Appendix A

PERMIT APPLICATION FORM

The following permit application form is designed to assist potential applicants in submitting a Ground Water Discharge Permit Application. This format is _not_ mandatory but only guidance. Applicants are free to use the format they deem appropriate as long as the requirements of R317-6-6.3 of the Ground Water Quality Protection Rules are met.

MAIL TO:
Division of Water Quality
Utah Department of Environmental Quality
Salt Lake City, Utah 84114-4870

Application No.:____________________
Date Received:____________________
(leave both lines blank)

UTAH GROUND WATER DISCHARGE PERMIT APPLICATION

Part A - General Facility Information

Please read and follow carefully the instructions on this application form. Please type or print, except for signatures. This application is to be submitted by the owner or operator of a facility having one or more discharges to groundwater. The application must be signed by an official facility representative who is: the owner, sole proprietor for a sole proprietorship, a general partner, an executive officer of at least the level of vice president for a corporation, or an authorized representative of such executive officer having overall responsibility for the operation of the facility.

1. **Administrative Information.** Enter the information requested in the space provided below, including the name, title and telephone number of an agent at the facility who can answer questions regarding this application.

Facility Name: **MCW Energy Group – Temple Mountain Mine**

Mail Address: **18653 Ventura Blvd Ste. 158, Tarzana, Ca 91356**

Facility Legal Location* County: **Uintah County, Utah**
T.__________, R.___________, Sec._________, __________1/4 of_________1/4,
Lat._________°_________'__________"N.Long.__________°__________'_________"W
SW1/4, W1/2 SE1/4 Section 31, T5S, R22E SLB&M; E1/2 SE1/4 S36, T5S, R21E SLB&M

*Note: A topographic map or detailed aerial photograph should be used in conjunction with a written description to depict the location of the facility, points of ground water discharge, and other relevant features/objects.

Contact's Name: **Donald Clark** Phone No.:**(718) 868-3763**
Title: **Chief Geologist – MCW Energy Group**

2. **Owner/Operator Information.** Enter the information requested below, including the name, title, and phone number of the official representative signing the application.

Owner
Name: **Vladimir Podlipskiy, Chief Technology Officer – MCW Energy Group**
Phone No.:**(323) 356 - 4768**

Mail Address: **10366 Roselle St. Suite B, San Diego, Ca 92121**
(Number & Street, Box and/or Route, City, State, Zip Code)

Operator
Name:___________________________Phone No.:(____)_________________________
(If different than Owner's above)

Mail Address:____
(Number & Street, Box and/or Route, City, State, Zip Code)

Official Representative
Name: **Donald Clark** Phone No.:**(718) 868-3763**
Title: **Chief Geologist – MCW Energy Group**

3. **Facility Classification** (check one)

[ ] New Facility

[ ] Existing Facility
[X] **Modification of Existing Facility**

4. **Type of Facility** (check one)

[] Industrial
[X] **Mining**
[ ] Municipal
[ ] Agricultural Operation
[ ] Other, please describe:______________________________

5. **SIC/NAICS Codes: SIC/NAICS code 13 1103 03 Tar Sands Mining**
6. Enter Principal 3 Digit Code Numbers Used in Census & Other Government Reports

7. **Projected Facility Life**: **20+ years**

8. **Identify principal processes used, or services preformed by the facility. Include the principal products produced, and raw materials used by the facility:**

See attached

9. **List all existing or pending Federal, State, and Local government environmental permits:**

		Permit Number
[ ]	NPDES or UPDES (discharges to surface water)	____________
[ ]	CAFO (concentrated animal feeding operation)	____________
[ ]	UIC (underground injection of fluids)	____________
[ ]	RCRA (hazardous waste)	____________
[]	PDS (air emissions from proposed sources)	____________
[ ]	Construction Permit (wastewater treatment)	
[ ]	Solid Waste Permit (sanitary landfills, incinerators)	____________
[ ]	Septic Tank/Drainfield	____________
[X]	Other, specify____________	**DOGM, LMO Permit**

9. Name, location (Lat.____°____’____”N,Long.____°____’____”W) and description of: each well/spring (existing, abandoned, or proposed), water usage(past, present, or future); water bodies; drainages; well-head protection areas; drinking water source protection zones according to UAC 309-600; topography; and man-made structures within one mile radius of the point(s) of discharge site. Provide existing well logs (include total depth and variations in water depths).

Name	Location	Description	Status	Usage

See Attached

The above information must be included on a plat map and attached to the application.

Part B - General Discharge Information

Complete the following information for each point of discharge to ground water. If more than one discharge point exists, photocopy and complete this Part B form for each discharge point.

1. **Location (if different than Facility Location in Part A):**
   County:________________________________
   T.__________, R.__________, Sec.__________, __________1/4 of __________1/4,
   Lat.__________°__________'__________"N.Long.__________°__________'__________"W

2. **Type of fluid to be Discharged or Potentially Discharged**
   (check as applicable)

   Discharges (fluids discharged to the ground) **None – See attached**

   [ ] Sanitary Wastewater: wastewater from restrooms, toilets, showers and the like
   [ ] Cooling Water: non-contact cooling water, non contact of raw materials, intermediate, final, or waste products
   [ ] Process Wastewater: wastewater used in or generated by an industrial process
   [ ] Mine Water: water from dewatering operations at mines
   [ ] Other, specify:________________________________

   Potential Discharges (leachates or other fluids that may discharge to the ground) – **Post processed oil sands will be returned to the Temple Mountain mine for backfill and mine remediation – see attached**

   [ ] Solid Waste Leachates: leachates from solid waste impoundments or landfills
   [ ] Milling/Mining Leachates: tailings impoundments, mine leaching operations, etc.
   [ ] Storage Pile Leachates: leachates from storage piles of raw materials, product, or wastes
   [ ] Potential Underground Tank Leakage: tanks not regulated by UST or RCRA only
   [**X**] Other, specify:________________________________

3. **Discharge Volumes**
   For each type of discharge checked in #2 above, list the volumes of wastewater discharged to the ground or ground water. Volumes of wastewater should be measured or calculated from water usage. If it is necessary to estimate volumes, enclose the number in parentheses. Average daily volume means the average per operating day: ex. For a discharge of 1,000,000 gallons per year from a facility operating 200 days, the average daily volume is 5,000 gallons.

Discharge Type:	Daily Discharge Volume (Average)	(Maximum)	all in units of
________	________	________	________
Not Applicable – see attached			
________	________	________	________

4. **Potential Discharge Volumes**
   For each type of potential discharge checked in #2 above, list the maximum volume of fluid that could be discharged to the ground considering such factors as: liner hydraulic conductivity and operating head conditions, leak detection system sensitivity, leachate collection system efficiency, etc. Attach calculation and raw data used to determine said potential discharge.

Discharge Type:	Daily Discharge Volume (Average)	(Maximum)	all in units of
________	________	________	________
Not Applicable – see attached			

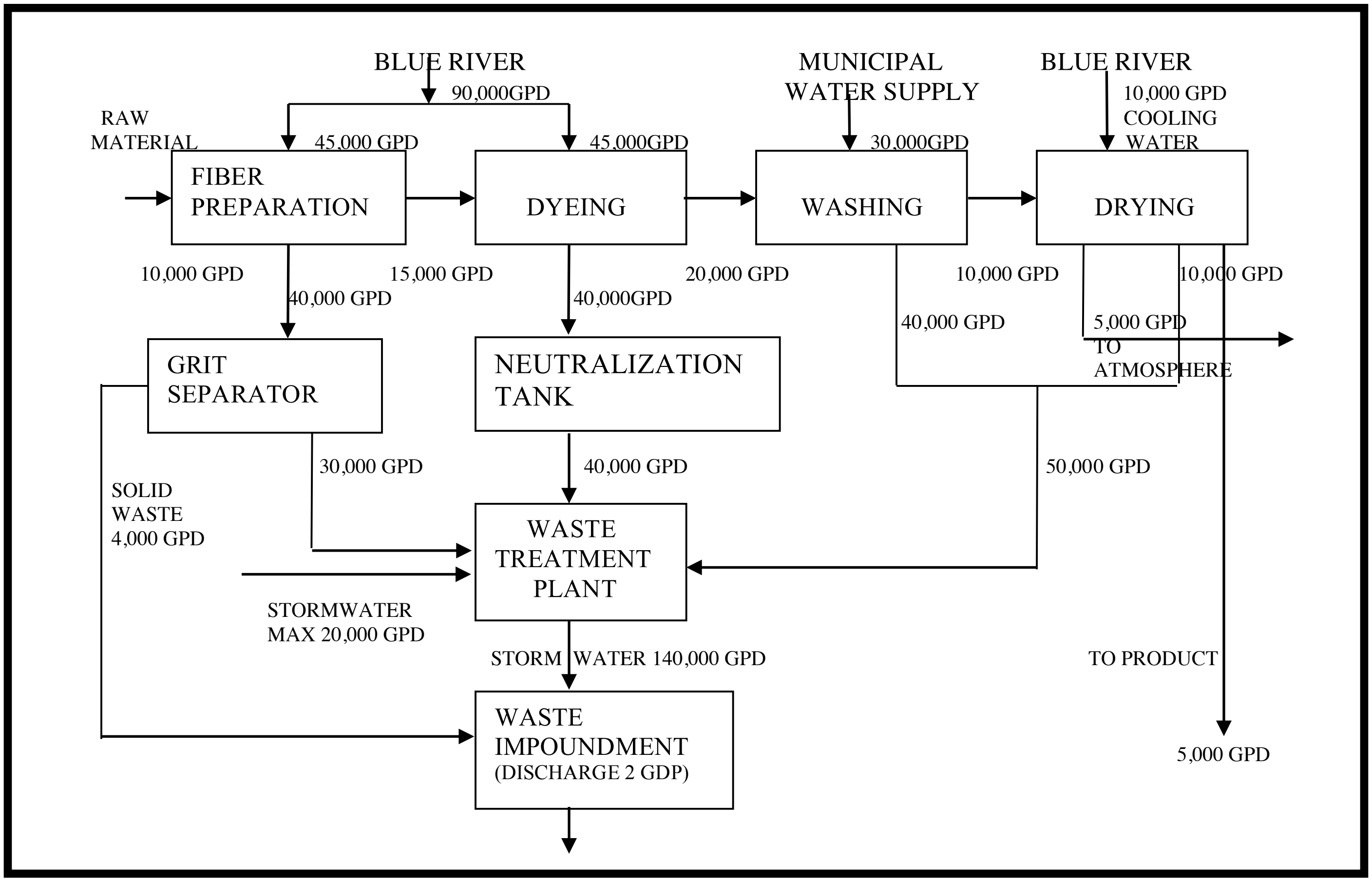
5. Means of Discharge or Potential Discharge (check one or more as applicable)

[ ] lagoon, pit, or surface impoundment (fluids)
[ ] land application or land treatment
[ ] discharge to an ephemeral drainage (dry wash, etc.)
[X] storage pile
[ ] landfill (industrial or solid wastes)
[ ] other, specify________________________
[ ] industrial drainfield
[ ] underground storage tank
[ ] percolation/infiltration basin
[ ] mine heap or dump leach
[ ] mine tailings pond

6. Flows, Sources of Pollution, and Treatment Technologies

Flows. Attach a line drawing showing: 1) water flow through the facility to the ground water discharge point, and 2) sources of fluids, wastes, or solids which accumulate at the potential ground water discharge point. Indicate sources of intake materials or water, operations contributing wastes or wastewater to the effluent, and wastewater treatment units. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and wastewater outfalls. If a water balance cannot be determined, provide a pictorial description of the nature and amount of any sources of water and any collection or treatment measures. See the following example.

See flow diagram in Appendix B of the attached



7. Discharge Effluent Characteristics

Established and Proposed Ground Water Quality Standards - Identify wastewater or leachate characteristics by providing the type, source, chemical, physical, radiological, and toxic characteristics of wastewater or leachate to be discharged or potentially discharged to ground water (with lab analytical data if possible). This should include the discharge rate or combination of discharges, and the expected concentrations of any pollutant (mg/l). If more than one discharge point is used, information for each point must be provided. **See attached.**

Hazardous Substances - Review the present hazardous substances found in the Clean Water Act, if applicable. List those substances found or believed present in the discharge or potential discharge. **See attached.**

Part C - Accompanying Reports and Plans

The following reports and plans should be prepared by or under the direction of a professional engineer or other ground water professional. Since ground water permits cover a large variety of discharge activities, the appropriate details and requirements of the following reports and plans will be covered in the pre-design meeting(s). For further instruction refer to the Ground Water Permit Application Guidance Document.

8. Hydrogeologic Report

Provide a Geologic Description, with references used, that includes as appropriate:

Structural Geology – regional and local, particularly faults, fractures, joints and bedding plane joints;
Stratigraphy – geologic formations and thickness, soil types and thickness, depth to bedrock;
Topography – provide a USGS MAP (7 ½ minute series) which clearly identifies legal site location boundaries, indicated 100 year flood plain area and applicable flood control or drainage barriers and surrounding land uses.

Provide a Hydrologic Description, with references used, that includes:
Ground water – depths, flow directions and gradients. Well logs should be included if available. Include name of aquifer, saturated thickness, flow directions, porosity, hydraulic conductivity, and other flow characteristics, hydraulic connection with other aquifers or surface sources, recharge information, water in storage, usage, and the projected aerial extent of the aquifer. Should include projected ground water area of influence affected by the discharge. Provide hydraulic gradient map indicating equal potential head contours and ground water flow lines. Obtain water elevations of nearby wells at the time of the hydrologic investigation. Collect and analyze ground water samples from the uppermost aquifer which underlies the discharge point(s). Historic data can be used if the applicant can demonstrate it meets the requirements contained within this section. Collection points should be hydraulically up and downgradient and within a one-mile radius of the discharge point(s). Ground water analysis should include each element listed in Ground Water Discharge Permit Application, Part B7.
NOTE Failure to analyze for background concentrations of any contaminant of concern in the discharge or potential discharge may result in the Executive Secretary's presumptive determination that zero concentration exist in the background ground water quality.
Sample Collection and Analysis Quality assurance – sample collection and Preservation must meet the requirements of the EPA RCRA Technical Enforcement Guidance Document, OSWER-9959.1, 1986 [UAC R317-6-6.3(I,6)]. Sample analysis must be performed by State of Utah certified laboratories and be certified for each of the parameters of concern. Analytical methods should be selected from the following sources [UAC R317-6-6.3L]: (Standard Methods for the Examination of Water and Wastewater, 20th Ed.,1998; EPA, Methods for Chemical Analysis of Water and Wastes, 1983; Techniques of Water Resources Investigation of the U.S. Geological Survey, 1998, Book 9; EPA Methods published pursuant to 40 CFR Parts 141, 142, 264 (including Appendix IX), and 270. Analytical methods selected should also include minimum detection limits below both the Ground Water Quality Standards and the anticipated ground water protection levels. Data shall be presented in accordance of accepted hydrogeologic standards and practice.

Provide Agricultural Description, with references used, that includes:
If agricultural crops are grown within legal boundaries of the site the discussion must include: types of crops produced; soil types present; irrigation system; location of livestock confinement areas (existing or abandoned).

Note on Protection Levels:

After the applicant has defined the quality of the fluid to be discharged (Ground Water Discharge Permit Application, Part B), characterized by the local hydrogeologic conditions and determined background ground water quality (Hydrogeologic Report), the Executive Secretary will determine the applicable ground water class, based on: 1) the location of the discharge point within an area of formally classified ground water, or the background value of total dissolved solids. Accordingly, the Executive Secretary will determine applicable protection levels for each pollutant of concern, based on background concentrations and in accordance with UAC R317-6-4.

9. Ground Water Discharge Control Plan:

Select a compliance monitoring method and demonstrate an adequate discharge control system. Listed are some of the Discharge Control Options available. **We believe the project qualifies for Permit by Rule under R317-6-6.2. Please see Attached.**

No Discharge – prevent any discharge of fluids to the ground water by lining the discharge point with multiple synthetic and clay liners. Such a system would be designed, constructed, and operated to prevent any release of fluids during both the active life and any post-closure period required.

Earthen Liner – control the volume and rate of effluent seepage by lining the discharge point with a low permeability earthen liner (e.g. clay). Then demonstrate that the receiving ground water, at a point as close as practical to the discharge point, does not or will not exceed the applicable class TDS limits and protection levels* set by the Executive Secretary. This demonstration should also be based on numerical or analytical saturated or unsaturated ground water flow and contaminant transport simulations.

Effluent Pretreatment – demonstrate that the quality of the raw or treated effluent at the point of discharge or potential discharge does not or will not exceed the applicable ground water class TDS limits and protection levels* set by the Executive Secretary.

Contaminant Transport/Attenuation – demonstrate that due to subsurface contaminant transport mechanisms at the site, raw or treated effluent does not or will not cause the receiving ground water, at a point as close as possible to the discharge point, to exceed the applicable class TDS limits and protection levels* set by the Executive Secretary.

Other Methods – demonstrate by some other method, acceptable to the Executive Secretary, that the ground water class TDS limits and protection levels* will be met by the receiving ground water at a point as close as practical to the discharge point.

*If the applicant has or will apply for an alternate concentration limit (ACL), the ACL may apply instead of the class TDS limits and protection levels.

Submit a complete set of engineering plans and specifications relating to the construction, modification, and operation of the discharge point or system. Construction Permits for the following types of facilities will satisfy these requirements. They include: municipal waste lagoons; municipal sludge storage and on-site sludge disposal; land application of wastewater effluent; heap leach facilities; other process wastewater treatment equipment or systems.

Facilities such as storage piles, surface impoundments and landfills must submit engineering plans and specifications for the initial construction or any modification of the facility. This will include the design data and description of the leachate detection, collection and removal system design and construction. Provide provisions for run on and run-off control.

10. **Compliance Monitoring Plan:**
The applicant should demonstrate that the method of compliance monitoring selected meets the following requirements: **We believe the project qualifies for Permit by Rule under R317-6-6.2. A collection lysimeter will be constructed as part of mine remediation. Please see Attached.**

Ground Water Monitoring – that the monitoring wells, springs, drains, etc., meet all of the following criteria: is completed exclusively in the same uppermost aquifer that underlies the discharge point(s) and is intercepted by the upgradient background monitoring well; is located hydraulically downgradient of the discharge point(s); designed, constructed, and operated for optimal detection (this will require a hydrogeologic characterization of the area circumscribed by the background sampling point, discharge point and compliance monitoring points); is not located within the radius of influence of any beneficial use public or private water supply; sampling parameters, collection, preservation, and analysis should be the same as background sampling point; ground water flow direction and gradient, background quality at the site, and the quality of the ground water at the compliance monitoring point.

Source Monitoring – must provide early warning of a potential violation of ground water protection levels, and/or class TDS limits and be as or more reliable, effective, and determinate than a viable ground water monitoring network.

Vadose Zone Monitoring Requirements – Should be: used in conjunction with source monitoring; include sampling for all the parameters required for background ground water quality monitoring; the application, design, construction, operation, and maintenance of the monitoring system should conform with the guidelines found in: Vadose Zone Monitoring for Hazardous Waste Sites; June 1983, KT-82-018(R).

Leak Detection Monitoring Requirements – Should not allow any leakage to escape undetected that may cause the receiving ground water the exceed applicable ground water protection levels during the active life and any required post-closure care period of the discharge point. This demonstration may be accomplished through the use of numeric or analytic, saturated or unsaturated, ground water flow or contaminant transport simulations, using actual filed data or conservative assumptions. Provide plans for daily observation or continuous monitoring of the observation sump or other monitoring point and for the reporting of any fluid detected and chemical analysis thereof.

Specific Requirements for Other Methods – Demonstrate that: the method is as or more reliable, effective, and determinate than a viable ground water monitoring well network at detecting any violation of ground water protection levels or class TDS limits, that may be caused by the discharge or potential discharge; the method will provide early warning of a potential violation of ground water protection levels or class TDS limits and meets or exceeds the requirements for vadose zone or leak detection monitoring.

Monitoring well construction and ground water sampling should conform to A Guide to the Selection of Materials for Monitoring Well Construction. Sample collection and preservation, should conform to the EPA RCRA Technical Enforcement Guidance Document, OSWER-9950.1, September, 1986. Sample analysis must be performed by State-certified laboratories by methods outlined in UAC R317-6-6.3L. Analytical methods used should have minimum detection levels which meet or are less than both the ground water quality standards and the anticipated protection levels.

11. **Closure and Post Closure Plan:** The purpose of this plan is to prevent ground water contamination after cessation of the discharge or potential discharge and to monitor the discharge or potential discharge point after closure, as necessary. This plan has to include discussion on: liquids or products, soils and sludges; remediation process; the monitoring of the discharge or potential discharge point(s) after closure of the activity.

12. **Contingency and Corrective Action Plans:** The purpose of this Contingency plan is to outline definitive actions to bring a discharge or potential discharge facility into compliance with the regulations or the permit, should a violation occur. This applies to both new and existing facilities. For existing facilities that may have caused any violations of the Ground Water Quality Standards or class TDS limits as a result of discharges prior to the issuance of the permit, a plan to correct or remedy any contaminated ground water must be included.

    <u>Contingency Plan</u> – This plan should address: cessation of discharge until the cause of the violation can be repaired or corrected; facility remediation to correct the discharge or violation.

    <u>Corrective Action Plan</u> – for existing facilities that have already violated Ground Water Quality Standards, this plan should include: a characterization of contaminated ground water; facility remediation proposed or ongoing including timetable for work completion; ground water remediation.

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 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.

VLADIMIR PODOLIPSKIY CTO
NAME & OFFICIAL TITLE (type or print)

323-356-4768
PHONE NO. (area code & no.)

SIGNATURE

2/25/15
DATE SIGNED

MCW Energy Group

Temple Mountain Mine

Asphalt Ridge, Uintah County, Utah

Project Background, Geology, Hydrology, & Operations Description

October 2015

Prepared for:

Utah Department of Environmental Quality

Division of Water Quality

Prepared by:

Donald Clark, PhD

Chief Geologist

MCW Energy Group

10100 Santa Monica Blvd
Suite 300
Century City, CA 90067

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and

Jon Schulman

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3995 South 700 East

Suite 300

Salt Lake City, Utah 84107-2540

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Introduction

TM Capital LLC, a wholly owned subsidiary of MCW CA, has acquired the Temple Mountain Mine (TMM) from Temple Mountain Energy, Inc. mineral lease and operations south of Vernal, Utah (Fig. 1). The lease, or leases, is composed of approximately 1,300 acres along Asphalt Ridge and operates under a Large Mining Operations permit (LMO)**.** TMC plans to mine the oil sands veins near and at the ground's surface using traditional surface-mining techniques to extract raw oil sands ore that is 6 to 15 percent oil by weight, with the balance being sand, clay and rocks. The mine is located at the southeast end of Asphalt Ridge where the ridge meets Ashley Valley. The tract is in the following parcels (Fig. 2):

> Township 5 South (T5S), Range 22 East (R22E), Salt Lake Base & Meridian (SLB&M), Section 31: NE¼ of SW¼; SE¼ of SW¼; SW¼ of SW¼; NW¼ of SW¼; NW¼ of SE¼; SW¼ of SE¼.
>
> T5S, R21E; Section 36, NE¼ of SE¼.

Once mined, TMM's oil sands ore can be used in the following ways (Fig. 3):

- Sold "as-is" for road construction asphalt, without any further processing (screening optional);
- Processed on-site into road asphalt binder (bitumen), a value-added product in high demand;
- Upgraded to light (42^o – 46^o API) sweet crude for sale to oil refiners;
- Sold as clean, high-quality sand (a byproduct of the oil extraction process) for applications such as hydraulic fracturing (for oil & gas production) and other industrial or construction uses.

The Asphalt Ridge project is expected to have a total lifetime of 20 to 30 years after expanded production occurs (early 2018 – estimated expansion completion).

This report has been prepared to provide the detailed background required to complete the Utah Ground Water Discharge Permit Application. It will also demonstrate that the design and location of the TMM facility ensures a very low probability that any contaminants would impact groundwater as a result of planned operations.

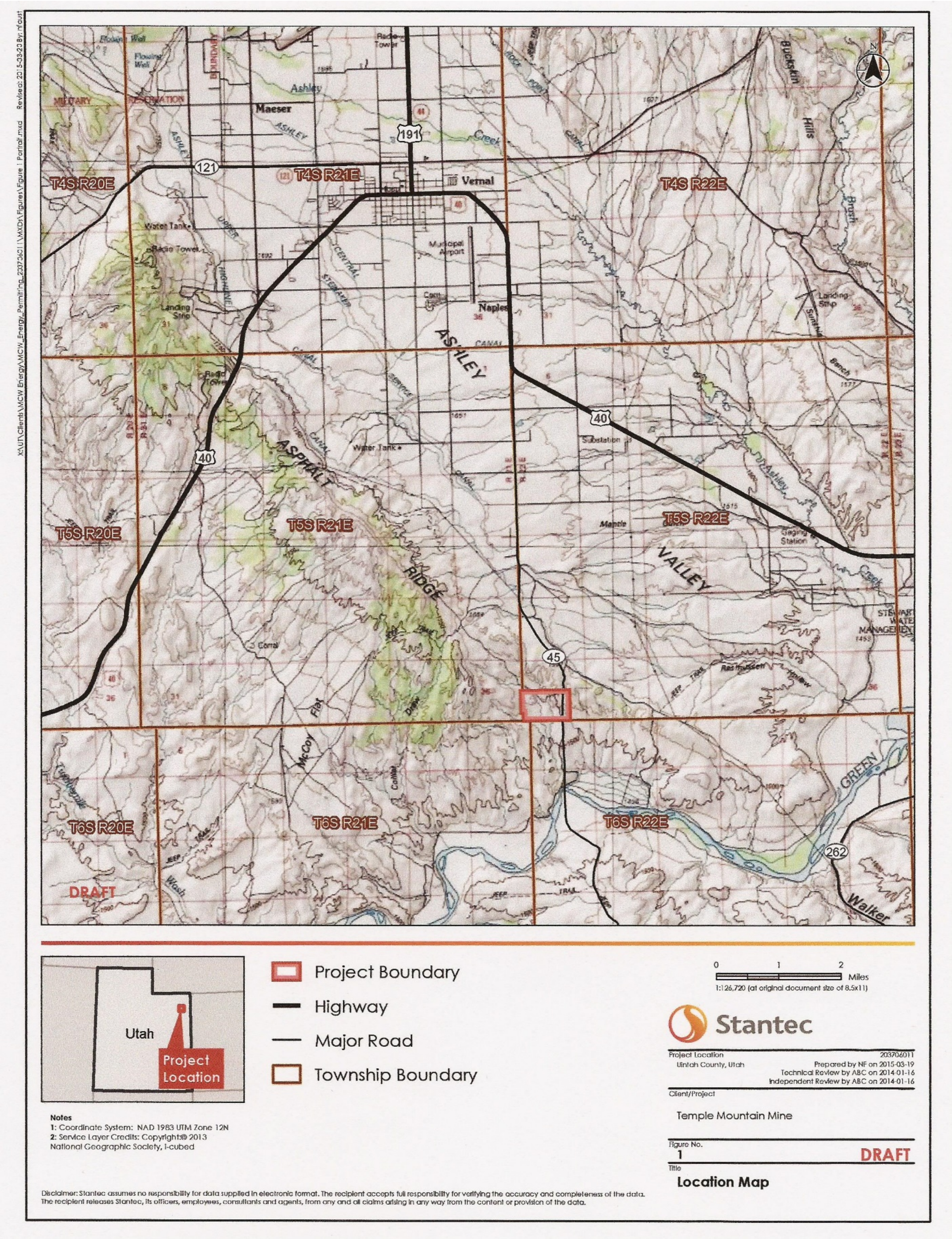


Figure 1 – Location of the TMM mine along Asphalt Ridge, Utah.

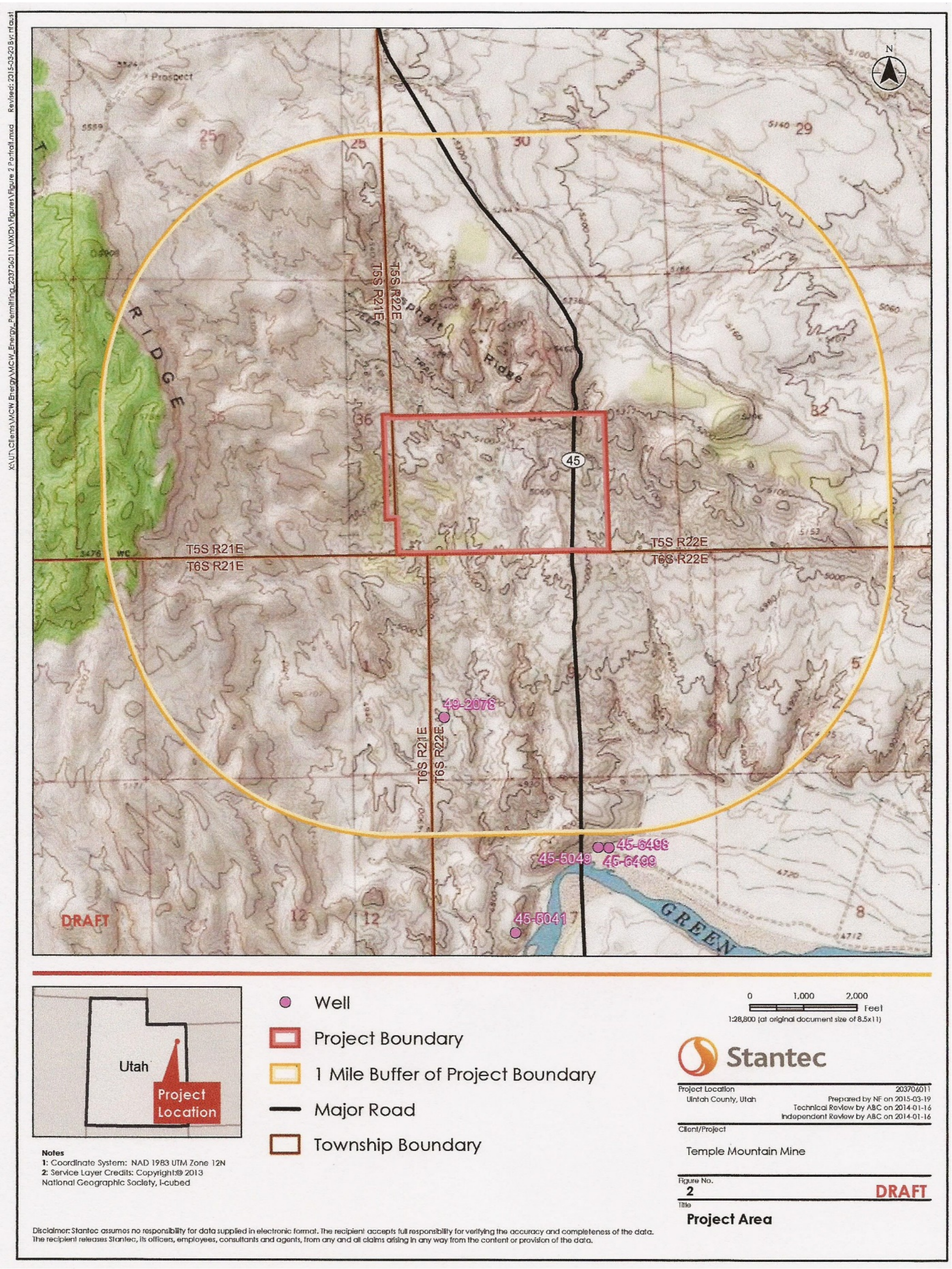


Figure 2 – Project Area & Water Wells within a One Mile Buffer.

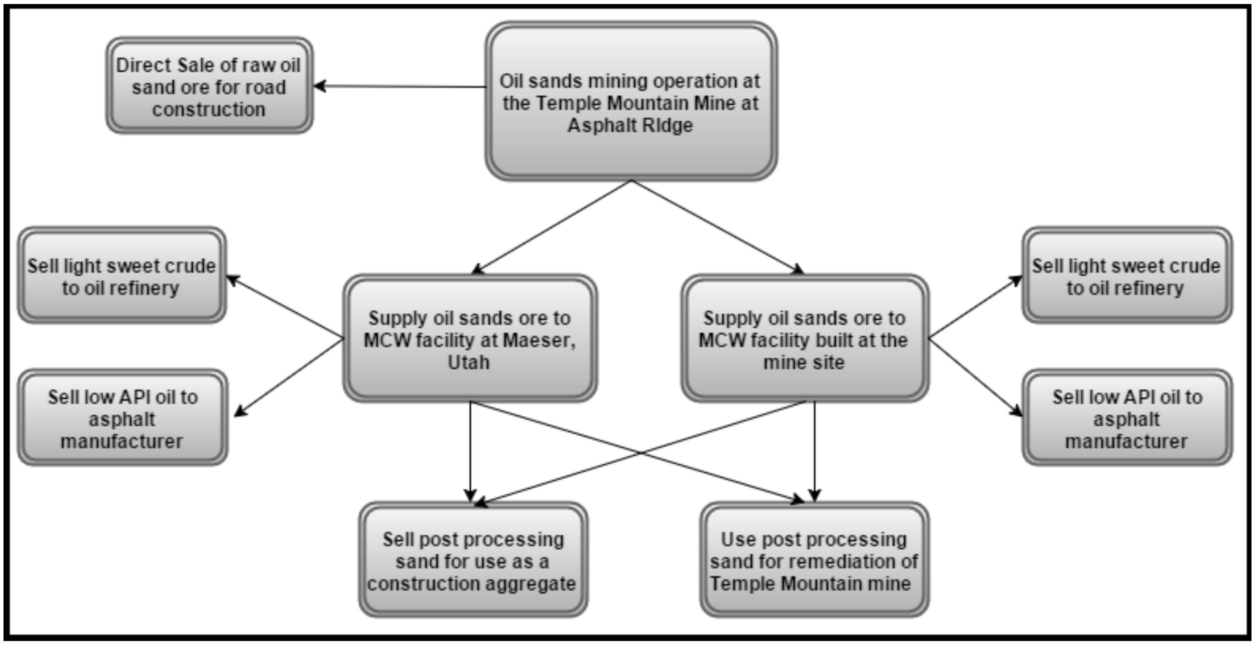


Figure 3. Process Flow Diagram

Operational Plans - Identify principal processes used, or services performed by the facility

Initially, the TMM will be used to supply oil sands ore to MCW Energy Group's (MCW) oil sands extraction facility located in Maeser, Utah. This facility is a pilot plant designed to further optimize MCW's proprietary oil sands extraction technology. This technology has already been tested and proven at a pilot plant in Russia in 2009. During this phase of testing, over 99% of the oil and bitumen contained in the oil sands were extracted. The results of the 2009 pilot plant testing were independently verified by a third party, certified engineering firm, Kvadra Energo Intellect.

MCW's proprietary technology uses a solvent, but absolutely no water, to extract the oil from the oil sands. This patented solvent is composed of multiple individual components (multiple light hydrocarbons and alcohols). Absolutely no chlorinated compounds, or dense non aqueous phase liquids (DNAPL) are added to the solvent. When used in MCW's patented oil sands extraction facility, these solvents are capable of dissolving and recovering over 99% of the heavy bitumen, heavy oil and other lighter hydrocarbons that are found in the naturally occurring oil sands. The extraction process takes place in a completely closed loop system that continuously recirculates the solvent. The closed loop system is capable of recovering over 99% of the solvents from the processed oil sands, making this technology very environmentally friendly. The use of a solvent, as opposed to heat as is used in Alberta, Canada, guarantees an extremely high level of energy efficiency during the oil extraction process. The energy efficiency of MCW's technology makes it extremely economical to operate. This energy efficiency also means that MCW's technology does not emit excessive levels of greenhouse gases in the form of carbon dioxide (CO_2). MCW's technology is explained in greater detail in an attached document labeled "MCW - Technology Overview".

MCW plans on constructing a 5,000 barrel per day oil sands extraction facility at TMM using the same closed loop, solvent based extraction technology that is currently being used at the pilot plant in Maeser, Utah (Fig. 4). This facility shall be constructed in two phases, the first phase will be a single 2,500 barrel per day facility. The second phase will be a second, identical 2,500 barrel per day facility. The second phase will be constructed after the first phase is operational. Mining operations at TMM will expand to meet the demands of this facility. Construction of both phases is contingent upon receiving financing (in progress). The completion of the first phase is anticipated to be in early 2018.

The processed sands that are not sold from the MCW processing facility in Maeser will be trucked back to the TMM for permanent storage and mine remediation. These processed sands will be capped in a manner that will prevent precipitation from leaching through the material and potentially percolating into the subsurface. Greater details of the permanent storage plan can be found in an attached document labeled "Processed Sand Storage and Monitoring Program for the Temple Mountain Mine Site".

TMM/MCW Environmental Footprint - Overview of Operations

MCW's oil sands extraction technology is a closed loop system that relies on the use of natural solvents, rather than heat in the form of hot water, or steam, to extract the oil and bitumen from the oil sands. This means that water use at the facility is very minimal (mainly used to create steam for transmitting heat and for dust control) and more importantly, no tailings ponds are needed, or created when using MCW's technology. Tailings ponds are a major environmental problem in Alberta, Canada where hot water extraction technologies are used for oil sands extraction. It must be emphasized that MCW's technology <u>does not bare any resemblance to the hot water extraction technology used to process oil sands in Alberta, Canada</u>.

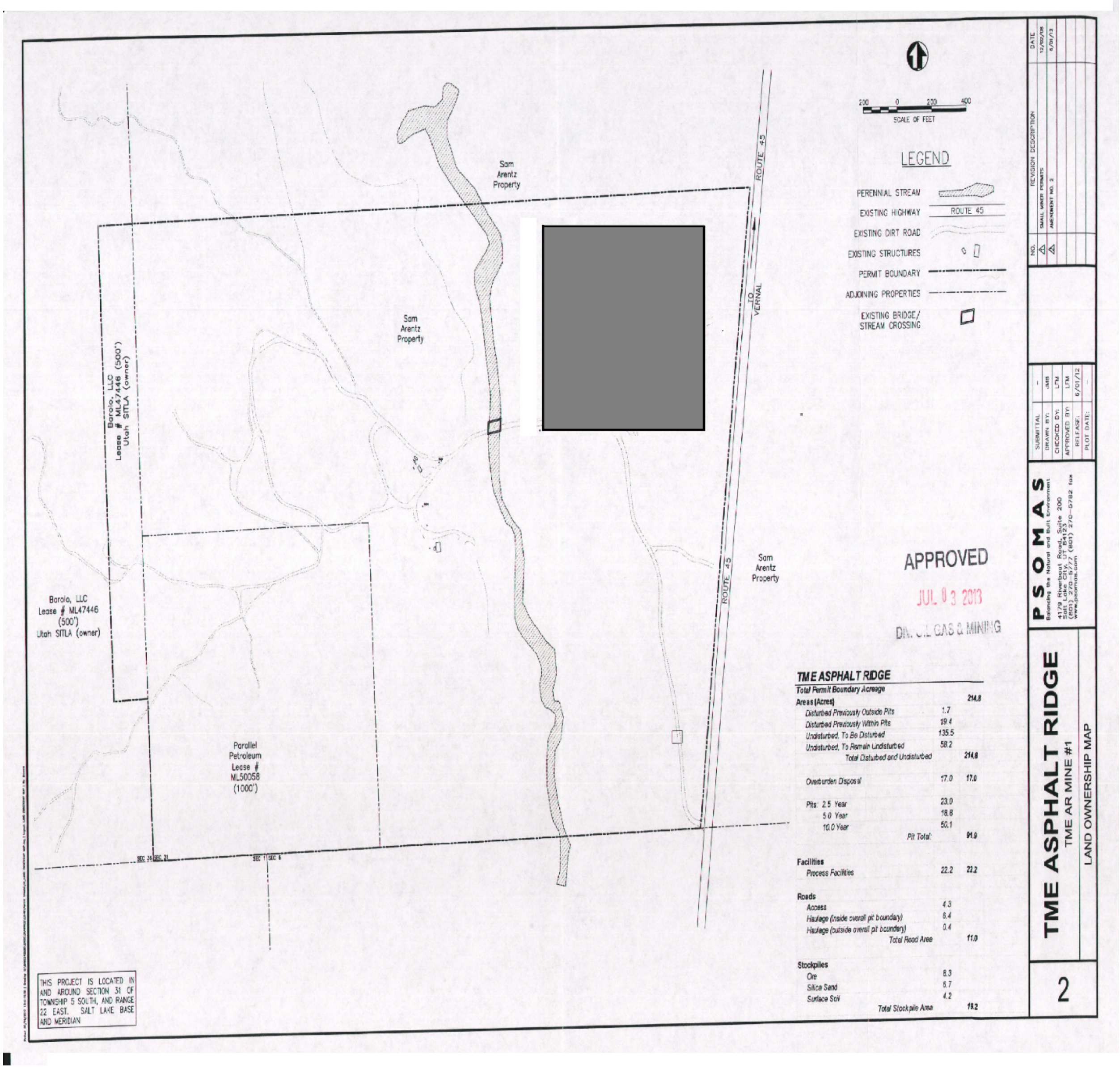


Figure 4 - Site plan showing proposed location (gray box) of oil sands extraction facility using MCW's solvent based extraction technology.

