and 10, T.10S., R.4E. In the northern area the tar-sand outcrops extend east-west for 1.3 miles (2 km) along the north wall of the canyon within one mile (1.6 km) of U.S. Highway 6 and a main line of the Denver and Rio Grande Western Railroad. In the southern area, bitumen-saturated outcrops extend from high ledges along the west side of Lake Fork Canyon northward, then southwestward in Wildcat Canyon. Access to the two areas is by Jeep trails and foot paths from U.S. Highway 6.

Peterson and Ritzma (1972) briefly discuss tar-sand deposits at Oil Hollow, a tributary to upper Lake Fork Creek where small exposures of bitumen-saturated sandstone crops out at the head of the tributary. This occurrence, described earlier in this report, is located about 6 miles (9.6 km) southeast of the confluence of Soldier Creek (Spanish Fork Canyon) and Lake Fork Creek.

Physiography and Land-Use

The area is mountainous, situated near the southern margin of the Middle Rocky Mountains physiographic province. Elevations in the northern outcrop area are around 5,800 feet (1,768 m). Elevations of the southern outcrops range from 5,600 to about 6,300 feet (1,707-1,920 m), since the exposure wraps around an unnamed mountain that has a peak elevation of 6,614 feet (2,016 m).

Along the northern outcrops, land ownership is a combination of private lands and federal lands managed by the USDA Forest Service, Uinta National Forest. In the southern outcrop area, the surface ownership is mostly private, but the Federal Government has reserved a patchwork of mineral ownership. The boundary of the Manti-La Sal National Forest lies 1 to 2 miles (1.6-3.2 km) southeast of the southern outcrop area (figure 54). Private land in the area is used for summer home sites and grazing. National Forest lands are typically used for summer-range grazing and for harvesting wood products.

Geologic Setting

Pinnell (1972) mapped the surface geology in the area surrounding the deposits and described the geologic units. Peterson and Ritzma (1972) studied the deposit(s) and reported some analytical results. The deposit is located in complex geologic terrain on the east (leading) edge of the Sevier orogenic belt where Mesozoic and older formations were thrust upon younger rocks along the southwest margin of the Uinta Basin during the Cretaceous Period. The North Horn, and Flagstaff Formations (latest Cretaceous-Paleocene), rest unconformably on the Price River Formation, which in-turn rests unconformably on highly folded and faulted Cretaceous and Jurassic rocks. The post-Sevier formations (North Horn and Flagstaff Formations), which were deposited against and across rocks of the overthrust complex, are much less deformed.

The northern area tar-sand deposit (figure 55) is in a group of fairly continuous lacustrine, sandstone lenses within the Flagstaff Formation that extend along a sinuous outcrop for 1.8 miles (2.9 km). Bitumen also occurs in interbedded oolitic limestone that grades laterally and vertically into sandstone. High-angle faults truncate this deposit on both east and west sides, although some bitumen persists across the west bounding fault into section 28. The bitumen-saturated zone is about 70 feet thick (21 m) on the west side, and 50 feet (15 m) thick on the east side. Four small-displacement faults cut the bitumen-saturated beds (Peterson and Ritzma, 1972).

In the southern part of the deposit (Asphaltum mine), the bitumen-saturated zone crops out for a distance of about 2 miles (3.2 km), curving from east to west around the flanks of a mountain and following a dip-slope within the Flagstaff Formation. The saturated zone is about 20 feet (6.1 m) thick on the northern tip of the mountain and thins to a feather edge about 1 mile (1.6 km) south in Wildcat Canyon. The lithology of the bitumen-saturated zone in the lower part of the Flagstaff Formation is similar to that of the northern area. The outcrops are mostly concealed beneath vegetation; only a few good exposures are observed in and near old adits. Pinnell (1972) mapped

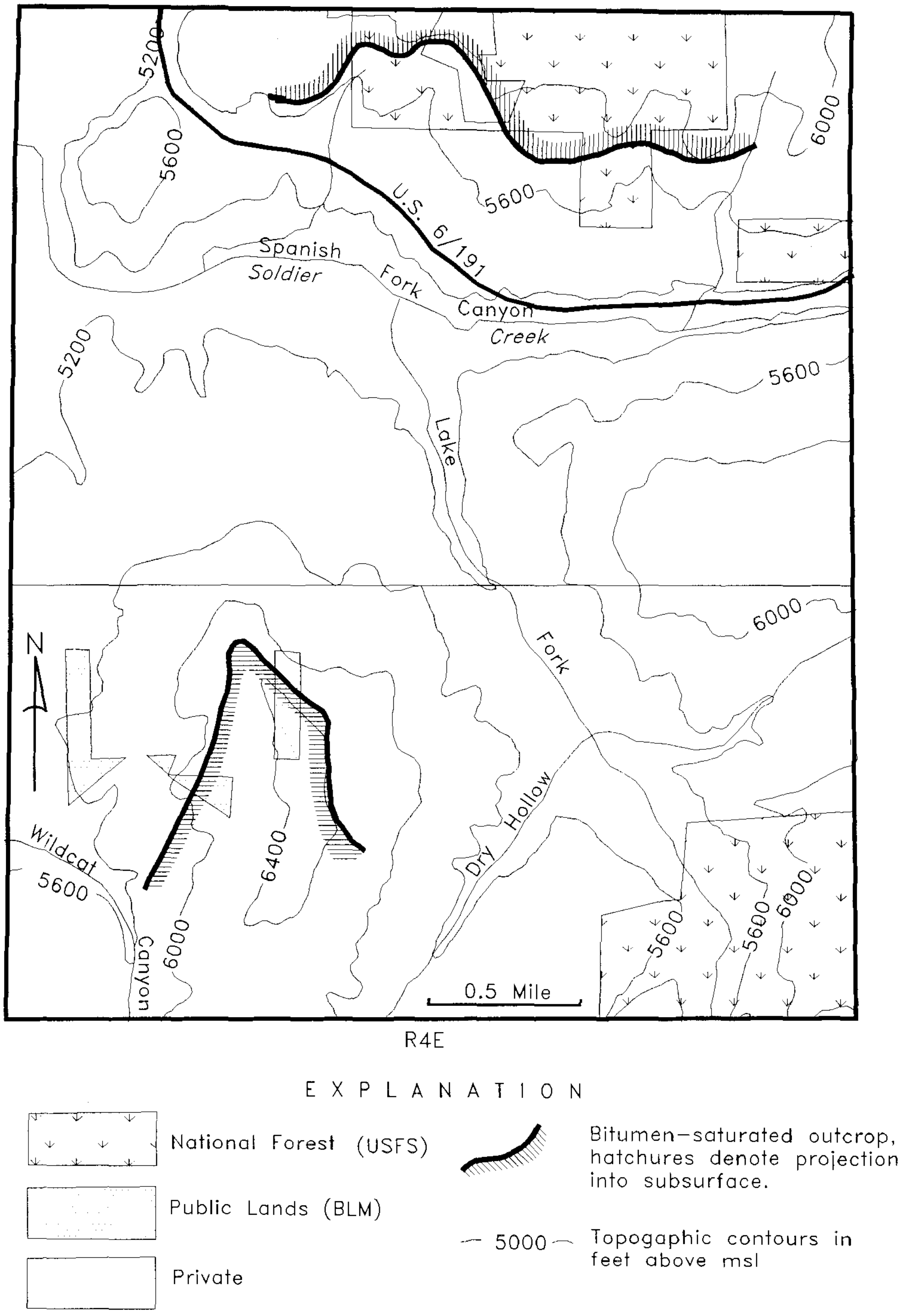
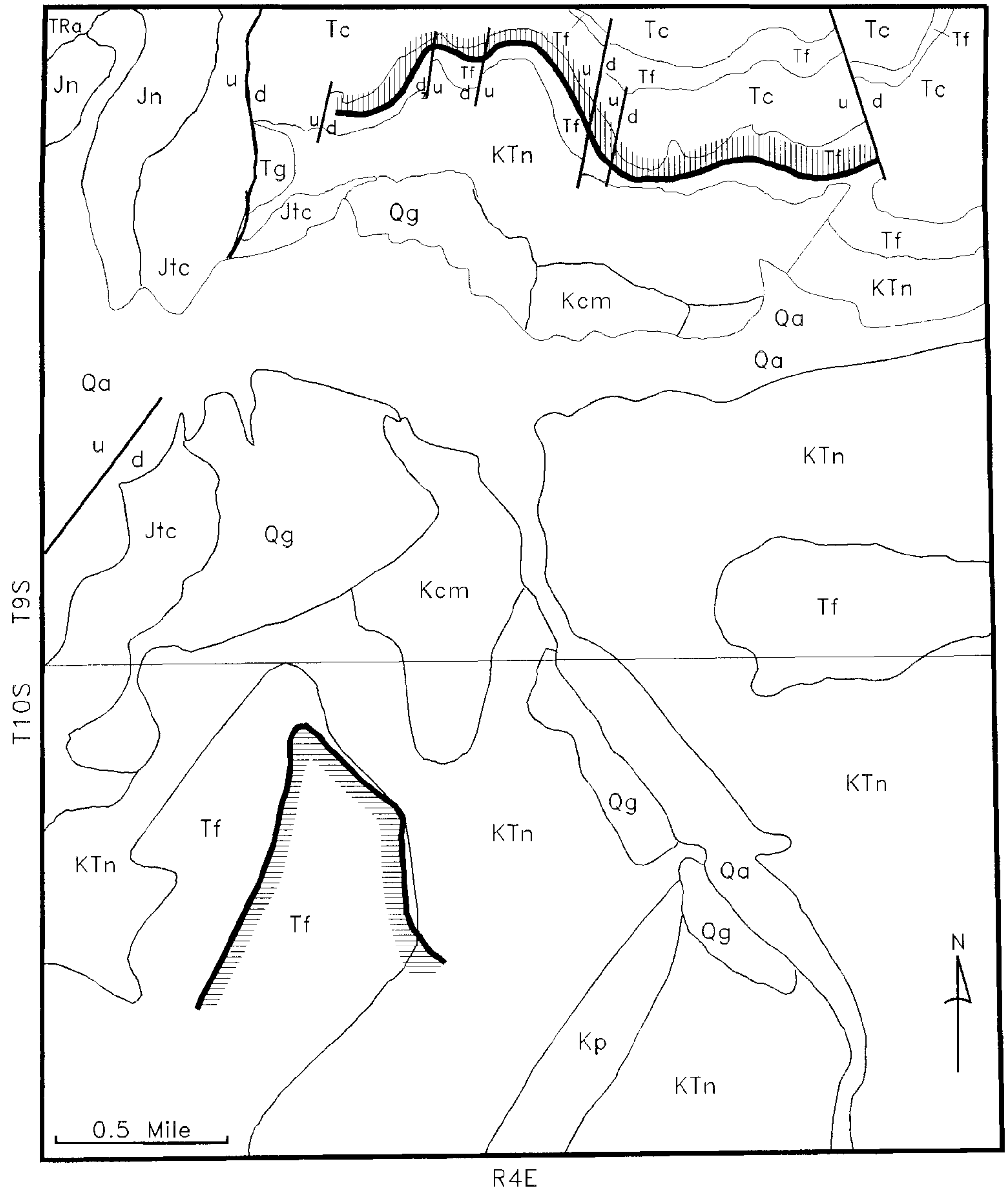


Figure 54. Land-ownership map of the Thistle tar-sand deposit area.



E X P L A N A T I O N

Qa	Alluvium	Kp	Price River Formation
Qg	Terrace gravel	Ki	Indianola Group
Tg	Green River Formation	Kcm	Cedar Mountain Formation
Tc	Colton Formation	Jtc	Twin Creek Limestone
Tf	Flagstaff Formation	Jn	Nugget Sandstone
KTn	North Horn Formation	TRa	Ankareh Shale

Bitumen-saturated outcrop, hatchures denote projection into subsurface.