Source – TME Asphalt Ridge, LLC. NOI, 2013, (Permit # M0470089, UDOGM Task 1749#)

The processed sands from MCW's technology are benign, consisting almost entirely of clean sand or a mixture of clean sand and clay, plus a small amount of water (for dust control). The sand can be sold as a marketable product for use in construction, or can be used in mine remediation. Processed sands from MCW's plant in Maeser, Utah have been independently tested by American West Analytical Laboratory (AWAL) in Salt Lake City, Utah using both the Synthetic Precipitation Leaching Procedure (SPLP) and dry analysis (mg/kg). The results of both the SPLP and dry analyses indicate that the processed sands have minimal amounts of detectable hydrocarbons. These residual hydrocarbon levels from the SPLP analysis are well below the Utah and EPA standards (Table 1 and Appendix A).

The majority of any greenhouse gas (GHG) emissions produced at TMM will be from the diesel fuel consumed by TMM's surface-mining equipment (e.g., earthmoving vehicles) and transportation vehicles. As a result, TMM's Asphalt Ridge operation has a relatively low carbon footprint, or a carbon footprint similar in magnitude to other surface-mining activities for any other natural resource. It is important to note that the energy content of the oil sands extracted through mining activities and MCW's extraction activities is far greater than the energy consumed to produce it, thus greatly reducing the total carbon impact of the activities at the TMM. The EROEI (energy recovered over energy invested) for MCW's technology has been independently verified at over 22:1 by Chapman Petroleum Engineering. This compares quite favorably to EROEI values of 4:1 to 6:1 for hot water and steam assisted methods of oil sands extraction as seen in Alberta, Canada. This energy efficiency is a direct result of using solvents, as opposed to heat, to extract the oil and bitumen from the sands. Low carbon emissions and a small carbon footprint are an important benefit of this energy efficiency.

Vegetative Diversity

An Ecological Baseline Report was performed and included in the Notice of Intention to Commence Large Mining Operations (NOI – Permit # M0470089 UDOGM Task 1749#) submitted by the previous lease holder. The Ecological Baseline Report noted that vegetation was sparse, due to the arid conditions of the area and that the plant community was dominated by drought tolerant species. The report also noted that the area where the mining operations will take place does not have a highly diverse vegetative population.

Table 1. Analytical Results for Overburden and MCW Processed Sands

Compound	**Native Overburden Analytical Results (mg/L)**	**MCW Processed Sands - SPLP Analytical Result (mg/L)**	**Numeric Standard (mg/L)** [1]
Arsenic	<0.050		0.05
Barium	<0.050		2.0
Cadmium	<0.010		0.005
Calcium	90	4.90	
Chromium (total)	<0.010		0.1
Lead	<0.050		0.015
Magnesium	16	<1.00	
Mercury	<0.0010		0.002
Potassium	3.8	<1.00	
Selenium	<0.050		0.05
Silver	<0.010		0.1
Sodium	28	1.94	
Alkalinity (as $CaCO_3$)	68	12.9	
Bicarbonate (as $CaCO_3$)		<10.0	
Carbonate (as $CaCO_3$)		<10.0	
Chloride	1.5	0.580	
Oil & Grease		<5.00	
Conductivity (µmhos/cm)	1300		
pH @ 25°C (reported in Standard Units)	7.96	10.0	6.5-8.5
SGT-HEM/Non-Polar Material		<5.00	
Sulfate	280	4.77	
Total Dissolved Solids (TDS)	440	84.0	1200[2]
Total Recoverable Petroleum Hydrocarbon	3.9		10[3]
Total Organic Carbon (TOC)		31.4	
Diesel Range Organics (DRO)		0.898	
Gasoline Range Organics (GRO)		0.149	
SVOA SPLP by GC/MS Method 8270D/1312/3510C (19 compounds reported, all below detection limit)		<0.0100	
Benzene		<0.00100	0.005
C5&C6 Aliphatic hydrocarbons[4]		0.00778	
C7&C8 Aliphatic hydrocarbons[4]		<0.0200	
C9&C10 Aliphatic hydrocarbons[4]		<0.0200	
C9&C10 Alkyl Benzenes		0.0286	
Ethylbenzene		0.00522	0.7
Naphthalene		0.00472	
Toluene		0.0378	1
Xylenes, Total		0.0554	10

[1] Source: R317-6-2, Ground Water Quality Standards, [2] R317-2-14, Numeric Criteria
[3] Utah Tier 1, [4] EPA and Utah do not have standards for aliphatic hydrocarbons; for comparison, Massachusetts has a maximum contaminant level (MCL) for aliphatic hydrocarbons of 0.3 mg/L

Threatened or Endangered Species.

The Ecological Baseline Report included in the Notice of Intention to Commence Large Mining Operations (NOI – Permit # M0470089 UDOGM Task 1749#) indicated that no threatened or endangered species, or potential habitats of protected or endangered species were identified on the lease property.

The low vegetative diversity on the lease, the absence of threatened or endangered species on the lease, the absence of threatened or endangered species habitat on the lease, the lack of need for tailings ponds on the lease coupled with the relatively low carbon footprint of the planned operations strongly suggest that the overall environmental footprint of the TMM/MCW operation will be relatively small.

Name and description of each well/spring; water body; drainage; well-head protection area; drinking water source protection zones; topography; and man-made structures within one mile radius of the point(s) of discharge.

There will be no points of water discharge and no water discharged to the groundwater from TMM or MCW's planned operations. Processed sands from TMM and MCW's operations will be returned to the mine pit as back fill and will be capped with low ($<10^{-7}$ cm/sec) compacted clays to prevent infiltration and the formation of leachate from precipitation or snowmelt.

The only man-made structures within one mile of the project area are State Route 45 and the subject project facilities (Figure 2).

Several small springs, approximately 0.6 miles north of the permit boundary, are the source of the head waters for the perennial/intermittent stream running through the permit area. There is only one well within one mile of the project area (Utah Division of Water Resources [UDWR] well database, 2015). Please see Part C, below, for more complete report on the hydrology of the project area.

A separate and supplemental seep and spring survey was performed at the request of the Division of Water Quality and is attached as a separate document labeled "TMM Seep and Spring Survey – June 2015".

The stream on the east side of the lease property that was identified as an intermittent stream in the Ecological Baseline Report that was performed and included in the Notice of Intention to Commence Large Mining Operations (NOI – Permit # M0470089 UDOGM Task 1749#). This steam was also identified in the "TMM Seep and Spring Survey – June 2015". It should be noted that the quality of the water flowing in this stream was very poor and characterized by low pH, high levels of cadmium, sulfate and total dissolved solids (Table 2, Appendix B, TMM Seep and Spring Survey – June 2015). It should also be noted that there was no flowing water contact with the Green River in September 2008, when the Ecological Baseline Report field work was conducted, or in June 2015, when the Seep and Spring Survey field work was conducted.

Part B – General Discharge Information

1. Locations of discharges.

Not Applicable

2. Type of fluid to be discharged or potentially discharged.

There will be no discharges to ground water. MCW's technology is a waterless technology that does not emit any form of liquid discharges. Processed sands that aren't sold will be used for mine remediation work and capped or covered to prevent precipitation from infiltrating and leaching through the material. Overburden and material that has only been processed mechanically will be used as backfill and will contain only native material.

3. Discharge Volumes

Not applicable

4. Potential Discharge Volumes

Not Applicable

5. Flows, Sources of Pollution, and Treatment Technologies

Not Applicable.

6. Discharge Effluent Characteristics

Not applicable. However, Synthetic Precipitation Leachate Procedure (SPLP) was performed on native overburden from the mine (Table 1 and Appendix A). The table also provides SPLP analytical results for MCW processed sands, which will be returned to the mine pit as back fill, but capped with low permeable clays ($<10^{-7}$ cm/sec) to prevent any leachate from infiltrating to ground water.

Part C – Accompanying Reports and Plans

Hydrogeological Report

In general, the study area is typical of the Colorado Plateau Region with a terrain characterized by broad plateaus and deeply dissected valleys. The topography of the project site (Figure 2) is transitional between Asphalt Ridge to the west and the Ashley Valley to the east, sloping generally towards the Green River, which is a little more than a mile to the south. Most of the site has been disturbed as a result of historic and current mining.

The site is dissected by several ephemeral channels and one spring-fed channel which is termed perennial in a hydrology report prepared for an amended Notice of Intent (NOI) (PSOMAS, 2012) but classed as intermittent in the USGS National Hydrography Dataset (NHD); the spring is not shown on USGS topographic maps or in the NHD and originates well north of the mine site. As discussed above and in the TMM Seep and Spring Survey – June 2015, the stream water is of poor quality with low pH and high levels of cadmium, sulfate and TDS (Appendix B, TMM Seep and Spring Survey – June 2015).

Because this area is semi-arid, the vegetation is sparse and, in most cases, the plant communities are dominated by drought-tolerant species. The PSOMAS storm water report includes a topographic map outlining the sub-basins affected by the project (Appendix C). The vegetation in the area is dominated by ricegrass, rabbitbrush, and cheatgrass. Temperatures range from average highs of 89.1°F in July to average lows of 5.0°F in January. Precipitation averages 8.42 inches annually, including 18.5 inches of snowfall (WRCC, 2015), for the period of 11/01/1894 to 12/31/2010 as reported for the Vernal Airport approximately seven miles north of the site. Elevation at the project site ranges from approximately 4,965 feet to 5,317 feet above mean sea level. State Route 45 runs north south through the east side of the project area.

Geology

As noted above, the project site is on the southeast edge of Asphalt Ridge, in a transition area between Asphalt Ridge and the Ashley Valley. Asphalt Ridge is a 15-mile-long northwest trending cuesta (hogback), with the Duchesne River Formation lying over the Mesaverde Group

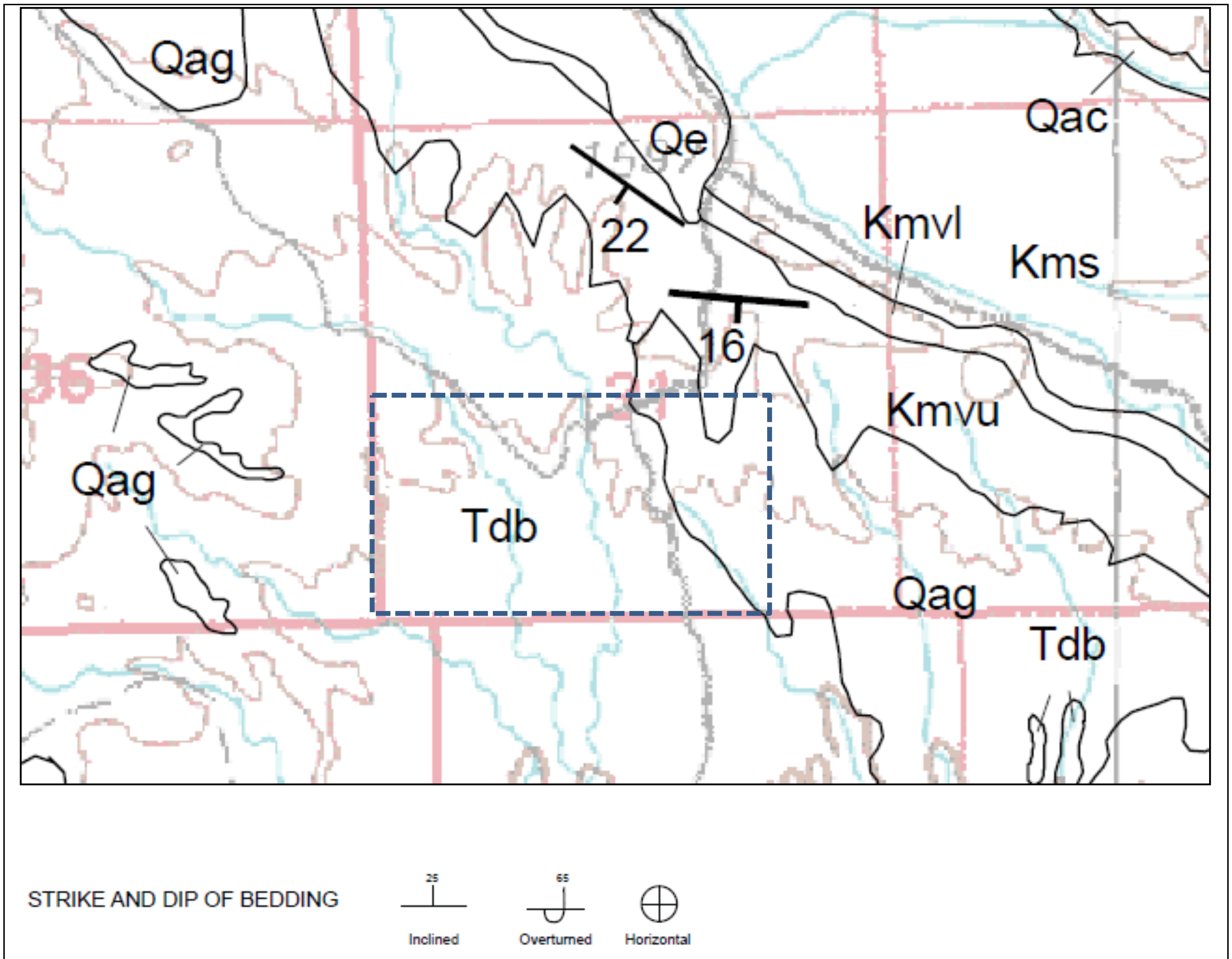
(Kohler, 2011). A geologic map of the project area clearly shows the transitional nature of the geology at the project site from the Duchesne River Formation of Asphalt Ridge (Tdb) in the project area and to the west, through the Mesa Verde Formation upper and lower units (Kmvu and Kmvl) moving east, and into the Mancos Shale (Kms) in Ashley Valley (Fig. 5). Figure 6 shows a stratigraphic section through Asphalt Ridge. Figure 7 shows Uintah Basin tar sands deposits, including Asphalt Ridge. Figure 8 shows a general cross-section through Asphalt Ridge.

Two series of core logs have been taken in the project area (Fig. 9). The six cores marked F-1, F-2, F-3, F-4, CF-1, and CG-1 were drilled in 1957 by Sohio Petroleum Company (Appendix D). The remaining cores, all in the NW ¼ of the SW ¼ of Section 31, T5S, R22E, were drilled in 1975 for Burmah Oil and Gas (Appendix D). The maximum drilling depth of the 1975 series was 173 feet below ground surface (BGS). No water was recorded in the well logs. The shallowest of the 1957 cores was drilled to 210 feet BGS (F-2) and the deepest was drilled to 441 feet BGS (F-1).

Both sets of cores confirm that the underlying strata consist of numerous layers of conglomerate, shale, and sandstone. Many of the conglomerates and sandstones layers are noted to contain oil (bitumen). Cores CF-1 and F-4 have relatively shallow surface layers of alluvium. Otherwise, with the exception of core CG-1, they are in the Duchesne River Formation for their entire depth. CG-1 is in the Duchesne River Formation to 214 feet and the Mesaverde Formation from 214 feet to 300 feet.

Howells et al (1987) describe the Duchesne River Formation as follows:

> A mostly fluvial facies. Shale, mainly red, but including green and other pale colors, siltstone, sandstone, and conglomerate, unconformably underlying younger rocks from near the Colorado State line to near Strawberry Reservoir. Coarsest grain sizes are near basin margins where the formation interfingers with other formations. In central part of basin, formation grades up from underlying Uinta Formation and consists of interbedded sandstone and shale. Sandstone is most abundant in lower part and, with conglomerate, in upper part. Sandstones are of two basic types--a light-colored (commonly yellow) channel deposit and a darker, more compacted, better cemented interchannel (?) lenticular deposit. In most of its extent the formation is slightly to strongly fractured. Fractures are locally re-cemented with calcium sulfate. Maximum thickness is more than 3,000 ft (910 m).



⬚	PROJECT AREA
Qac	MIXED ALLUVIUM AND COLLUVIUM (HOLOCENE) - Unconsolidated mud, silt, sand, and gravel in intermittent stream drainages and in areas of low topographic relief; less than 10m thick.
Qe	EOLIAN DEPOSITS (HOLOCENE) - Unconsolidated, well-sorted, fine-grained, windblown sand and silt; less than 10 m thick.
Qag	ALLUVIAL-GRAVEL DEPOSITS (HOLOCENE AND PLEISTOCENE) – Unconsolidated to moderately consolidated, poorly sorted sand, gravel, cobbles, and boulders deposited on near-planar bedrock surfaces; 220-600 m thick.
Tdb	BRENNAN BASIN MEMBER OF DUCHESNE RIVER FORMATION (EOCENE) - fine- to medium-grained lithic sandstone and siltstone with minor amounts of mudstone and conglomerate; the basal part of the Brennan Basin Member, as much as 60 m, intertongues with the underlying Uinta Formation throughout most of the quadrangle
Kmvu	UPPER UNIT OF MESAVERDE GROUP (UPPER CRETACEOUS) – Moderately resistant, fine-grained, lenticular cross-bedded sandstone with carbonaceous shale and thick coal beds; 425-550 m thick.
Kmvl	LOWER UNIT OF MESAVERDE GROUP (UPPER CRETACEOUS) - Resistant, cross-bedded sandstone with subordinate carbonaceous shale and minor coal; likely includes beds of the Sego Sandstone, Buck Tongue of the Mancos Shale, and Castlegate Sandstone; locally defined by Walton (1944) as the Rim Rock Formation; 200-250 m thick.
Kms	MANCOS SHALE (UPPER CRETACEOUS) - Dark-gray, soft, slope-forming calcareous shale containing beds of siltstone and bentonitic clay; 1,500-4,900 m thick.

Figure 5. Geologic Map of the Project Area (Adapted from Sprinkel, 2006)

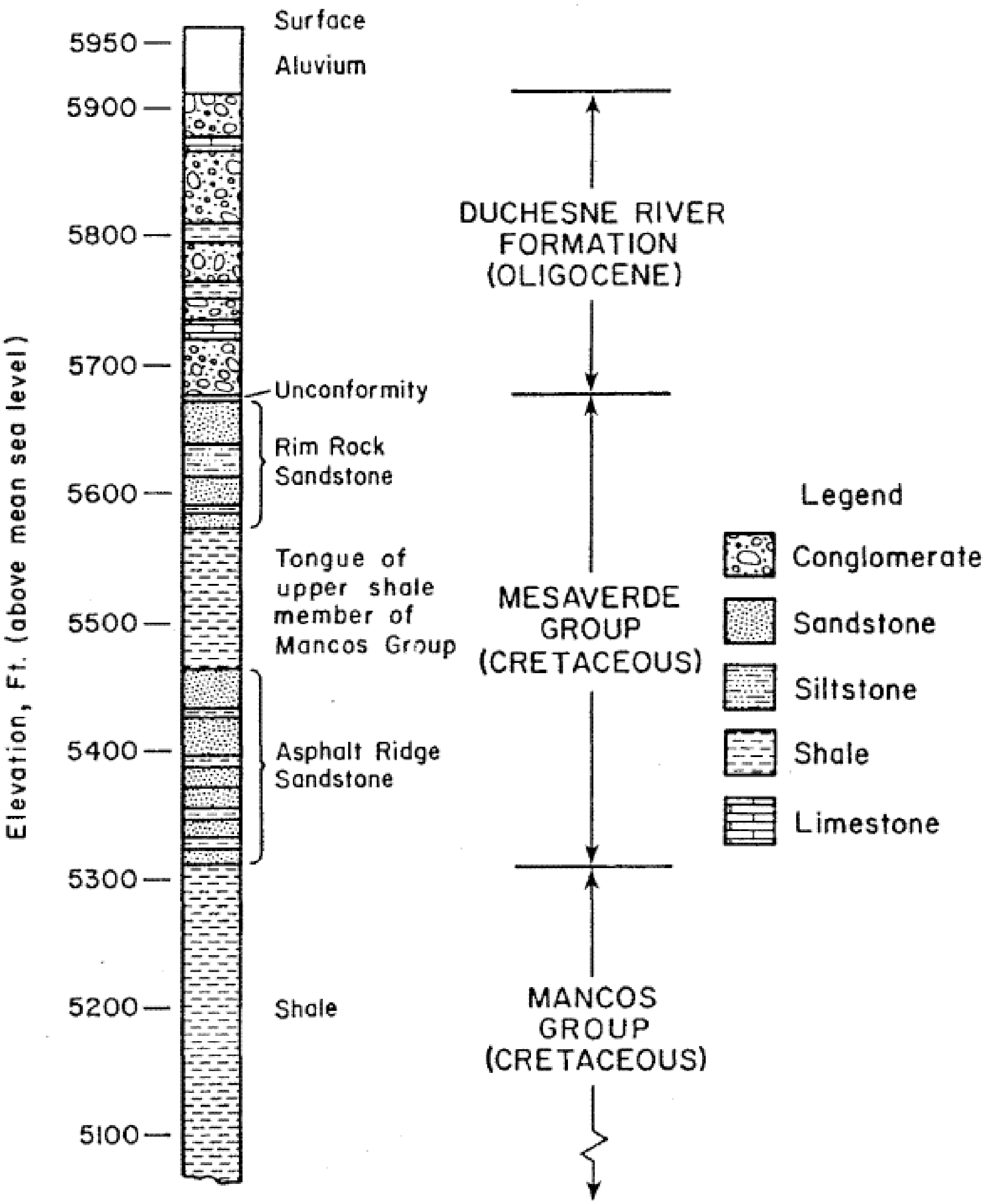


Figure 6. Stratigraphic Section of the NW Asphalt Ridge Area (from Sinks, 1985)

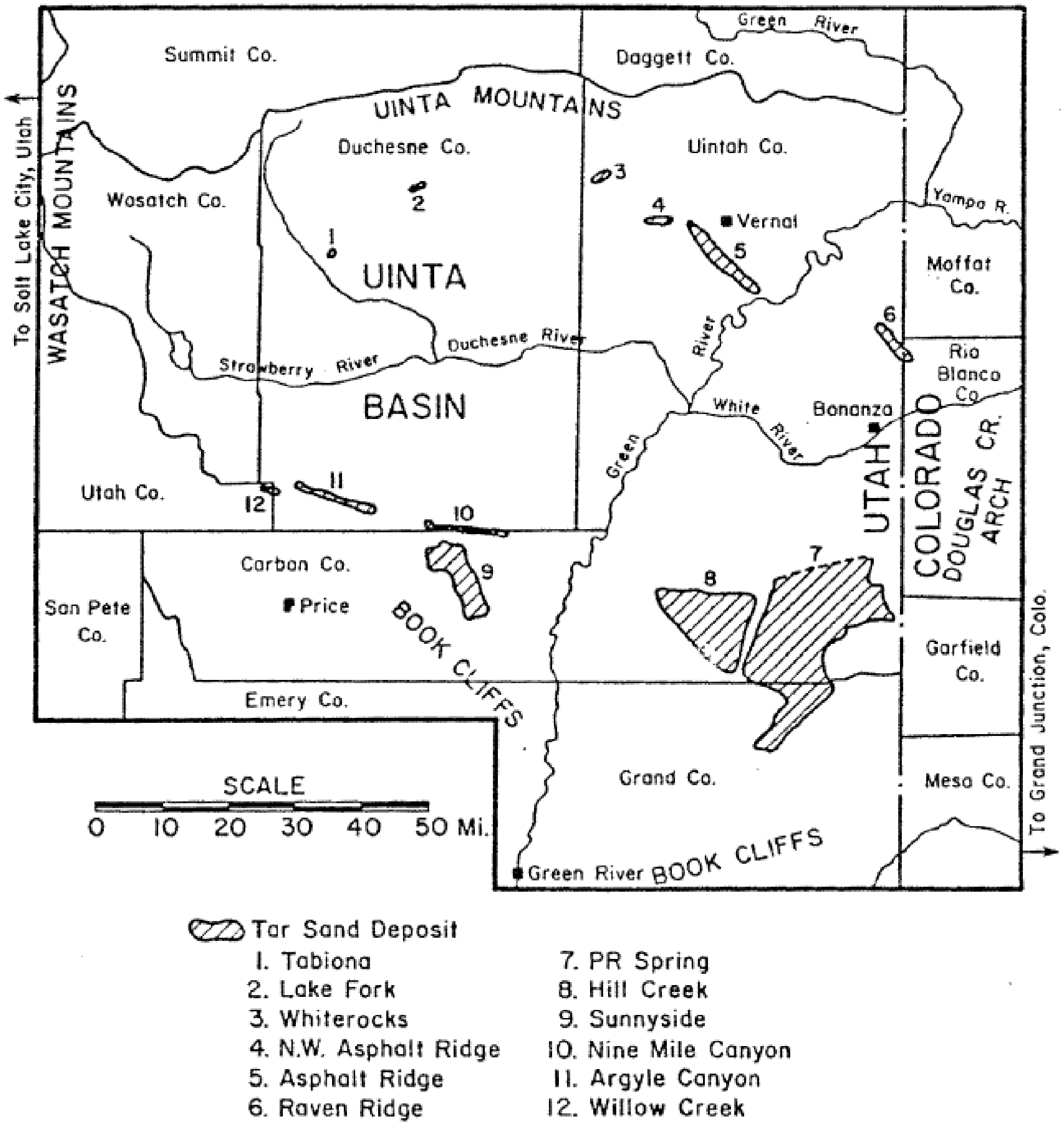


Figure 7. Uintah Basin Tar Sands Deposits (Kohler, 2011)

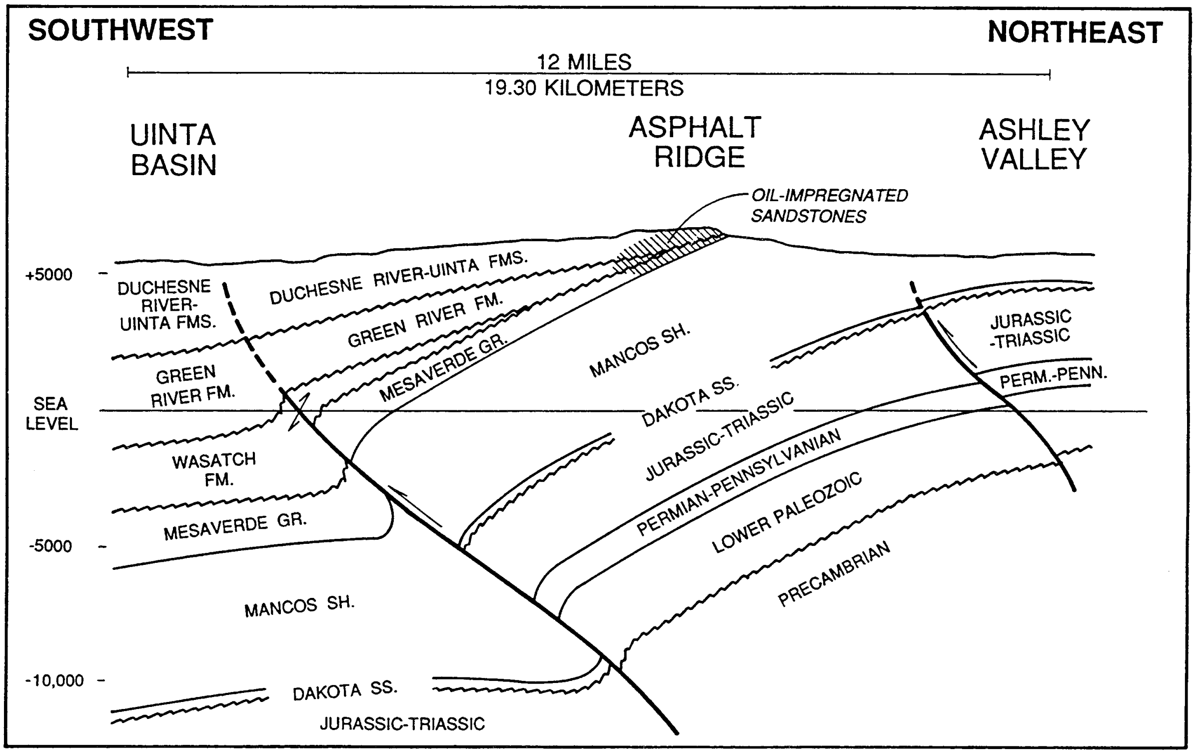


Figure 8. Generalized Cross Section of Asphalt Ridge (Blackett, 1996; after Campbell and Ritzma, 1979)

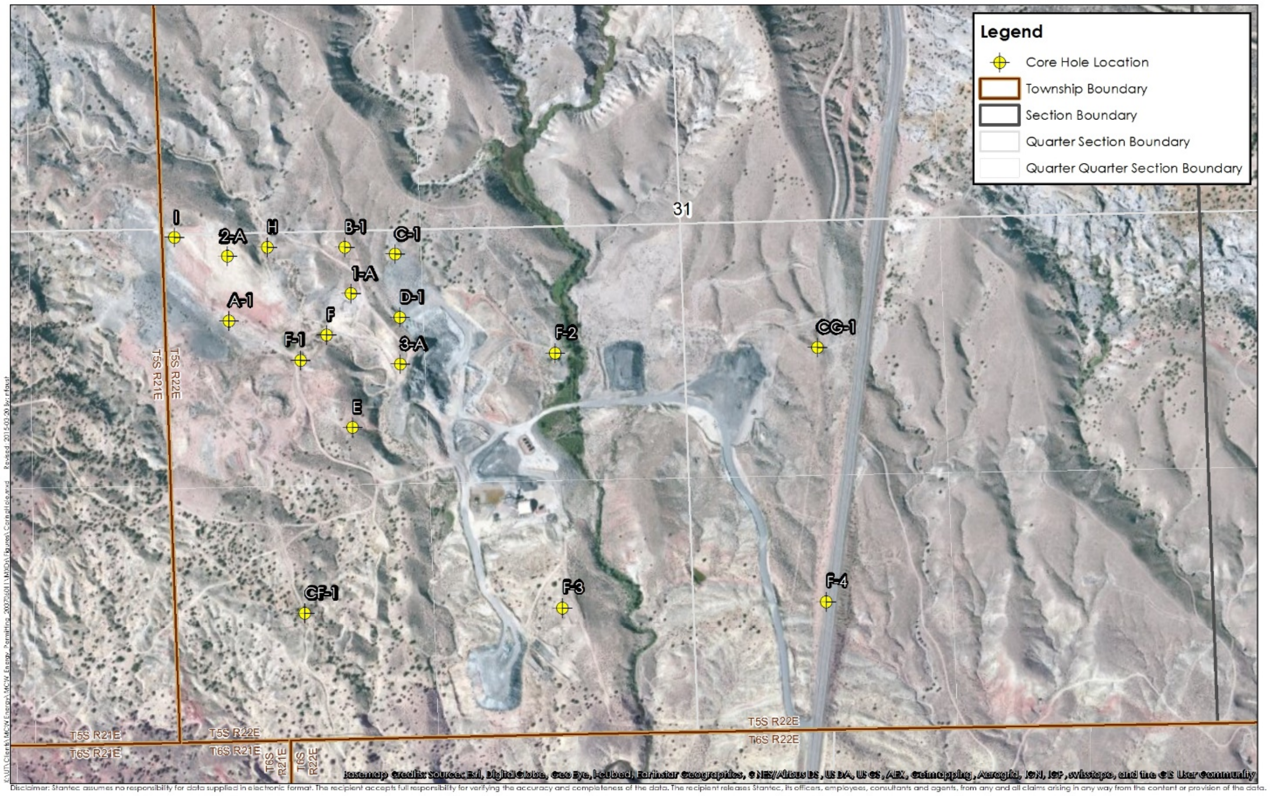


Figure 9. Core Hole Locations at the project site.

The same publication describes the "hydrologic significance" of the formation as follows (Howells et al, 1987):

> Very low to very high permeability. The horizontal intergranular permeability of 19 sandstone samples ranged from 0.000033 to 3.28 feet/day (ft/d). Total porosity ranged from 7 to 32 percent. Aquifer permeability is enhanced by fracturing. Yields to wells and springs range from less than 1 to more than 300 gallons/minute (gal/min), usually with large drawdowns in wells. The most permeable rocks seem to be near edges of outcrops west of Roosevelt in the central basin; the least permeable seem to be in areas north and east of Fort Duchesne. Water movement may be impeded locally by gilsonite dikes. Near recharge areas, or where the formation is fractured or moderately permeable, the water usually is fresh. At greater depths where the formation is of very low permeability, the water is slightly saline to briny. Confined conditions are common. In the lower parts of the basin, such as near Roosevelt, artesian heads may be more than 100 feet above land surface, but in higher areas of the basin, water levels are below land surface.

The core logs frequently describe the shale layers as "calcareous", suggesting that fractures within the rock have been cemented to some degree. See the *Groundwater* section, below, for additional, site-specific discussion.

Hydrology

Surface Water

The unnamed channel that parallels State Route 45 has been discussed above. The USGS describes the channel as intermittent; an independent hydrology consultant, PSOMAS, described the channel as perennial. Figure 9 shows that there is a distinct riparian area along the channel, which suggests the channel and/or its substrate (hyporheic zone) contains water a high percentage of the year. Figure 4 shows how the project facilities have been designed around this unnamed stream to minimize impacts. The second amendment to the TME NOI (2013) provides the following:

> The head waters for the perennial stream running through the permit area are approximately 0.6 miles north of the permit boundary. The head waters are at approximately 5,073 feet above mean sea level, approximately 63 feet above the ground surface elevation of the upper end of phase 1 open pit.

The amendment goes on to say the following:

> The intermittent stream runs on the naturally occurring exposed tar sand/asphalt and clay zone surfaces in the confined drainage channel. Observations have shown the stream is confined to the near surface narrow channel system. Past and historic open pit mining operations have been conducted within 20 linear feet of the stream bed with mining some 40 feet below the stream channel elevation. During mining no seepage of water from the stream was observed in the pit high walls. With this fact it is highly unlikely that the intermittent stream will be affected by the planned open pit mining. The surface water is constrained by the low permeable clays and oil sands. In addition the open pit moves further away from the stream channel as the pit progress to the northwest. There is also a major ridge line separating the open pit and the existing stream channel.

The above quote strongly suggests that 1) mining within a short distance of the channel in the past has not breached the hyporheic zone and 2) the hyporheic zone must not be connected to a very large saturated zone.

A storm water plan was prepared for the project area, which includes berms to route run-on around the mine and other facilities, and back to existing channels downgradient (Appendix C). The storm water study also contains a topographic map showing the basin and sub-basins that are wholly or partly within the project area.

No gauging stations are in or near the project area and no discharge data has been found for the perennial/intermittent stream that runs through the project area. A water sample was taken upstream of the project area from the perennial/intermittent stream in 2008 (Table 2 Appendix B). Levels of cadmium exceeded the standard and pH was outside (below) the acceptable range. Additional water quality analyses were performed in 2015 (TMM Seep and Spring Survey – June 2015)

Table 2. Upstream Water Sample Analytical Results

Compound	**Units**	**Upstream Water Quality Sample**	**Numeric Standard (mg/L) [1]**
Arsenic	mg/L	0.0012	0.01
Barium	mg/L	0.0092	1.0
Cadmium	mg/L	0.014	0.01
Calcium	mg/L	180	
Chromium (total)	mg/L	<0.010	0.05
Lead	mg/L	0.00039	0.015
Magnesium	mg/L	66	
Mercury	mg/L	<0.00020	0.002
Potassium	mg/L	7.2	
Selenium	mg/L	0.023	0.05
Silver	mg/L	<0.00040	0.05
Sodium	mg/L	21	
Alkalinity (as $CaCO_3$)	mg/L	<10	
Chloride	mg/L	8.7	
Conductivity	µmhos/cm	1500	
pH @ 25 °C	Standard Units	3.13	6.5-9.0
Sulfate	mg/L	1100	
Total Suspended Solids (TSS)	mg/L	<3.0	
Total Recoverable Petroleum Hydrocarbon	mg/L	<3.0	

[1] R317-2-14 Domestic Source

Ground water

The State of Utah defines an aquifer as "***a geologic formation, group of geologic formations or part of a geologic formation that contains sufficiently saturated permeable material to yield usable quantities of water to wells and springs***" (R317-6-1).

Of the 17 wells that were drilled in the project area, only four contained intervals that were described in well logs as "water wet" (Table 3, Fig. 9 and Appendix D). Core F-1, drilled to a depth of 441 feet BGS, only encountered "water wet" conditions between 259.1 feet BGS and 260.2 feet BGS (1.1 feet total). It is unlikely that a saturated layer so thin would carry enough water to be considered an aquifer under Utah regulations. Given that the maximum depth of the mine pit would be 200 feet BGS, we can infer that there is no aquifer within 241 feet of the bottom of the pit at that location. Additionally, the well log between 200 and 250 feet shows sandstones and conglomerates that are "well saturated" with oil. This interval may negatively affect any water in the 259.1 – 260.2 foot interval.

Table 3. Summary of Well Logs in the Project area (Appendix D).

Feature	**F-1**	**F-2**	**CG-1**	**CF-1**	**F-3**	**F-4**	**Oct 2015**
Maximum Depth of core (feet BGS)	**441**	**210**	**296**	**378**	**382**	**358**	**275**
Saturated Interval (feet BGS)	259.1-260.2		244.7-248.7	58.1-60.7		337.7-349.7	
Saturated Interval (feet BGS)			252.0-258.1	215.5-217.0			
Saturated Interval (feet BGS)			276.1-296.0	218.5-237.3			
Saturated Interval (feet BGS)				240.0-242.1			
Saturated Interval (feet BGS)				244.2-247.5			
Saturated Interval (feet BGS)				248.5-256.4			
Saturated Interval (feet BGS)				260.0-263.9			
Saturated Interval (feet BGS)				266.4-271.4			
Saturated Interval (feet BGS)				272.9-285.8			
Maximum Thickness of Contiguous Saturated Intervals (feet)*	**1.1**	**0.0**	**19.9**	**58.0**	**0.0**	**12.0**	**0.0**

* <10 feet separating saturated intervals
BGS – below ground surface

Cores F-2 and F-3 were drilled east of the proposed mine pit and within 124 and 330 feet of the stream, respectively (Table 3, Fig. 9). They were drilled to depths of 210 and 382 feet BGS, respectively. Neither core encountered water-saturated conditions. Cores CG-1 and F-4 are well east of the mine pit and had only minor saturated zones.

Core CF-1 was at the very southern end of the proposed mine pit. A shallow saturated layer was encountered between 58.1 and 60.7 feet BGS. As with Core F-1, this is likely an isolated pocket rather than an aquifer. Beneath this near-surface "water wet" interval was a series of eight intervals described as "water wet", ranging from 1.5 feet thick to 18.8 feet thick, and separated by unsaturated material up to 3.6 feet thick; the top of this series of saturated layers was at 215.5 feet BGS. It is noteworthy that all of the layers described as "water wet" are also described as having light to fair oil saturation; this suggests that the water may be of limited quality.

On October 1 and 2, 2015, a ground water monitoring well was drilled approximately 100 feet to the east of the location where well CF-1 was drilled (Fig. 9) (Table 3). The well first targeted the interval described as "water wet" in the CF-1 well log that was at a depth of 58.1 - 60.7 feet. This interval was dry. The intervals between 215 and 285 feet below ground surface that were described in the CF-1 well log as "water wet" were then targeted. The well was drilled to a depth of 275 feet and no "water wet" intervals were encountered. The well was drilled using an air rotary drill rig. All the cutting that came to the surface were exceptionally dry, no traces of moisture were encountered. It should be remembered that well CF-1 was drilled in 1957 and is not a good indicator of current subsurface conditions, which clearly are water free at this time.

There is only one water well within one-mile of the project area. This is the well associated with water right #49-2078 (Fig. 2). There is no well log for this well, which was drilled in 1951 by QEP Energy, and had a maximum flow rate of 0.2 cfs (~90 GPM). The water right is for domestic and irrigation use.

Surface and Ground Water Quality

As described above and in the TMM Seep and Spring Survey – June 2015, the quality of the surface stream water is very poor (Table 2). Table 1, Part B, shows the results of SPLP leachate tests run on the two materials that would be used as backfill in the pit. The SPLP analysis was performed on the sands immediately after processing. The native overburden is material removed from the pit to access the oil sands, temporarily stockpiled, then returned to the pit as backfill. Processed sand from MCW is comprised of oil sands from TMM that have been processed using a solvent extraction method and returned to TMM for use as backfill. A liner will be placed below and a cap will be placed over the processed sands to prevent any precipitation from leaching through the processed sands and infiltrating into the ground. Abundant gray clay in the mine pit has been permeability tested at less than 10^{-7} cm/sec making it an ideal material to cap the processed sands (Appendix E).

No historic water quality samples for groundwater were found, essentially due to the fact that there is little to no ground water beneath the project area. No water samples were or could be taken from the well that was drilled on October 1 and 2, 2015, since no water was encountered in that well.

Summary and Conclusion

In the project area, no groundwater that might meet the state definition of an aquifer was found within 300 to 400 feet of the ground surface. Within a mile of the project area only one water well is in the state database, and there is very little information about the well (no well depth, well log, or water quality).

MCW’s proprietary technology uses a light hydrocarbon and alcohol based solvent in a closed loop system, but does not use any water in the extraction process. Processed sands will be used for mine backfill, but this material will be capped to prevent any precipitation or other water from leaching through and possibly infiltrating to groundwater. Overburden will also be returned to the mine pit for use as backfill and to cover the capped processed sands to further encapsulate them.

In summary, TMC believes that its oil sands extraction operations pose a *de minimis* risk of contaminating groundwater for the following reasons:

- Scarcity of groundwater within the one-mile buffer area indicates there is little groundwater at risk in this area

- Thin lenses of groundwater recorded in historic well logs have a relatively low risk of contamination from mining and remediation activities based on the underlying geology and the distance (depth) to groundwater.
- The thin “water wet” sandstone layers beneath the mine pit described in historic well logs are also described as having light to heavy oil saturation, strongly suggesting that any water in these thin layers may already be poor in quality.
- The potential groundwater monitoring well drilled adjacent to well CF-1 in October 2015 targeted the intervals that were described as “water wet” in the CF-1 well log. This suggests that the thin “water wet” intervals have lost any water that was in them 60 years ago when the original wells were drilled.
- Water quality analyses of the stream that runs through the property indicates that it is already a poor source of water in the area.
- TMC is taking all appropriate measures to protect the environment, including extensive storm water management and isolation of tailings that may contain residual bitumen.

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February 4, 20089

069936-AC-UDWQ-GWQDP-L002
By Certified Mail

Mr. Rob Herbert, Manager
Groundwater Protection Section
Division of Water Quality
Utah Department of Environmental Quality
P.O. Box 144870
Salt Lake City, Utah 84114-4870

CERTIFIED MAIL #: 7006 0100 0002 5943 3767

Dear Mr. Herbert:

Re: Application for Groundwater Discharge Permit and
Request for Permit By Rule (PBR)
TME Asphalt Ridge Mine #1
South of Vernal, Utah (Uintah County)

Ames Construction, Inc., (Ames) on behalf of the owner Temple Mountain Energy (TME), submitted December 27, 2007 a Groundwater Quality Discharge Permit Application and supporting documentation for the proposed TME Asphalt Ridge Mine #1 Large Mining Operation.

Further discussions with Mr. Mark Novak of your staff resulted in our obtaining soil and water quality samples January 14, 2008 for the native asphaltic material (ore) stockpiled for processing and also to be used for process pond liner material and the perennial stream that flows through the property. Attached please find the results of this sampling effort as completed by American West Analytical Laboratories.

Our assessment of the analytical data does not alter our December 27, 2008 request for a PBR. After your review please contact Mr. Glenn M. Eurick at 801.541.3577 or myself with any questions or concerns on either the data submitted or our request for a PBR.

Thank you for your consideration.

Sincerely;

Leonard Boteilho
Senior Manager and Manager Environmental Affairs

C:
Eurick (Ames)
Oglesby (Ames)
Runquist (TME)
Trent (TME)
Bower (TME)

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Kyle F. Gross
Laboratory Director

Jose Rocha
QA Officer

January 24, 2008

Glenn Eurick
Ames Construction
3737 West 2100 South
Salt Lake City, UT 84120

TEL: (801) 977-8012
FAX: (801) 977-8088

RE: TME-AR Mine #1 / 069936-GME-002

Lab Set ID: L81980

Dear Glenn Eurick:

American West Analytical Labs received 3 samples on 1/14/2008 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.

Thank you.

Approved by: ______________________
Laboratory Director or designee

INORGANIC ANALYSIS REPORT

Client: Ames Construction
Contact: Glenn Eurick
Project ID: TME-AR Mine #1 / 069936-GME-002

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Jose Rocha
QA Officer

Lab Sample ID: L81980-01
Field Sample ID: **#1 Asphalt / Liner**
Collected: 1/14/2008
Received: 1/14/2008

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result	
Alkalinity,(As CaCO3)	mg/L	1/15/2008 10:30:00 AM	2320B	20	**110**	* [2]
Chloride	mg/L	1/18/2008 12:03:21 AM	300.0	1.0	**1.4**	[2]
Conductivity	µmhos/cm	1/15/2008 8:15:00 AM	9050A	10	**460**	*
pH @ 25° C	pH units	1/14/2008 5:46:00 PM	9045D	1.00	**8.39**	
Sulfate	mg/L	1/18/2008 12:03:21 AM	300.0	1.0	**6.4**	[2]
TDS	mg/L	1/18/2008 7:30:00 AM	160.1	20	**76**	[2]
Total Recoverable Petroleum Hydrocarbons	mg/L	1/16/2008 2:00:00 PM	1664A SGT	3.0	**3.7**	[2]

**Analysis is performed on a 1:1 DI water extract for soils.*

[2] Sample was prepped by SPLP method 1312 prior to analysis.

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INORGANIC ANALYSIS REPORT

Client: Ames Construction

Contact: Glenn Eurick

Project ID: TME-AR Mine #1 / 069936-GME-002

Lab Sample ID: L81980-01A
Field Sample ID: **#1 Asphalt / Liner**
Collected: 1/14/2008
Received: 1/14/2008

SPLP METALS Method 1312

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result	
Arsenic	mg/L	1/18/2008 1:39:00 PM	6010B	0.050	< 0.050	
Barium	mg/L	1/18/2008 1:39:00 PM	6010B	0.050	< 0.050	
Cadmium	mg/L	1/18/2008 1:39:00 PM	6010B	0.010	< 0.010	
Calcium	mg/L	1/18/2008 1:39:00 PM	6010B	1.0	**5.4**	
Chromium	mg/L	1/18/2008 1:39:00 PM	6010B	0.010	< 0.010	
Lead	mg/L	1/18/2008 1:39:00 PM	6010B	0.050	< 0.050	
Magnesium	mg/L	1/18/2008 1:39:00 PM	6010B	1.0	**1.5**	
Mercury	mg/L	1/21/2008 9:31:16 AM	7470A	0.0010	< 0.0010	
Potassium	mg/L	1/18/2008 1:39:00 PM	6010B	1.0	**1.1**	
Selenium	mg/L	1/18/2008 1:39:00 PM	6010B	0.050	< 0.050	
Silver	mg/L	1/18/2008 1:39:00 PM	6010B	0.010	< 0.010	
Sodium	mg/L	1/18/2008 2:22:00 PM	6010B	10	**24**	#

 # The reporting limits were raised due to high analyte concentration.

INORGANIC ANALYSIS REPORT

Client: Ames Construction
Contact: Glenn Eurick
Project ID: TME-AR Mine #1 / 069936-GME-002

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L81980-02
Field Sample ID: **#2 Overburden**
Collected: 1/14/2008
Received: 1/14/2008

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Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result	
Alkalinity,(As CaCO3)	mg/L	1/15/2008 10:30:00 AM	2320B	20	**68**	* 2
Chloride	mg/L	1/18/2008 12:26:38 AM	300.0	1.0	**1.5**	2
Conductivity	µmhos/cm	1/15/2008 8:15:00 AM	9050A	10	**1300**	*
pH @ 25° C	pH units	1/14/2008 5:46:00 PM	9045D	1.00	**7.96**	
Sulfate	mg/L	1/23/2008 1:33:22 AM	300.0	75	**280**	2
TDS	mg/L	1/18/2008 7:30:00 AM	160.1	20	**440**	2
Total Recoverable Petroleum Hydrocarbons	mg/L	1/16/2008 2:00:00 PM	1664A SGT	3.0	**3.9**	2

**Analysis is performed on a 1:1 DI water extract for soils.*

[2] Sample was prepped by SPLP method 1312 prior to analysis.

INORGANIC ANALYSIS REPORT

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Client: Ames Construction
Contact: Glenn Eurick
Project ID: TME-AR Mine #1 / 069936-GME-002

Lab Sample ID: L81980-02A
Field Sample ID: **#2 Overburden**
Collected: 1/14/2008
Received: 1/14/2008

SPLP METALS Method 1312

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result	
Arsenic	mg/L	1/18/2008 1:55:00 PM	6010B	0.050	< 0.050	
Barium	mg/L	1/18/2008 1:55:00 PM	6010B	0.050	< 0.050	
Cadmium	mg/L	1/18/2008 1:55:00 PM	6010B	0.010	< 0.010	
Calcium	mg/L	1/18/2008 2:34:00 PM	6010B	10	**90**	#
Chromium	mg/L	1/18/2008 1:55:00 PM	6010B	0.010	< 0.010	
Lead	mg/L	1/18/2008 1:55:00 PM	6010B	0.050	< 0.050	
Magnesium	mg/L	1/18/2008 1:55:00 PM	6010B	1.0	**16**	
Mercury	mg/L	1/21/2008 9:41:15 AM	7470A	0.0010	< 0.0010	
Potassium	mg/L	1/18/2008 1:55:00 PM	6010B	1.0	**3.8**	
Selenium	mg/L	1/18/2008 1:55:00 PM	6010B	0.050	< 0.050	
Silver	mg/L	1/18/2008 1:55:00 PM	6010B	0.010	< 0.010	
Sodium	mg/L	1/18/2008 2:34:00 PM	6010B	10	**28**	#

 # The reporting limits were raised due to high analyte concentration.

INORGANIC ANALYSIS REPORT

Client: Ames Construction
Contact: Glenn Eurick
Project ID: TME-AR Mine #1 / 069936-GME-002

AMERICAN WEST ANALYTICAL LABORATORIES

Lab Sample ID: L81980-03
Field Sample ID: **#3 Upstream WQ**
Collected: 1/14/2008
Received: 1/14/2008

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Result
Alkalinity,(As CaCO3)	mg/L	1/15/2008 10:30:00 AM	2320B	10	< 10 [1]
Chloride	mg/L	1/18/2008 12:49:55 AM	300.0	1.0	**8.7**
Conductivity	µmhos/cm	1/15/2008 8:00:00 AM	2510B	2.0	**1500**
pH @ 25° C	pH Units	1/14/2008 5:46:00 PM	4500H+B	1.00	**3.13**
Sulfate	mg/L	1/23/2008 1:56:39 AM	300.0	75	**1100**
Total Recoverable Petroleum Hydrocarbons	mg/L	1/16/2008 2:00:00 PM	1664A SGT	3.0	< 3.0
TSS	mg/L	1/15/2008 3:45:00 PM	2540D	3.0	< 3.0

[1] *Spike recovery indicates matrix interference. The method is in control as indicated by the laboratory control sample (LCS).*

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INORGANIC ANALYSIS REPORT

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Client: Ames Construction
Contact: Glenn Eurick
Project ID: TME-AR Mine #1 / 069936-GME-002

Lab Sample ID: L81980-03A
Field Sample ID: **#3 Upstream WQ**
Collected: 1/14/2008
Received: 1/14/2008

TOTAL METALS

Analytical Results	Units	Date Analyzed	Method Used	Reporting Limit	Analytical Results	
Arsenic	mg/L	1/17/2008 3:09:23 PM		0.00060	**0.0012**	
Barium	mg/L	1/17/2008 3:09:23 PM		0.00040	**0.0092**	
Cadmium	mg/L	1/17/2008 3:09:23 PM		0.00018	**0.014**	
Calcium	mg/L	1/17/2008 5:20:00 PM		0.50	**180**	[2] #
Chromium	mg/L	1/17/2008 5:48:00 PM		0.010	< 0.010	
Lead	mg/L	1/17/2008 3:09:23 PM		0.00010	**0.00039**	
Magnesium	mg/L	1/17/2008 5:20:00 PM		0.50	**66**	[2] #
Mercury	mg/L	1/18/2008 9:03:37 AM		0.00020	< 0.00020	[1]
Potassium	mg/L	1/17/2008 5:48:00 PM		0.10	**7.2**	
Selenium	mg/L	1/17/2008 3:09:23 PM		0.00080	**0.023**	
Silver	mg/L	1/17/2008 3:09:23 PM		0.00040	< 0.00040	
Sodium	mg/L	1/17/2008 5:48:00 PM		0.10	**21**	

[2] *Analyte concentration is too high for accurate spike and/or RPD recovery.*

 # The reporting limits were raised due to high analyte concentration.

[1] *Spike recovery indicates matrix interference. The method is in control as indicated by the laboratory control sample (LCS).*

American West Analytical Labs

WORK ORDER Summary

14-Jan-08

Work Order L81980

Client ID: AME200

QC Level: 1

Project: TME-AR Mine #1 / 069936-GME-002

Location: HoKSB DB

Contact: Glenn Eurick

Comments: QCLevel: 1. Samples are for SPLP.

Sample ID	Client Sample ID	Collection Date	Date Received	Date Due	Matrix	Test Code	Storage	
L81980-01A	#1 Asphalt / Liner	1/14/2008	1/14/2008	1/28/2008	Soil	1312LM	SPLP - met/hg	3
				1/28/2008		3005A-TCLP	SPLP - met/hg	3
				1/28/2008		HG-PREP-TCLP	SPLP - met/hg	3
				1/28/2008		HG-TCLP	SPLP - met/hg	3
				1/28/2008		ICP-W	SPLP - met/hg	3
L81980-01B				1/28/2008	Leachate	OGF-W	ogf - SPLP	1
L81980-01C				1/28/2008		2320B-ALK-W	jan 14 - wc/SPLP	1
				1/28/2008		300.0-W	jan 14 - wc/SPLP	1
L81980-01D				1/28/2008		TDS-W	ww - tds/SPLP	1
L81980-01E				1/28/2008	Soil	COND-A-S	jan 14 - wc	1
				1/28/2008		PH-9045D	jan 14 - wc	1
				1/28/2008		Soil_Prep	jan 14 - wc	1
L81980-02A	#2 Overburden			1/28/2008		1312LM	SPLP - met/hg	3
				1/28/2008		3005A-TCLP	SPLP - met/hg	3
				1/28/2008		HG-PREP-TCLP	SPLP - met/hg	3
				1/28/2008		HG-TCLP	SPLP - met/hg	3
				1/28/2008		ICP-W	SPLP - met/hg	3
L81980-02B				1/28/2008	Leachate	OGF-W	ogf - SPLP	1
L81980-02C				1/28/2008		2320B-ALK-W	jan 14 - wc/SPLP	1
				1/28/2008		300.0-W	jan 14 - wc/SPLP	1
L81980-02D				1/28/2008		TDS-W	ww - tds/SPLP	1
L81980-02E				1/28/2008	Soil	COND-A-S	jan 14 - wc	1
				1/28/2008		PH-9045D	jan 14 - wc	1
				1/28/2008		Soil_Prep	jan 14 - wc	1
L81980-03A	#3 Upstream WQ			1/28/2008	Aqueous	3005A-ICPMS	jan 14 - met/hg	1
				1/28/2008		6020-W	jan 14 - met/hg	1
				1/28/2008		Hg-prep-W	jan 14 - met/hg	1

WORK ORDER Summary

14-Jan-08

Work Order L81980

Client ID: AME200 **QC Level:** 1

Project: TME-AR Mine #1 / 069936-GME-002 **Location:**

Contact: Glenn Eurick

Comments: QCLevel: 1. Samples are for SPLP.

Sample ID	Client Sample ID	Collection Date	Date Received	Date Due	Matrix	Test Code	Storage	
L81980-03A	#3 Upstream WQ	1/14/2008	1/14/2008	1/28/2008	Aqueous	HG-W	jan 14 - met/hg	1
				1/28/2008		ICP-W	jan 14 - met/hg	1
L81980-03B				1/28/2008		OGF-W	ogf	3
L81980-03C				1/28/2008		2320B-ALK-W	jan 14 - wc	1
				1/28/2008		300.0-W	jan 14 - wc	1
				1/28/2008		COND-W	jan 14 - wc	1
				1/28/2008		PH-W-4500H+B	jan 14 - wc	1
L81980-03D				1/28/2008		TSS-W-2540D	ww - tss	1

Sample Set: 81980

Preservation Check Sheet

Sample Set Extension and pH

Bottle Type	Preservative	All OK	Except	Except	Except	Except	Except	Except	Except	Except	Except	Except	Except	Except	Except	Except	Except
Ammonia	pH <2 H_2SO_4																
COD	pH <2 H_2SO_4																
Cyanide	PH >12 NaOH																
Metals	pH <2 HNO_3	✓															
NO_2 & NO_3	pH <2 H_2SO_4																
Nutrients	pH <2 H_2SO_4																
O & G	pH <2 HCL	✓															
Phenols	pH <2 H_2SO_4																
Sulfide	pH > 9NaOH, Zn Acetate																
TKN	pH <2 H_2SO_4																
TOC	pH <2 H_3PO_4																
TOX	pH <2 H_2SO_4																
T PO_4	pH <2 H_2SO_4																
TPH	pH <2 HCL																

Procedure:
1) Pour a small amount of sample in the sample lid
2) Pour sample from Lid gently over wide range pH paper
3) **Do Not** dip the pH paper in the sample bottle or lid
4) If sample is not preserved properly list its extension and receiving pH in the appropriate column above
5) Flag COC, notify client if requested
6) Place client conversation on COC
7) Samples may be adjusted

Frequency: All samples requiring preservation

Client AMES CONSTRUCTION, INC.
Address 3737 W 2100 S
WVC UT 84120
City State Zip
Phone 801.541.3577 Fax 801.977.8088
Contact GLENN EURICK
E-mail geurick@amesco.com
Project Name TME-AR Mine #1
Project Number/[✓ P.O.#] 069936-GME-002
Sampler Name GLENN EURICK

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CHAIN OF CUSTODY

Lab Sample Set # 81980
Page 1 of 1

Turn Around Time (Circle One)
1 day 2 day 3 day 4 day 5 day [✓ Standard]

Sample ID	Date/Time Collected	Matrix	Number of Containers (Total)	METHOD 1312	TRPH	TOTAL "D" LIST METALS	WATER CHEMISTRY							QC LEVEL 1 2 2+ 3 3+ 4 COMMENTS
#1 ASPHALT LINER	1/14/08 AM		4	X										
#2 OVERBURDEN	1/14/08 AM		4	X										
#3 UPSTREAM WQ	1/14/08 AM		5 ~~3~~ HE		X	X	X							
~~#4 DOWNSTREAM WQ~~ HE	~~1/14/08 AM~~		~~3~~		~~X~~	~~X~~	~~X~~							

Relinquished By: *Signature*	Date	Received By: *Signature*
G Eurick	1/14/08	Samantha Broadhead
PRINT NAME GLENN EURICK	Time 16:38	PRINT NAME Samantha Broadhead
Relinquished By: *Signature*	Date	Received By: *Signature*
PRINT NAME	Time	PRINT NAME
Relinquished By: *Signature*	Date	Received By: *Signature*
PRINT NAME	Time	PRINT NAME
Relinquished By: *Signature*	Date	Received By: *Signature*
PRINT NAME	Time	PRINT NAME

Special Instructions:
SEE MEMO (ATTACHED) ON DETAILS FROM PAT NOTEBOOM:

METHOD 1312 LEACHATE FOR MULTIPLE TESTS (ATTACHED)

W.Q. SAMPLES FOR MULTIPLE TESTS (ATTACHED)

LABORATORY USE ONLY

SAMPLES WERE:
1 Shipped or [✓ hand delivered]
Notes:
2 Ambient or [✓ Chilled]
Notes:
3 Temperature 1°C
4 Received Broken/Leaking (Improperly Sealed)
Y [✓ N]
Notes:
5 Properly Preserved
[✓ Y] N
Notes:
6 Received Within Holding Times
[✓ Y] N
Notes:

COC Tape Was:
1 Present on Outer Package
Y [✓ N] NA
2 Unbroken on Outer Package
Y N [✓ NA]
3 Present on Sample
Y [✓ N] NA
4 Unbroken on Sample
Y N [✓ NA]
Notes:

Discrepancies Between Sample Labels and COC Record?
Y [✓ N]
Notes:

MEMORANDUM

To: Mr. Lennie Boteilho, Ames Construction

From: Leslie Morton, P.E.

Date: February 25, 2008

Subject: TME AR Mine #1 Stormwater System Analysis

This memo is intended to provide a summary of the procedure and findings for existing stormwater flows into the TME AR Mine #1 located approximately 10 miles south of Vernal, Utah. HEC-HMS v3.1.0, developed by the US Army Corps of Engineers, was used to model the overall impacts to the mine. Peak flows and volumes generated by the model were used to determine minimum stormwater mitigation measures such as interceptor channel sizing. The stormwater management measures were divided into four main mitigation activities as follows:

1. Intercept off-site drainage from the north of the proposed pit site and convey them to a proposed stilling basin.

2. Intercept off-site drainage from the north of the proposed ore stock pile and divert the runoff to an adjacent existing ephemeral drainage path.

3. Intercept off-site drainage from the west of the proposed pit site and divert the runoff to an adjacent existing ephemeral drainage path.

4. Install V- ditches along side the overburden and surface stock pile such that runoff may be conveyed off the pile without significant erosion and sediment loading downstream.

Model Parameters and Assumptions

To accommodate runoff, earthen channels and v-ditches have been sized and routed to carry runoff around the mining area and the processing plant. A detention pond and a sedimentation pond have also been designed to manage stormwater runoff.

This hydrology study has been developed in accordance with Utah Administrative Code (UAC) R645-301. As required, temporary sedimentation ponds, detention ponds, and channels are designed for the 10-year, 24-hour storm event.

Drainage Basin Delineations and Concentration Points

For the purposes of this study the existing topography was used to delineate drainage basins. Concentration points, or nodes, were located in the hydrologic model to represent outlet locations for the purpose of analyzing peak discharge values. These nodes (labeled as J1, J2, J3 etc.) with their associated drainage basin can be seen in Exhibit 1.

Watershed Description and Assumptions

The watershed characteristics that dictate the amount and rate of runoff were determined using standard methods such as those outlined by United States Department of Agricultural's (USDA) Technical Release 55 (TR-55). Time of concentration (and therefore lag time) and each watershed's Composite Curve Number (CCN) are examples of such characteristics. An SCS Type II temporal distribution was used for all drainage basins and storms. Table 1 below shows the size and CCN for each watershed basin.

Table 1: Basin Area and CCN Schedule

Basin Name	***Area*** *(acres)*	***CCN***
1	43.82	*89*
2	5.89	89
3	5.46	89
4	6.43	71
5	289.48	84
6	9.78	85
7	28.35	78
8	4.28	84

The CCN value is a watershed parameter that predicts the amount of rainfall lost to soil infiltration and therefore the amount of direct runoff from precipitation. This CCN value is dependant on the watershed's land use and hydrologic soil group. Based on available GIS data and the provided aerial photography, it was determined that any given area of the site's watershed may be one of four possible different land uses as follows:

1. **Pinyon-Juniper** – Consistent with pinyon, juniper, or both; grass understory. Declared as in *fair* condition (from 30% to 70% ground cover).
2. **Herbaceous** – Consistent with mixture of grass, weeds, and low-growing brush, with brush the minor element. Declared as in *fair* condition (from 30% to 70% ground cover).
3. **Herbaceous** – Consistent with mixture of grass, weeds, and low-growing brush, with brush the minor element. Declared as in *poor* condition (less that 30% ground cover).
4. **Newly Graded Areas –** Consistent with pervious areas with no vegetation.

5. **Asphalt** –Impervious, paved , open ditches

Based on a soil survey from the USDA's Natural Resource Conservation Service (NRCS), the hydrologic soil group for the site's watershed varies from soil group B, C, and D.

Rainfall data for the site was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 for the location of 40°18'54" latitude 109°32'35" at elevation 5,022'. The rainfall data was used for the 100 and 10-year, 24 and 6-hour storms. These are the design storm events referenced in the hydrology section of UAC R645-301, Division of Oil, Gas, and Mining. The precipitation data for these storms are shown in the appendix.

Results

A summary of the flows for the specific points of concentration are summarized below in Table 2. A summary of the stormwater management designs are described by task as seen below.

Table 2: Estimated Peak Runoff (cfs)

LOCATION	100-YR 24-HR	*100-YR 6-HR*	*10-YR 24HR*
J1	*39.74*	*23.95*	*21.56*
J2	*10.6*	*6.65*	*5.19*
J3	*8.8*	*5.49*	*4.43*
J4	*2.9*	*4.1*	*0.4*
J5	252.9	264.1	96.6
J6	15.1	16.1	6.4
J7	21.2	25.1	6.5
J8	5.7	6.2	2.3

Stormwater Mitigation Activity 1

The runoff entering the mine site from the north was quantified at nodes J4 and J5 as shown in Exhibit 1. The estimated peak discharge from the 10-yr 24-hr storm event for these two drainage areas is 97 cfs. This flow is intercepted by Channel 1 (see Exhibits 2, 3 and 3a) with a base width of 8.5 feet and a minimum depth of 3 feet. The proposed channel is lined with riprap where slopes exceed 0.5% slope in order to minimize erosion and overburdening downstream systems. Channel 1 terminates in a 1.5 ac-ft sedimentation pond (see Exhibit 8) to allow sediment to settle before being discharged into the existing perennial stream. Sediment removal from this pond must be maintained regularly.

Stormwater Mitigation Activity 2

Off-site drainage that would normally continue through the proposed pit is mitigated by means of one interceptor ditch along the western side of the permit boundary. Runoff intercepted by this channel (Channel 2) is diverted to a downstream ephemeral drainage path. Channel 2 intercepts drainages from nodes J6, J7 and J8. For the 10-yr 24-hr storm event these nodes add up to an estimated flow of 15.2 cfs. Like Channel 1's design, Channel 2 (see Exhibits 4 and 5) is armored with riprap where slopes exceed 0.5% slope. This channel is trapezoidal with a base width of 4 feet and a flow minimum depth of 2 feet.

Based on the contour data provided, an existing depression was found upstream of the western edge of the permit boundary and between basins 6 and 7 as shown in Exhibit 1. This depression has a storage capacity of approximately 3.1 ac-ft. The total estimated runoff volume produced by the existing depression's contributing basin for the 100-year, 24-hour storm event is only 0.8 ac-ft. Because the storage capacity of the existing depression is larger than the total runoff volume of its contributing watershed, no runoff volume from this basin contributes to the proposed mining site.

Stormwater Mitigation Activity 3

The total flow coming into the Processing plant site from a 10-year, 24-hour storm event is 31.18 cubic feet per second (cfs). This flow is the combination of flow from nodes 1, 2, and 3 as shown in Exhibit 1. This flow is diverted around the plant site through an earthen/riprap trapezoidal channel with a base width of 4 feet and minimum depth of 2 foot. The flow from this channel is released into an existing drainage channel located along State Route (SR) 45 (see Exhibit 6).

Stormwater Mitigation Activity 4

Stormwater management and sediment mitigation for the stockpile and overburden area was considered. V-ditches are proposed along the sides of the piles in a tiered fashion to reduce stormwater erosion and sediment loading downstream (see Exhibit 7).

Feel free to contact us with any questions or concerns.

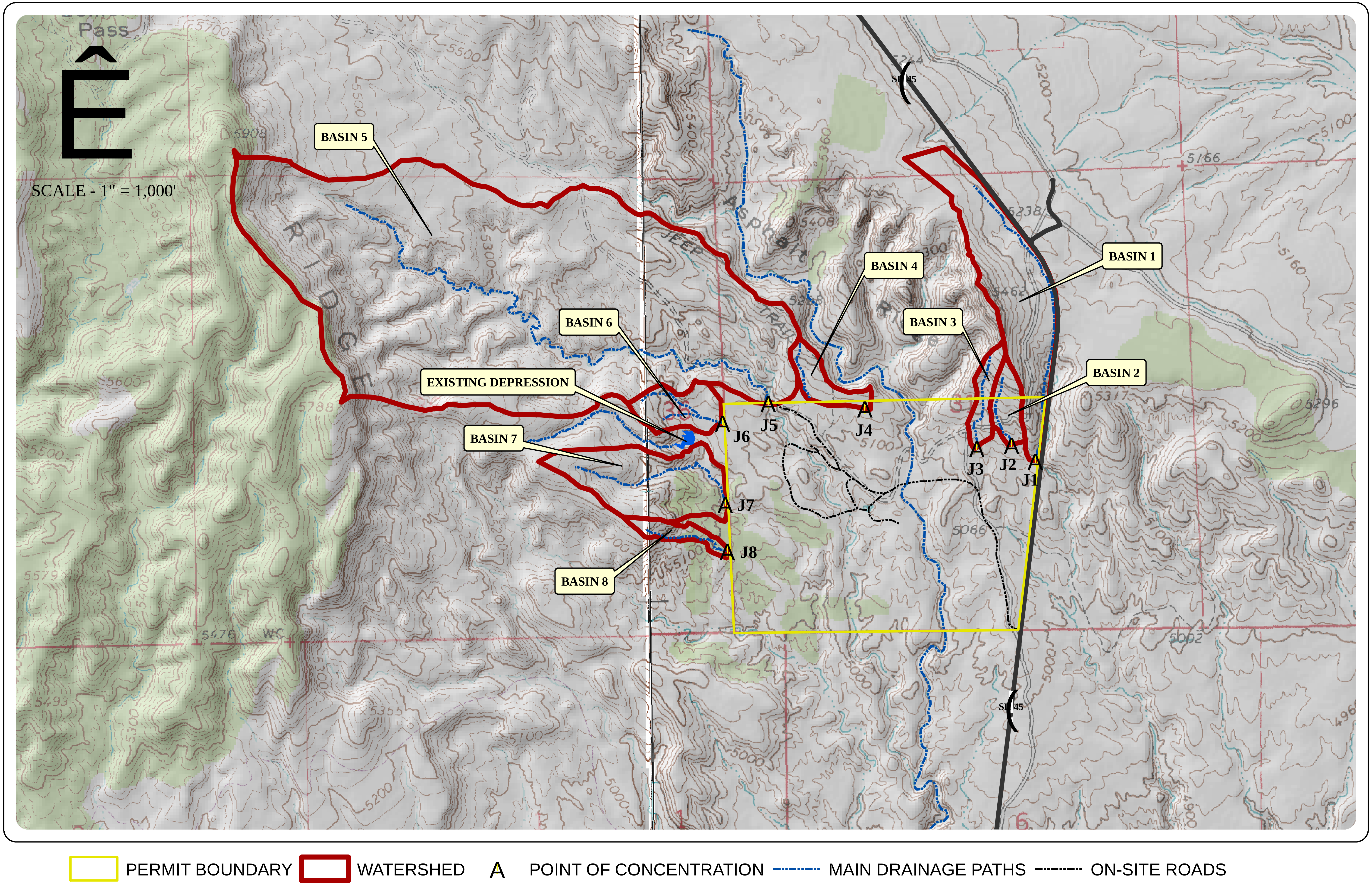
PSOMAS

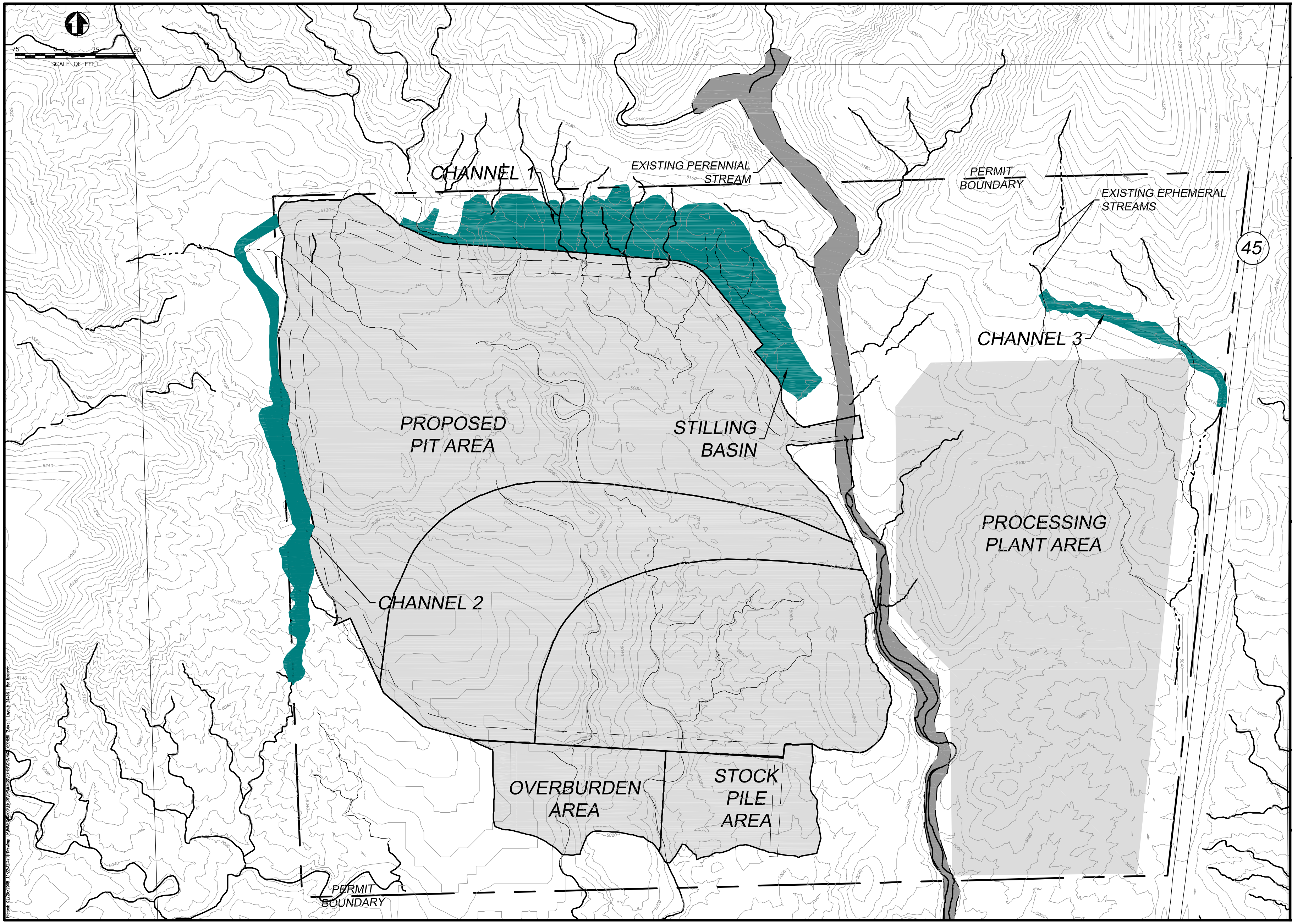
Appendix

NOAA Altas 14 Precipitation Data

PSOMAS

EXHIBIT 1 - TME AR MINE #1 WATERSHEDS WITH USGS QUADRANGLE MAP





LICENSED PROFESSIONAL ENGINEER No. 186163 LESLIE F. MORTON STATE OF UTAH

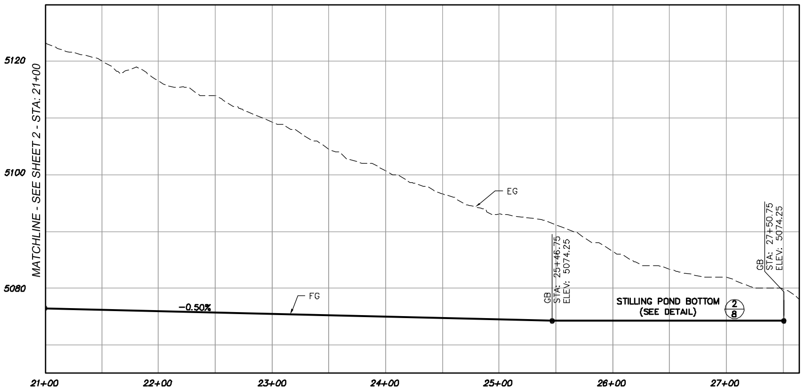
DATE: 02-25-08
PLOT DATE:
SCALE AS SHOWN
PROJECT NUMBER 8AME0405

TME AR MINE #1
OVERALL EXHIBIT
STORM WATER MANAGEMENT

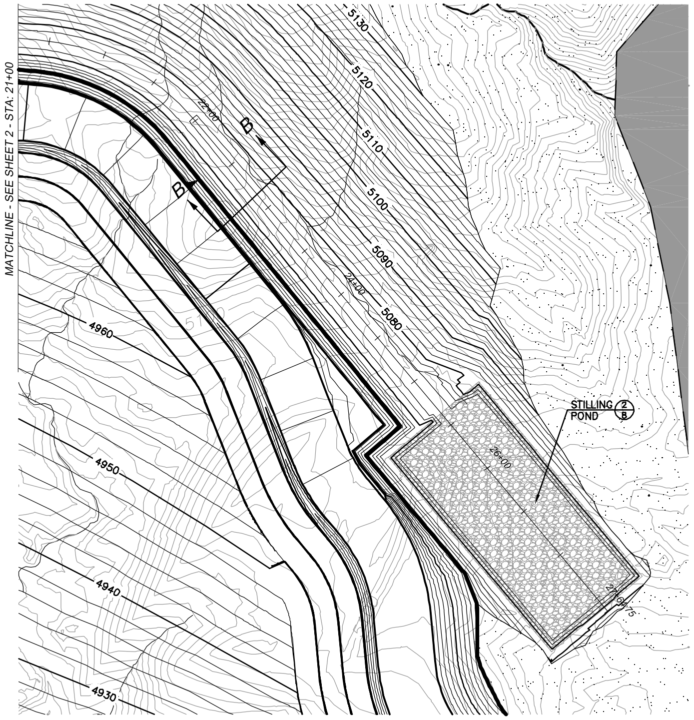
PSOMAS
4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270-5777 (801) 270-5782 (FAX)

DESIGNED JBS
DRAFTED JMB
CHECKED LFM

EXHIBIT 2 OF 8

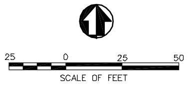


PROFILE OF CHANNEL 1



PLAN VIEW OF CHANNEL 1

STA 21+00 TO STA 27+64.75



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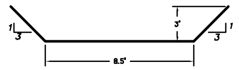
VERT:	1"=10'



CHANNEL
CROSS–SECTION "B"