Geologic contact

Fault

Figure 55. General geology of the Thistle tar-sand area (after Pinnell, 1972; and Young, 1976; tar-sand outcrops after Peterson and Ritzma, 1972).

the area surrounding the Oil Hollow occurrences as Green River Formation (Eocene) within the footwall of the Martin Mountain Fault.

The most common reservoir rock is calcareous sandstone which tends to be medium to coarse grained, well sorted, and porous. Interbedded with the sandstone is oolitic coquina containing fossil snails and clams, and oolitic, sandy limestone.

Ritzma (1979) estimated the resource for both northern and southern deposits between 2.2 and 2.5 million barrels, and included Oil Hollow in this estimate.

Bitumen Analyses

Peterson and Ritzma (1972) reported the results of analyses of a bitumen sample collected from the Asphaltum mine (table 2). The material yielded nearly 15 percent bitumen by weight, with sulfur content of 1.07 percent.

Development History

Peterson and Ritzma (1972) describe prospect pits, adits, haulage roads, and loading facilities at the Asphaltum mine. They also reported that the material was used extensively for paving streets in Utah towns, but cited no reference for this information. More recent reconnaissance, however, shows little evidence today of past tar-sand mining, possibly due to considerably more vegetative cover (C. Bishop, UGS, verbal communication, January 1996). At Oil Hollow, they reported an obscured bulldozer cut and remnants of a simple retorting operation (circa 1950).

Upper Kane Hollow

Location and Access

The Upper Kane Hollow tar-sand deposit consists of two small areas of bitumen-saturated rocks exposed about 2.5 miles (4 km) south of U.S. 40 in the area known as "The Rim Rock." This area is between Asphalt Ridge and Raven Ridge in the SW¼SW¼SW¼ section 13; and the NE¼NE¼NE¼ section 24, T.6S., R.23E. (SLM), northeastern Uintah County (figure 25). U.S. Highway 40 provides access to the area, which lies about 20 miles (36 km) southeast of Vernal. The outcrops can be approached by 4-wheel-drive vehicle, but are accessible only on foot over rough terrain.

Physiography and Land-Use

The deposit lies along the west side of a number of low-lying, west-northwest-trending hogbacks, collectively called the Rim Rock, that extend from Powder Springs Wash northwestward to upper Kane Hollow. The area is hilly, cut by deep gullies and washes. The Rim Rock, Cow Wash, and Upper Kane Hollow tar-sand deposits occur along this trend. The bitumen-saturated outcrops on the west side of the Upper Kane Hollow deposit are located along the steep sides of Kane Hollow at an elevation of about 5,050 feet (1,539 m). Tar-sands on the east side of the deposit crop out along the west bank of a small, unnamed tributary of upper Kane Hollow at an elevation of about 5,150 feet (1,570 m). Surface ownership in the area is mainly Public Land (BLM administered) with several scattered state school sections (SITLA administered). A contiguous tract of 640 acres of private land is situated within 2 miles (3.2 km) northeast of the deposit. Land is used mainly for stock grazing and oil and gas development.

Geologic Setting

The Upper Kane Hollow tar-sand deposit is one of many similar occurrences situated along the north flank of the Uinta Basin. The deposit is in sandstone beds in the Parachute Creek Member of the Green River Formation (Eocene), which dip south-southwest from 25 to 30 degrees (figure 56). In this area the Green River Formation overlies the Wasatch Formation (Eocene-Paleocene) and Mesaverde Group (Upper Cretaceous) with angular discordance. The Green River rests unconformably on Mesaverde beds that dip from 60 to 65 degrees south-southwest (Doelling and Graham, 1972).

The east side of the deposit is in an area of tightly compressed folds and small-displacement faults. Bitumen saturation is heaviest close to the faults, suggesting a genetic relationship.

Tar sands occur in discontinuous sandstone lenses which are medium to coarse grained and locally conglomeratic. Most are friable and soft, but some resistant ledges are calcareous and well-cemented. Bitumen is localized and varies in degree of saturation from very weak to moderate. Much of the bitumen is dry and disintegrates to powder when struck with a pick. Maximum thickness of impregnated sandstone in the eastern outcrop area is 15 feet (4.6 m). Maximum thickness of the western outcrops is about 23 feet (7 m). Total area of the deposit is estimated to be about five acres.

Bitumen Analyses

Wood and Ritzma (1972) extracted and analyzed one sample of bitumen from this deposit (table 2). The sample yielded an API gravity of 7.6 with a sulfur content of 0.32 percent, very close to the average of analyses from other Uinta Basin tar-sand deposits.

Development History

Discovery of this and other tar-sand occurrences in the Asphalt Ridge-Raven Ridge trend is thought to have helped promote exploration that led to the discovery of petroleum in the Green River Formation in the Red Wash Field situated 4 to 5 miles (6.4 to 8 km) to the south.

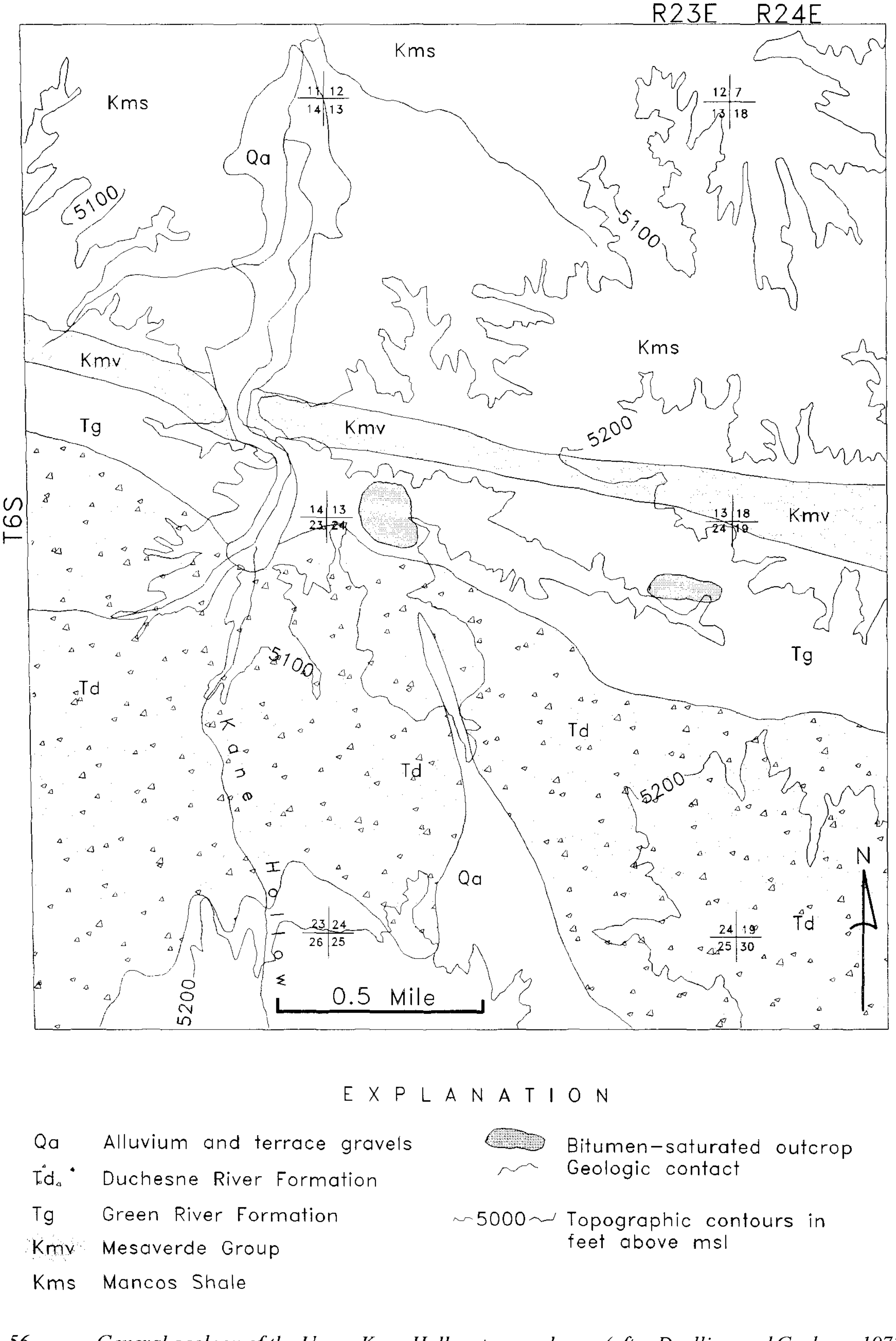


Figure 56. *General geology of the Upper Kane Hollow tar-sand area (after Doelling and Graham, 1972; tar-sand outcrops from K. Clem, unpublished data).*

Whiterocks

Location and Access

The Whiterocks deposit lies on the northern flank of the Uinta Basin, 27 miles (43.5 km) north of Roosevelt, Duchesne County, and 30 miles (48 km) northwest of Vernal, Uintah County (figure 25). The deposit is located near the mouth of Whiterocks Canyon, and is directly northwest of the Littlewater Hills deposit. The deposit is in sections 17-19, T.2N., R.1E., and section 24, T.2N., R.1W. (USM), Uintah County, and covers an area of about 400 acres. The deposit is found on the USGS Ice Cave Peak 7.5-minute quadrangle.

Access to the deposit is via various county roads either west from Vernal or north from Roosevelt toward the town of White Rocks. From White Rocks, there is a graded road which parallels the east side of Whiterocks River, crossing the deposit.

Physiography and Land-Use

The deposit is found within the marginal benches subsection of the Uinta Mountains physiographic province. Bitumen-saturated sandstone crops out on the east and west sides of Whiterocks Canyon and is probably continuous beneath valley alluvium (figure 57). The main part of the deposit lies at an elevation of 7,200 feet (2,195 m). The valley area is mostly private land surrounded on three sides by the Ashley National Forest. To the south lies the Uinta and Ouray Reservation. The Whiterocks River has eroded through the deposit, forming a flood-plain as wide as 3,500 feet (1,158 m). The Whiterocks River is a major tributary to the Duchesne and Green Rivers. The bitumen-saturated and other formations form steep cliffs at the mouth of Whiterocks Canyon. The west wall rises about 300 feet (91 m) and the east wall rises about 500 feet (152 m) above the valley (Peterson, 1985).

Geologic Setting

Exposed strata consists primarily of steep, southeast-dipping Triassic and Jurassic rocks (figure 58). At the mouth of Whiterocks Canyon, the Wasatch Formation (Paleocene-Eocene) lies unconformably upon south-dipping rocks of the Mancos Shale and Mesaverde Group (Cretaceous). The Navajo Sandstone (Jurassic) lies unconformably above the Chinle Formation (Triassic) and unconformably below the Carmel Formation (Jurassic). Other formations exposed in Whiterocks Canyon include Precambrian, Cambrian, Mississippian, Pennsylvanian, Permian, Triassic, and Jurassic age rocks.

The Navajo Sandstone, which is also called the Nugget Sandstone in northeastern Utah, is bitumen-saturated in and around Whiterocks Canyon (figure 58). The Navajo is divided into two units; a thin-bedded lower unit, and a highly cross-stratified upper unit (Uyger and Picard, 1985). The Navajo is mostly of eolian origin, deposited in dune fields and interdune environments (Picard, 1975; Uygur, 1983). The enclosing Chinle and the Carmel Formations are comprised mainly of impervious shales that may have acted to seal in oil migrating into the Navajo.

The deposit is associated with the crest of a steep, south-plunging anticlinal nose (Whiterocks anticline) that subparallels the Whiterocks River. The influence of this structure on bitumen saturation is unknown.

Covington (1963) suggested several theories about the origin of the oil. He favored a Pennsylvanian age for the oil migrating from the Weber Sandstone. He also suggested the Green River Formation (Eocene) as a possible source due to similarities in chemical analyses. Sulfur isotopes (Mauger and others, 1973) support this theory.

The bitumen-saturated zone occurs almost entirely within the Navajo Sandstone, and is about 900 feet (274 m) thick. The deposit strikes N65°E for about 1.5 miles (2.4 km). The outcrop is covered on both sides by the Duchesne River Formation (Eocene-Oligocene).