KEYMAP

LICENSED PROFESSIONAL ENGINEER
No. 186163
LESLIE F. MORTON
STATE OF UTAH

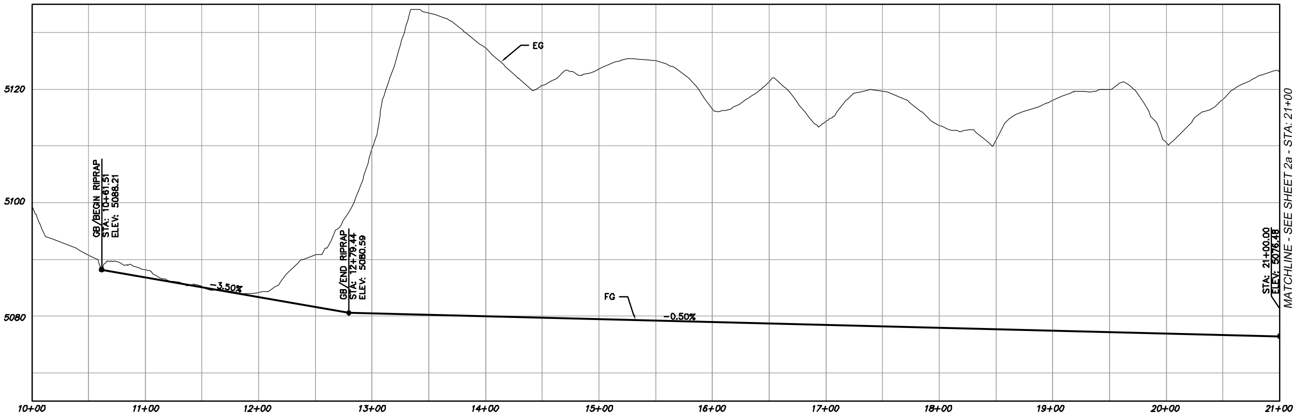
DATE: 02-25-08
PLOT DATE:
SCALE AS SHOWN
PROJECT NUMBER 8AME0405

TME AR MINE #1
CANAL 1 EXHIBIT
STORM WATER MANAGEMENT

PSOMAS
4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270-5777 (801) 270-5782 (FAX)

DESIGNED JBS
DRAFTED JMB
CHECKED LFM

EXHIBIT
2a
OF 8



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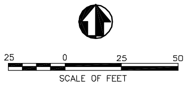

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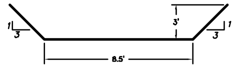
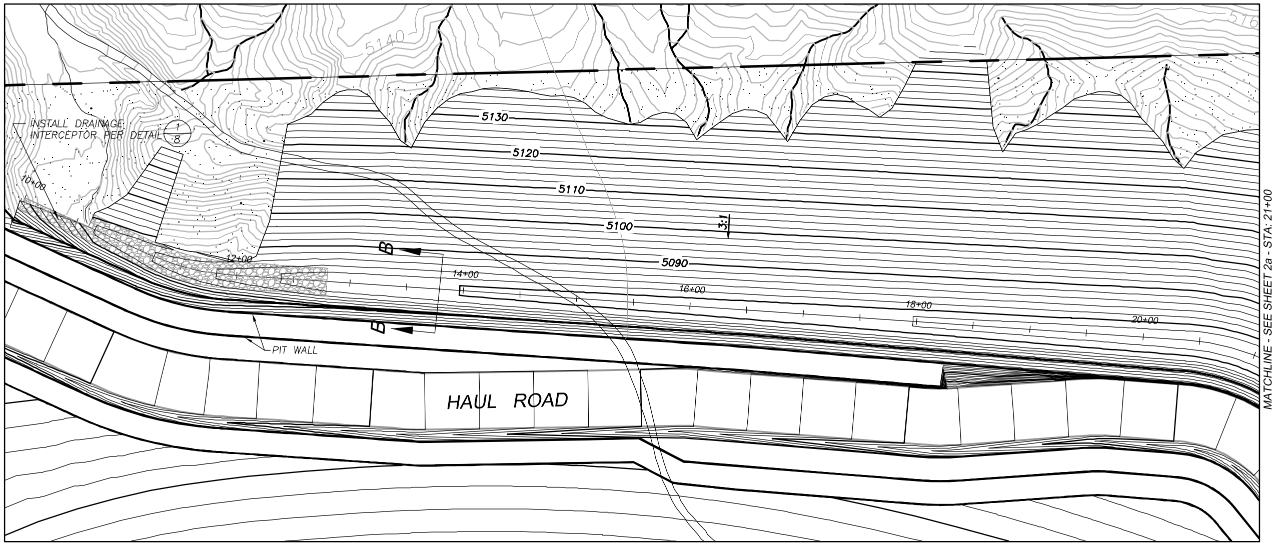


CHANNEL CROSS–SECTION "B"



PLAN VIEW OF CHANNEL 1
STA 10+00 TO STA. 21+00

KEYMAP

TME AR MINE #1
CANAL 1 EXHIBIT
STORM WATER MANAGEMENT

DATE: 02-25-08
PLOT DATE:
SCALE: AS SHOWN
PROJECT NUMBER: 8AME0405

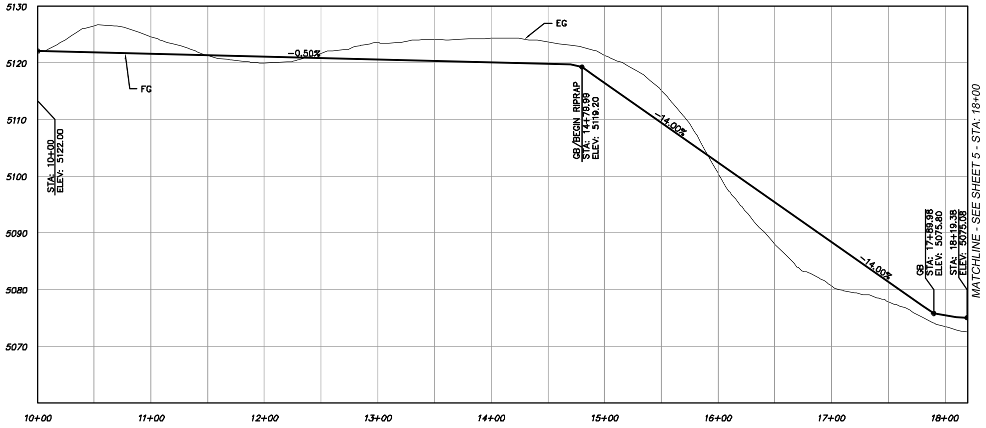
No. 188163
LESLIE F. MORTON

PSOMAS
4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270-5777 (801) 270-5782 (FAX)

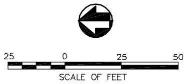
DESIGNED: JBS
DRAFTED: JMB
CHECKED: LFM

EXHIBIT 3 OF 8

Plotted: 02/25/2008 11:15:33.29 | Drawing: U:\8AME040500\ENGR\DRAWINGS\EXHIB\DRAINAGE\EXHIBIT 3.dwg | Layout: 24x36 | By: bpalmer



PROFILE OF CHANNEL 2



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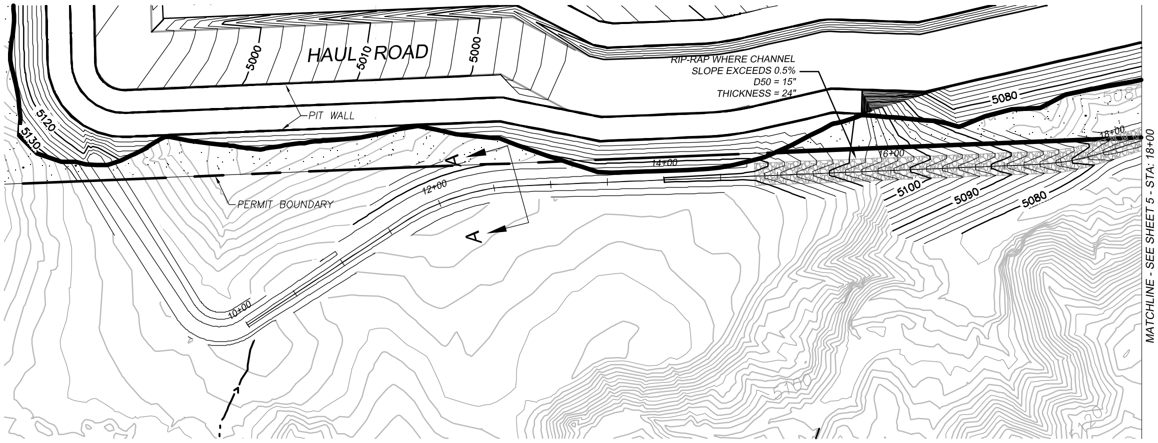
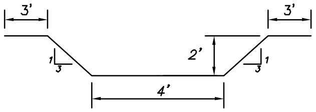
KEYMAP



PLAN VIEW OF CHANNEL 2
STA. 10+00 TO STA. 18+00



CHANNEL
CROSS-SECTION "A"

LICENSED PROFESSIONAL ENGINEER
No. 188163
LESLIE F. MORTON
STATE OF UTAH

DATE: 02-25-08
PLOT DATE:
SCALE AS SHOWN
PROJECT NUMBER 8AME0405

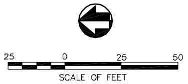
TME AR MINE #1
CHANNEL 2 EXHIBIT
STORM WATER MANAGEMENT

PSOMAS
4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270-5777 (801) 270-5782 (FAX)

DESIGNED JBS
DRAFTED JMB
CHECKED LFM

EXHIBIT
4
OF 8

Plotted: 02/25/2008 11:14:47.06 | Drawing: U:\8AME040500\ENGR\DRAWINGS\EXHIB\DRAINAGE\EXHIBIT 4.dwg | Layout: 24x36 | By: bpalmer



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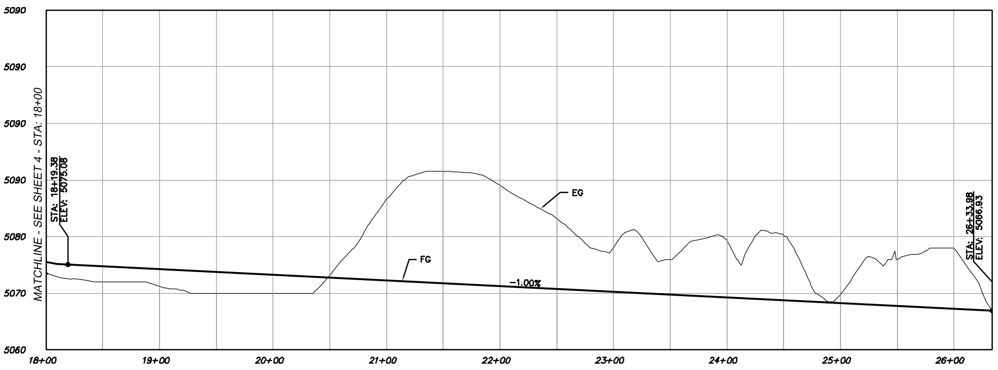

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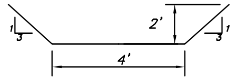

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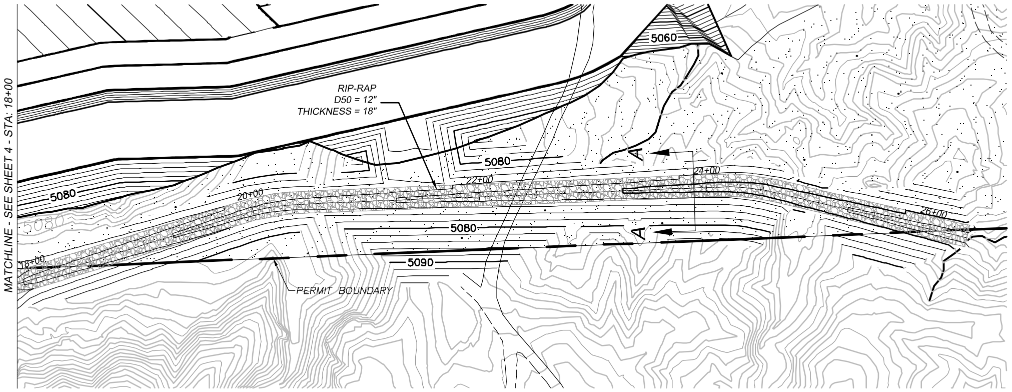


PLAN VIEW OF CHANNEL 2
STA. 18+00 TO STA. 26+00

KEYMAP

DATE: 02-25-08
PLOT DATE:
SCALE AS SHOWN
PROJECT NUMBER 8AME0405

TME AR MINE #1
CHANNEL 2 EXHIBIT
STORM WATER MANAGEMENT

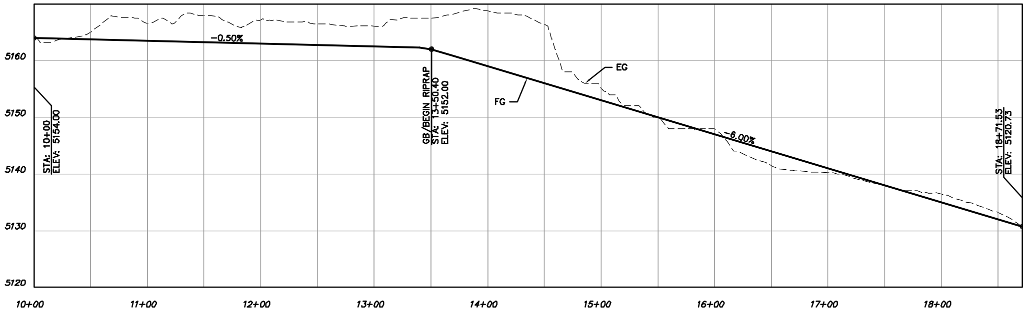
PSOMAS
4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270-5777 (801) 270-5782 (FAX)

DESIGNED JBS
DRAFTED JMB
CHECKED LFM

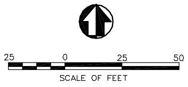
EXHIBIT 5
OF 8

No. 186168
LESLIE F. MORTON

Plotted: 02/25/2008 11:11:01.21 | Drawing: U:\8AME040500\ENGR\DRAWINGS\EXHIB\DRAINAGE\EXHIBIT 5.dwg | Layout: 24x36 | By: bpalmer



PROFILE OF CHANNEL 3



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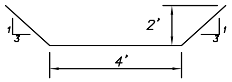

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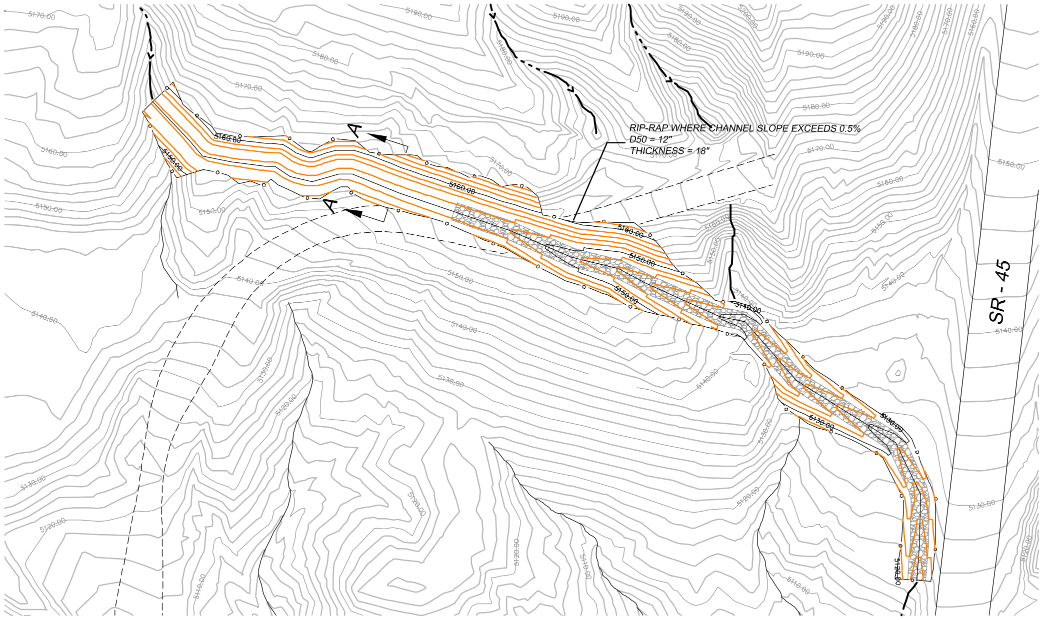


PLAN VIEW OF CHANNEL 3

KEYMAP

TME AR MINE #1
CHANNEL 3 EXHIBIT
STORM WATER MANAGEMENT

LICENSED PROFESSIONAL ENGINEER
No. 186163
LESLIE F. MORTON
STATE OF UTAH

DATE: 02−25−08
PLOT DATE:
SCALE AS SHOWN
PROJECT NUMBER 8AME0405

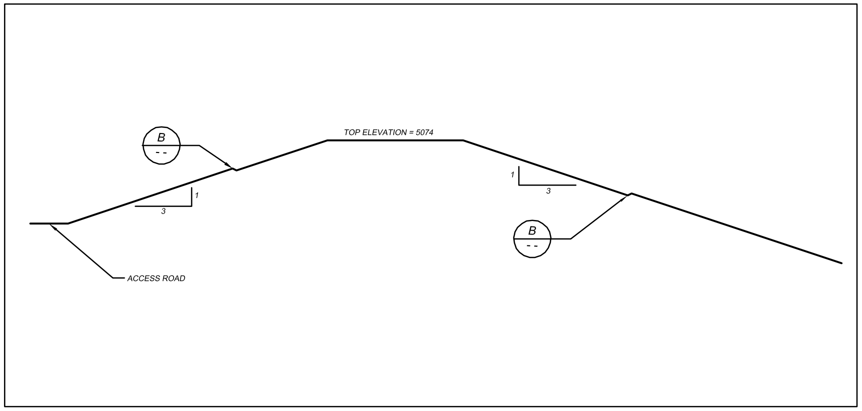
PSOMAS
4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270−5777 (801) 270−5782 (FAX)

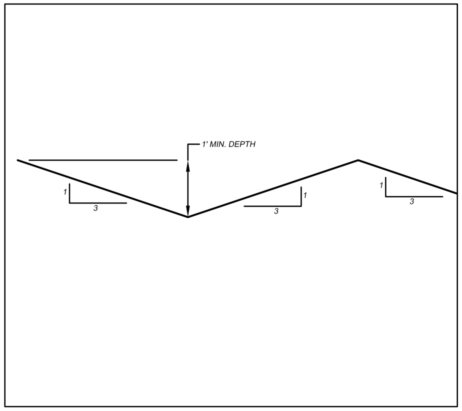
DESIGNED JBS
DRAFTED JMB
CHECKED LFM

EXHIBIT
6
OF 8

Plotted: 02/25/2008 11:17:36.21 | Drawing: U:\8AME040500\ENGR\DRAWINGS\EXHIB\DRAINAGE\EXHIBIT 6.dwg | Layout: 24x36 | By: bpalmer

KEYMAP



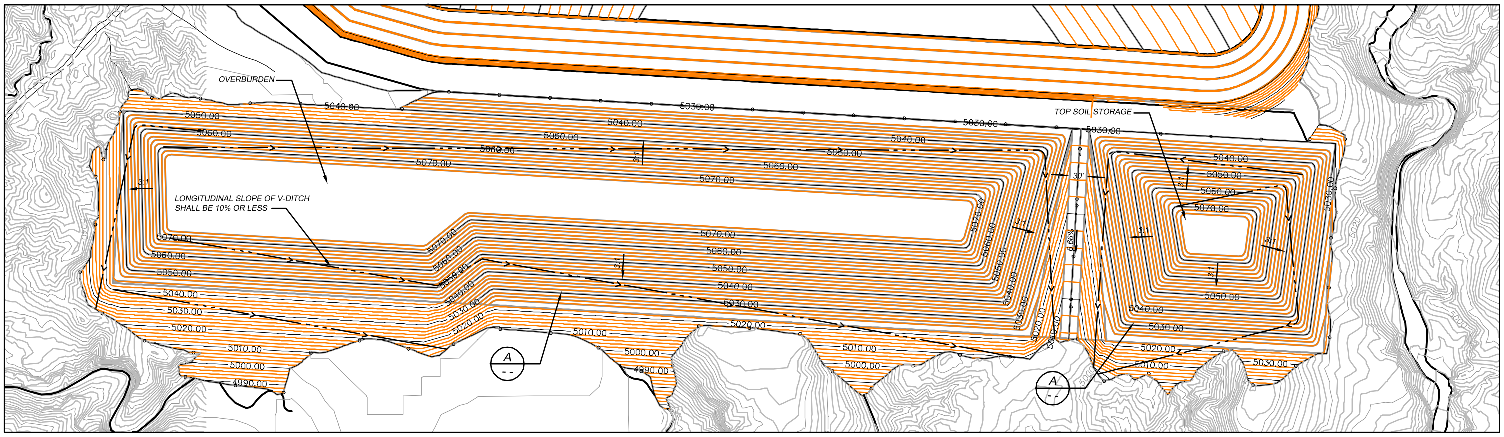


A — — TYPICAL CROSS SECTION

N.T.S.

B — — V–DITCH DETAIL

N.T.S.



PLAN VIEW OF OVERBURDEN

100 0 100 200

SCALE OF FEET

LICENSED PROFESSIONAL ENGINEER
No. 186163
LESLIE F.
MORTON
STATE OF UTAH

DATE: 02–25–08
PLOT DATE:
SCALE AS SHOWN
PROJECT NUMBER 8AME0405

TME AR MINE #1
OVERBURDEN
STORM WATER MANAGEMENT

PSOMAS
4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270-5777 (801) 270-5782 (FAX)

DESIGNED JBS
DRAFTED JMB
CHECKED LFM

EXHIBIT 7
OF 8

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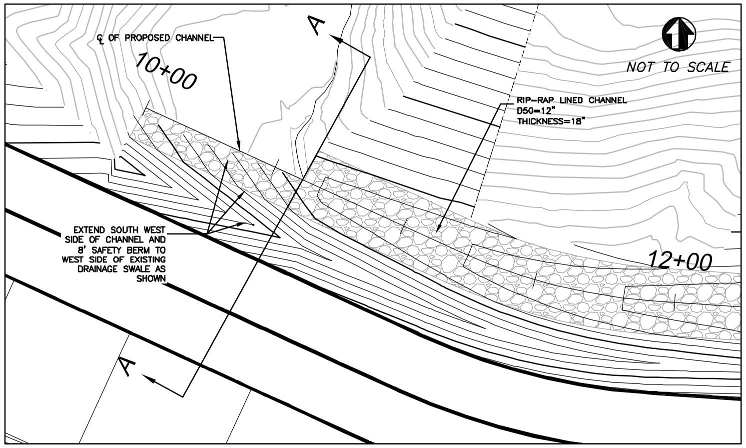

1
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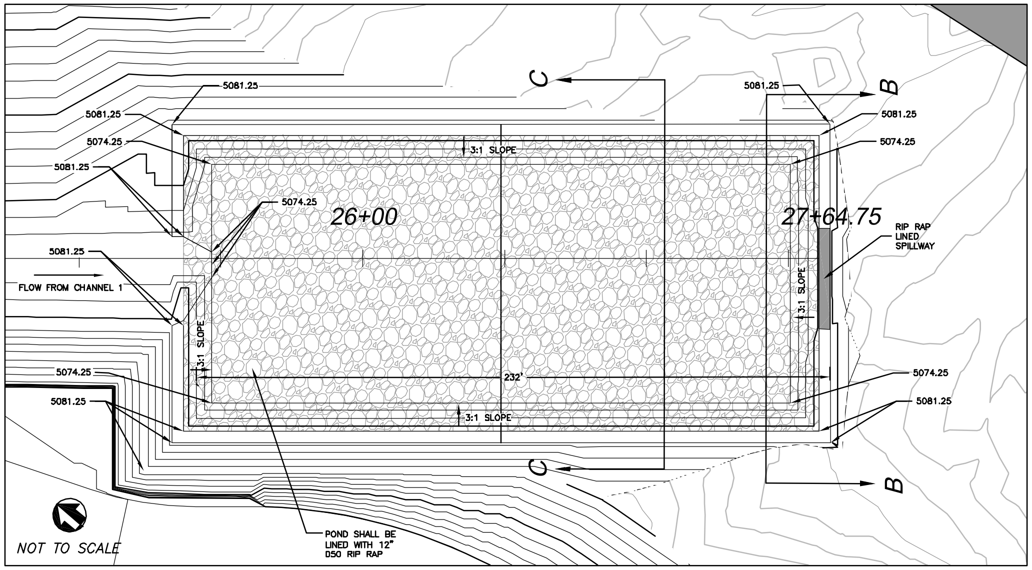
DRAINAGE INTERCEPTOR



2
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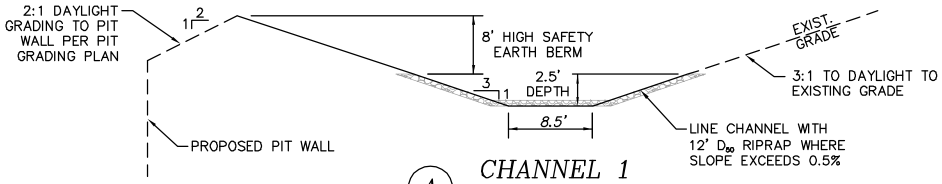
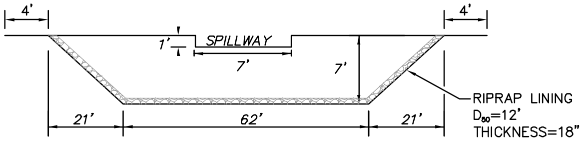
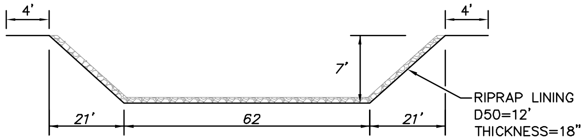
STILLING POND



A
CHANNEL 1



STILLING POND CROSS–SECTION
B



STILLING POND CROSS–SECTION
C

KEYMAP

LICENSED PROFESSIONAL ENGINEER
No. 188163
LESLIE F. NORTON
STATE OF UTAH

DATE: 02-25-08
PLOT DATE:
SCALE AS SHOWN
PROJECT NUMBER 8AME0405

TME AR MINE #1
STILLING POND DETAIL
STORM WATER MANAGEMENT

P S O M A S
4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270-5777 (801) 270-5782 (FAX)

DESIGNED JBS
DRAFTED JMB
CHECKED LFM

EXHIBIT 8
OF 8

Plotted: 02/25/2008 11:17:08.94 | Drawing: U:\8AME040500\ENGR\DRAWINGS\EXHIB\DRAINAGE\EXHIBIT 8.dwg | Layout: 24x36 | By: bpalmer

Appendix

NOAA Altas 14 Precipitation Data

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.315 N 109.543 W 5022 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
Extracted: Thu Sep 20 2007

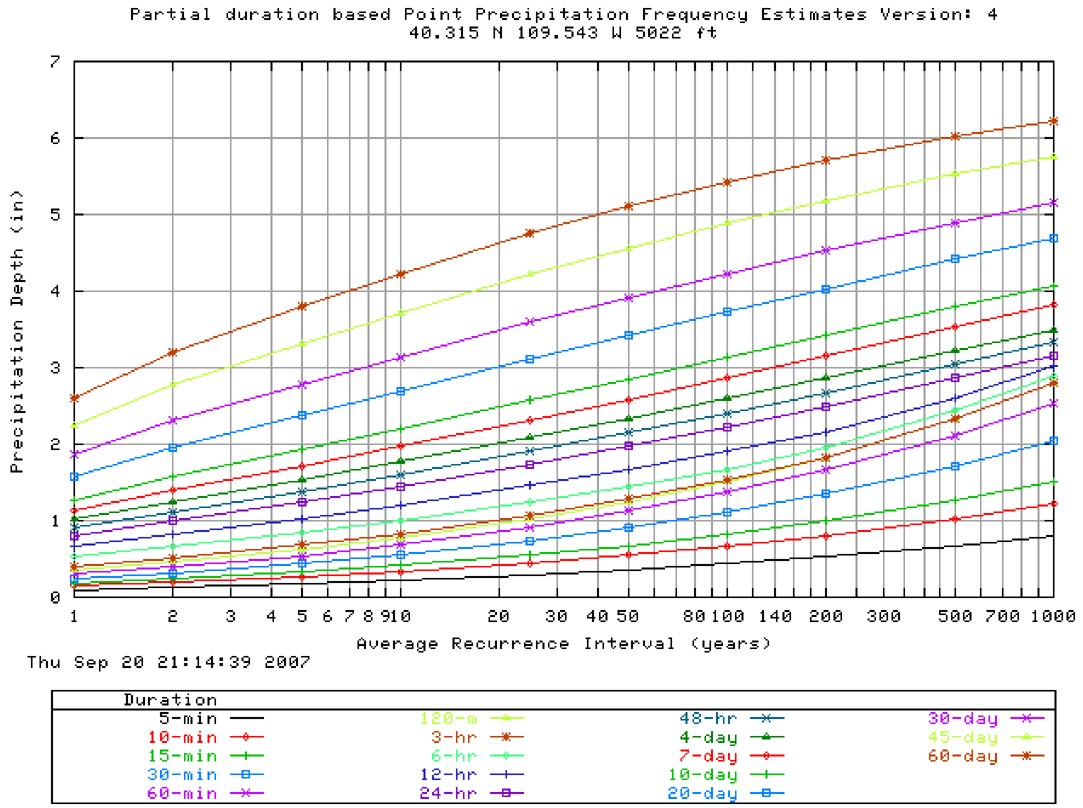
Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Help | Docs | U.S. Map

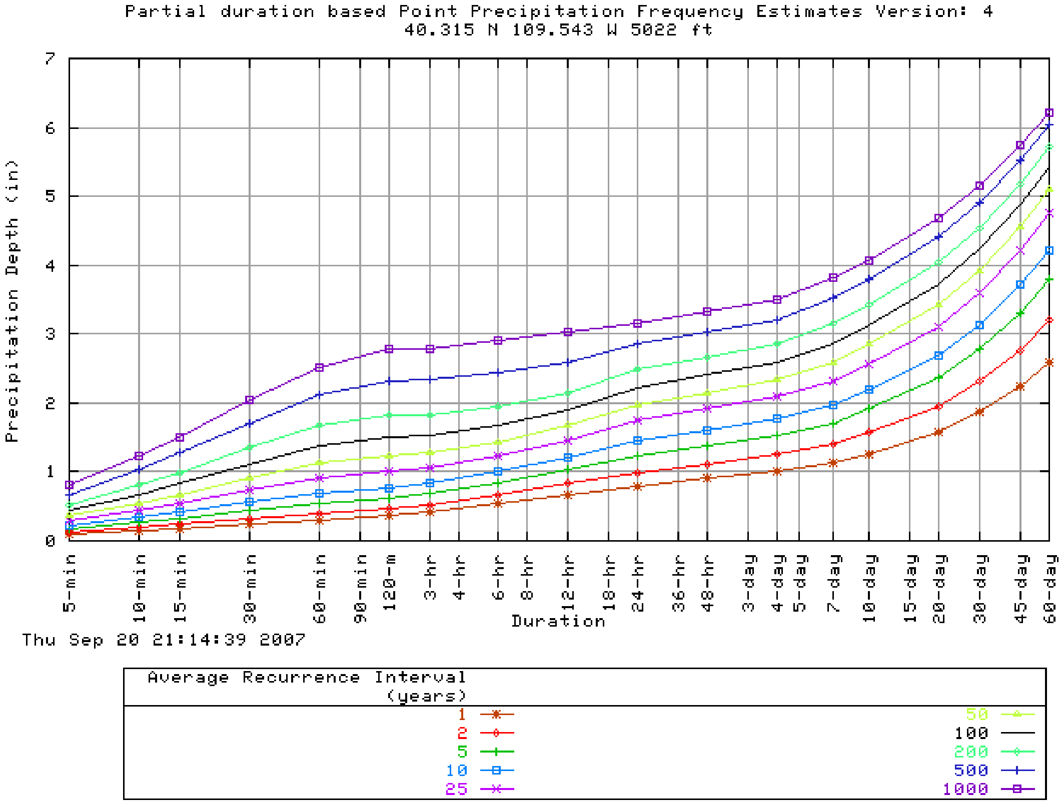
Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.10	0.15	0.18	0.25	0.30	0.37	0.41	0.53	0.67	0.80	0.90	1.01	1.14	1.27	1.57	1.88	2.24	2.60
2	0.12	0.19	0.23	0.32	0.39	0.46	0.52	0.66	0.83	1.00	1.12	1.25	1.40	1.57	1.95	2.32	2.77	3.20
5	0.17	0.26	0.33	0.44	0.54	0.62	0.68	0.85	1.03	1.24	1.39	1.54	1.71	1.92	2.37	2.78	3.31	3.79
10	0.22	0.33	0.41	0.56	0.69	0.77	0.83	1.01	1.21	1.45	1.61	1.77	1.97	2.20	2.69	3.14	3.72	4.22
25	0.29	0.44	0.55	0.74	0.92	1.01	1.07	1.24	1.46	1.74	1.91	2.09	2.31	2.57	3.12	3.59	4.22	4.75
50	0.36	0.55	0.68	0.91	1.13	1.24	1.28	1.44	1.67	1.97	2.15	2.34	2.58	2.85	3.43	3.92	4.57	5.11
100	0.44	0.67	0.83	1.11	1.38	1.50	1.53	1.67	1.90	2.22	2.41	2.60	2.86	3.13	3.73	4.23	4.89	5.43
200	0.53	0.81	1.00	1.34	1.66	1.82	1.83	1.95	2.15	2.48	2.67	2.86	3.15	3.42	4.03	4.53	5.18	5.71
500	0.67	1.03	1.27	1.71	2.12	2.33	2.33	2.44	2.60	2.86	3.04	3.22	3.53	3.79	4.41	4.89	5.53	6.03
1000	0.80	1.22	1.51	2.04	2.52	2.79	2.79	2.90	3.03	3.16	3.33	3.49	3.82	4.07	4.69	5.16	5.75	6.22

Text version of table

* These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.





Confidence Limits -

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)																		
ARI (years)**	**5 min**	**10 min**	**15 min**	**30 min**	**60 min**	**120 min**	**3 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**4 day**	**7 day**	**10 day**	**20 day**	**30 day**	**45 day**	**60 day**
1	0.12	0.18	0.22	0.29	0.36	0.43	0.48	0.61	0.75	0.87	0.98	1.09	1.22	1.37	1.70	2.01	2.40	2.76
2	0.15	0.23	0.28	0.38	0.47	0.55	0.60	0.76	0.93	1.08	1.22	1.35	1.51	1.70	2.10	2.48	2.96	3.41
5	0.21	0.32	0.39	0.53	0.66	0.73	0.80	0.97	1.16	1.34	1.50	1.66	1.83	2.07	2.55	2.98	3.54	4.03
10	0.26	0.40	0.50	0.67	0.83	0.91	0.97	1.15	1.36	1.56	1.73	1.91	2.10	2.36	2.90	3.35	3.96	4.48
25	0.35	0.54	0.66	0.89	1.10	1.20	1.25	1.43	1.65	1.87	2.06	2.24	2.47	2.75	3.34	3.83	4.48	5.03
50	0.43	0.66	0.82	1.10	1.36	1.46	1.50	1.66	1.90	2.12	2.32	2.50	2.75	3.05	3.68	4.18	4.85	5.40
100	0.53	0.81	1.00	1.35	1.67	1.80	1.83	1.94	2.19	2.39	2.59	2.78	3.05	3.36	4.01	4.51	5.19	5.74
200	0.65	0.99	1.23	1.66	2.05	2.20	2.21	2.29	2.50	2.68	2.88	3.06	3.36	3.67	4.33	4.83	5.51	6.04
500	0.84	1.28	1.59	2.14	2.65	2.88	2.91	2.93	3.09	3.12	3.28	3.45	3.77	4.08	4.76	5.24	5.87	6.38
1000	1.02	1.55	1.93	2.59	3.21	3.52	3.56	3.60	3.65	3.69	3.73	3.76	4.09	4.38	5.07	5.52	6.11	6.58

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

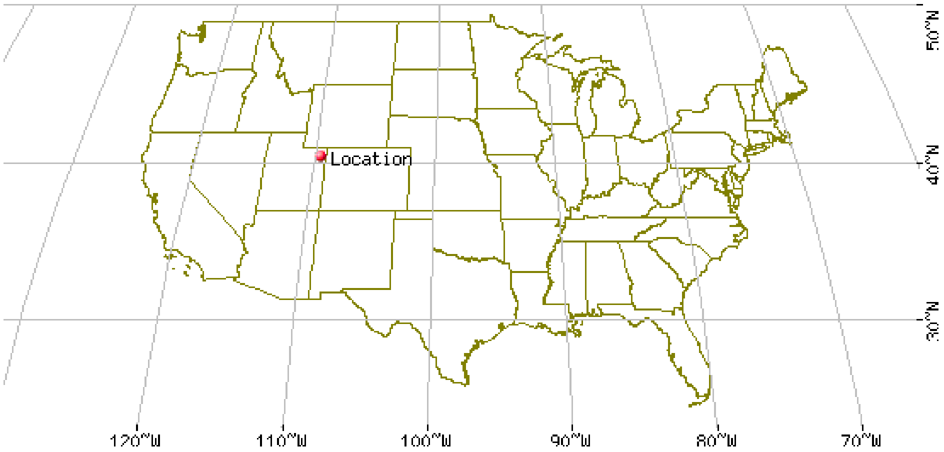
* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)																		
ARI (years)**	**5 min**	**10 min**	**15 min**	**30 min**	**60 min**	**120 min**	**3 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**4 day**	**7 day**	**10 day**	**20 day**	**30 day**	**45 day**	**60 day**
1	0.08	0.13	0.16	0.21	0.26	0.32	0.36	0.47	0.60	0.74	0.83	0.94	1.05	1.18	1.46	1.75	2.09	2.43
2	0.11	0.16	0.20	0.27	0.34	0.40	0.45	0.59	0.75	0.92	1.03	1.16	1.30	1.46	1.81	2.16	2.59	3.00
5	0.15	0.23	0.28	0.38	0.46	0.54	0.59	0.75	0.93	1.14	1.28	1.43	1.59	1.79	2.20	2.60	3.10	3.56
10	0.18	0.28	0.35	0.47	0.58	0.66	0.72	0.88	1.08	1.33	1.48	1.64	1.83	2.04	2.50	2.92	3.47	3.96
25	0.24	0.37	0.45	0.61	0.76	0.84	0.90	1.07	1.29	1.59	1.75	1.93	2.15	2.38	2.89	3.35	3.94	4.46

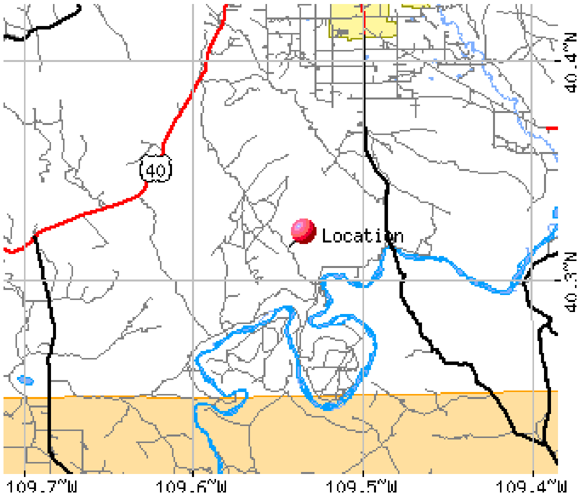
50	0.29	0.44	0.54	0.73	0.91	1.00	1.05	1.22	1.45	1.79	1.97	2.15	2.39	2.63	3.17	3.64	4.27	4.80
100	0.34	0.52	0.65	0.87	1.08	1.18	1.23	1.39	1.62	2.01	2.19	2.38	2.64	2.88	3.44	3.92	4.57	5.10
200	0.40	0.61	0.75	1.01	1.26	1.37	1.43	1.58	1.79	2.23	2.41	2.60	2.88	3.13	3.71	4.19	4.84	5.37
500	0.48	0.74	0.91	1.23	1.52	1.67	1.74	1.92	2.10	2.54	2.71	2.90	3.21	3.45	4.04	4.52	5.17	5.67
1000	0.56	0.84	1.05	1.41	1.75	1.93	2.00	2.21	2.38	2.78	2.95	3.13	3.45	3.69	4.28	4.74	5.37	5.85

* The **lower** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **less** than.
** These precipitation frequency estimates are based on a partial duration maxima series. **ARI** is the Average Recurrence Interval.

Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

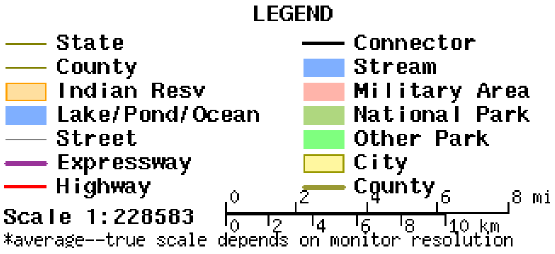
Maps -





These maps were produced using a direct map request from the U.S. Census Bureau Mapping and Cartographic Resources **Tiger Map Server**.

Please read disclaimer for more information.



Other Maps/Photographs -

View USGS digital orthophoto quadrangle (DOQ) covering this location from TerraServer; **USGS Aerial Photograph** may also be available from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the USGS for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, *please refer to our documentation.*

Using the **National Climatic Data Center's (NCDC)** station search engine, locate other climate stations within:

[+/-30 minutes] ...OR... [+/-1 degree] of this location (40.315/-109.543). Digital ASCII data can be obtained directly from **NCDC**.

Find Natural Resources Conservation Service (NRCS) SNOTEL (SNOwpack TELemetry) stations by visiting the
Western Regional Climate Center's state-specific SNOTEL station maps.

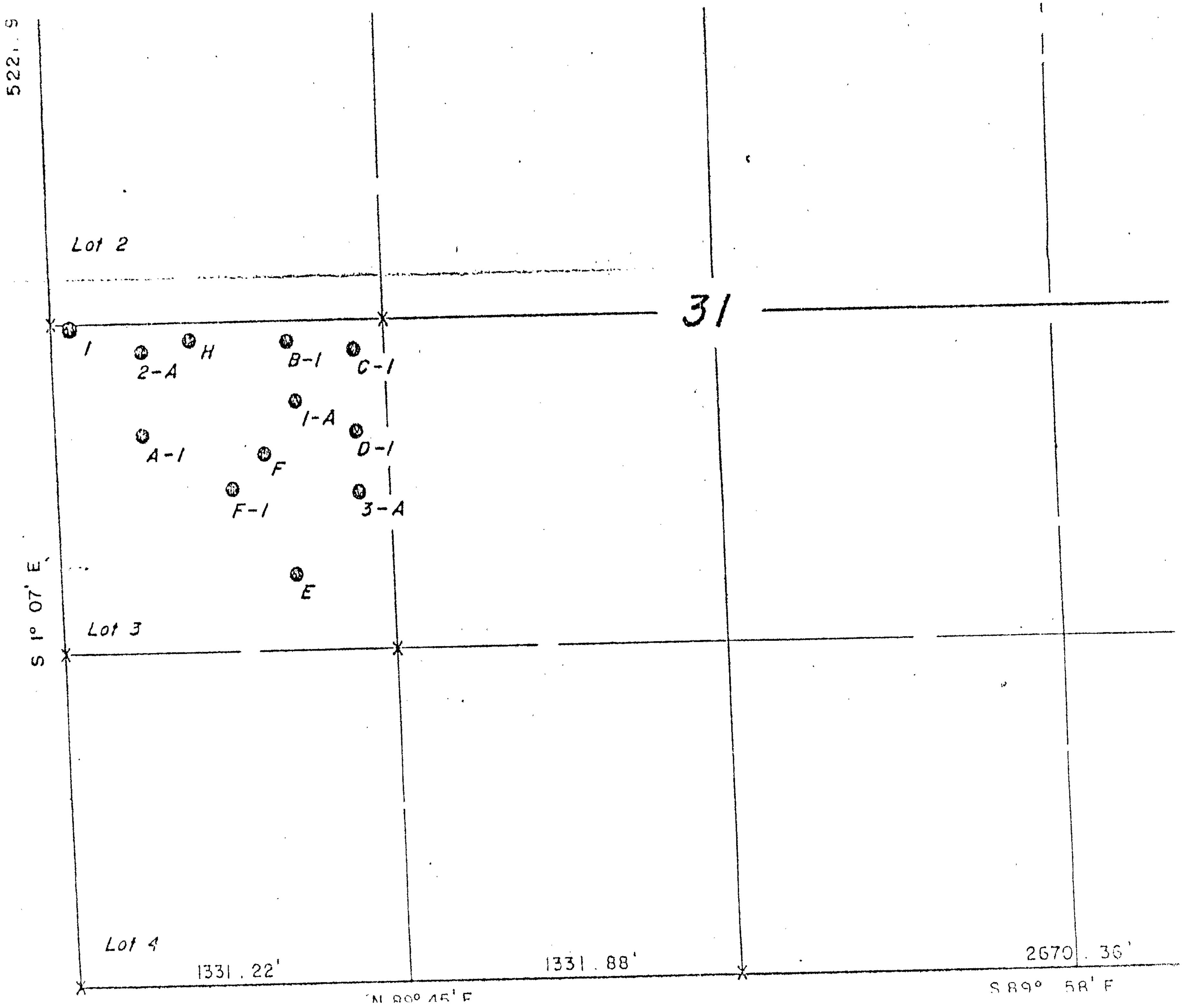
Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910

(301) 713-1669
Questions?: HDSC.Questions@noaa.gov

Disclaimer

ARIZONA FUELS

NAME	F. 1/4 S.L.	F.W.L.	ELEV.
A - 1	442'	346'	5114'
E	1000'	940'	5092'
F	525'	830'	5073'
H	70'	545'	5092'
2 - A	109'	358'	5135'
1 - A	315'	965'	5127'
3 - A	682'	1210'	5097'
B - 1	77'	935'	5141'
C - 1	111'	1207'	5139'
D - 1	422'	1197'	5114'
F - 1	662'	695'	5082'
I	15'	81'	5139'


522.9
Lot 2
31
I
2-A
H
B-1
C-1
1-A
A-1
D-1
F
F-1
3-A
E
S 1° 07' E
Lot 3
Lot 4
1331.22'
1331.88'
2670.36'
N 89° 45' E
S 89° 58' E

TAR SAND ANALYSIS FOR

BURMAH OIL AND GAS COMPANY
ARIZONA FUELS COMPANY

CORE HOLE NO. 1-A

ASPHALT RIDGE FIELD

UINTAH COUNTY, UTAH

CL-811-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

Company	BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY	Formation		File	RP-2-4838
Well	CORE HOLE NO. 1-A	Core Type	DIAMOND 2.125	Date Report	4-1-75
Field	ASPHALT RIDGE	Drilling Fluid	WATER BASE MUD	Analysts	EJ
County	UINTAH State UTAH	Elev.	5127' GL	Location	NW SW SEC. 31-5S-R22E

Lithological Abbreviations

SAND-SD SHALE-SH LIME-LM DOLOMITE-DOL CHERT-CH GYPSUM-GYP ANHYDRITE-ANHY CONGLOMERATE-CONG FOSSILIFEROUS-FOSS SANDY-SDY SHALY-SHY LIMY-LMY FINE-FN MEDIUM-MED COARSE-CSE CRYSTALLINE-XLN GRAIN-GRN GRANULAR-GRNL BROWN-BRN GRAY-GY VUGGY-VGY FRACTURED-FRAC LAMINATION-LAM STYLOLITIC-STY SLIGHTLY-S VERY-V/ WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

Weight Percent

Sample No.	Depth	Oil	Water	Sand	Grain Density
1	17.0-19.5	4.8	0.4	94.7	2.59
2	19.5-22.0	7.5	0.5	92.0	2.61
3	22.0-24.5	6.1	0.9	93.1	2.63
4	24.5-27.0	2.8	0.4	96.8	
5	34.0-36.5	5.3	2.9	91.8	
6	36.5-39.0	10.9	1.2	87.9	2.66
7	39.0-41.5	6.4	1.3	92.2	
8	41.5-44.0	8.3	0.7	91.0	
9	44.0-46.5	7.3	0.9	91.7	
10	46.5-49.0	6.5	0.9	92.6	
11	49.0-51.5	7.2	0.7	92.1	
12	51.5-54.0	5.8	0.6	93.5	
13	57.0-59.5	9.7	0.4	89.9	
14	59.5-62.0	6.4	0.7	93.0	
15	62.0-64.5	7.0	2.0	91.0	
16	64.5-67.0	1.6	0.7	97.7	
17	67.0-69.5	0.2	0.2	99.8	
18	69.5-72.0	11.6	0.4	88.0	
19	72.0-74.5	2.0	0.3	97.7	
20	74.5-77.0	0.6	1.5	97.9	
21	77.0-79.5	4.7	1.5	93.8	
22	79.5-82.0	12.3	1.3	86.4	
23	82.0-84.5	3.1	0.9	96.0	
24	84.5-87.0	7.5	0.6	91.9	
25	87.0-89.5	4.4	0.5	95.1	
26	89.5-92.0	6.7	0.5	92.8	
27	92.0-94.5	4.0	0.4	95.6	
28	94.5-97.0	9.8	1.0	89.2	
29	97.0-99.5	7.3	0.8	92.0	
30	99.5-02.0	3.0	1.6	95.4	
31	102.0-04.5	0.3	0.0	99.7	
32	104.5-07.0	3.1	0.3	96.6	
33	107.0-09.5	3.1	0.3	96.7	
34	109.5-12.0	4.2	0.2	95.5	
35	112.0-14.5	0.6	0.2	99.1	

Cu NW NX 2.5 N

①

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4838
Well CORE HOLE NO. 1-A
Core Type DIAMOND 2.125
Date Report 4-1-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts EJ
County UINTAH
State UTAH
Elev. 5127' GL
Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

SAND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-
SHALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
LIME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

AMPLE UMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

		Weight Percent			
Sample No.	Depth	Oil	Water	Sand	Grain Density
36	114.5-17.0	2.2	0.2	97.6	
37	117.0-19.5	0.8	0.1	99.1	
38	119.5-22.0	6.9	0.1	93.0	
39	122.0-24.5	1.1	0.1	98.8	
40	124.5-27.0	6.4	0.3	93.3	
41	127.0-29.5	0.6	0.5	98.9	
42	129.5-32.0	1.2	0.2	98.5	
43	132.0-34.5	1.7	0.5	97.8	
44	134.5-37.0	0.3	0.7	99.1	
45	137.0-39.5	1.1	0.2	98.6	
46	139.5-42.0	1.3	0.3	98.4	
47	142.0-44.5	2.1	0.3	97.7	
48	144.5-47.0	1.0	0.3	98.7	
49	147.0-49.5	3.6	0.6	95.8	
50	149.5-52.0	3.1	0.5	96.3	
51	152.0-54.5	4.8	1.0	94.2	
52	154.5-57.0	0.1	0.8	99.1	
53	157.0-59.5	6.0	0.6	93.4	
54	159.5-62.0	0.6	0.5	98.9	
55	162.0-64.5	1.1	0.8	98.1	
56	164.5-67.0	5.3	0.5	94.2	
57	167.0-69.5	1.8	0.5	97.8	
58	169.5-72.0	3.6	0.9	95.5	
59	172.0-74.5	6.0	0.6	93.4	
60	174.5-77.0	5.3	1.1	93.7	
61	177.0-79.5	0.8	1.2	98.0	
62	179.5-82.0	0.2	0.5	99.3	
63	182.0-84.5	3.7	0.5	95.8	
64	184.5-87.0	2.4	0.8	96.8	
65	187.0-89.5	1.9	0.5	97.6	
66	189.5-92.0	1.1	0.5	98.4	
67	192.0-94.5	2.4	0.3	97.3	
68	194.5-97.0	0.4	1.0	98.6	
69	197.0-99.5	0.3	0.7	99.0	
70	199.5-02.0	3.0	1.1	95.9	
71	202.0-04.5	0.8	0.6	98.6	

CORE ANALYSIS RESULTS

BURMAH OIL & GAS COMPANY
Company ARIZONA FUELS COMPANY | Formation | File RP-2-4838
Well CORE HOLE NO. 1-A | Core Type DIAMOND 2.125 | Date Report 3-24-75
Field ASPHALT RIDGE | Drilling Fluid WATER BASE MUD | Analysts EJ
County UINTAH | State UTAH | Elev. 5127' GL | Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

AND-SD
HALE-SH
IME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

Weight Percent

Sample No.	Depth	Oil	Water	Sand	Grain Density
72	204.5-07.0	1.7	0.2	98.1	
73	207.0-09.5	1.5	0.5	98.0	
74	209.5-12.0	4.6	0.8	94.6	
75	212.0-14.5	3.1	0.5	96.4	
76	214.5-17.0	5.0	0.3	94.7	2.65
77	217.0-19.5	3.4	0.3	96.3	
78	219.5-22.0	0.3	0.6	99.1	
79	222.0-24.5	0.8	0.5	98.7	
80	224.5-27.0	1.8	1.3	96.9	2.64
81	227.0-29.5	0.0	1.1	98.9	
82	229.5-32.0	2.2	0.4	97.4	
83	232.0-34.5	5.8	0.2	94.0	2.61

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

ompany BURMAH OIL & GAS COMPANY
ARIZONA FUELS COMPANY
Formation
File RP-2-4838
ell CORE HOLE NO. 1-A
Core Type DIAMOND 2.125
Date Report 4-1-75
eld ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts EJ
ounty UINTAH
State UTAH
Elev. 5127' GL
Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

ID-SS
ALE-SH
E-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL/
VERY-V/
WITH-W/

E ER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Weight Percent

Sample No.	Depth	gal/yd³	Oil	Water	Sand	Grain Density
1	17.0-19.5	20.7	4.8	0.4	94.7	2.59
2	19.5-22.0	32.4	7.5	0.5	92.0	2.61
3	22.0-24.5	23.4	6.1	0.9	93.1	2.63
4	24.5-27.0	12.1	2.8	0.4	96.8	
5	34.0-36.5	22.9	5.3	2.9	91.8	
6	36.5-39.0	47.1	10.9	1.2	87.9	2.66
7	39.0-41.5	27.6	6.4	1.3	92.2	
8	41.5-44.0	35.9	8.3	0.7	91.0	
9	44.0-46.5	31.5	7.3	0.9	91.7	
10	46.5-49.0	28.1	6.5	0.9	92.6	
11	49.0-51.5	31.1	7.2	0.7	92.1	
12	3' x 51.5-54.0	25.1	5.8	0.6	93.5	
13	57.0-59.5	41.9	9.7	0.4	89.9	
14	59.5-62.0	27.6	6.4	0.7	93.0	
15	62.0-64.5	30.2	7.0	2.0	91.0	
16	64.5-67.0	6.9	1.6	0.7	97.7	
17	2½ x 67.0-69.5	.9	0.2	0.2	99.8	
18	69.5-72.0	50.1	11.6	0.4	88.0	
19	72.0-74.5	7.5	2.0	0.3	97.7	
20	2½ x 74.5-77.0	2.6	0.6	1.5	97.9	
21	77.0-79.5	20.3	4.7	1.5	93.8	
22	79.5-82.0	[illegible]	12.3	1.3	86.4	
23	82.0-84.5	13.4	3.1	0.9	96.0	
24	84.5-87.0	32.4	7.5	0.6	91.9	
25	87.0-89.5	19.0	4.4	0.5	95.1	
26	89.5-92.0	27.9	6.7	0.5	92.8	
27	92.0-94.5	17.3	4.0	0.4	95.6	
28	94.5-97.0	42.3	9.8	1.0	89.2	
29	97.0-99.5	31.3	7.3	0.8	92.0	
30	99.5-02.0	13.0	3.0	1.6	95.4	
31	102.0-04.5	1.3	0.3	0.0	99.7	
32	104.5-07.0	13.4	3.1	0.3	96.6	
33	107.0-09.5	13.4	3.1	0.3	96.7	
34	109.5-12.0	18.1	4.2	0.2	95.5	
35	112.0-14.5	2.6	0.6	0.2	99.1	

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

ompany BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4838
Vell CORE HOLE NO. 1-A
Core Type DIAMOND 2.125
Date Report 4-1-75
ield ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts EJ
ounty UINTAH State UTAH Elev. 5127' GL Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

ND-SD
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SLIGHTLY-SL
VERY-V/
WITH-W/

LE ER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Weight Percent

Sample No.	Depth	gal/yd³	Oil	Water	Sand	Grain Density
36	114.5-17.0	9.5	2.2	0.2	97.6	
37	117.0-19.5	3.5	0.8	0.1	99.1	
38	119.5-22.0	29.8	6.9	0.1	93.0	
39	122.0-24.5	4.8	1.1	0.1	98.8	
40	124.5-27.0	27.6	6.4	0.3	93.3	
41	127.0-29.5	2.6	0.6	0.5	98.9	
42	129.5-32.0	5.2	1.2	0.2	98.5	
43	132.0-34.5	7.3	1.7	0.5	97.8	
44	134.5-37.0	1.3	0.3	0.7	99.1	
45	137.0-39.5	4.8	1.1	0.2	98.6	
46	139.5-42.0	5.6	1.3	0.3	98.4	
47	142.0-44.5	9.7	2.1	0.3	97.7	
48	144.5-47.0	4.3	1.0	0.3	98.7	
49	147.0-49.5	15.6	3.6	0.6	95.8	
50	149.5-52.0	13.4	3.1	0.5	96.3	
51	152.0-54.5	20.7	4.8	1.0	94.2	
52	154.5-57.0	0.4	0.1	0.8	99.1	
53	157.0-59.5	25.9	6.0	0.6	93.4	
54	159.5-62.0	2.6	0.6	0.5	98.9	
55	162.0-64.5	4.8	1.1	0.8	98.1	
56	164.5-67.0	22.9	5.3	0.5	94.2	
57	167.0-69.5	7.8	1.8	0.5	97.8	
58	169.5-72.0	15.6	3.6	0.9	95.5	
59	172.0-74.5	25.9	6.0	0.6	93.4	
60	174.5-77.0	22.9	5.3	1.1	93.7	
61	177.0-79.5	3.5	0.8	1.2	98.0	
62	179.5-82.0	.9	0.2	0.5	99.3	
63	182.0-84.5	16.0	3.7	0.5	95.8	
64	184.5-87.0	10.4	2.4	0.8	96.8	
65	187.0-89.5	7.2	1.9	0.5	97.6	
66	189.5-92.0	4.8	1.1	0.5	98.4	
7	192.0-94.5	10.4	2.4	0.3	97.3	
8	194.5-97.0	1.7	0.4	1.0	98.6	
9	197.0-99.5	1.3	0.3	0.7	99.0	
0	199.5-02.0	13.0	3.0	1.1	95.9	
1	202.0-04.5	3.5	0.8	0.6	98.6	

-3:1-1

RELIMINARY COPY

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 3

CORE ANALYSIS RESULTS

BURMAH OIL & GAS COMPANY
mpany ARIZONA FUELS COMPANY
ell CORE HOLE NO. 1-A
eld ASPHALT RIDGE
unty UINTAH State UTAH Elev. 5127' GL

Formation
Core Type DIAMOND 2.125
Drilling Fluid WATER BASE MUD
Location NW SW SEC. 31-T5S-R22E

File RP-2-4838
Date Report 3-24-75
Analysts EJ

Lithological Abbreviations

D-SD
LE-SH
E-LM

DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP

ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS

SANDY-SDY
SHALY-SHY
LIMY-LMY

FINE-FN
MEDIUM-MED
COARSE-CSE

CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL

BROWN-BRN
GRAY-GY
VUGGY-VGY

FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY

SLIGHTLY-SL/
VERY-V/
WITH-W/

E ER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Weight Percent

Sample No.	Depth		Oil	Water	Sand	Grain Density
72	204.5-07.0	7.3	1.7	0.2	98.1	
73	207.0-09.5	6.5	1.5	0.5	98.0	
74	209.5-12.0	19.9	4.6	0.8	94.6	
75	212.0-14.5	13.4	3.1	0.5	96.4	
76	214.5-17.0	21.6	5.0	0.3	94.7	2.65
77	217.0-19.5	14.7	3.4	0.3	96.3	
78	219.5-22.0	1.3	0.3	0.6	99.1	
79	222.0-24.5	3.5	0.8	0.5	98.7	
80	224.5-27.0	7.8	1.8	1.3	96.9	2.64
81	227.0-29.5	0	0.0	1.1	98.9	
82	229.5-32.0	9.5	2.2	0.4	97.4	
83	232.0-34.5	25.1	5.8	0.2	94.0	2.61

avg = 2.63

T. W. EHRING

GEOLOGIC

STATE UTAH ELEV. 5127'

COUNTY UINTAH

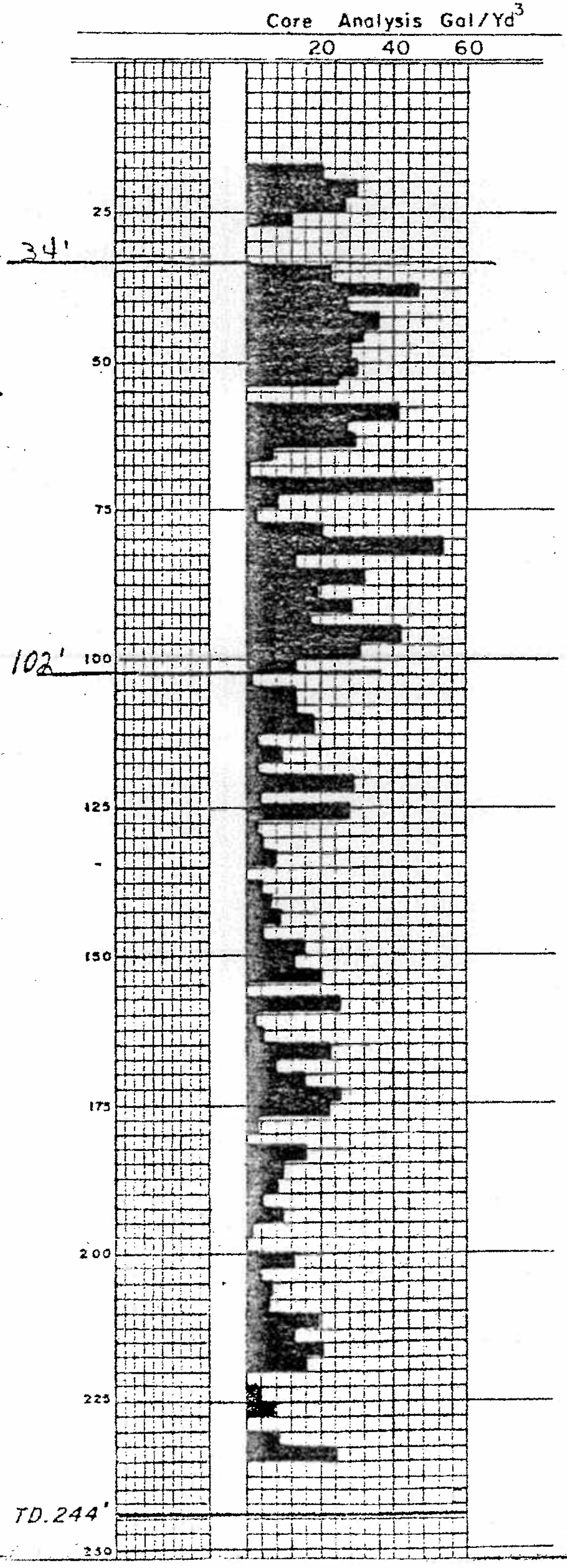
COMPANY ARIZONA FUELS CORPORATION

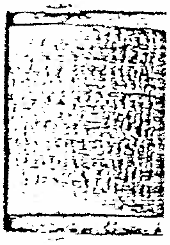
FARM BOAG-SOHIO WELL NO. CH 1-A

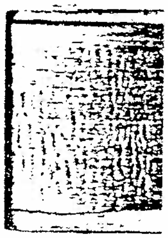
LOCATION 315'S, 965'E FW 1/4 CORNER,
SEC. 31, T-5-S, R-22-E, S.L.B.&M.

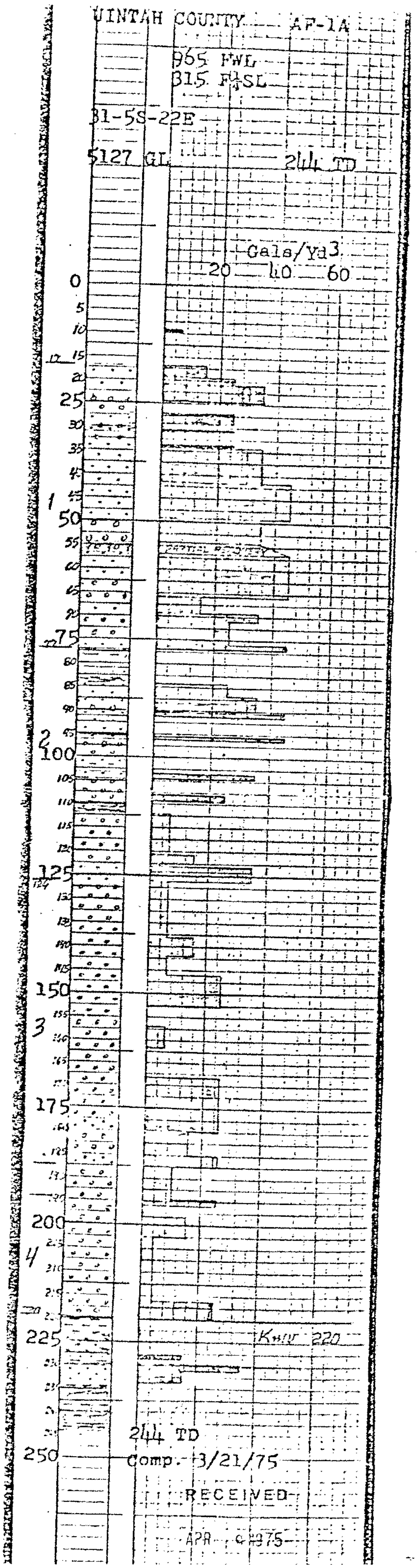
T.D. 244' TOOLS LONGYEAR 44

1-3/4" WIRELINE CORE








UINTAH COUNTY
AF-1A
965 FWL
315 FSL
31-5S-22E
5127 GL
244 TD
Gals/Yd3
20
40
60
0
5
10
15
12
20
25
30
35
40
45
1
50
55
PARTIAL RECOVERY
60
65
70
75
77
80
85
90
95
2
100
105
110
115
120
125
124
130
135
140
145
150
155
3
160
165
170
175
180
185
190
195
200
205
4
210
215
220
225
Kmr 220
230
235
240
245
244 TD
250
Comp. 3/21/75
RECEIVED
APR 1975

Arizona Fuels 1-A

4/15/75

122 GL	Depth	% Oil wt	G/Y³	actual	Est.	
LEVEL 1	17-19.5	4.8	20.7	III-	II+	17.0
	19.5-22.0	7.5	32.4	III-	III+	
	22.0-24.5	6.1	26.4	IV	II	
	24.5-27.0	2.8	12.1	II-	24.5-27.0 29.0-30.5 31.0-33.5 barren	} 6.5
	7.0					
	34.0-36.5	5.3	22.9	III-	IV	
	36.5-39.0	10.9	47.1	V-	IV	
	39.0-41.5	6.4	27.6	III+	IV	
	41.5-44.0	8.3	35.9	IV	V	
	44.0-46.5	7.3	31.5	IV-	V	
LEVEL 2	46.5-49.0	6.5	28.1	III+	V	
	49.0-51.5	7.2	31.1	IV-	IV	
	51.5-54.0	5.8	25.1	III	IV	
	3.0				54.0-56.5 lost	
	57.0-59.5	9.7	41.9	IV+	V	
	59.5-62.0	6.4	27.6	III+	V	
	62.0-64.5	7.0	30.2	III+	IV-	
	64.5-67.0	1.6	6.9	I+	II	
	67.0-69.5	.2	.9	I	III+	
	69.5-72.0	11.6	50.1	V-	III+	
	72.0-74.5	2.0	8.6	II-	III	
	74.5-77.0	.6	2.6	I	III	
	77.0-79.5	4.7	20.3	III-	76.7-84.0 Grn sh	7.3
	79.5-82.0	12.3	53.1	V	-	
	82.0-84.5	3.1	13.4	II	-	
	84.5-87.0	7.5	32.4	III+	III	
	87.0-89.5	4.4	19.0	II+	IV	
LEVEL 1	89.5-92.0	6.7	28.9	III	V-	
	92.0-94.5	4.0	17.3	II	91.3-91.7 92.5-94.0 94.4-95.0 95.2-95.4	1.3 III (2.8) barren
	94.5-97.0	9.8	423	IV	V	
	97.0-99.5	7.3	31.5	III+	96.3-100.1 cgl w 0 stn	
7.7	99.5-102.0	3.0	13.0	II-	100.1-103.5 (7.2) SS, shy, tr 0 stn	
	102.0-104.5	0.3	1.3	I	IV	
		III- 5.8	III 25.2	III	III+ 29.14	Barren 13.8
		181.1	782.2		IV 35.2	17.0 overburden

25.0 G/Y = 950 BO/Ac-ft

968 x 77.5' = 75,107 3

Arizona Fuels 1-A 4/15/75 P2

127 GL	Depth	% wt	Gals/yd³	Class Actual	Est.			
	104.5-107.0	3.1	13.4	II	-	104.6-108.0 barren	3.4	
	107.0-109.5	3.1	13.4	II	III			
	109.5-112.0	4.2	18.1	II+	-	109.3-110.7 barren	1.4	
	112.0-114.5	.6	2.6	I-	-	112.1-120.7 barren		
	114.5-117.0	2.2	9.5	II-	-			
	117.0-119.5	.8	3.5	I	-			
	119.5-122.0	6.0	25.8	III				
LEVEL 3	122.0-124.5	1.1	4.8	I+				
	124.5-127.0	6.4	27.6	III				
	127.0-129.5	.6	2.6	I				
	129.5-132.0	1.2	5.2	I+				
	132.0-134.5	1.7	7.3	I+				
	134.5-137.0	.3	1.3	I				
	137.0-139.5	1.1	4.8	I+				
	139.5-142.0	1.3	5.6	I+				
	142.0-144.5	2.1	9.1	II-				
	144.5-147.0	1.0	4.3	I				
	147.0-149.5	3.6	15.6	II				
	149.5-152.0	3.1	13.4	II				
	152.0-154.5	4.8	20.7	II+		152.6-156.8 barren	4.2	
	154.5-157.0	.1	.4	I				
	157.0-159.5	6.0	25.9	III-				
	159.5-162.0	.6	2.6	I		161.5-168.3 barren	6.8	
	162.0-164.5	1.1	4.8	I+				
	164.5-167.0	5.3	22.9	III-				
	167.0-169.5	1.8	7.8	I+				
	169.5-172.0	3.6	15.6	II				
	172.0-174.5	6.0	25.9	III-				
	174.5-177.0	5.3	22.9	III-				
LEVEL 4	177.0-179.5	.8	3.5	I		178.9-180.2 barren	1.3	
	179.5-182.0	.2	.9	I				
	182.0-184.5	3.7	16.0	II				
	184.5-187.0	2.4	10.4	II-				
34	187.0-189.5	1.9	8.2	I+				
		58.[illegible]	380.4					

Arizona Fuels 1-A

4/15/75 P 3

27 GL

LEVEL A

Depth	% Wt Oil	Gals/yd³	Class Actual	Est.
189.5-192.0	1.1	4.8	I+	
192.0-194.5	2.4	10.4	II-	
194.5-197.0	.4	1.7	I	
197.0-199.5	.3	1.3	I	
199.5-202.0	3.0	13.0	II-	
202.0-204.5	.8	3.5	I	
204.5-207.0	1.7	7.3	I+	
207.0-209.5	1.5	6.9	I+	
209.5-212.0	4.6	19.9	II+	
212.0-214.5	3.1	13.4	II	
214.5-217.0	5.0	21.6	II+	
217.0-219.5	3.4	14.7	II	
	27.3	118.5	P3	
	88.0	380.4	P2	
	115.3/46	498.9/46		

12
44
Gnv

196.0-198.8

2.4
19.5 AP 2.3

17.0-104.5 5.84 25.23 = 969.1 × 77.5 = 75107.75 BO/

104.5-219.5 2.50 10.84 × 1613.3 / 42 = 416.4 BO/Ac-Ft × 115 = 47884.28 BO/

122,992.

TAR SAND ANALYSIS

BURMAH OIL & GAS COMPANY-ARIZONA FUELS COMPANY

CORE HOLE NO. 2-A

ASPHALT RIDGE FIELD

UINTAH COUNTY, UTAH

RECEIVED

JUN 30 1975

T. W. EHRING

-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

mpany BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4844
ell CORE HOLE NO. 2-A
Core Type DIAMOND 2.125
Date Report 4-22-75
ld ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
unty UINTAH State UTAH Elev 5135' GL Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

D-SD
LE-SH
E-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
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GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

E ER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Weight Percent

Sample No.	Depth	Oil	Water	Sand	Grain Density	Natural Densit
1	12.0-14.5	0.1	1.5	98.4		
2	14.5-17.0	4.2	1.7	94.1		
3	17.0-19.5	0.0	0.9	99.1		
4	19.5-22.0	5.3	1.3	93.4		
5	22.0-24.5	4.0	2.3	93.7		
6	24.5-27.0	4.0	2.3	93.7		
7	27.0-29.5	1.2	1.5	97.3		
8	32.0-34.5	1.1	1.6	97.3		
9	34.5-37.0	1.0	2.1	96.9		
10	37.0-39.5	0.4	1.6	98.0		
11	39.5-42.0	2.8	3.1	94.1		
12	42.0-44.5	4.0	1.8	94.2		
13	44.5-47.0	1.4	2.6	96.0	2.68	2.54
14	47.0-49.5	0.1	3.0	96.9		
15	49.5-52.0	5.4	2.2	92.4		
16	52.0-54.5	14.9	1.3	83.8	2.64	2.05
17	54.5-57.0	13.2	0.6	86.2		
18	57.0-59.5	10.8	3.8	85.4		
19	59.5-62.0	11.4	0.6	88.0	2.64	2.11
20	62.0-64.5	9.0	1.7	89.3		
21	64.5-67.0	6.6	2.0	91.4		
22	67.0-69.5	11.7	1.5	86.8		
23	69.5-72.0	11.3	1.4	87.3		
24	72.0-74.5	9.8	1.6	88.6		
25	74.5-77.0	11.6	1.4	87.6		
26	77.0-79.5	3.0	0.5	96.5		
27	79.5-82.0	8.6	0.7	90.7		
28	82.0-84.5	6.3	0.3	93.4		
29	84.5-87.0	4.0	0.6	95.4	2.64	2.02
30	87.0-89.5	5.9	0.3	93.8		
31	89.5-92.0	2.5	1.9	95.6		
32	92.0-94.5	4.4	2.0	93.6		
33	94.5-97.0	3.9	1.0	95.1	2.64	1.91
34	97.0-99.5	9.3	0.9	89.8		

Pay

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

ompany BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY — Formation — File RP-2-4844
ell CORE HOLE NO. 2-A — Core Type DIAMOND 2.125 — Date Report 4-22-75
eld ASPHALT RIDGE — Drilling Fluid WATER BASE MUD — Analysts WW
ounty UINTAH State UTAH Elev. 5135' GL Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

ND-SD
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E-LM

DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP

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GRAY-GY
VUGGY-VGY

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LAMINATION-LAM
STYLOLITIC-STY

SLIGHTLY-
VERY-V/
WITH-W/

LK ER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Weight Percent

Sample No.	Depth	Oil	Water	Sand
35	99.5-101.0	0.1	2.0	97.9
36	101.0-103.0	9.6	0.4	90.0
37	103.0-105.5	4.8	0.3	94.9
38	105.5-108.0	9.3	0.7	90.0
39	108.0-110.5	7.8	1.6	90.6
40	110.5-113.0	7.4	0.4	92.2
41	113.0-115.5	6.0	0.7	93.3
42	115.5-118.0	0.1	1.3	98.6
43	118.0-120.5	1.4	0.2	98.4
44	120.5-123.0	0.1	0.3	99.6
45	123.0-125.5	1.5	1.0	97.5
46	125.5-128.0	2.3	0.4	97.3
47	128.0-130.5	0.8	0.2	99.0
48	130.5-133.0	0.1	0.5	99.3
49	133.0-135.5	5.9	0.3	93.8
50	135.5-138.0	0.0	0.9	99.1
51	138.0-140.5	1.8	2.9	95.3
52	140.5-143.0	0.6	0.4	99.0
53	143.0-145.5	1.7	0.8	97.5
54	145.5-148.0	2.6	0.2	97.2
55	148.0-150.5	1.4	0.2	98.4
56	150.5-153.0	1.1	1.0	97.9
57	153.0-155.5	2.9	0.5	96.6
58	155.5-158.0	2.7	0.9	96.5
59	158.0-160.5	5.0	0.5	94.5
60	160.5-163.0	0.5	0.7	98.8
61	163.0-165.5	4.3	0.4	95.3
62	165.5-168.0	4.7	0.9	94.3
63	168.0-170.5	0.8	1.4	97.8
64	170.5-172.5	4.1	0.4	95.5
65	170.5-175.0	1.5	0.8	97.7
66	175.0-177.5	0.5	0.7	98.8
67	177.5-180.0	3.0	0.8	96.2
68	180.0-182.5	7.4	0.5	92.1
69	182.5-185.0	2.5	1.7	95.8
70	185.0-187.5	1.2	1.3	97.5

L-511-1

CORE ANALYSIS RESULTS

ompany BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4844
Well CORE HOLE NO. 2-A
Core Type DIAMOND 2.125
Date Report 4-22-75
ield ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
ounty UINTAH State UTAH Elev. 5135' GL Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

AND-SD
HALE-SH
IME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
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FOSSILIFEROUS-FOSS
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GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY
VERY-V/
WITH-W/

PLE IBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

Sample No.	Depth	Weight Percent Oil	Weight Percent Water	Weight Percent Sand
71	187.5-190.0	0.2	1.2	98.6
72	190.0-192.5	1.9	2.2	95.9
73	192.5-195.0	1.8	7.0	91.2
74	195.0-197.5	5.3	2.1	92.6
75	197.5-200.0	5.2	2.8	92.1
76	200.0-202.5	3.2	2.2	94.6
77	202.5-205.0	0.0	1.4	98.6
78	205.0-207.5	1.6	1.6	96.8
79	20.75-210.0	4.7	0.5	94.8
80	210.0-212.5	1.8	1.0	97.3
81	212.5-215.0	7.3	0.8	91.9
82	215.0-217.5	5.4	0.6	94.1
83	217.5-220.0	0.7	1.9	97.4
84	220.0-222.5	0.4	2.1	97.5

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CORE LABORATORIES, INC
Petroleum Reservoir Engineering
DALLAS, TEXAS

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MAY 23 1975
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Page No. 1

CORE ANALYSIS RESULTS

ompany BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-48
ell CORE HOLE NO. 2-A
Core Type DIAMOND 2.125
Date Report 4-22-75
eld ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
ounty UINTAH State UTAH Elev 5135' GL Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

ND-SD, ALE-SH, ME-LM
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FRACTURED-FRAC, LAMINATION-LAM, STYLOLITIC-STY
SLIGHT, VERY, WITH-W/

LE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

Weight Percent

Sample No.	Depth	Gal/yd³	Oil × 4.37	Water	Sand	Grain Density	Natural Densi
1	12.0-14.5	.43	0.1	1.5	98.4		
2	14.5-17.0	18.14	4.2	1.7	94.1		
3	17.0-19.5	.0	0.0	0.9	99.1		
4	19.5-22.0	22.90	5.3	1.3	93.4		
5	22.0-24.5	17.28	4.0	2.3	93.7		
6	24.5-27.0	17.28	4.0	2.3	93.7		
7	27.0-29.5	5.18	1.2	1.5	97.3		
8	32.0-34.5	4.75	1.1	1.6	97.3		
9	34.5-37.0	4.32	1.0	2.1	96.9		
10	37.0-39.5	1.73	0.4	1.6	98.0		
11	39.5-42.0	12.10	2.8	3.1	94.1		
12	42.0-44.5	17.28	4.0	1.8	94.2		
13	44.5-47.0	6.05	1.4	2.6	96.0	2.68	2.54
14	47.0-49.5	.43	0.1	3.0	96.9		
15	49.5-52.0	23.33	5.4	2.2	92.4		
16	52.0-54.5	64.37	14.9	1.3	83.8	2.64	2.05
17	54.5-57.0	57.02	13.2	0.6	86.2		
18	57.0-59.5	46.66	10.8	3.8	85.4		
19	59.5-62.0	49.25	11.4	0.6	88.0	2.64	2.11
20	62.0-64.5	38.88	9.0	1.7	89.3		
21	64.5-67.0	28.51	6.6	2.0	91.4		
22	67.0-69.5	50.54	11.7	1.5	86.8		
23	69.5-72.0	48.82	11.3	1.4	87.3		
24	72.0-74.5	42.34	9.8	1.6	88.6		
25	74.5-77.0	50.11	11.6	1.4	87.6		
26	77.0-79.5	12.96	3.0	0.5	96.5		
27	79.5-82.0	37.15	8.6	0.7	90.7		
28	82.0-84.5	27.22	6.3	0.3	93.4		
29	84.5-87.0	17.28	4.0	0.6	95.4	2.64	2.02
30	87.0-89.5	25.49	5.9	0.3	93.8		
31	89.5-92.0	10.80	2.5	1.9	95.6		
32	92.0-94.5	19.01	4.4	2.0	93.6		
33	94.5-97.0	16.85	3.9	1.0	95.1	2.64	1.91
34	97.0-99.5	40.18	9.3	0.9	89.8		