The Navajo is a consolidated, fine-grained, and well-sorted subarkose. Poorly sorted zones of sandstone with a bimodal grain-size distribution are also present. Mineralogically, the Navajo Sandstone is mature and relatively uniform, with varying amounts of clays, iron oxides, and carbonate cements. Shale, siltstone, and calcareous zones are uncommon. Fracturing is common, although orientation is variable. The degree of bitumen saturation is dependent on permeability and is, therefore, not uniform; barren zones are adjacent to rich zones.

Numerous resource estimates have been calculated for the Whiterocks deposit. Severy (1943) estimated resources of 9.52 million barrels based on outcrop mapping. Based upon the results of 11 core-holes, Shirley (1961)

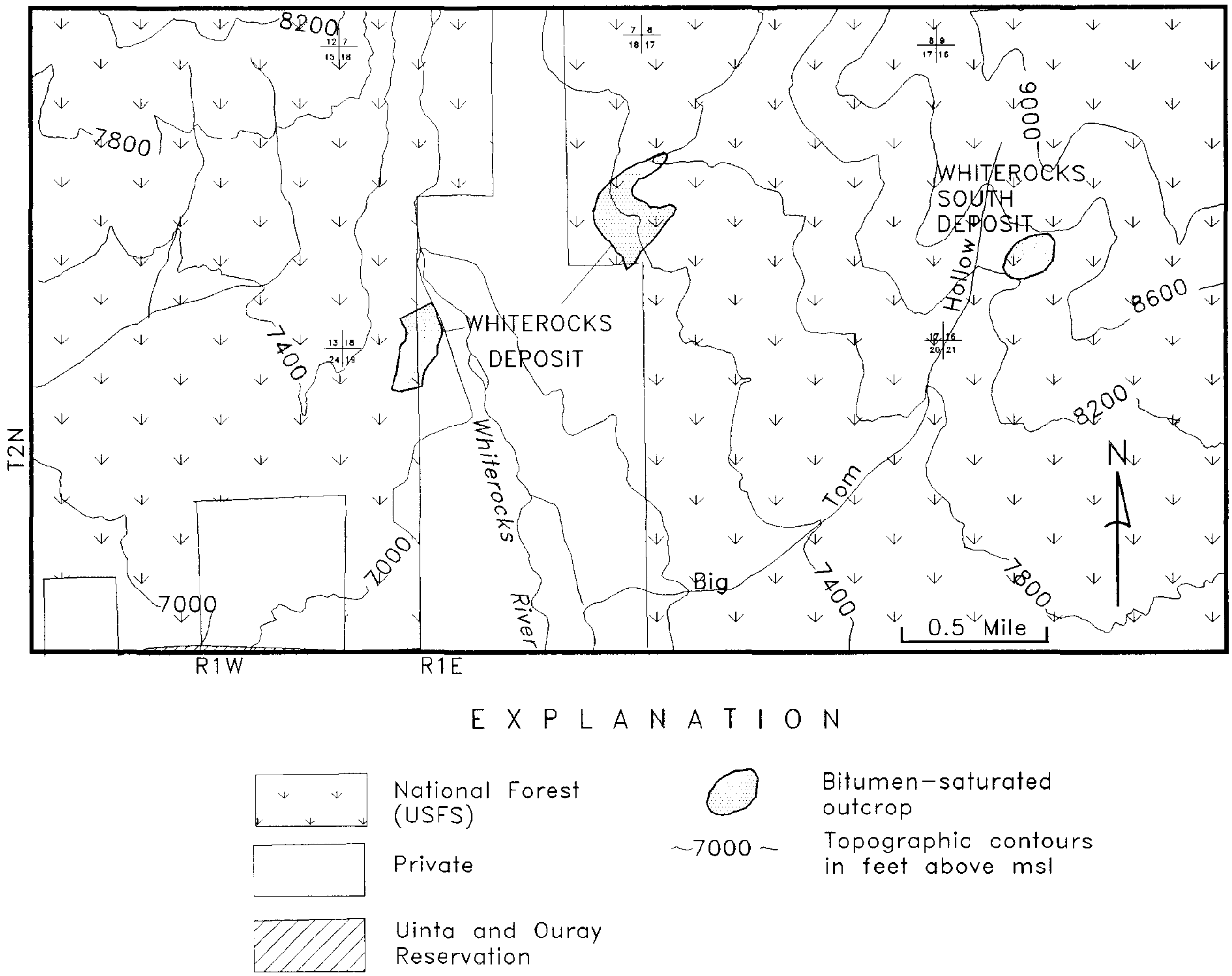


Figure 57. Land-ownership map of the Whiterocks and Whiterocks South tar-sand area.

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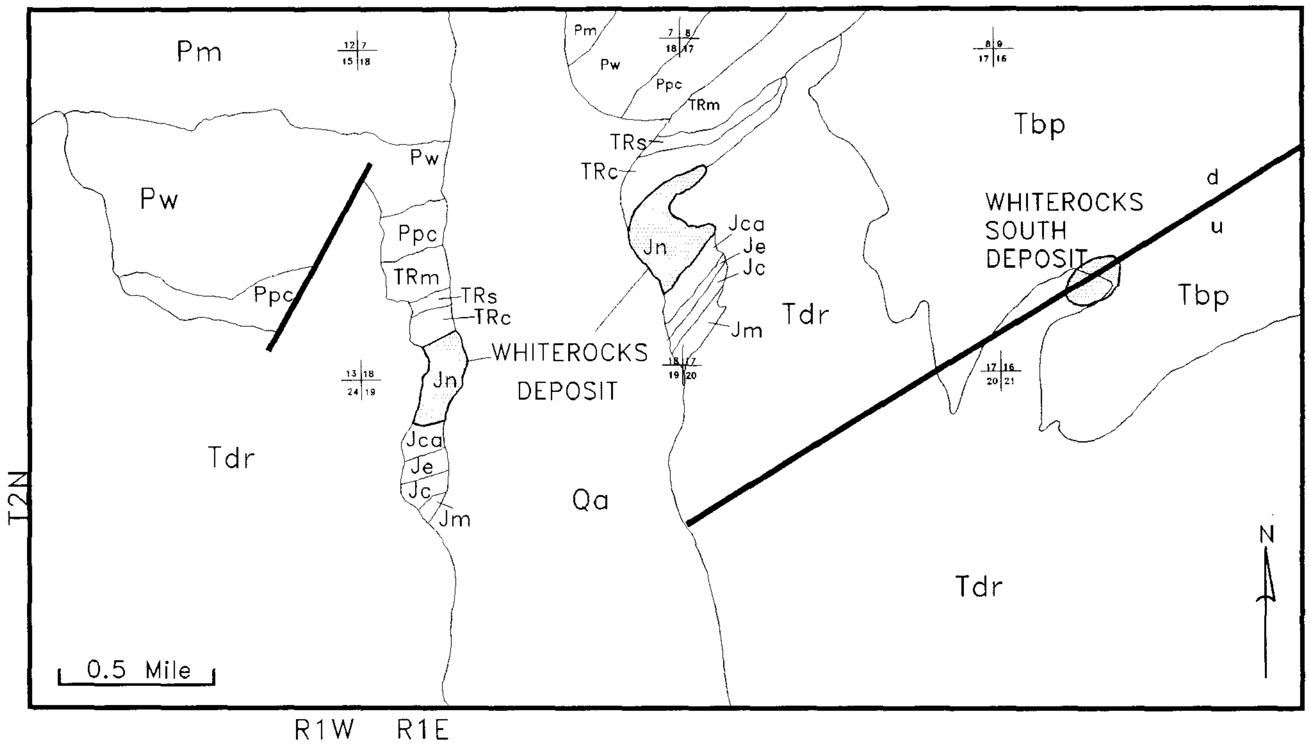

E X P L A N A T I O N

Qa Alluvium
Tbp Browns Park Formation
Tdr Duchesne River Formation
Jm Morrison Formation
Jc Curtis Formation
Je Entrada Formation
Jca Carmel Formation
Jn Navajo Formation

TRc Chinle Formation
TRs Shinarump Formation
TRm Moenkopi Formation
Ppc Park City Formation
Pw Weber Sandstone
Pm Morgan Formation

Bitumen–saturated outcrop
Geologic contact
Fault

Figure 58. General geology of the Whiterocks and Whiterocks South tar-sand areas (after Covington, 1964; tar-sand outcrops from K. Clem, unpublished data).

calculated total resources of 105 million barrels. Of this total, Shirley classified 57 million barrels as proven reserves and 27 million barrels as probable resources. Covington (1963), using existing core-hole data and results of surface mapping, estimated approximately 50 million barrels. Lewin and Associates (1984) reported a measured resource of 60 million barrels in-place for 200 acres, with speculative resources of another 60 million barrels on 200 acres, calculating 600 feet (183 m) of saturation. Peterson (1985) suggested that the deposit contains more than 100 million barrels of oil in-place. Campbell (1975a) calculated 37.3 million barrels of oil-in-place, assuming 182 acres with 500 vertical feet (152 m) of saturation. Ritzma (1979) classified the deposit as "very large," with 65 to 125 million barrels of oil in-place. From this he categorized 50 million barrels as measured, 15 million barrels as indicated, and the remainder inferred.

It is interesting to note that the lower portion of the Duchesne River Formation, which overlies the eastern extent of the deposit, contains saturated pebbles of Navajo Sandstone. Bitumen occurs in the Duchesne River Formation, however, only along the contact with the Navajo Sandstone. This might indicate that oil migration was prior to deposition of the Duchesne River Formation.

Bitumen Analyses

Wood and Ritzma (1972) reported standard analyses of bitumen samples from the deposit, and Mauger and others (1973) presented data for sulfur isotopes (table 2). Sample 68-10E was collected from the Navajo Sandstone prospect pit, located in the SW¼NE¼SE¼ section 18, T.2N., R.2E. The WR-1, WR-2, and WR-3 samples are from the Navajo, located at T.2N., R.1E.

Development History

Peterson (1985) reported the results of exploratory drilling and presented a brief synopsis of development activities. Tar-sand exploration and development at Whiterocks until the 1940s was limited to small mining operations in pits and adits. In 1957 and 1958, three exploratory wells were drilled along the trend of the deposit in an effort to find liquid crude-oil. Two extraction plants were constructed in the early 1960s and used hot water and solvents in their processes. Also in the early 1960s, White Rocks Oil Properties of Salt Lake City drilled 11 core holes in the deposit; nine of these drill holes reportedly penetrated the entire bitumen-saturated interval. Western Industries of Las Vegas, Nevada, opened a strip-mine and built a pilot plant along the east side of the Whiterocks River apparently in the late 1960s. Major Oil Company, in the early 1970s, opened a strip-mine and built a pilot plant on the west side of the Whiterocks River (Peterson, 1985). Although other companies conducted exploratory work in the early 1980s, no other processing facilities were constructed. The quarry on the west side of the Whiterocks River is now being mined by Duchesne county for highway paving use.

Whiterocks South

Location and Access

The Whiterocks South deposit lies on the northern flank of the Uinta Basin in the SW¼ section 16, T.2N., R.1E. (USM), Uintah County (figure 25). Access to the deposit is by various county roads either west from Vernal or north from Roosevelt to the town of Whiterocks. From Whiterocks, a graded road parallels the mountain front, on the east side of Whiterocks Canyon. Located about one mile (1.6 km) east of the Whiterocks deposit, the Whiterocks South deposit can only be reached by fire-control roads and hiking trails.

To date, no analytical data are available and no exploratory work has been done for the Whiterocks South tar-sand occurrence.

Physiography and Land-Use

The Whiterocks South deposits consists of one small, bitumen-saturated outcrop near the head of a small side-canyon (Big Tom Hollow) of Whiterocks Canyon, and lies entirely within Ashley National Forest. The occurrence is located in mountainous terrain at an elevation of about 8,500 feet (2,591 m), is mostly obscured by brush, and occupies an area of less than one square mile (figure 57).