477.83

45.64
avg

511-1

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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Page No. 2

CORE ANALYSIS RESULTS

ipany BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4848
Core Type DIAMOND 2.125
Date Report 4-22-75
ll CORE HOLE NO. 2-A
Drilling Fluid WATER BASE MUD
Analysts WW
d ASPHALT RIDGE
nty UINTAH State UTAH Elev. 5135' GL Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

-SD E-SH -LM	DOLOMITE-DOL CHERT-CH GYPSUM-GYP	ANHYDRITE-ANHY CONGLOMERATE-CONG FOSSILIFEROUS-FOSS	SANDY-SDY SHALY-SHY LIMY-LMY	FINE-FN MEDIUM-MED COARSE-CSE	CRYSTALLINE-XLN GRAIN-GRN GRANULAR-GRNL	BROWN-BRN GRAY-GY VUGGY-VGY	FRACTURED-FRAC LAMINATION-LAM STYLOLITIC-STY	SLIGHTLY-SL VERY-V/ WITH-W/

	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Weight Percent

ample o.	Depth	Gal/yd³	Oil × 4.32	Water	Sand
35 Y 1½	99.5-101.0	.43	0.1	2.0	97.9
36 3	101.0-103.0	41.47	9.6	0.4	90.0
37	103.0-105.5	20.74	4.8	0.3	94.9
38	105.5-108.0	40.18	9.3	0.7	90.0
39	108.0-110.5	33.70	7.8	1.6	90.6
40	110.5-113.0	31.97	7.4	0.4	92.2
41	113.0-115.5	25.92	6.0	0.7	93.3
42	115.5-118.0	.43	0.1	1.3	98.6
43	118.0-120.5	6.05	1.4	0.2	98.4
44	120.5-123.0	.43	0.1	0.3	99.6
45	123.0-125.5	6.48	1.5	1.0	97.5
46	125.5-128.0	9.92	2.3	0.4	97.3
47	128.0-130.5	3.46	0.8	0.2	99.0
48	130.5-133.0	.43	0.1	0.5	99.3
49	133.0-135.5	25.49	5.9	0.3	93.8
50	135.5-138.0	0	0.0	0.9	99.1
51	138.0-140.5	7.78	1.8	2.9	95.3
52	140.5-143.0	2.59	0.6	0.4	99.0
53	143.0-145.5	7.34	1.7	0.8	97.5
54	145.5-148.0	11.23	2.6	0.2	97.2
55	148.0-150.5	6.05	1.4	0.2	98.4
56	150.5-153.0	4.75	1.1	1.0	97.9
57	153.0-155.5	12.53	2.9	0.5	96.6
58	155.5-158.0	11.66	2.7	0.9	96.5
59	158.0-160.5	21.60	5.0	0.5	94.5
60	160.5-163.0	2.16	0.5	0.7	98.8
61	163.0-165.5	18.58	4.3	0.4	95.3
62	165.5-168.0	20.30	4.7	0.9	94.3
63	168.0-170.5	3.46	0.8	1.4	97.8
64	170.5-172.5	17.71	4.1	0.4	95.5
65	170.5-175.0	6.48	1.5	0.8	97.7
66	175.0-177.5	2.16	0.5	0.7	98.8
67	177.5-180.0	12.96	3.0	0.8	96.2
68	180.0-182.5	31.97	7.4	0.5	92.1
69	182.5-185.0	10.80	2.5	1.7	95.8
70	185.0-187.5	5.18	1.2	1.3	97.5

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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Page No. 3

CORE ANALYSIS RESULTS

ompany BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4848
Vell CORE HOLE NO. 2-A
Core Type DIAMOND 2.125
Date Report 4-22-75
ield ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
ounty UINTAH State UTAH Elev. 5135' GL Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

ND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
ALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
ME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

Sample No.	Depth	Gal/yd^3	Weight Percent Oil ×4.32	Water	Sand
71	187.5-190.0	.86	0.2	1.2	98.6
72	190.0-192.5	8.21	1.9	2.2	95.9
73	192.5-195.0	7.78	1.8	7.0	91.2
74	195.0-197.5	22.90	5.3	2.1	92.6
75	197.5-200.0	22.46	5.2	2.8	92.1
76	200.0-202.5	13.82	3.2	2.2	94.6
77	202.5-205.0	0	0.0	1.4	98.6
78	205.0-207.5	6.91	1.6	1.6	96.8
79	20.75-210.0	20.30	4.7	0.5	94.8
80	210.0-212.5	7.78	1.8	1.0	97.3
81	212.5-215.0	31.54	7.3	0.8	91.9
82	215.0-217.5	23.33	5.4	0.6	94.1
83	217.5-220.0	3.02	0.7	1.9	97.4
84	220.0-222.5	1.73	0.4	2.1	97.5

Field Classification
Tar Sands

Class	% wt	Gals Ton	Gals yd³	avg GT	avg GY
I	< 1.0	< 24	< 3.9	2.0	3.0
I+	1.1-20	2.5-4.9	4.0-7.9	3.5	5.5
II-	2.1-3.0	5.0-7.3	8.0-11.7	6.0	9.5
II	3.1-4.0	7.4-9.7	11.8-15.5	8.5	13.5
II+	4.1-5.0	9.8-12.1	15.6-19.4	11.0	17.5
III-	5.1-6.0	12.2-14.5	19.5-23.2	13.5	21.5
III	6.1-7.0	14.6-16.9	23.3-27.0	16.0	25.5
III+	7.1-8.0	17.0-19.3	27.1-30.9	18.0	29.0
IV-	8.1-9.0	19.4-21.7	31.0-34.8	20.5	33.0
IV	9.1-10.0	21.8-24.1	34.9-38.6	23.0	37.0
IV+	10.1-11.0	24.2-26.5	38.7-42.4	25.5	41.0
V-	11.1-12.0	26.6-28.9	42.5-46.2	28.0	45.0
V	> 12.0	> 28.9	> 46.2	30.0	48.0

STATE UTAH ELEV. 5135'

COUNTY UINTAH

COMPANY ARIZONA FUELS CORPORATION

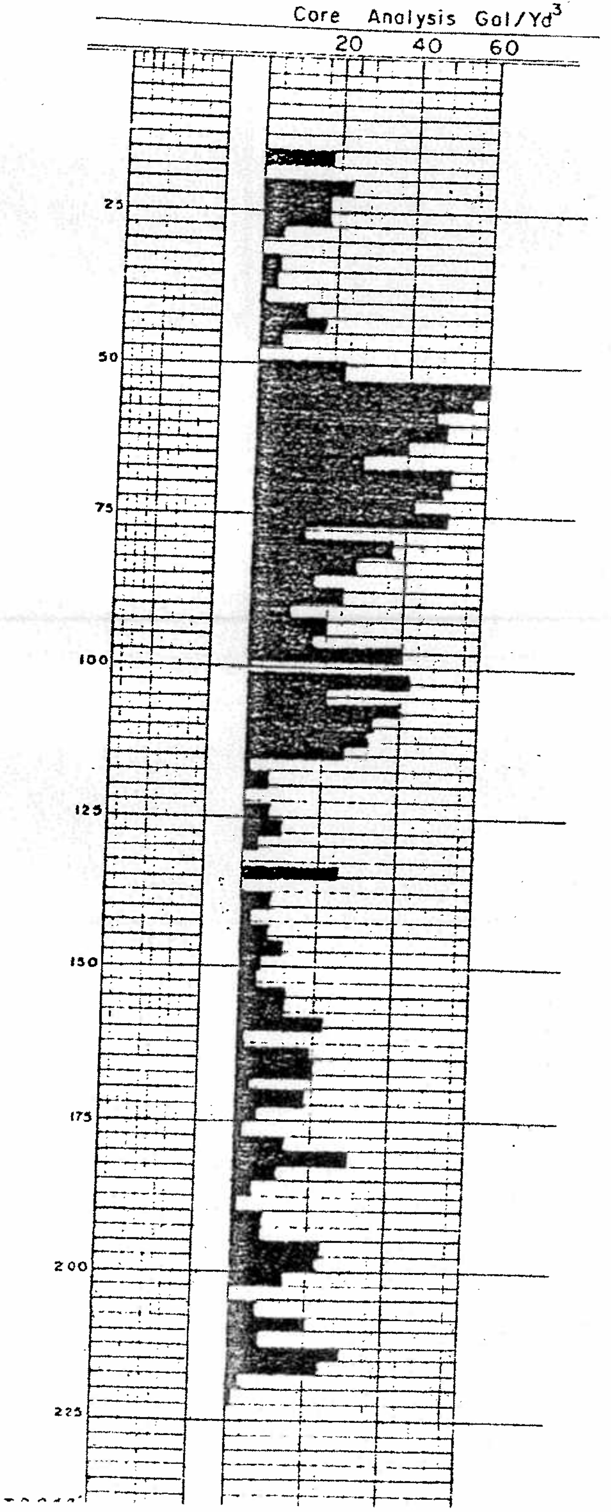
FARM BOAG-SOHIO WELL NO. CH 2-A

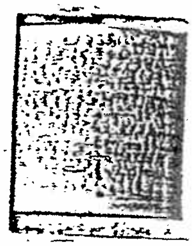
LOCATION 109' F 1/4 SL, 358' FWL,

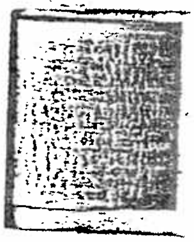
SEC. 31, T-5-S, R-22-E, SLB&M

TD. 242' TOOLS LONGYEAR 44

2-1/2" WIRELINE CORE







Arizona Fuels 2-A

H. W. EHRING

First Data Sheet 2A
4/2/75

5135 GL	¢ #	Depths	Barren	I	II	III	IV	V
		0.0-12.7	12.7					
	1	12.7-16.2				3.5		
	"		3.8					
	"	20.0-21.5				1.5		
	1,2	21.5-22.5		1.0				
	2		2.1					
	"	24.6-25.7				1.1		
	"		1.5					
	"	27.2-29.5			2.3			
	"	(29.5-32.0)	Lost					
	3		3.5					
	"	35.5-42.0				6.5		
	4		8.8					
	4,5	50.8-60.7					IV+ 9.9	
	5	60.7-62.5				III+ 1.8		
	"	62.5-64.6					2.1	
	6	64.6-66.7				2.1		
	"	66.7-67.9			1.2			
	"	67.9-73.6					IV- 5.7	
	6,7	73.6-76.9					3.3	
	7	76.9-81.8				4.9		
	"		.6					
	8	82.4-84.1				III- 1.7		
	"	84.1-85.0					9	
	"	85.0-86.7				III+ 1.7		
	"	86.7-88.0					IV- 1.3	
	8,9	88.0-92.7				4.7		
	9	92.7-94.0					1.3	
	"	94.0-96.3				2.3		
	"	96.3-97.7					1.4	
	"	97.7-99.8			2.1			
	"		1.5					
	"	101.3-106.1				5.8		

TAR SAND ANALYSIS
FOR
BURMAH OIL AND GAS COMPANY
ARIZONA FUELS COMPANY
CORE HOLE NO. 3-A
ASPHALT RIDGE FIELD
UINTAH COUNTY, UTAH

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L-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No 1

CORE ANALYSIS RESULTS

BURMAH OIL & GAS COMPANY
ompany ARIZONA FUELS COMPANY
Formation
File RP-2-4842
Vell CORE HOLE NO. 3-A
Core Type DIAMOND 2.125
Date Report 4-10-75
ield ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts EJ
ounty UINTAH State UTAH Elev. 5097' GL Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

ND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
ALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
ME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

		Weight Percent				
Sample No.	Depth	Oil	Water	Sand	Grain Density	Natural Density
1	12.0-14.5	0.1	4.2	95.7		
2	14.5-17.0	0.2	4.8	95.0		
3	17.0-19.5	6.0	2.0	92.0		
4	19.5-22.0	7.1	2.0	90.9		
5	22.0-24.5	7.8	1.5	90.7		
6	24.5-27.0	7.4	1.7	90.9		
7	27.0-29.5	3.8	4.3	91.9		
8	29.5-32.0	6.0	2.0	92.0		
9	32.0-34.5	9.3	1.1	89.6		
10	34.5-37.0	11.1	1.2	87.7		
11	37.0-39.5	9.4	2.5	88.1	2.66	2.07
12	39.5-42.0	11.0	1.3	87.7		
13	42.0-44.5	1.2	1.5	97.3	2.63	2.17
14	44.5-47.0	2.8	1.8	95.4		
15	47.0-49.5	5.7	2.9	91.5		
16	49.5-52.0	0.1	3.3	96.6	2.67	2.22
17	52.0-54.5	0.8	3.0	96.1		
18	54.5-57.0	0.4	4.1	95.5		
19	57.0-59.5	6.1	1.7	92.1	2.63	2.16
20	59.5-62.0	1.0	1.8	97.1		
21	62.0-64.5	5.7	2.1	92.2		
22	64.5-67.0	4.0	6.6	89.4		
23	67.0-69.5	3.5	1.3	95.2		
24	69.5-72.0	8.5	0.4	91.1		
25	72.0-74.5	5.2	0.4	94.4		
26	74.5-77.0	2.4	1.1	96.5	2.65	2.57
27	77.0-79.5	4.3	3.0	92.7	2.65	2.05
28	79.5-82.0	6.0	1.6	92.4		
29	82.0-84.5	10.4	0.5	89.1	2.61	1.96
30	84.5-87.0	6.8	0.4	92.8		
31	87.0-89.5	7.8	2.3	89.9		
32	89.5-92.0	5.7	1.3	93.0		
33	92.0-94.5	6.3	1.1	92.6		
34	94.5-97.0	0.8	3.1	96.1		
35	97.0-99.5	0.8	3.5	95.7		

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4842
Well CORE HOLE NO. 3-A
Core Type DIAMOND 2.125
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Lithological Abbreviations

SAND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-
SHALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
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AMPLE UMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

Sample No.	Depth	Weight Percent Oil	Weight Percent Water	Weight Percent Sand	Grain Density	Natural Densit
36	99.5-02.0	2.2	2.6	95.1		
37	102.0-04.5	6.6	1.8	91.6		
38	104.5-07.0	0.3	2.1	97.6		
39	107.0-09.5	3.1	1.9	95.0		
40	109.5-12.0	3.1	1.2	95.7		
41	112.0-14.5	8.7	1.9	89.4		
42	114.5-17.0	1.7	1.4	96.9		
43	117.0-19.5	0.8	0.8	98.4		
44	119.5-22.0	1.0	0.4	98.6		
45	122.0-24.5	12.3	1.6	86.1		
46	124.5-27.0	0.1	0.8	99.1		
47	127.0-29.5	3.4	0.8	95.8		
48	129.5-32.0	2.4	1.1	96.5		
49	132.0-34.5	0.7	0.8	98.5		
50	134.5-37.0	0.6	0.8	98.6		
51	137.0-39.5	0.4	1.2	98.4	2.66	2.32
52	139.5-42.0	2.2	1.3	96.5		
53	142.0-44.5	7.6	1.1	91.3		
54	144.5-47.0	0.0	1.8	98.2	2.68	2.33
55	147.0-49.5	0.5	1.5	98.0		
56	149.5-52.0	0.2	1.3	98.5		
57	152.0-54.5	0.1	1.6	98.3	2.68	2.52
58	154.5-57.0	9.2	1.8	89.0		
59	157.0-59.5	0.7	0.7	98.6		
60	159.5-62.0	0.1	1.5	98.4		
61	162.0-64.5	1.8	0.8	97.4		
62	164.5-67.0	0.3	0.2	99.5		
63	167.0-69.5	3.3	0.8	95.9		
64	169.5-72.0	1.9	0.9	97.2		
65	172.0-74.5	4.3	0.5	95.2		
66	174.5-77.0	0.3	0.4	99.3		
67	177.0-79.5	0.4	0.9	98.7		
68	179.5-82.0	0.8	0.5	98.7		
69	182.0-84.5	0.6	0.8	98.6	2.67	2.46
70	184.5-87.0	2.5	0.4	97.1		

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY Formation ______ File RP-2-4842
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FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL/
VERY-V/
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PLE IBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

		Weight Percent				
Sample No.	Depth	Oil	Water	Sand	Grain Density	Natural Density
71	187.0-89.5	1.1	0.4	98.5		
72	189.5-92.0	6.9	0.6	92.5		
73	192.0-94.5	6.9	0.6	92.5		
74	194.5-97.0	6.5	0.5	93.0		
75	197.0-99.5	11.0	2.0	87.0	2.63	2.36
76	199.5-02.0	2.6	0.2	97.2		
77	202.0-04.5	1.9	0.4	97.7		
78	204.5-07.0	4.9	0.5	94.6		
79	207.0-09.5	1.3	0.4	98.3		
80	209.5-12.0	11.5	0.4	88.1	2.69	2.19
81	212.0-14.5	1.2	0.5	98.3		
82	214.5-17.0	2.4	0.8	96.8		
83	217.0-19.5	1.9	0.5	97.6		
84	219.5-22.0	1.2	0.5	98.3		
85	222.0-24.5	2.6	0.8	96.6		
86	224.5-27.0	2.3	0.6	97.1		
87	227.0-29.5	1.7	0.5	97.8		
88	229.5-32.0	1.0	0.8	98.2	2.66	2.57
89	232.0-34.5	1.2	0.4	98.4		
90	234.5-37.0	1.7	0.6	97.7		
91	237.0-39.5	0.8	0.8	98.3		
92	239.5-42.0	0.5	0.5	99.0		

ARIZONA FUELS
CORE HOLE 5A
CORE LAB ANALYSIS

Depth	Wt. % Oil	Wt. % H_2O	Wt. % Sand	Grain Density gm/cc	Natural Bulk Density gm/cc	gal./yd^3
12.0-14.5	0.1	4.2	95.7			.4
14.5-17.0	0.2	4.8	95.0			.8
17.0-19.5	6.0	2.0	92.0			25.9
19.5-22.0	7.1	2.0	90.9			30.7
22.0-24.5	6.8	1.5	90.7			29.4
24.5-27.0	7.4	1.7	90.9			32.0
27.0-29.5	3.8	4.3	91.9			16.4
29.5-32.0	6.0	2.0	92.0			25.9
32.0-34.5	9.3	1.1	89.6			40.2
34.5-37.0	11.1	1.2	87.7			48.0
37.0-39.5	9.4	2.5	88.1	2.66	2.07	40.6
39.5-42.0	11.0	1.3	87.7			47.5
42.0-44.5	1.2	1.5	97.3	2.63	2.17	5.2
44.5-47.0	2.8	1.8	95.4			12.1
47.0-49.5	5.7	2.9	91.5			24.6
9.5-52.0	0.1	3.3	96.6	2.67	2.22	.4
52.0-54.5	0.8	3.0	96.1			3.5
54.5-57.0	0.4	4.1	95.5			1.7
57.0-59.5	6.1	1.7	92.1	2.63	2.16	26.3
59.5-62.0	1.0	1.8	97.1			4.3
62.0-64.5	5.7	2.1	92.2			24.6
64.5-67.0	4.0	6.6	89.4			17.3
67.0-69.5	3.5	1.3	95.2			15.1
69.5-72.0	8.5	0.4	91.1			36.7
72.0-74.5	5.2	0.4	94.4			22.5
74.5-77.0	2.4	1.1	96.5	2.65	2.57	10.4
77.0-79.5	4.3	3.0	92.7	2.65	2.05	18.6
79.5-82.0	6.0	1.6	92.4			25.9
82.0-84.5	10.4	0.5	89.1	2.61	1.96	44.9
84.5-87.0	6.8	0.4	92.8			29.4
87.0-89.5	7.8	2.3	89.9			33.7
89.5-92.0	5.7	1.3	93.0			24.6
92.0-94.5	6.3	1.1	92.6			27.2
94.5-97.0	0.8	3.1	96.1			3.5
97.0-99.5	0.8	3.5	95.7			3.5
99.5-102.0	2.2	2.6	95.1			9.5
102.0-104.5	6.6	1.8	91.6			28.5
104.5-107.0	0.3	2.1	97.6			1.3
107.0-109.5	3.1	1.9	95.0			13.4
109.5-112.0	3.1	1.2	95.7			13.4

ARIZONA FUELS - CORE HOLE 3A - CORE LAB ANALYSIS

Depth	Wt. % Oil	Wt. % H_2O	Wt. % Sand	Grain Density gm/cc	Natural Bulk Density gm/cc	gal/yd^3
112.0-114.5	8.7	1.9	89.4			37.6
114.5-117.0	1.7	1.4	96.9			7.3
117.0-119.5	0.8	0.8	98.4			3.5
119.5-122.0	1.0	0.4	98.6			4.3
122.0-124.5	12.3	1.6	86.1			53.1
124.5-127.0	0.1	0.8	99.1			.4
127.0-129.5	3.4	0.8	95.8			14.7
129.5-132.0	2.4	1.1	96.5			10.4
132.0-134.5	0.7	0.8	98.5			3.0
134.5-137.0	0.6	0.8	98.6			2.6
137.0-139.5	0.4	1.2	98.4	2.66	2.32	1.7
139.5-142.0	2.2	1.3	96.5			9.5
142.0-144.5	7.6	1.1	91.3			32.8
144.5-147.0	0.0	1.8	98.2	2.68	2.33	2.2
147.0-149.5	0.5	1.5	98.0			0.9
149.5-152.0	0.2	1.3	98.5			0.4
152.0-154.5	0.1	1.6	98.3	2.68	2.52	39.7
154.5-157.0	9.2	1.8	89.0			3.0
157.0-159.5	0.7	0.7	98.6			.4
159.5-162.0	0.1	1.5	98.4			7.8
162.0-164.5	1.8	0.8	97.4			1.3
164.5-167.0	0.3	0.2	99.5			14.4
167.0-169.5	3.3	0.8	95.9			8.2
169.5-172.0	1.9	0.9	97.2			18.6
172.0-174.5	4.3	0.5	95.2			1.3
174.5-177.0	0.3	0.4	99.3			1.7
177.0-179.5	0.4	0.9	98.7			3.9
179.5-182.0	0.8	0.5	98.7			2.6
182.0-184.5	0.6	0.8	98.6	2.67	2.46	10.8
184.5-187.0	2.5	0.4	97.1			4.8
187.0-189.5	1.1	0.4	98.5			29.8
189.5-192.0	6.9	0.6	92.5			29.8
192.0-194.5	6.9	0.6	92.5			28.1
194.5-197.0	6.5	0.5	93.0			47.5
197.0-199.5	11.0	2.0	87.0	2.63	2.36	8.7
199.5-202.0	2.6	0.2	97.2			11.2
202.0-204.5	1.9	0.4	97.7			8.2
204.5-207.0	4.9	0.5	94.6			35.4
207.0-209.5	1.3	0.4	98.3			5.6
209.5-212.0	11.5	0.4	88.1	2.69	2.54	49.7
212.0-214.5	1.2	0.5	98.3			5.2
214.5-217.0	2.4	0.8	96.8			10.4
217.0-219.5	1.9	0.5	97.6			8.2
219.5-222.0	1.2	0.5	98.3			5.2
222.0-224.5	2.6	0.8	96.6			11.3

ARIZONA FUELS - CORE HOLE 3A - CORE LAB ANALYSIS

Depth	Wt. % Oil	Wt. % H_2O	Wt. % Sand	Grain Density gm/cc	Natural Bulk Density gm/cc	gal/yd^3
224.5-227.0	2.3	0.6	97.1			9.9
227.0-229.5	1.7	0.5	97.8			-
229.5-232.0	1.0	0.8	98.2	2.66	2.08	4.3
232.0-234.5	1.2	0.4	98.4			5.2
234.5-237.0	1.7	0.6	97.7			7.3
237.0-239.5	0.8	0.8	98.3			-
239.5-242.0	0.5	0.5	99.0			-

STATE UTAH ELEV. 5097'

COUNTY UINTAH

COMPANY ARIZONA FUELS CORPORATION

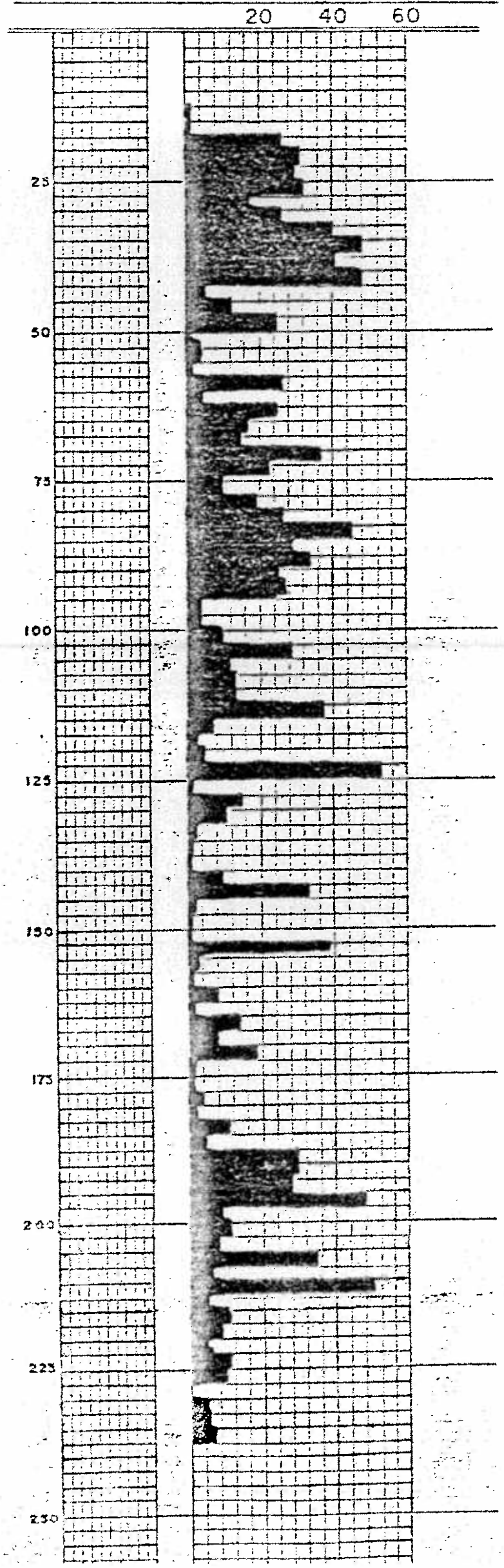
FARM BOAG-SOHIO WELL NO. CH 3-A

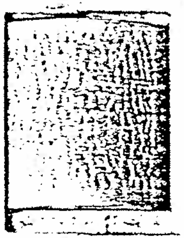
LOCATION 682'S, 1210'E FW 1/4 CORNER,
SEC. 31, T-5-S, R-22-E, S.L.B.&M.

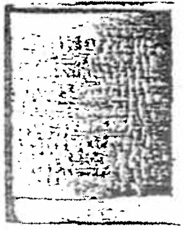
TD. 262' TOOLS LONGYEAR 44

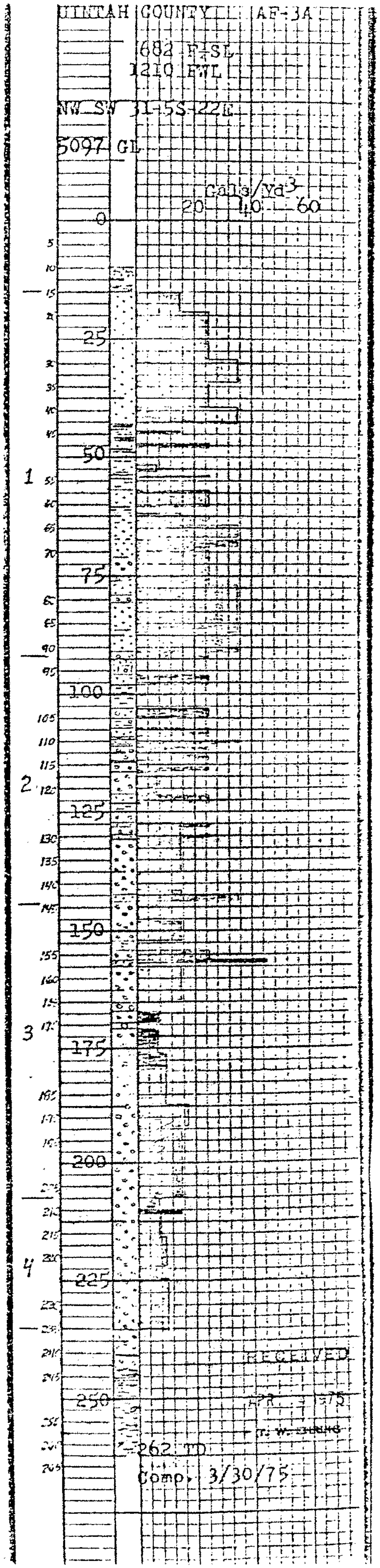
2-1/2" WIRELINE CORE

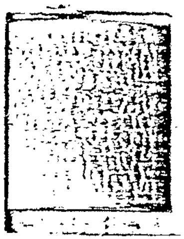
Core Analysis Gal/Yd^3

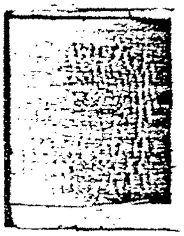







UINTAH COUNTY
AF-3A
682 F¼SL
1210 FWL
NW SW 31-5S-22E
5097 GL
Gals/Yd³
20
40
60
0
25
50
75
100
125
150
175
200
225
250
1
2
3
4
262 TD
Comp. 3/30/75





SPECIAL TAR SAND ANALYSIS

BURMAH OIL & GAS COMPANY
ARIZONA FUELS COMPANY

CORE HOLE NO. A-1

ASPHALT RIDGE FIELD

UINTAH COUNTY, UTAH

GEOLOGIC

J. W. EHRING

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4899
Well CORE HOLE NO. A-1
Core Type DIAMOND 2.125
Date Report 8-1-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
County UINTAH
State UTAH
Elev.
Location SEC. 31-T5S-R22E

Lithological Abbreviations

SAND-SD
SHALE-SH
LIME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-S
VERY-V/
WITH-W/

MPLE JMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

		Weight Percent				
Sample No.	Depth	Oil	Water	Sand	Grain Density	Natural Density
1	10.0-12.5	2.0	1.8	96.2		
2	12.5-15.0	0.3	0.4	99.3		
3	15.0-17.5	3.2	1.0	95.8		
4	17.5-20.0	0.0	0.4	99.6		
5	20.0-22.5	2.8	3.2	94.0		
6	22.5-25.0	7.4	1.9	90.7		
7	25.0-27.5	0.6	0.7	98.7		
8	27.5-30.0	0.0	1.1	98.9		
9	50.0-52.5	0.4	1.3	98.3	2.60	2.14
10	52.5-55.0	3.1	0.8	96.1		
11	55.0-57.5	0.2	0.7	99.1		
12	57.5-60.0	0.5	0.3	99.2		
13	60.0-62.5	0.1	0.7	99.2		
14	62.5-65.0	6.6	0.4	93.0		
15	65.0-67.5	9.0	0.7	90.3		
16	67.5-70.0	0.0	1.2	98.8		
17	70.0-72.5	8.3	0.7	91.0		
18	72.5-75.0	5.8	2.1	92.1	2.60	2.27
19	75.0-77.5	1.1	0.8	98.1		
20	77.5-80.0	0.1	1.2	98.7		
21	80.0-82.5	8.2	0.3	91.5		
22	82.5-85.0	12.0	0.2	87.8		
23	85.0-87.5	5.7	0.3	94.0		
24	87.5-90.0	6.5	0.3	93.2		
25	90.0-92.5	4.7	0.9	94.4	2.62	2.15
26	92.5-95.0	8.8	0.6	90.6		
27	95.0-97.5	9.9	0.5	89.6		
28	97.5-00.0	6.2	0.2	93.6		
29	100.0-02.5	6.3	0.3	93.4		
30	102.5-05.0	5.5	0.2	94.3		
31	105.0-07.5	8.7	0.6	90.7		
32	107.5-10.0	3.9	0.4	95.7		
33	110.0-12.5	5.4	0.3	98.3		
34	112.5-15.0	8.7	0.5	90.8		

CL-311-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 2

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4899
Well CORE HOLE NO. A-1
Core Type DIAMOND 2.125
Date Report 8-1-75
ield ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WJ
ounty UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

AND-SD
HALE-SH
IME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
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SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
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VUGGY-VGY
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LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL/
VERY-V/
WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

		Weight Percent				
Sample No.	Depth	Oil	Water	Sand	Grain Density	Natural Density
35	115.0-17.5	9.4	1.1	89.5		
36	117.5-20.0	7.9	0.3	91.8	2.64	2.04
37	120.0-22.5	8.4	0.4	91.2		
38	122.5-25.0	2.6	0.5	96.9		
39	125.0-27.5	5.8	0.4	93.8		
40	127.5-30.0	10.5	1.0	88.5		
41	130.0-32.5	3.7	2.6	93.7		
42	132.5-35.0	6.0	0.7	93.3		
43	135.0-37.5	7.5	1.0	91.5		
44	137.5-40.0	8.8	0.4	90.8		
45	140.0-42.5	3.6	1.9	94.5	2.69	2.03
46	142.5-45.0	7.7	1.6	90.7		
47	145.0-47.5	4.6	0.2	95.2		
48	147.5-50.0	3.1	3.0	93.9		

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Petroleum Reservoir Engineering
DALLAS, TEXAS

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COARSE-CSE
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GRAIN-GRN
GRANULAR-GRNL
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GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
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STYLOLITIC-STY
SLIGHTLY-SL
VERY-V
WITH-W/

MPLE MBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

Sample No.	Depth	Gal/Yd.^{3}	Weight Percent Oil	Weight Percent Water	Weight Percent Sand	Grain Density	Natural Density
1	10.0-12.5	9.6	2.0	1.8	96.2		
2	12.5-15.0	1.3	0.3	0.4	99.3		
3	15.0-17.5	13.8	3.2	1.0	95.8		
4	17.5-20.0	0	0.0	0.4	99.6		
5	20.0-22.5	12.1	2.8	3.2	94.0		
6	22.5-25.0	32.0	7.4	1.9	90.7		
7	25.0-27.5	2.6	0.6	0.7	98.7		
8	27.5-30.0	0	0.0	1.1	98.9		
9	50.0-52.5	1.7	0.4	1.3	98.3	2.60	2.14
10	52.5-55.0	13.4	3.1	0.8	96.1		
11	55.0-57.5	.9	0.2	0.7	99.1		
12	57.5-60.0	2.2	0.5	0.3	99.2		
13	60.0-62.5	.4	0.1	0.7	99.2		
14	62.5-65.0	28.5	6.6	0.4	93.0		
15	65.0-67.5	38.9	9.0	0.7	90.3		
16	67.5-70.0	0	0.0	1.2	98.8		
17	70.0-72.5	35.9	8.3	0.7	91.0		
18	72.5-75.0	25.1	5.8	2.1	92.1	2.60	2.27
19	75.0-77.5	4.8	1.1	0.8	98.1		
20	77.5-80.0	.4	0.1	1.2	98.7		
21	80.0-82.5	35.4	8.2	0.3	91.5		
22	82.5-85.0	51.8	12.0	0.2	87.8		
23	85.0-87.5	24.6	5.7	0.3	94.0		
24	87.5-90.0	28.1	6.5	0.3	93.2		
25	90.0-92.5	20.3	4.7	0.9	94.4	2.62	2.15
26	92.5-95.0	38.0	8.8	0.6	90.6		
27	95.0-97.5	42.8	9.9	0.5	89.6		
28	97.5-00.0	26.8	6.2	0.2	93.6		
29	100.0-02.5	27.1	6.3	0.3	93.4		
30	102.5-05.0	23.8	5.5	0.2	94.3		
31	105.0-07.5	37.6	8.7	0.6	90.7		
32	107.5-10.0	16.8	3.9	0.4	95.7		
33	110.0-12.5	23.3	5.4	0.3	98.3		
34	112.5-15.0	37.6	8.7	0.5	90.8		

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 2

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GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL/
VERY-V/
WITH-W/

MPLE MBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

		Weight Percent				
Sample No.	Depth	*GAL/Yd.³* Oil	Water	Sand	Grain Density	Natural Density
35	115.0-17.5	✓40.6 9.4	1.1	89.5		
36	117.5-20.0	✓34.1 7.9	0.3	91.8	2.64	2.04
37	120.0-22.5	✓36.3 8.4	0.4	91.2		
38	122.5-25.0	✓11.2 2.6	0.5	96.9		
39	125.0-27.5	✓25.1 5.8	0.4	93.8		
40	127.5-30.0	✓45.4 10.5	1.0	88.5		
41	130.0-32.5	✓16. 3.7	2.6	93.7		
42	132.5-35.0	✓25.9 6.0	0.7	93.3		
43	135.0-37.5	✓32.4 7.5	1.0	91.5		
44	137.5-40.0	✓38.0 8.8	0.4	90.8		
45	140.0-42.5	✓15.6 3.6	1.9	94.5	2.69	2.03
46	142.5-45.0	✓33.3 7.7	1.6	90.7		
47	145.0-47.5	✓19.9 4.6	0.2	95.2		
48	147.5-50.0	✓13.4 3.1	3.0	93.9		

STATE UTAH ELEV. 5114'

COUNTY UINTAH

COMPANY ARIZONA FUELS CORPORATION

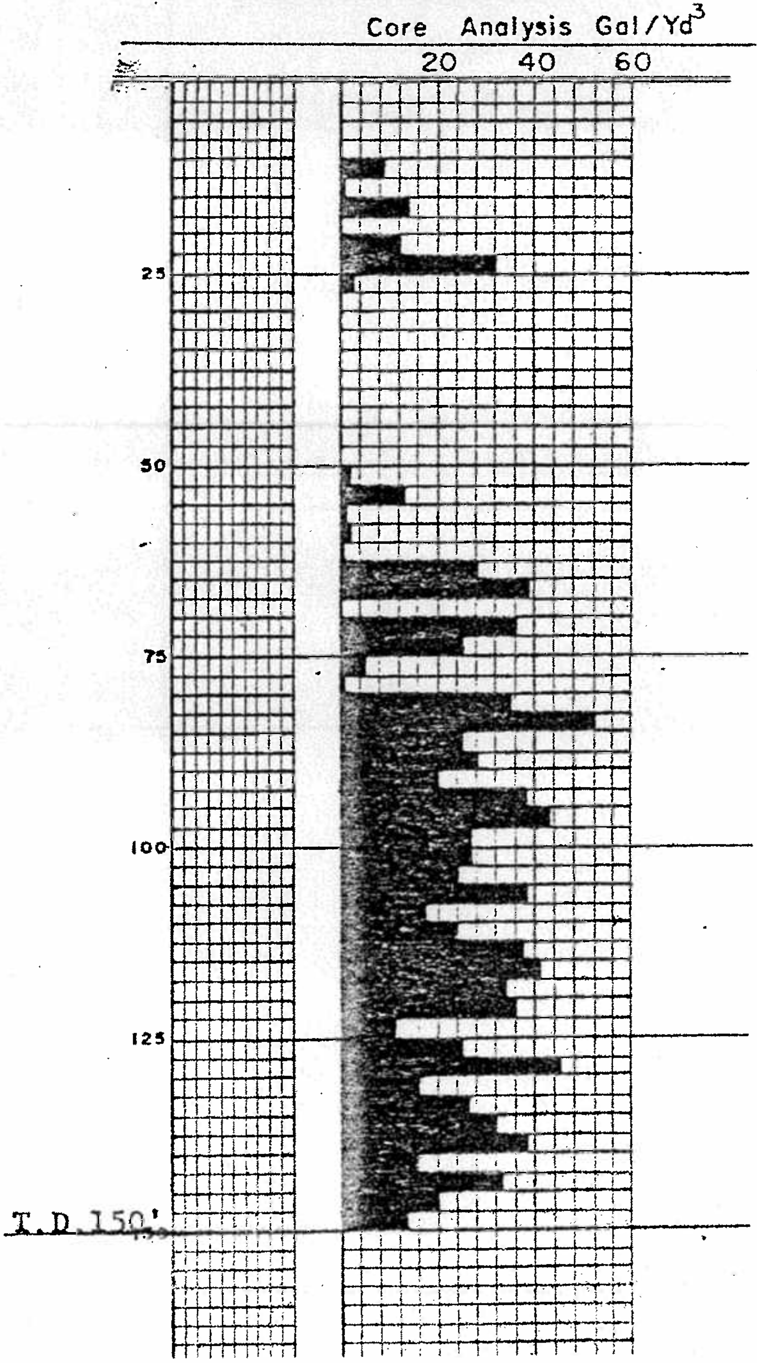
FARM BOAG-SOHIO WELL NO. CH-A-1

LOCATION 442' F.1/4 S.L., 346' F.W.L.

Sec. 31, T-5-S, R-22-E, S.L.B.M.

TD. 150' TOOLS Longyear 44

2-1/2" Wireline Core



STATE UTAH ELEV. 5114'

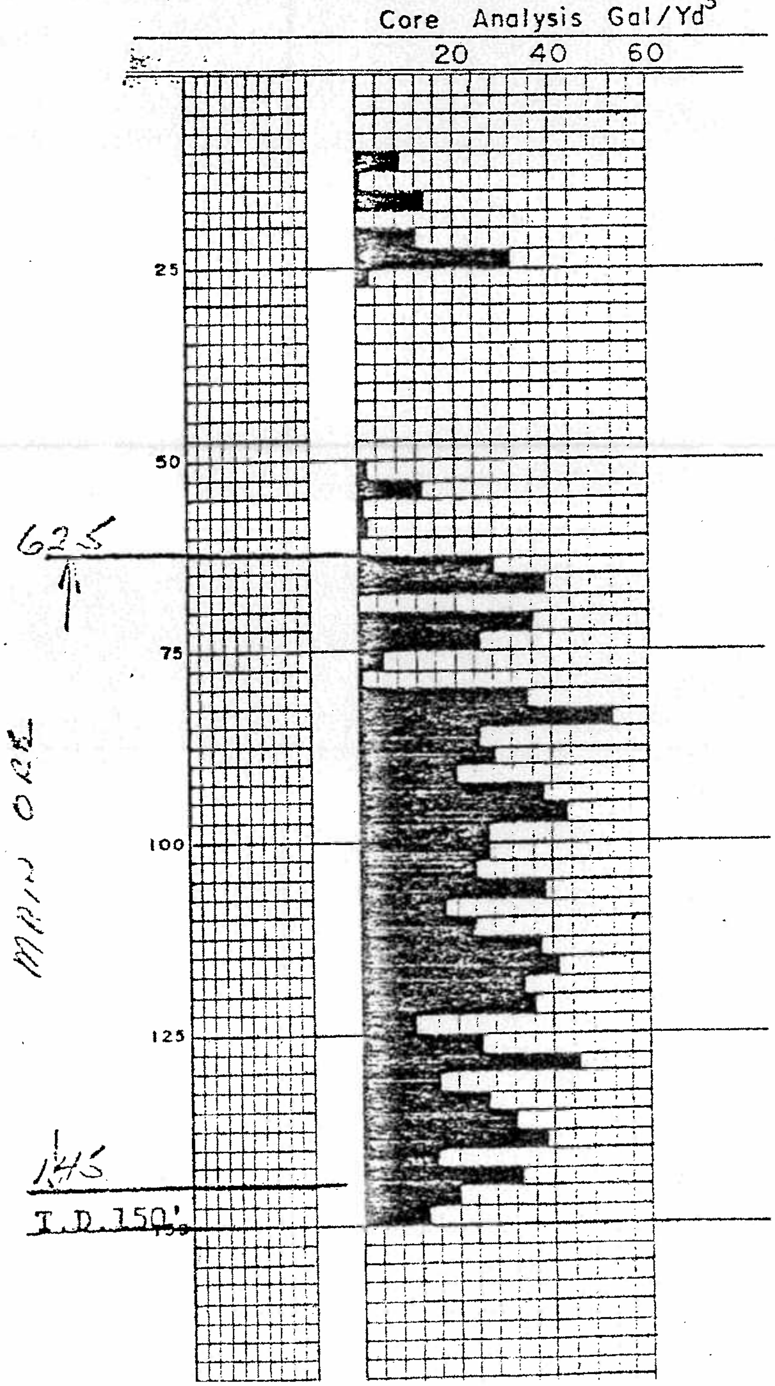
COUNTY UINTAH

COMPANY ARIZONA FUELS CORPORATION

FARM BOAG-SOHIO WELL NO. CH-A-1

LOCATION 442' F.1/4 S.L., 346' F.W.L.
Sec. 31, T-5-S, R-22-E, S.L.B.M.

TD. 150' TOOLS Longyear 44
2-1/2" Wireline Core



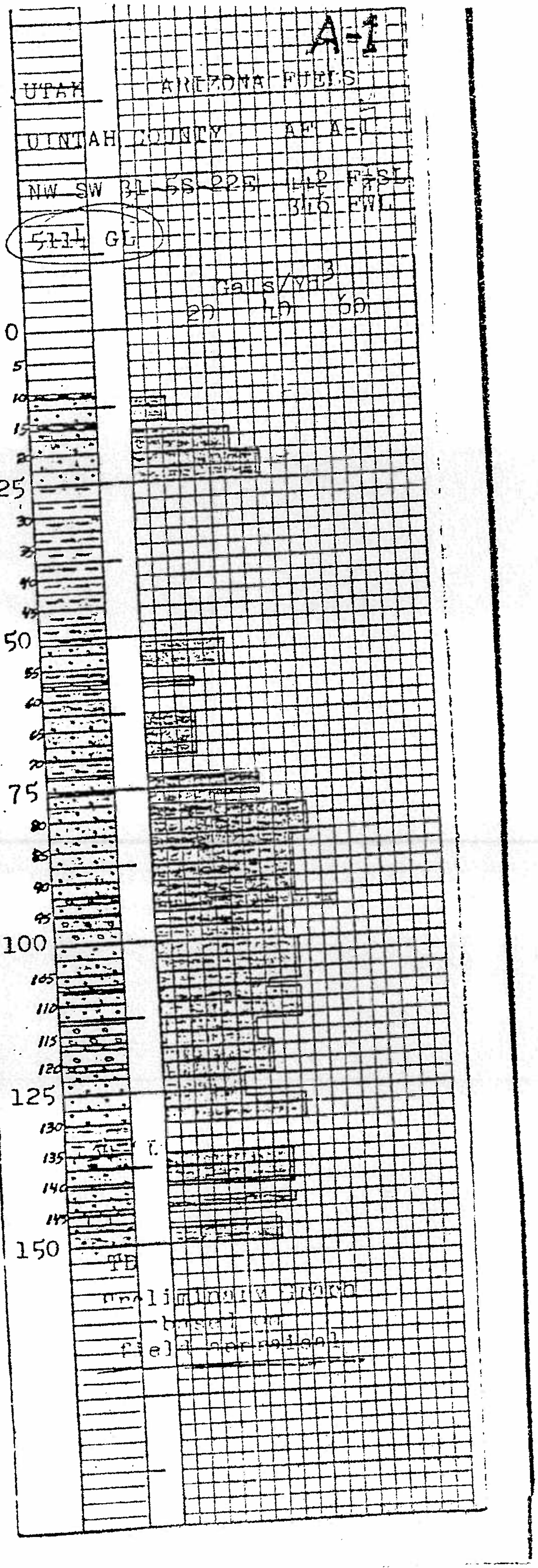
4-28-75 Tue MR

moved to NW corner "I" location Dalton [illegible]

A-1 Location moved 17' SE

13 Jim Pete 442 S 346 E FRM W LINE Elev 5114

DEPTH	FI	GRADE	LITH
11.2 - 14.5	3.3	I−	os
14.5 - 16.3	1.8	Barren	shale
16.3 - 20.3	4.0	III	os
20.3 - 24.7	4.4	II−	os
24.7 - 51.2	26.5	Barren	shale
51.2 - 54.9		II	
54.9 - 57.1		Barren	shale
57.1 - 58.1	1	II+	
58.1 - 62.3		Barren	gy sh
62.3 - 69.3	7.0	II	
69.3 - 73.0		Barren	gy sh
73.0 - 74.5		II	
74.5 - 75.2		Barren	ls
75.2 - 76.3		III+	1 sf good rich os
76.3 - 78.0		II+	
78.0 - 83.5		IV	
83.5 - 92.3		IV	
92.3 - 93.6		I	o/ cgl
93.6 - 95.0		V	o cgl
95.0 - 95.4	.4	B	sh
95.4 - 100.2	4.8	IV−	o cgl
100.2 - 106.5		IV	o cgl
106.5 - 108.0		III	–
108 - 113.5		II	os
113.5 - 116.5		II	o cgl
116.5 - 121.0		III+	os
121.0 - 122.3		II+	o cgl
122.3 - 126.2		III−	os
126.2 - 130.0		I	os
130.0 - 135.0		B	Shale
135.0 - 140.8		IV−	os
140.8 - 142.4	1.6	B	gy sh
142.4 - 144.0		II	os
144.0 - 146.5	6.5	B	sdy ls


A-1
UTAH
ARIZONA FUELS
UINTAH COUNTY
AF A-1
NW SW 31-5S-22E
442 FSL
316 FWL
5114 GL
Gals/yd3
20
40
60
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
TD
Preliminary [illegible]
based on
field appraisal

TAR SAND ANALYSIS
FOR

BURMAH OIL AND GAS COMPANY
ARIZONA FUELS COMPANY
CORE HOLE NO. B-1
ASPHALT RIDGE FIELD
UINTAH COUNTY, UTAH

RECEIVED

JUN 23 1975

J. W. EHRING

L-311-1

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

ompany BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY Formation ______ File RP-2-4867
Vell CORE HOLE NO. B-1 Core Type DIAMOND 2.125 Date Report 5-20-75
ield ASPHALT RIDGE Drilling Fluid WATER BASE MUD Analysts WW
ounty UINTAH State UTAH Elev. ______ Location SEC. 31-T5S-R22E

Lithological Abbreviations

ND-SD
ALE-SH
ME-LM

DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP

ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS

SANDY-SDY
SHALY-SHY
LIMY-LMY

FINE-FN
MEDIUM-MED
COARSE-CSE

CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL

BROWN-BRN
GRAY-GY
VUGGY-VGY

FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY

SLIGHTLY-SL/
VERY-V/
WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Weight Percent

Sample No.	Depth	Oil	Water	Sand	Grain Density	Natural Density
1	13.0-15.5	3.7	6.3	90.0		
2	15.5-18.0	8.2	3.7	88.1		
3	18.0-20.5	7.7	2.5	89.8		
4	20.5-23.0	7.8	3.4	88.8		
5	23.0-25.5	5.3	0.7	94.6		
6	25.5-28.0	0.7	2.0	97.3	2.63	2.10
7	28.0-30.5	8.3	0.9	90.8		
8	30.5-33.0	6.5	0.6	92.9		
9	33.0-35.5	8.3	0.7	91.0		
10	38.0-40.5	1.6	1.8	96.6		
11	40.5-43.0	0.2	2.0	97.8		
12	43.0-45.5	10.3	2.6	87.1		
13	45.5-48.0	2.8	1.1	96.1	2.73	2.35
14	48.0-50.5	4.5	1.1	94.4		
15	50.5-53.0	7.4	1.3	91.3		
16	53.0-55.5	3.6	1.3	95.1		
17	55.5-58.0	0.5	2.2	97.3		
18	58.0-60.5	3.6	1.3	95.1	2.61	2.29
19	60.5-63.0	3.3	0.8	95.9		
20	63.0-65.5	0.1	0.8	99.1		
21	65.5-68.0	0.5	1.0	98.5		
22	68.0-70.5	0.5	0.6	98.9		
23	70.5-73.0	6.9	1.8	91.3		
24	73.0-75.5	0.6	0.6	98.8	2.61	2.28
25	75.5-78.0	0.5	0.9	98.6		
26	78.0-80.5	0.4	0.7	98.9		
27	80.5-83.0	0.5	1.4	98.1		
28	83.0-85.5	0.2	0.9	98.9		
29	85.5-88.0	2.2	1.3	96.5		
30	88.0-90.5	0.6	0.7	98.7	2.61	2.58
31	90.5-93.0	6.2	1.5	92.3		

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY / ARIZONA FUELS COMPANY
Formation
File RP-2-4867
Well CORE HOLE NO. B-1
Core Type DIAMOND 2.125
Date Report 5-20-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
County UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

AND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTL-
HALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V
IME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W

PLE / IBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE: OIL	RESIDUAL SATURATION PER CENT PORE: TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

Weight Percent

5.5

2.5

Sample No.	Depth	Calcd	Oil	Water	Sand	Grain Density	Natural Density
1	13.0-15.5	16.0	3.7	6.3	90.0		
2	15.5-18.0	35.4	8.2	3.7	88.1		
3	18.0-20.5	33.3	7.7	2.5	89.8		
4	20.5-23.0	33.7	7.8	3.4	88.8		
5	23.0-25.5	22.9	5.3	0.7	94.6		
6	25.5-28.0	3.0	0.7	2.0	97.3	2.63	2.10
7	28.0-30.5	35.9	8.3	0.9	90.8		
8	30.5-33.0	28.1	6.5	0.6	92.9		
9	33.0-35.5	35.9	8.3	0.7	91.0		
10	38.0-40.5	6.9	1.6	1.8	96.6		
11	40.5-43.0	.9	0.2	2.0	97.8		
12	43.0-45.5	44.5	10.3	2.6	87.1		
13	45.5-48.0	12.1	2.8	1.1	96.1	2.73	2.35
14	48.0-50.5	19.4	4.5	1.1	94.4		
15	50.5-53.0	32.0	7.4	1.3	91.3		
16	53.0-55.5	15.6	3.6	1.3	95.1		
17	55.5-58.0	2.2	0.5	2.2	97.3		
18	58.0-60.5	15.6	3.6	1.3	95.1	2.61	2.29
19	60.5-63.0	14.3	3.3	0.8	95.9		
20	63.0-65.5	.4	0.1	0.8	99.1		
21	65.5-68.0	2.2	0.5	1.0	98.5		
22	68.0-70.5	2.2	0.5	0.6	98.9		
23	70.5-73.0	29.8	6.9	1.8	91.3		
24	73.0-75.5	2.6	0.6	0.6	98.8	2.61	2.28
25	75.5-78.0	2.2	0.5	0.9	98.6		
26	78.0-80.5	1.7	0.4	0.7	98.9		
27	80.5-83.0	2.2	0.5	1.4	98.1		
28	83.0-85.5	.9	0.2	0.9	98.9		
29	85.5-88.0	9.5	2.2	1.3	96.5		
30	88.0-90.5	2.6	0.6	0.7	98.7	2.61	2.58
31	90.5-93.0	26.8	6.2	1.5	92.3		

These analyses, opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential use this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but

STATE UTAH ELEV. 5141'

COUNTY UINTAH

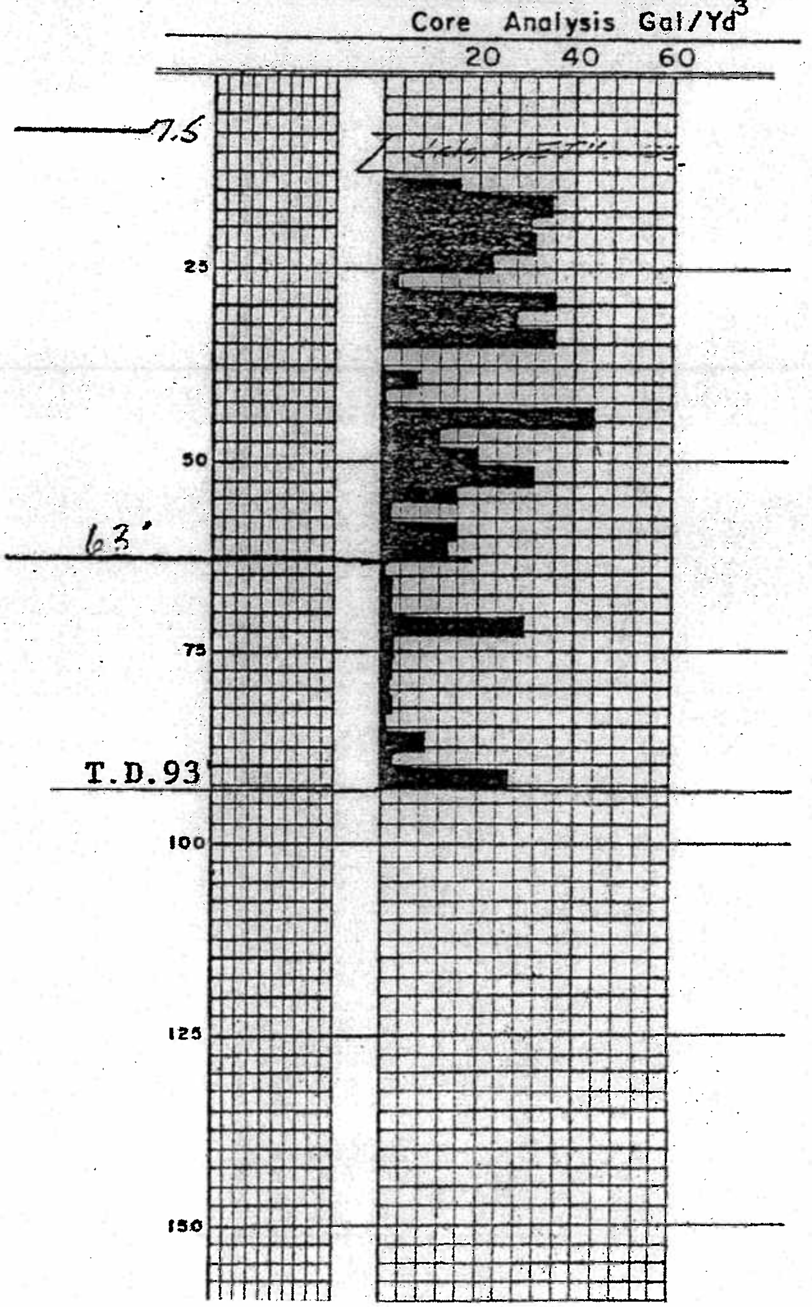
COMPANY ARIZONA FUELS CORPORATION

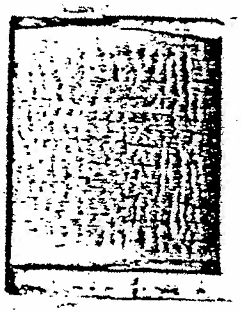
FARM BOAG-SOHIO WELL NO. CH B-1

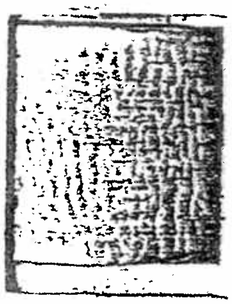
LOCATION 51' F.1/4 S.L., 893' F.W.L.,
Sec. 31, T-5-S, R-22-E, S.L.B.& M.

TD. 93' TOOLS Longyear 44

2-1/2" Wireline Core







STATE UTAH ELEV. 5141'

COUNTY UINTAH

COMPANY ARIZONA FUELS CORPORATION

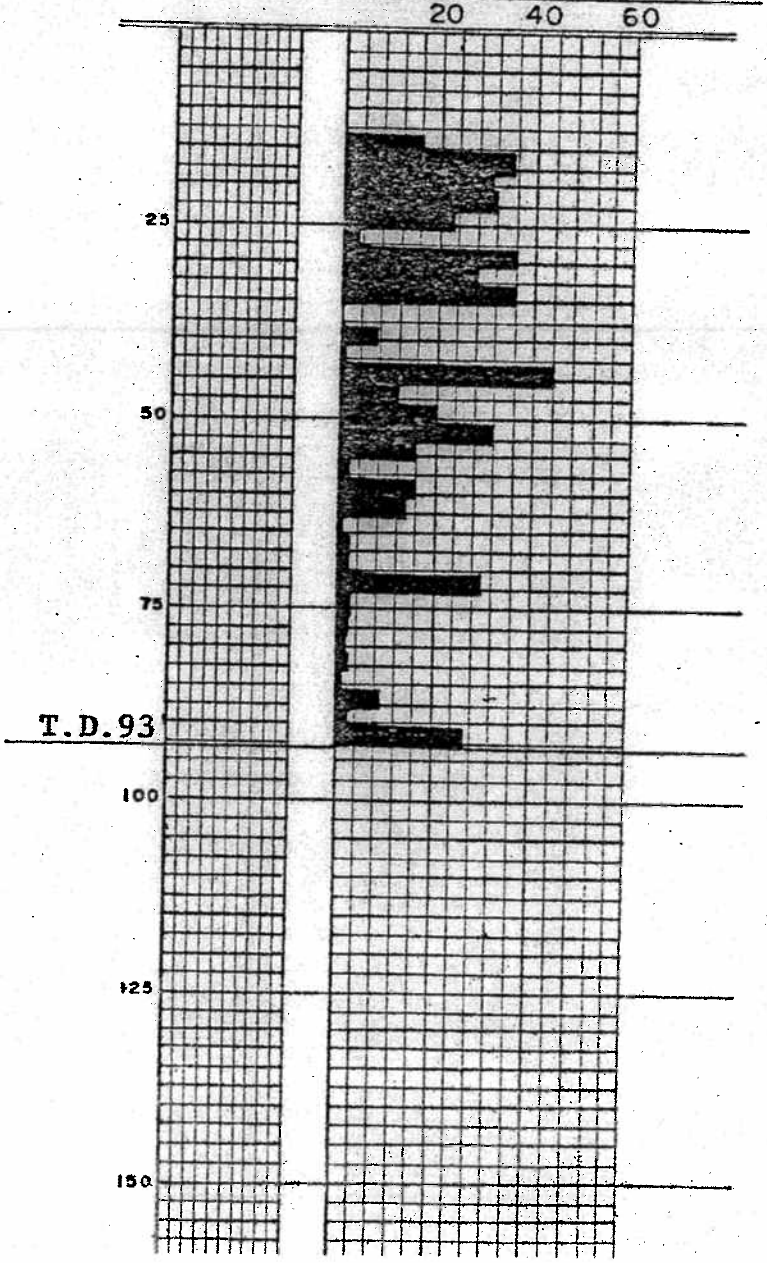
FARM BOAG-SOHIO WELL NO. CH B-1

LOCATION 51' F.1/4 S.L., 893' F.W.L., Sec. 31, T-5-S, R-22-E, S.L.B.& M.

TD. 93' TOOLS Longyear 44

2-1/2" Wireline Core

Core Analysis Gal/Yd^3



5-15-75 ASPHALT RIDGE

to 51FSL 8893'FEL

Bl-x Location model

935
47
982

14yds west of stake.
and is 17yds south of west line.
51'

Prob. will not resurvey and could be off few ~~[illegible]~~

51 S

DRILLED to 13'.

0-7½ yel gy sh
7½-12 os weathered II
12-13

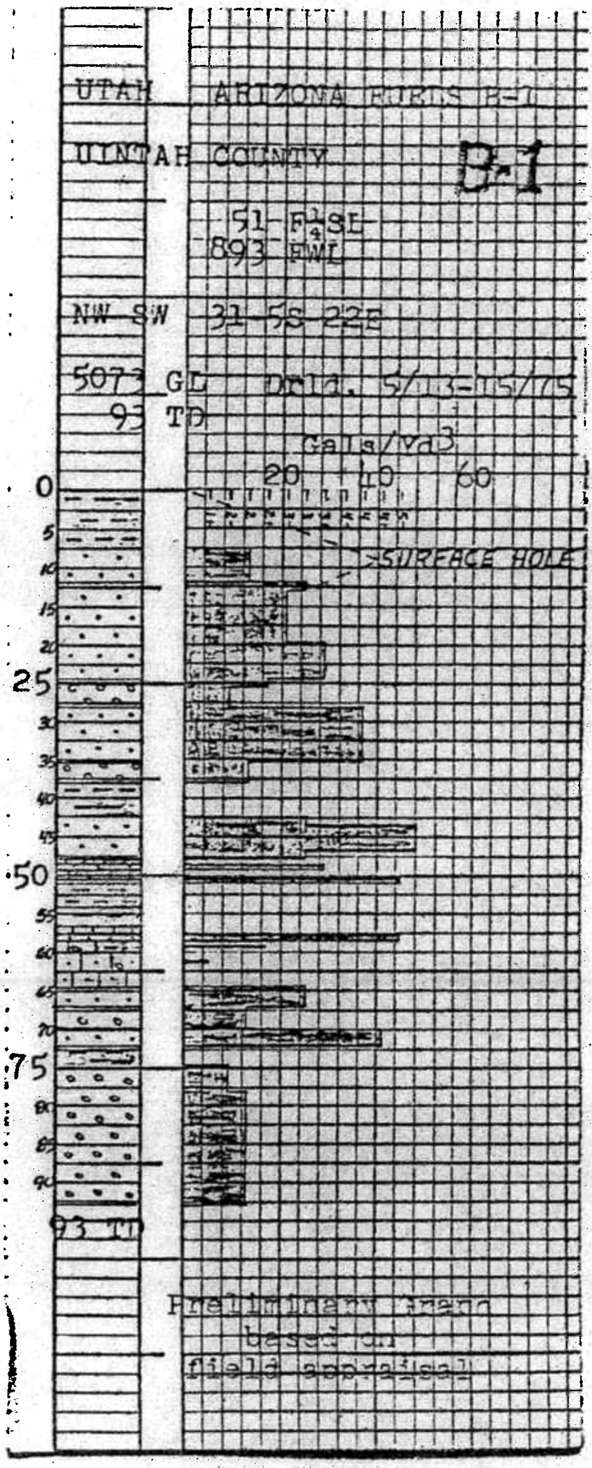
Core Depth	FT	CLASS	LITH
13-22.3		III-	os
22.3-24.3	2	II+	os
24.3-25.4	1.1	II+	ccgl
25.4-28.3	2.9	II	ccgl
28.3-35.2	6.9	II	os
35.2-38.3	3.1	II	ccgl
38.3-42.4	4.1	B	sh gy grn
42.4-43.7	1.3	III	os
43.7-46.7	3.0	I	os
46.7-47.7	1.0	III	os
47.7-48.4	.7	B	ls gy grn
48.4-49.2	.8	III+	os
49.2-50.4	1.2	B	ls gy grn
50.4-51.0	.6	I-	os
51.0-54.1	3.1	B	sh gy
54.1-56.7	2.6	B	sh gy grn
56.7-57.6	.9	B	gy ls
57.6-58.5	.9	II-	os
58.5-64.7	6.2	B	ls gy grn sdy
64.7-67.2		II ori	os-ls interbed.
67.2-69.9	2.7	II	ccgl
69.9-72.1	2.2	II+	os
72.1-85	—	II cit	ccgl incomplete

5-14-75 Thu ASPHALT RIDGE

Ⓑ hole Present depth 35'
D, finished TD 109

Shipped E-C, -D to core lab.
Contacted Ernie Johnson

Depth	Class	Lith.
84. - 88.3	III +	0 cgl
88.3 - 92.5	III	0 cgl
92.5 - 97.3	II	0 cgl
97.3 - 98.3	II	OS
98.3 - 106.5	I +	0 cgl
106.5 - 109. TD	II	0 cgl


UTAH
ARIZONA FUELS B-1
UINTAH COUNTY
B-1
51 F¼SL
893 FWL
NW SW
31 5S 22E
5073 GL
93 TD
Drld. 5/13-15/75
Gals/yd3
20
40
60
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
SURFACE HOLE
93 TD
Preliminary Graph
based on
field appraisal

TAR SAND ANALYSIS
FOR

BURMAH OIL AND GAS COMPANY
ARIZONA FUELS COMPANY
CORE HOLE NO. C-1
ASPHALT RIDGE FIELD
UINTAH COUNTY, UTAH

RECEIVED

JUN 23 1975

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4864
Well CORE HOLE NO. C-1
Core Type DIAMOND 2.125
Date Report 6-9-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WN
County UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

AND-SD
HALE-SH
IME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Weight Percent

ample No.	Depth	Oil	Water	Sand	Grain Density	Natural Density
1	8.0-10.5	4.3	0.7	95.0		
2	15.5-18.0	0.6	0.5	98.9		
3	18.0-20.5	3.6	0.4	96.0		
4	20.5-23.0	9.9	0.7	89.4		
5	23.0-25.5	0.3	0.6	99.1		
6	25.5-28.0	2.0	0.8	97.2	2.59	2.02
7	28.0-30.5	0.3	0.1	99.6		
8	30.5-33.0	10.2	0.6	89.2		
9	33.0-35.5	7.0	0.4	92.6		
10	35.5-38.0	10.2	0.9	88.9		
11	38.0-40.5	1.6	0.2	98.2		
12	40.5-43.0	7.1	0.1	92.8	2.56	2.07
13	43.0-45.5	10.3	0.1	89.6		
14	45.5-48.0	0.8	0.1	99.2		
15	48.0-50.5	2.9	0.2	96.9		
16	50.5-53.0	5.2	0.3	94.5		
17	53.0-55.5	1.1	0.4	98.5		
18	55.5-58.0	5.1	0.3	94.6	2.60	2.08
19	58.0-60.5	0.0	0.6	99.4		
20	60.5-63.0	0.3	0.3	99.4		
21	63.0-65.5	2.6	0.3	97.1		
22	65.5-68.0	8.5	0.3	91.2		
23	68.0-70.5	4.6	0.1	95.3		
24	70.5-73.0	0.9	0.1	99.0	2.64	2.40
25	73.0-75.5	0.8	0.1	99.1		
26	75.5-78.0	1.7	0.1	98.2		
27	78.0-80.5	1.9	0.2	97.9		
28	80.5-83.0	1.3	0.2	98.5		
29	83.0-85.5	2.4	0.2	97.4		
30	85.5-88.0	0.6	0.2	99.2	2.63	2.57

CL-311-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4364
Well CORE HOLE NO. C-1
Core Type DIAMOND 2.125
Date Report 6-9-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WJ
County UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

SAND-SD
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LIME-LM
DOLOMITE-DOL
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GYPSUM-GYP
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CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

MPLE MBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

		Weight Percent		
ample No.	Depth	Oil	Water	Sand
31	88.0-90.5	5.0	0.6	94.4
32	90.5-93.0	1.4	0.7	97.9
33	93.0-95.5	0.3	0.2	99.5
34	95.5-98.0	2.8	0.3	96.9
35	98.0-00.0	0.4	0.3	99.3
36	105.0-08.0	0.3	0.4	99.3

:L-811-1

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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JUN 16 1975
J. W. EHRING

Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY / ARIZONA FUELS COMPANY
Well CORE HOLE NO. C-1
Field ASPHALT RIDGE
County UINTAH State UTAH Elev.
Formation
Core Type DIAMOND 2.125
Drilling Fluid WATER BASE MUD
Location SEC. 31-T5S-R22E
File RP-2-4864
Date Report 6-9-75
Analysts WW

Lithological Abbreviations

AND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
HALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
IME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

			Weight Percent				
ample No.	Depth	Gal/yd³	Oil	Water	Sand	Grain Density	Natural Density
1	~~80.0~~ 8.0-10.5	18.6	4.3	0.7	95.0		
2	15.5-18.0	2.6	0.6	0.5	98.9		
3	18.0-20.5	15.6	3.6	0.4	96.0		
4	20.5-23.0	42.8	9.9	0.7	89.4		
5	X 23.0-25.5	1.3	0.3	0.6	99.1		
6	25.5-28.0	8.6	2.0	0.8	97.2	2.59	2.02
7	X 28.0-30.5	1.3	0.3	0.1	99.6		
8	30.5-33.0	44.1	10.2	0.6	89.2		
9	33.0-35.5	30.2	7.0	0.4	92.6		
.0	35.5-38.0	44.1	10.2	0.9	88.9		
1	38.0-40.5	6.9	1.6	0.2	98.2		
.2	40.5-43.0	30.7	7.1	0.1	92.8	2.56	2.07
.3	43.0-45.5	44.5	10.3	0.1	89.6		
.4	X 45.5-48.0	3.5	0.8	0.1	99.2		
.5	48.0-50.5	12.5	2.9	0.2	96.9		
.6	50.5-53.0	22.5	5.2	0.3	94.5		
.7	X 53.0-55.5	4.5	1.1	0.4	98.5		
.8	55.5-58.0	22.0	5.1	0.3	94.6	2.60	2.08
.9	X 58.0-60.5	0	0.0	0.6	99.4		
20	X 60.5-63.0	1.3	0.3	0.3	99.4		
21	63.0-65.5	11.2	2.6	0.3	97.1		
22	65.5-68.0	36.7	8.5	0.3	91.2		
23	68.0-70.5	19.9	4.6	0.1	95.3		
24	70.5-73.0	3.9	0.9	0.1	99.0	2.64	2.40
25	73.0-75.5	3.5	0.8	0.1	99.1		
26	75.5-78.0	7.3	1.7	0.1	98.2		
27	78.0-80.5	8.2	1.9	0.2	97.9		
28	80.5-83.0	5.6	1.3	0.2	98.5		
29	83.0-85.5	10.4	2.4	0.2	97.4		
30	85.5-88.0	2.6	0.6	0.2	99.2	2.63	2.57

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

ompany BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4864
Vell CORE HOLE NO. C-1
Core Type DIAMOND 2.125
Date Report 6-9-75
ield ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
ounty UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

ND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
ALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
ME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

LE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

mple No.	Depth		Weight Percent Oil	Water	Sand
31	88.0-90.5	21.6	5.0	0.6	94.4
32	90.5-93.0	6.6	1.4	0.7	97.9
33	93.0-95.5	1.3	0.3	0.2	99.5
34	95.5-98.0	12.1	2.8	0.3	96.9
35	98.0-00.0	1.7	0.4	0.3	99.3
36	105.0-08.0	1.3	0.3	0.4	99.3

STATE UTAH ELEV. 5137'

COUNTY UINTAH

COMPANY ARIZONA FUELS CORPORATION

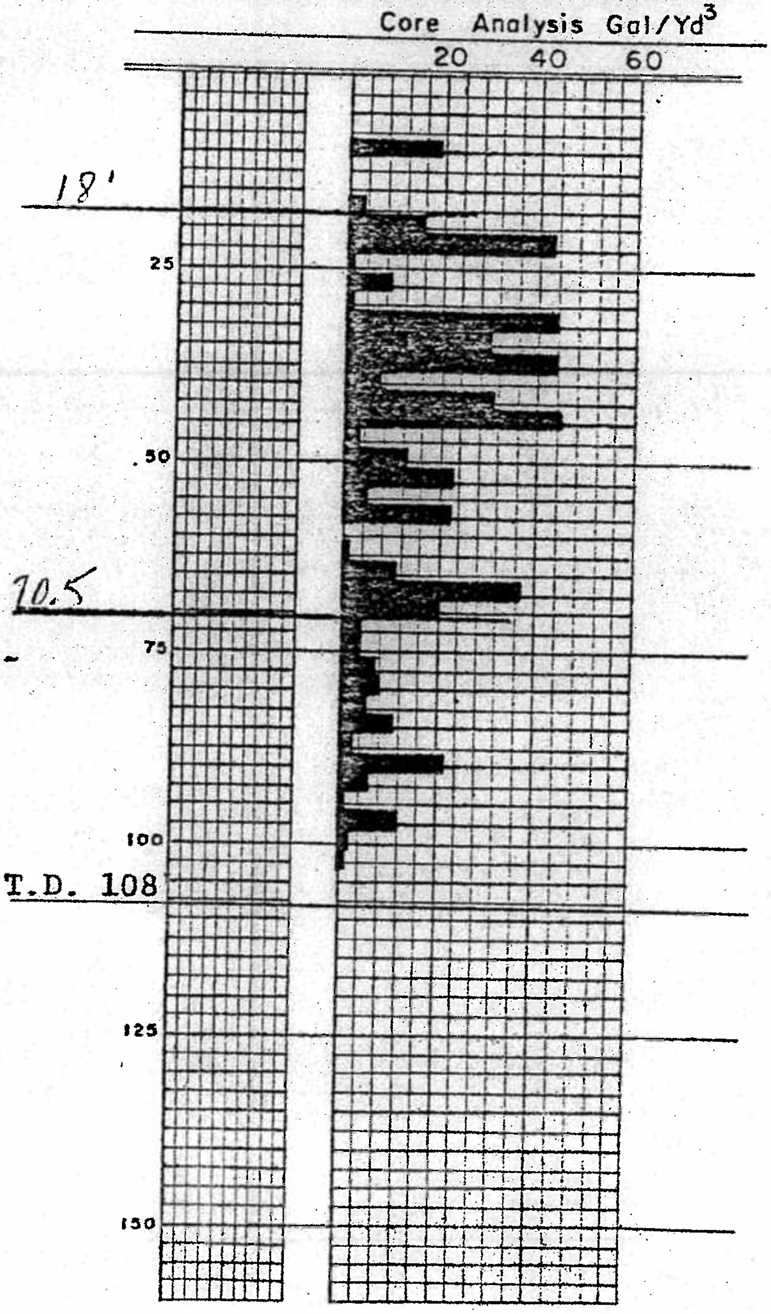
FARM BOAG-SOHIO WELL NO. CH C-1

LOCATION 111' F.1/4 S.L., 1207' F.W.L.

Sec.31, T-5-S, R22-E, S.L.B.& M.