Geologic Setting

The Whiterocks South deposit (figure 58) is geologically similar to the Littlewater Hills deposit located about three miles (4.8 km) to the southeast. The deposit is located on the north flank of the Uinta Basin in the belt of south-dipping beds that marks the basin margin in this area. One mile (1.6 km) east of this deposit, the Navajo Sandstone (Jurassic) dips 65 degrees south.

The Duchesne River Formation (Eocene-Oligocene) rests unconformable upon the buried Mesozoic section and is overlain by the Browns Park Formation (Miocene). The Duchesne River Formation is composed of diverse fluvial sedimentary rocks. These fluvial deposits consist of heterogeneous, laterally discontinuous sandstone lenses with varying amounts of conglomerate and poorly stratified, fine-grained rocks (Anderson and Picard, 1972). Along south-facing slopes, dense brush obscures exposures of the upper Duchesne River contact.

Bitumen saturates less than 15 feet (5 m) of the basal part of the Duchesne River Formation (Ball Associates, Ltd, 1964). A small northeast-trending fault in the area suggests a possible relationship to the bitumen occurrence. Ball Associates, Ltd. (1964) classified this deposit as a "minor" occurrence with no economic significance.

Willow Creek

Location and Access

The Willow Creek deposit is located on the southwest flank of the Uinta Basin, about 15 miles (24 km) north-northeast of Price in T.6-7S., R.8-9W. (USM), and T.11S., R.9-10E. (SLM), Duchesne, Utah, and Wasatch Counties (figure 25). Bitumen-saturated outcrops extend eastward from near the Utah-Duchesne County line to Willow Creek, a distance of about 4 miles (6.4 km). The elevation of bitumen-saturated outcrops range between 7,600 and 9,400 feet (2,317-2,865 m).

Vehicle access is gained by driving north from Price via U.S. Highway 6 for about 10 miles (16 km), then turning east onto State Highway 33. The Avintaquin Campground Road, located about 14 miles (23 km) from the Highway 6 turnoff, provides access to the northern outcrops. The Willow Creek Road, located about 10 miles (16 km) from the Highway 6 turnoff, provides access to the southern outcrops.

Physiography and Land-Use

The Willow Creek deposit is located on the western part of the southern limb of the Uinta Basin. The Roan Cliffs extend into the deposit area from the southeast, arbitrarily ending at Willow Creek. Willow Creek, a perennial stream, is the main drainage of the area, and flows southwest into the Price River. The surrounding area is characterized as high plateaus dissected by streams that form deep, steep-walled canyons. Emma Park, a homoclinal valley, lies less than 3 miles (5 km) south of the deposit area, and trends southeast to Whitmore Park along the base of the Roan Cliffs.

The southern boundary of the Ashley National Forest lies less than 1 mile (1.6 km) north of the outcrops. The main deposit area consists of a patchwork of private and state lands, and small tracts of Public Land (BLM administered) are scattered throughout the deposit area (figure 59). The Federal Government has reserved mineral rights on most of the private land in the area, and, as of 1980, had established protective withdrawals, presumably for solid hydrocarbons (U.S. Bureau of Land Management, 1980).

Geologic Setting

Strata exposed in Willow Creek are the upper part of the Garden Gulch Member and the basal part of the Parachute Creek Member of the Green River Formation (figure 60). The Garden Gulch Member consists of alternating thin sandstone, siltstone, shale, and limestone beds. The Parachute Creek Member consists of massive beds that become thin upward and consist of fine-grained sandstone, interbedded with siltstone and shale. The sandstone beds are fluvial-deltaic and exhibit channeling characteristics. Regional dip is northward from 4 to 6 degrees toward the center of the Uinta Basin.

Channel sandstones are commonly the bitumen-saturated units. Although extensive ground cover masks the surface expression of the deposit, Tripp (1986a) estimated total thickness of the saturated zone at about 80 feet (24 m). Surface evidence for much of the deposit is limited to bitumen-saturated "float," stones that have eroded from the deposit. Degree of saturation varies both vertically and horizontally. Ritzma (1979) classified the deposit as "large," and estimated that the Willow Creek deposit contains between 10 and 15 million barrels of oil in-place.

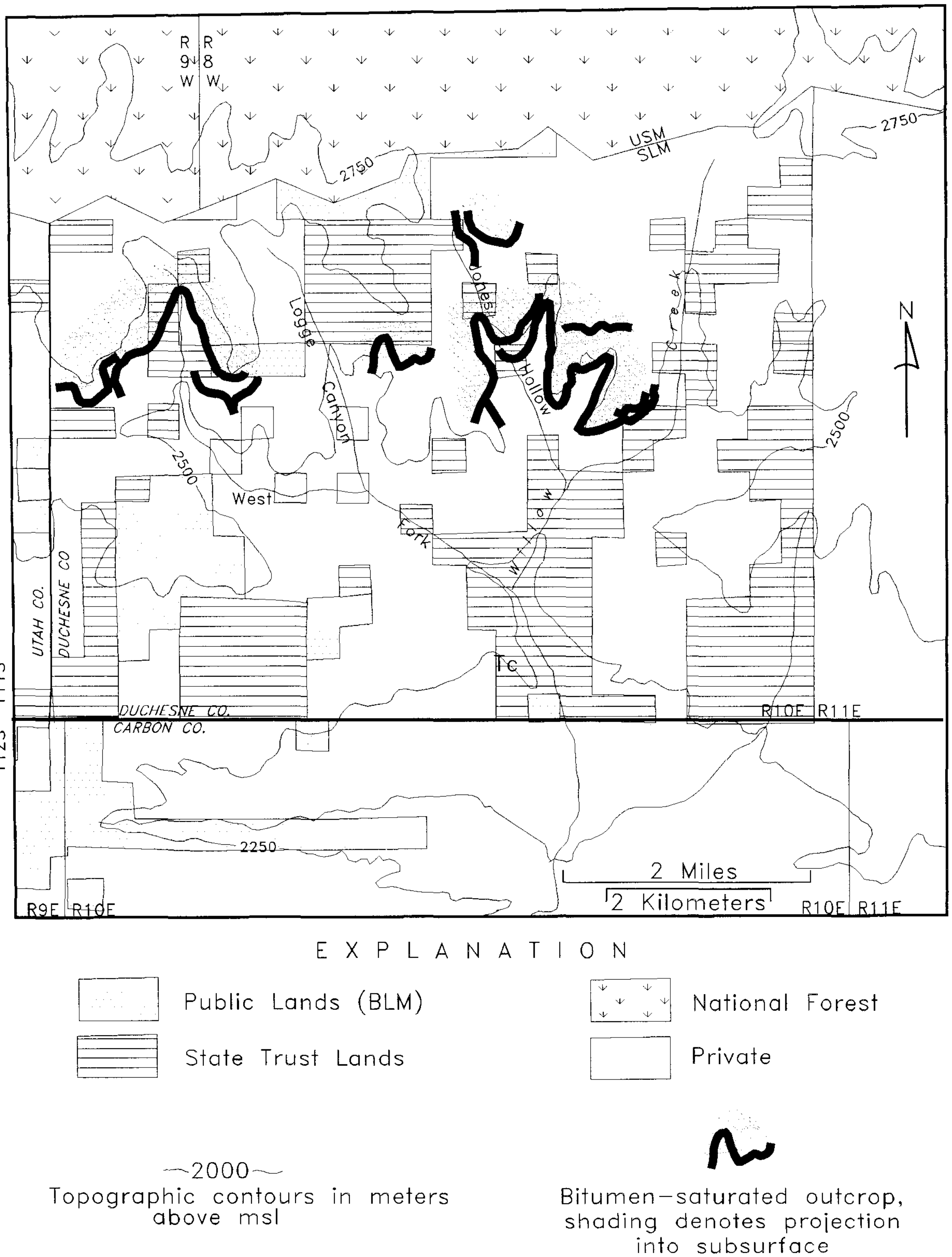

Figure 59. Land-ownership map of the Willow Creek tar-sand area.

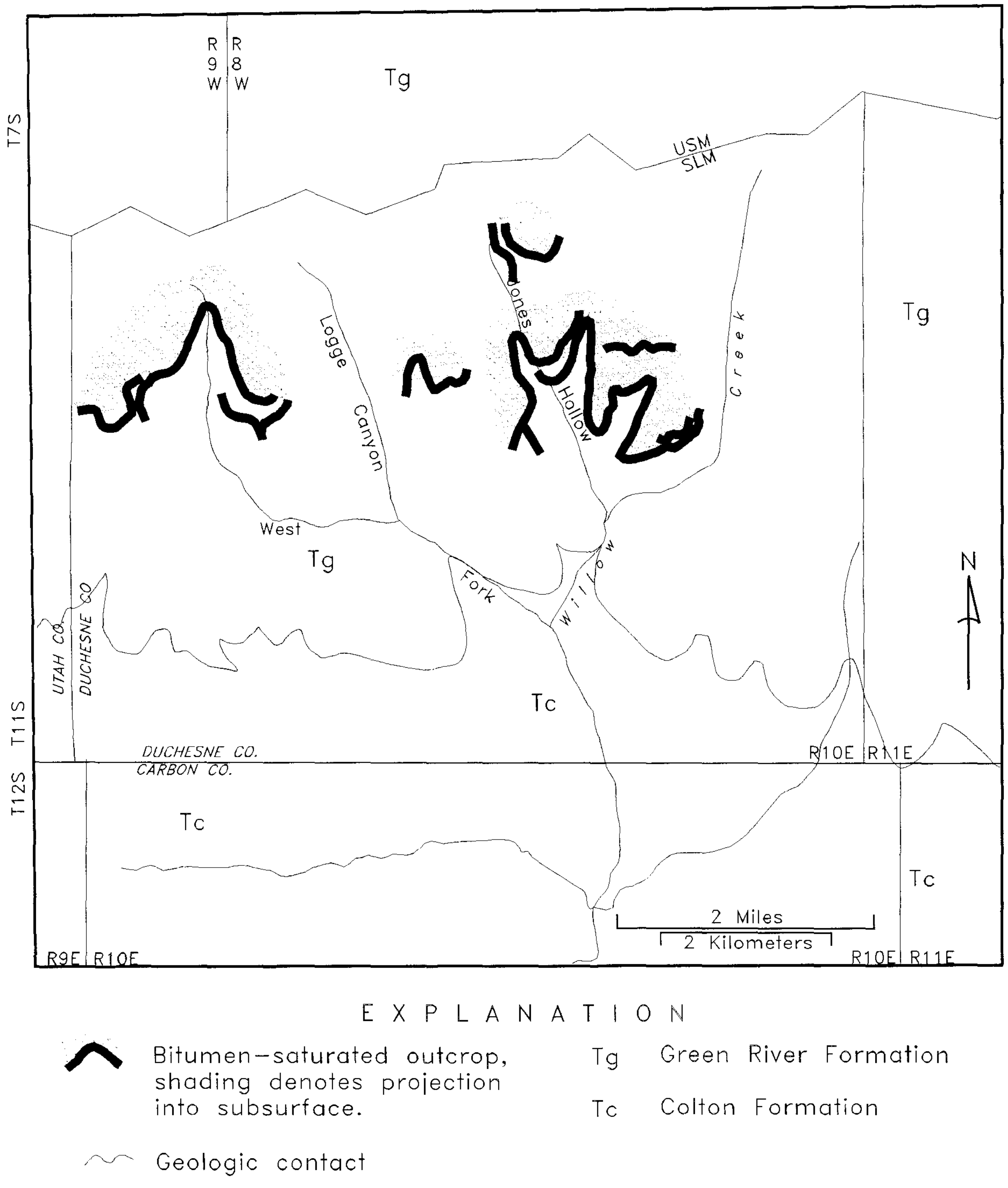

Figure 60. *General geology of the Willow Creek tar-sand area (after Witkind and others, 1978; tar-sand outcrops from K. Clem, unpublished data).*

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