TD. 108' TOOLS Longyear 44

2-1/2" Wireline Core



STATE UTAH ELEV. 5137'

COUNTY UINTAH

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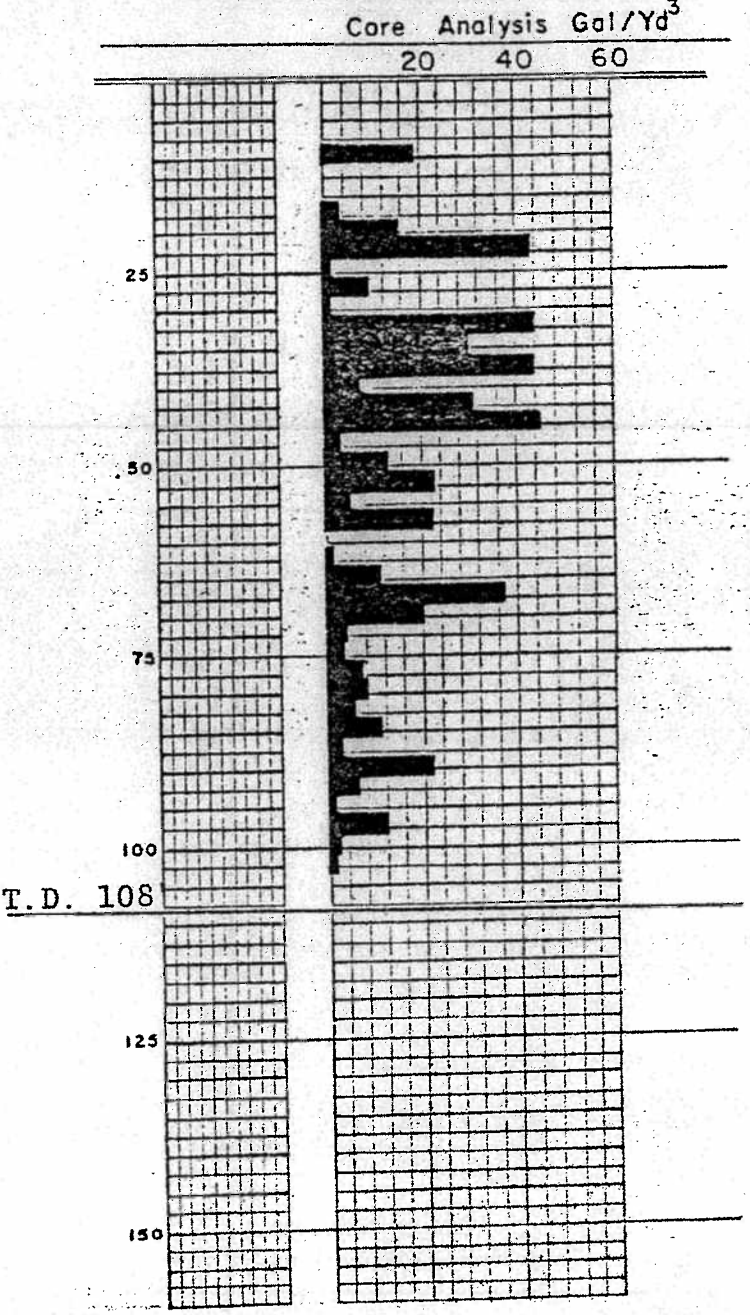
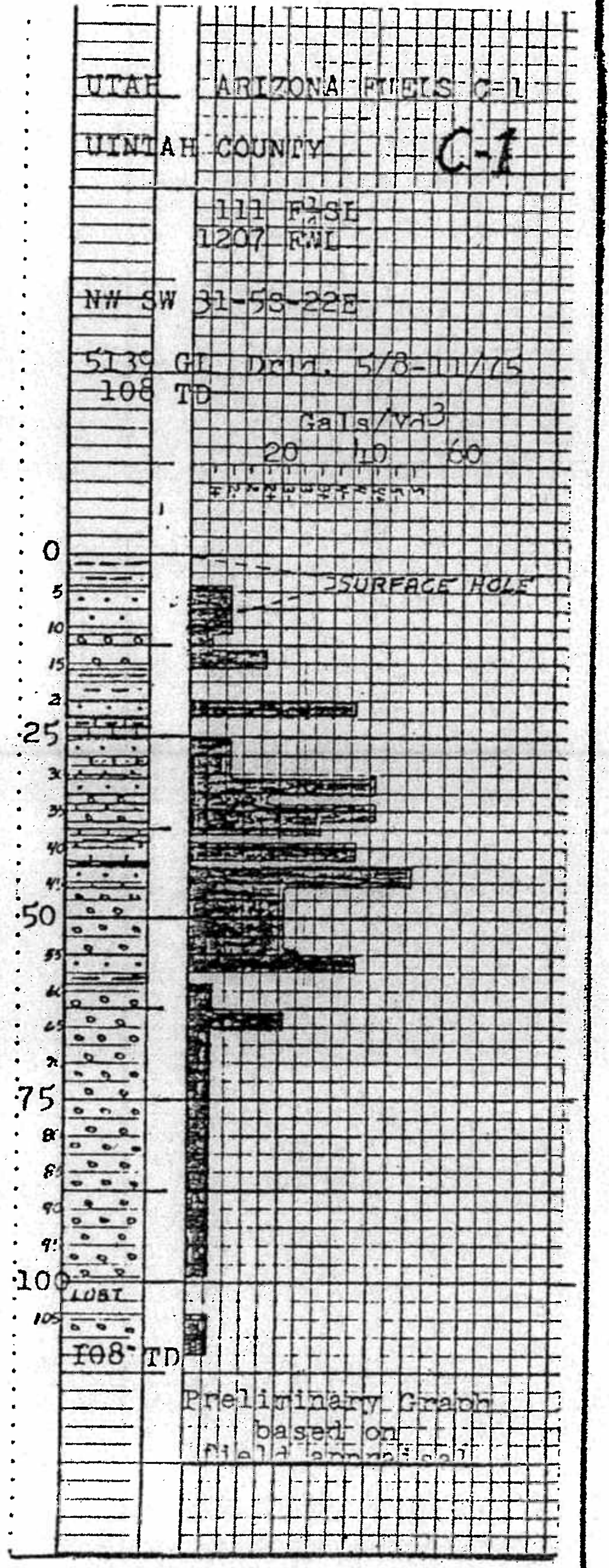
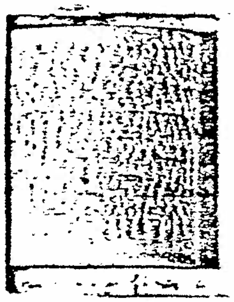
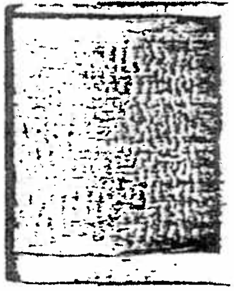



UTAH
ARIZONA FUELS C-1
UINTAH COUNTY
C-1
111 FSL
1207 FWL
NW SW 31-5S-22E
5139 GL Drld. 5/8-11/75
108 TD
Gals/Yd3
20
40
60
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
SURFACE HOLE
LOST
108 TD
Preliminary Graph
based on
field appraisal





TAR SAND ANALYSIS
FOR

BURMAH OIL AND GAS COMPANY
ARIZONA FUELS COMPANY
CORE HOLE NO. D-1
ASPHALT RIDGE FIELD
UINTAH COUNTY, UTAH

CL-311-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY Formation ______ File RP-2-4878

Well CORE HOLE NO. D-1 Core Type DIAMOND 2.125 Date Report 6-2-75

Field ASPHALT RIDGE Drilling Fluid WATER BASE MUD Analysts WW

County UINTAH State UTAH Elev. ______ Location SEC. 31-T5S-R22E

Lithological Abbreviations

AND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL
HALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
IME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

IPLE IBER | DEPTH FEET | PERMEABILITY MILLIDARCYS | POROSITY PER CENT | RESIDUAL SATURATION PER CENT PORE: OIL, TOTAL WATER | SAMPLE DESCRIPTION AND REMARKS

		Weight Percent				
Sample No.	Depth	Oil	Water	Sand	Grain Density	Natural Density
1	9.0-11.5	5.2	0.6	94.2		
2	14.0-16.5	0.3	1.8	97.9		
3	16.5-19.0	2.7	0.7	96.6		
4	19.0-21.5	5.9	0.4	93.7		
5	21.5-24.0	6.9	0.4	92.7		
6	24.0-26.5	7.0	0.6	92.4		
7	26.5-29.0	6.8	0.4	92.8	2.69	2.11
8	29.0-31.5	1.1	0.4	98.5		
9	31.5-34.0	2.2	0.2	97.6		
10	34.0-36.5	10.7	0.8	88.5		
11	36.5-39.0	12.0	1.7	86.3		
12	39.0-41.5	6.3	0.5	93.2		
13	41.5-43.0	12.8	1.8	85.4		
14	43.0-45.5	1.9	1.9	96.2	2.69	2.46
15	45.5-48.0	11.6	1.8	86.6		
16	48.0-50.5	2.7	2.3	95.0		
17	50.5-53.0	6.1	1.9	92.0		
18	53.0-55.5	4.3	1.8	93.9		
19	55.5-58.0	4.7	0.8	94.5		
20	58.0-60.5	3.4	2.0	94.6		
21	60.5-63.0	0.0	0.6	99.4	2.68	2.50
22	63.0-65.5	1.1	0.8	98.1		
23	65.5-68.0	0.7	0.6	98.7		
24	68.0-70.5	0.5	0.3	99.2		
25	70.5-73.0	0.4	0.6	99.0		
26	73.0-75.5	5.1	0.3	94.6		
27	75.5-78.0	8.0	0.6	91.4		

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 2

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File FP-2-4878
Well CORE HOLE NO. D-1
Core Type DIAMOND 2.125
Date Report 6-2-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
County UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

SAND-SD
SHALE-SH
LIME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

MPLE NBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

		Weight Percent				
Sample No.	Depth	Oil	Water	Sand	Grain Density	Natural Density
28	78.0-80.5	3.6	0.9	95.5	2.66	2.17
29	80.5-83.0	6.1	0.3	93.6		
30	83.0-85.5	6.1	0.4	93.5		
31	85.5-88.0	4.8	1.1	94.1		
32	88.0-90.5	1.0	0.4	98.6		
33	90.5-93.0	8.8	0.3	90.9		
34	93.095.5	2.8	0.7	96.5		
35	95.5-98.0	9.4	0.7	89.9	2.61	2.10
36	98.0-00.5	0.2	0.7	99.1		
37	100.5-03.0	0.4	0.3	99.3		
38	103.0-06.0	1.6	0.7	97.7		
39	106.0-09.0	1.9	0.5	97.6		

C1-511-1

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
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CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS

SANDY-SDY
SHALY-SHY
LIMY-LMY

FINE-FN
MEDIUM-MED
COARSE-CSE

CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL

BROWN-BRN
GRAY-GY
VUGGY-VGY

FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY

SLIGHTLY-
VERY-V/
WITH-W/

AMPLE UMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

			Weight Percent				
Sample No.	Depth	Gal/Yd.^{3}	Oil	Water	Sand	Grain Density	Natural Density
1	9.0-11.5	22.5	5.2	0.6	94.2		
2	X X 14.0-16.5	1.3	0.3	1.8	97.9		
3	16.5-19.0	11.7	2.7	0.7	96.6		
4	19.0-21.5	25.5	5.9	0.4	93.7		
5	21.5-24.0	29.8	6.9	0.4	92.7		
6	24.0-26.5	30.2	7.0	0.6	92.4		
7	26.5-29.0	29.4	6.8	0.4	92.8	2.69	2.11
8	X 29.0-31.5	4.8	1.1	0.4	98.5		
9	31.5-34.0	9.5	2.2	0.2	97.6		
10	34.0-36.5	46.2	10.7	0.8	88.5		
11	36.5-39.0	51.8	12.0	1.7	86.3		
12	39.0-41.5	27.2	6.3	0.5	93.2		
13	41.5-43.0	55.3	12.8	1.8	85.4		
14	43.0-45.5	8.2	1.9	1.9	96.2	2.69	2.46
15	45.5-48.0	50.1	11.6	1.8	86.6		
16	48.0-50.5	11.7	2.7	2.3	95.0		
17	50.5-53.0	26.4	6.1	1.9	92.0		
18	53.0-55.5	18.6	4.3	1.8	93.9		
19	55.5-58.0	20.3	4.7	0.8	94.5		
20	58.0-60.5	14.7	3.4	2.0	94.6		
21	X 60.5-63.0	0	0.0	0.6	99.4	2.68	2.50
22	X 63.0-65.5	4.8	1.1	0.8	98.1		
23	X 65.5-68.0	3.0	0.7	0.6	98.7		
24	X 68.0-70.5	2.2	0.5	0.3	99.2		
25	X 70.5-73.0	1.7	0.4	0.6	99.0		
26	73.0-75.5	22.0	5.1	0.3	94.6		
27	75.5-78.0	34.6	8.0	0.6	91.4		

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Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

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STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

MPLE MBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

			Weight Percent				
Sample No.	Depth	Gal/Yd3	Oil	Water	Sand	Grain Density	Natural Density
28	78.0-80.5	15.6	3.6	0.9	95.5		
29	80.5-83.0	26.4	6.1	0.3	93.6	2.66	2.17
30	83.0-85.5	21.4	6.1	0.4	93.5		
31	85.5-88.0	20.7	4.8	1.1	94.1		
32	X 88.0-90.5	4.3	1.0	0.4	98.6		
33	90.5-93.0	38.0	8.8	0.3	90.9		
34	93.095.5	12.1	2.8	0.7	96.5		
35	95.5-98.0	40.6	9.4	0.7	89.9		
36	98.0-00.5	.9	0.2	0.7	99.1	2.61	2.10
37	100.5-03.0	1.7	0.4	0.3	99.3		
38	103.0-06.0	6.9	1.6	0.7	97.7		
39	106.0-09.0	8.2	1.9	0.5	97.6		

STATE UTAH ELEV. 5114'

COUNTY UINTAH

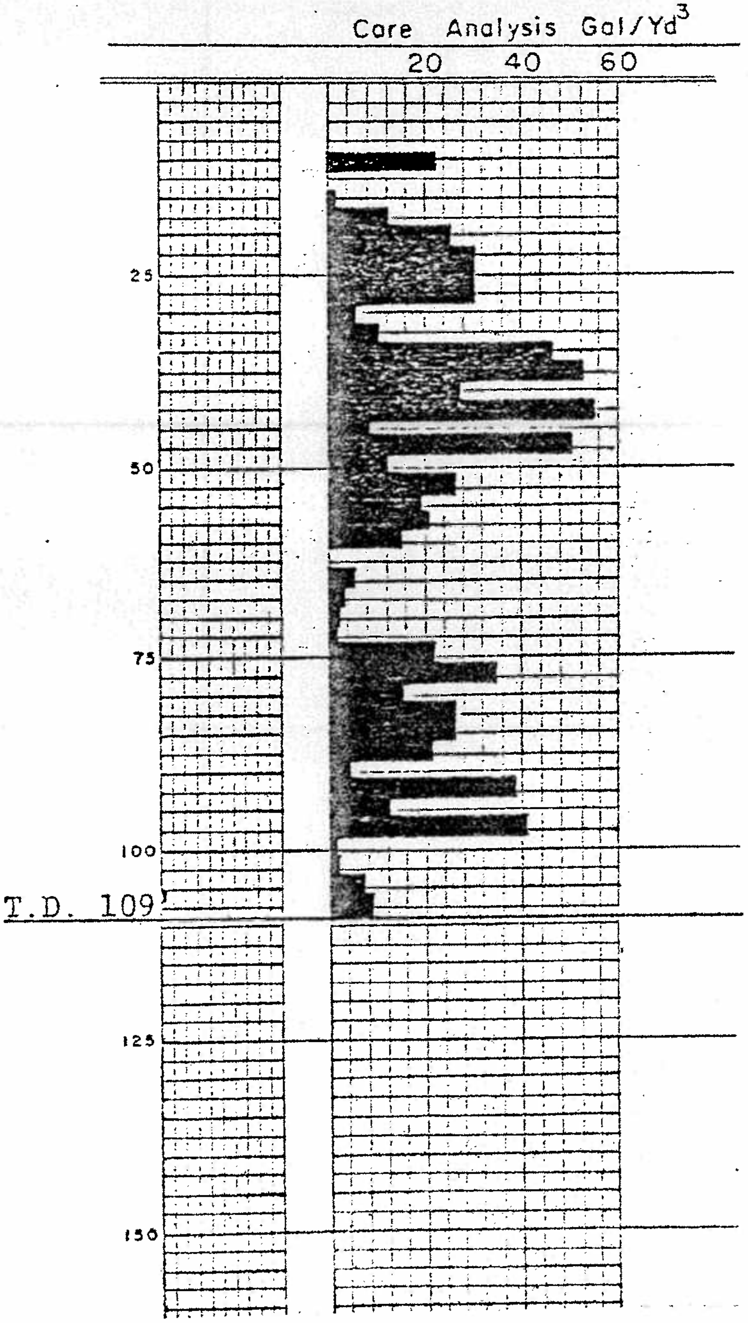
COMPANY ARIZONA FUELS CORPORATION

FARM BOAG-SOHIO WELL NO. CH D-1

LOCATION 422' F.1/4 S.L., 1197' F.W.L., Sec. 31, T-5-S, R-22-E, S.L.B.M.

T.D. 109' TOOLS Longyear 44

2-1/2" Wireline Core



STATE UTAH ELEV. 5114'

COUNTY UINTAH

COMPANY ARIZONA FUELS CORPORATION

FARM BOAG-SOHIO WELL NO. CH D-1

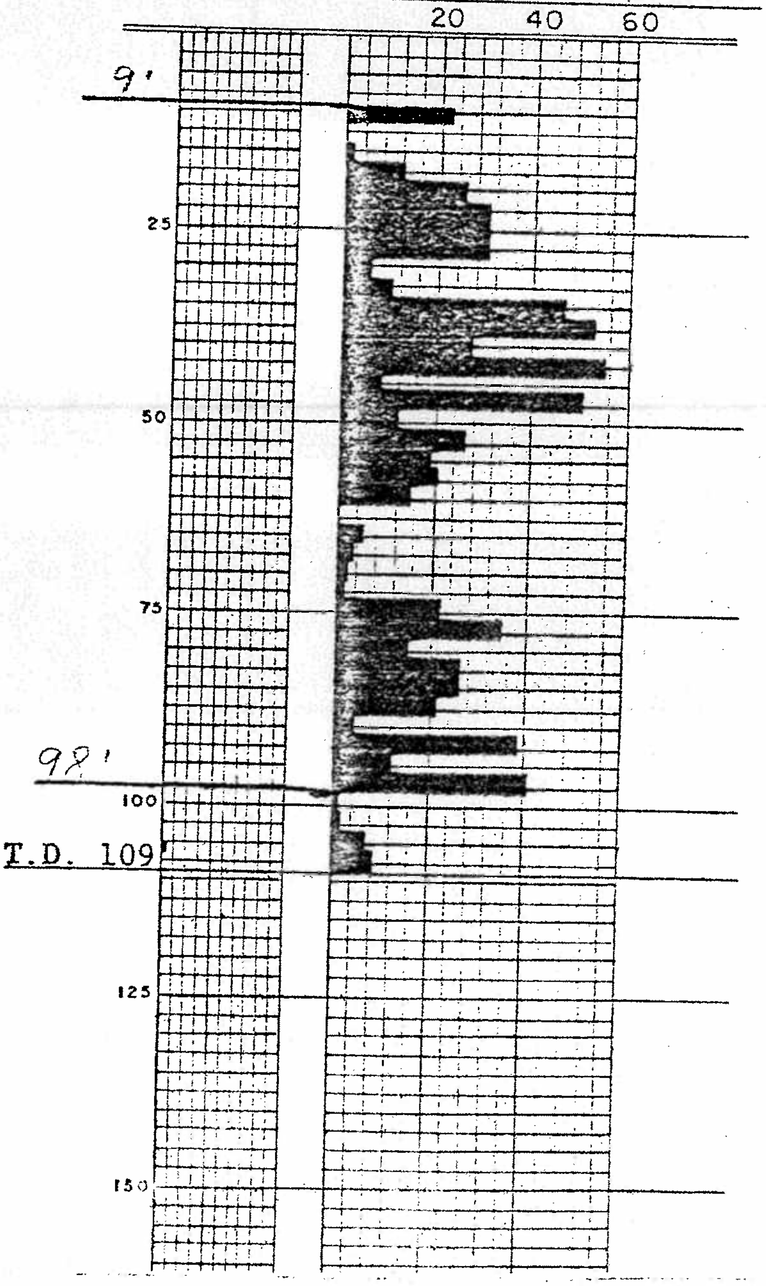
LOCATION 422' F.1/4 S.L., 1197' F.W.L.,

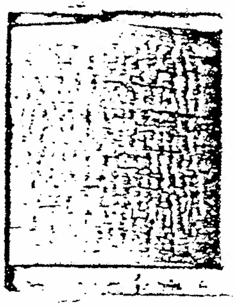
Sec. 31, T-5-S, R-22-E, S.L.B.M.

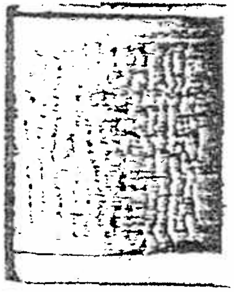
TD. 109' TOOLS Longyear 44

2-1/2" Wireline Core

Core Analysis Gal/Yd^3







STATE UTAH

COUNTY UINTAH

BLOCK NW SW

SEC. 31

T. 5S **R.** 22E

ALTITUDE 5114 GL

PRODUCTION

COMPANY ARIZONA FUELS

FARM D-1

SURVEY 122 F¼SL, 1197 FWL

109

TOTAL DEPTH

CONTRACTOR Hlmes Drilling

COMMENCED May 11, 1975

COMPLETED May 13, 1975

REMARKS

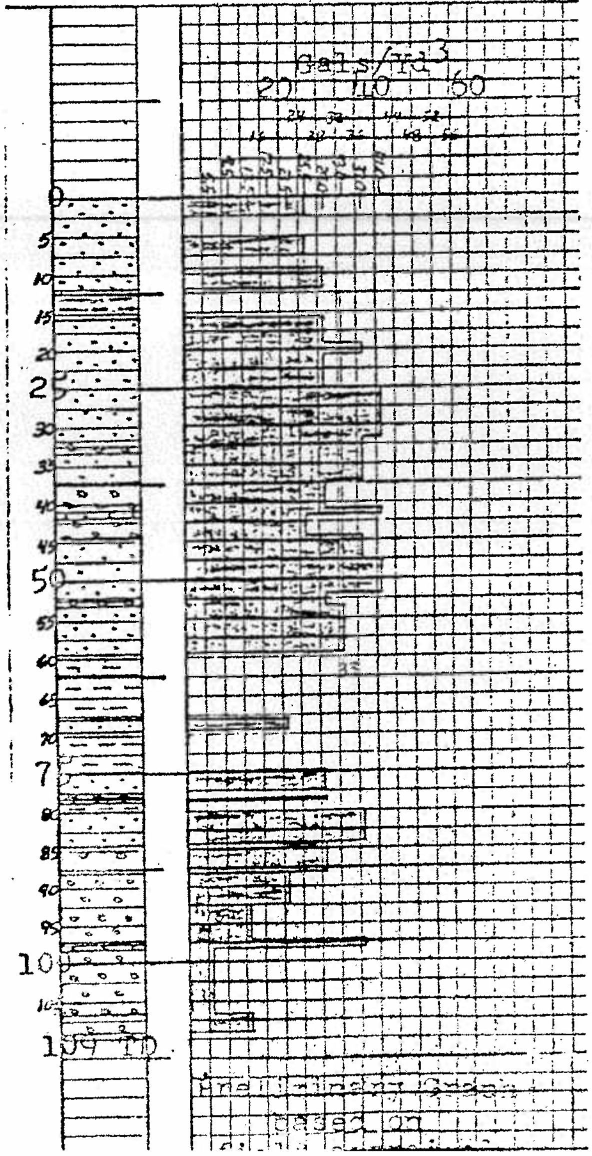
CASING RECORD

SHOT QUARTS BETWEEN

TIME RATE SCALE: 1/10" — MINUTES

450 PRINTED IN U.S.A.

TIME RATE: 1/10" SQUARES



Preliminary Grade

based on

5-13-75 Tues Asphalt Ridge File

Coring on D-1 Core Hole

0-9' drilled [illegible] stm. Class III os

Core #1	Depth	feet	class	Lith
	9.0 - 11.7	2.7	III+	os
	11.7 - 15.7	4	B	shale yel grn
	15.7 - 19.0	3.3	III+	os
	19.0 - 21.0	2.0	IV	os
	21.0 - 25.0	4.0	III+	os
	25.0 - 31.4	6.4	IV+	os o/r ch
	31.4 - 33.6	2.2	IV+	o cgl
	33.6 - 37.3	3.7	IV	os
	37.3 - 40.9	3.6	III+	o cgl
	40.9 - 41.7	.8	IV+	os
	41.7 - 44.6	2.9	III	o cgl
	44.6 - 47.6	3.0	IV	os
	47.6 - 52.0	4.4	IV+	os
	52.0 - 53.4	1.4	III+	o cgl
	53.4 - 59.3	5.9	IV	os
	59.3 - 62.2		B	sh gy grn
	62.2 - 65.5		B	sh ltm. gy. cal h.
	65.5 - 67.9		B	sh
	67.9 - 69.2		III−	os
	69.2 - 74.9		B	sh ltm gy h. cal h
	74.9 - 77.4		III	os
	77.4 - 78.5		B	sh h. limey
	78.5 - 79.0	½	III−	os
	79.0 - 80.0	1		sh mottled 60% w o cgl class III
	80 - 84.0		IV OA	o cgl
	84 - 87.0		III	o cgl incomplete

New & bigger fuel tank on [illegible]
going [illegible] hill moving dirt & [illegible].

5-14-75 Tue   ASPHALT RIDGE

B1 hole Present depth 35'
(D1) finished TD 109.

Shipped E-C1-D to ecn lab.
Contacted Emer Jensen

Depth	Class	Lith.
84. – 88.3	III +	0 cgl
88.3 – 92.5	III	0 cgl
92.5 – 97.3	II	0 cgl
97.3 – 98.3	II	ss
98.3 – 106.5	I +	0 cgl
106.5 – 109. TD	II	0 cgl

TAR SAND ANALYSIS
FOR

BURMAH OIL AND GAS COMPANY
ARIZONA FUELS COMPANY

CORE HOLE NO. E
ASPHALT RIDGE FIELD
UINTAH COUNTY, UTAH

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JUL 21 1975
[illegible]

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY
ARIZONA FUELS COMPANY
Formation
File RP-2-4880
Well CORE HOLE NO. E
Core Type DIAMOND 2.125
Date Report 6-23-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts EG
County UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

AND-SD HALE-SH IME-LM DOLOMITE-DOL CHERT-CH GYPSUM-GYP ANHYDRITE-ANHY CONGLOMERATE-CONG FOSSILIFEROUS-FOSS SANDY-SDY SHALY-SHY LIMY-LMY FINE-FN MEDIUM-MED COARSE-CSE CRYSTALLINE-XLN GRAIN-GRN GRANULAR-GRNL BROWN-BRN GRAY-GY VUGGY-VGY FRACTURED-FRAC LAMINATION-LAM STYLOLITIC-STY SLIGHTLY-SL/ VERY-V/ WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Weight Percent

ample No.	Depth	Oil	Water	Sand	Grain Density
1	41.0-43.5	0.5	1.0	98.5	
2	43.5-46.0	0.0	0.8	99.2	
3	46.0-48.5	0.2	0.9	98.9	
4	48.5-51.0	4.1	4.1	91.8	
5	51.0-53.5	4.8	4.0	91.2	
6	53.5-56.0	4.4	2.2	93.4	
7	56.0-58.5	5.4	3.6	91.0	
8	50.5-61.0	8.5	4.9	86.6	2.72
9	61.0-63.5	2.8	0.8	96.4	
10	77.0-79.5	1.1	0.4	98.5	
11	79.5-82.0	3.2	0.3	96.5	
12	82.0-84.5	0.1	0.7	99.2	
13	84.5-87.0	1.2	0.9	97.9	
14	87.0-89.5	0.2	1.3	98.5	2.67
15	89.5-92.0	3.3	0.4	96.3	
16	94.5-97.0	0.8	0.7	98.5	
17	102.0-04.5	4.2	2.8	93.0	
18	104.5-07.0	1.1	2.3	96.6	
19	109.5-12.0	4.9	0.4	94.7	
20	112.0-14.5	9.0	0.9	90.1	
21	114.5-17.0	6.8	1.1	92.1	
22	117.0-19.5	12.8	0.9	86.3	
23	119.5-21.0	13.1	1.0	85.8	
24	121.0-23.5	13.2	1.0	85.8	
25	123.5-26.0	13.4	0.5	86.1	
26	126.0-28.5	10.1	1.2	88.8	
27	128.5-31.0	9.3	1.0	89.6	
28	131.0-33.5	11.5	1.2	87.3	
29	133.5-36.0	9.3	0.4	90.3	
30	136.0-38.5	5.7	1.0	93.3	2.71

L-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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CORE ANALYSIS RESULTS

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ARIZONA FUELS COMPANY
Formation
File RP-2-4880
Vell CORE HOLE NO. E
Core Type DIAMOND 2.125
Date Report 6-23-75
ield ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts EG
ounty UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

ND-SD
ALE-SH
ME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL/
VERY-V/
WITH-W/

LE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

ample No.	Depth	Weight Percent			Grain Density
		Oil	Water	Sand	
31	138.5-41.0	7.3	0.9	91.8	
32	141.0-43.5	7.1	0.8	92.1	
33	143.5-46.0	2.8	0.8	96.4	
34	146.0-48.5	2.3	0.7	97.0	
35	148.5-51.0	10.5	1.0	88.5	
36	151.0-53.5	10.3	0.8	88.9	
37	153.5-56.0	6.3	0.8	92.9	
38	156.0-58.5	9.6	1.1	89.3	
39	158.5-61.0	6.5	1.0	92.5	2.71
40	161.0-63.5	7.2	1.1	91.7	
41	163.5-66.0	0.6	0.3	99.1	
42	166.0-68.5	4.3	0.2	95.5	
43	168.5-71.0	2.6	1.1	96.3	
44	171.0-73.0	0.6	1.3	98.1	

[illegible] the client to whom and for whose [illegible]

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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JUL 14 1975
I. W. ESSING

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SANDY-SDY
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FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-S
VERY-V/
WITH-W/

SAMPLE NUMBER | DEPTH FEET | PERMEABILITY MILLIDARCYS | POROSITY PER CENT | RESIDUAL SATURATION PER CENT PORE: OIL, TOTAL WATER | SAMPLE DESCRIPTION AND REMARKS

Sample No.	Depth	Gal/Yd³	Oil	Water	Sand	Grain Density
1	2½ 41.0-43.5	2.2	0.5	1.0	98.5	
2	43.5-46.0	0	0.0	0.8	99.2	
3	46.0-48.5	.9	0.2	0.9	98.9	
4	48.5-51.0	17.7	4.1	4.1	91.8	
5	51.0-53.5	20.7	4.8	4.0	91.2	
6	53.5-56.0	19.0	4.4	2.2	93.4	
7	56.0-58.5	23.3	5.4	3.6	91.0	
8	50.5-61.0	36.7	8.5	4.9	86.6	
9	61.0-63.5	12.1	2.8	0.8	96.4	2.72
10	2½ 77.0-79.5	4.0	1.1	0.4	98.5	
11	79.5-82.0	13.8	3.2	0.3	96.5	
12	82.0-84.5	.4	0.1	0.7	99.2	
13	84.5-87.0	5.2	1.2	0.9	97.9	
14	87.0-89.5	.9	0.2	1.3	93.5	
15	89.5-92.0	14.3	3.3	0.4	96.3	2.67
16	2½ 94.5-97.0	3.5	0.8	0.7	98.5	
17	2½ 102.0-04.5	18.1	4.2	2.8	93.0	
18	104.5-07.0	4.8	1.1	2.3	96.6	
19	109.5-12.0	21.2	4.9	0.4	94.7	
20	2½ 112.0-14.5	28.9	9.0	0.9	90.1	
21	114.5-17.0	29.4	6.8	1.1	92.1	
22	117.0-19.5	55.3	12.8	0.9	86.3	
23	1½ 119.5-21.0	56.6	13.1	1.0	85.8	
24	1½ 121.0-23.5	57.0	13.2	1.0	85.8	
25	123.5-26.0	57.9	13.4	0.5	86.1	
26	126.0-28.5	43.6	10.1	1.2	88.8	
27	128.5-31.0	40.2	9.3	1.0	89.6	
28	131.0-33.5	49.7	11.5	1.2	87.3	
29	133.5-36.0	40.2	9.3	0.4	90.3	
30	136.0-38.5	24.6	5.7	1.0	93.3	2.71

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CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Well CORE HOLE NO. E
Field ASPHALT RIDGE
County UINTAH State UTAH Elev.
Formation
Core Type DIAMOND 2.125
Drilling Fluid WATER BASE MUD
Location SEC. 31-T5S-R22E
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Date Report 6-23-75
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SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Sample No.	Depth	Gal/Yd3	Weight Percent			Grain Density
			Oil	Water	Sand	
31	138.5-41.0	31.5	7.3	0.9	91.8	
32	141.0-43.5	30.7	7.1	0.8	92.1	
33	143.5-46.0	12.1	2.8	0.8	96.4	
34	146.0-48.5	9.9	2.3	0.7	97.0	
35	148.5-51.0	45.4	10.5	1.0	88.5	
36	151.0-53.5	44.5	10.3	0.8	88.9	
37	153.5-56.0	27.2	6.3	0.8	92.9	
38	156.0-58.5	41.5	9.6	1.1	89.3	2.71
39	158.5-61.0	28.1	6.5	1.0	92.5	
40	161.0-63.5	31.1	7.2	1.1	91.7	
41	163.5-66.0	2.6	0.6	0.3	99.1	
42	166.0-68.5	18.6	4.3	0.2	95.5	
43	168.5-71.0	11.2	2.6	1.1	96.3	
44	171.0-73.0	2.6	0.6	1.3	98.1	

STATE UTAH ELEV. 5092'

COUNTY UINTAH

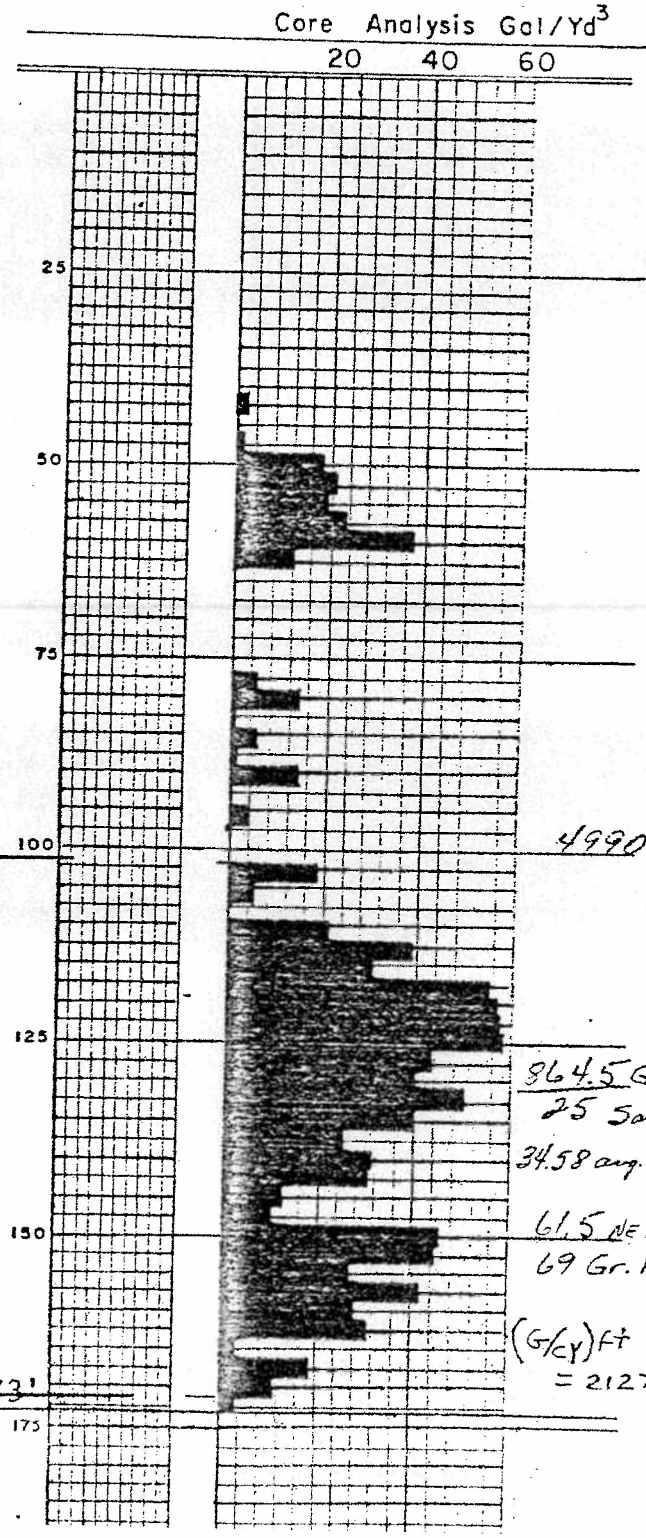
COMPANY ARIZONA FUELS CORPORATION

FARM BOAG-SOHIO WELL NO. CH "E"

LOCATION 1000' F.1/4 S.L., 940' F.W.L., Sec. 31, T-5-S, R-22-E, S.L.B.M.

TD. 173' TOOLS Longyear 44

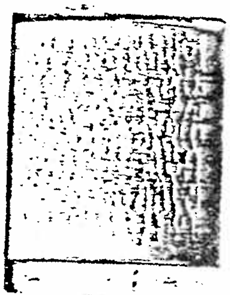
2-1/2" Wireline Core

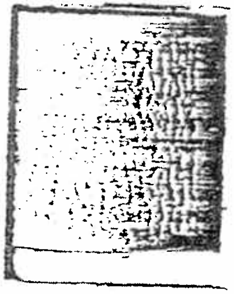


864.5 G/cy
25 Sampled =
34.58 avg. G/cy.

61.5 NET FT.
69 Gr. FT.

(G/cy) Ft
= 2127





STATE UTAH ELEV. 5092'
COUNTY UINTAH
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FARM BOAG-SOHIO WELL NO. CH "E"
LOCATION 1000' F.1/4 S.L., 940' F.W.L.,
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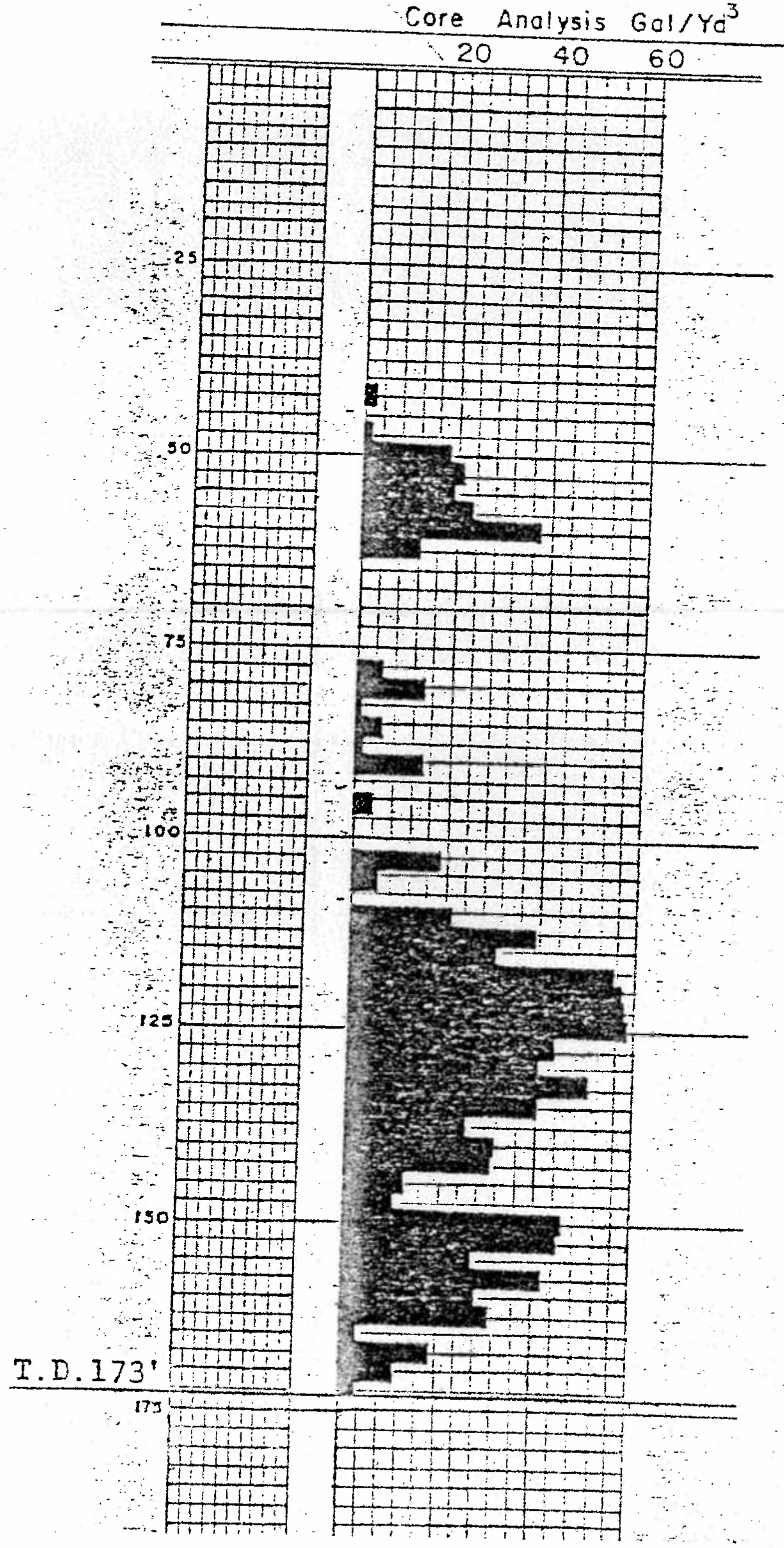
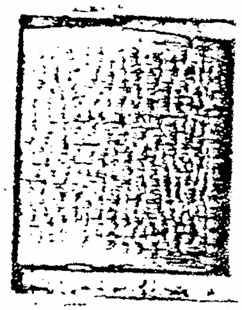
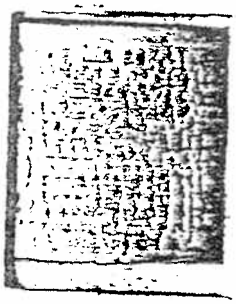
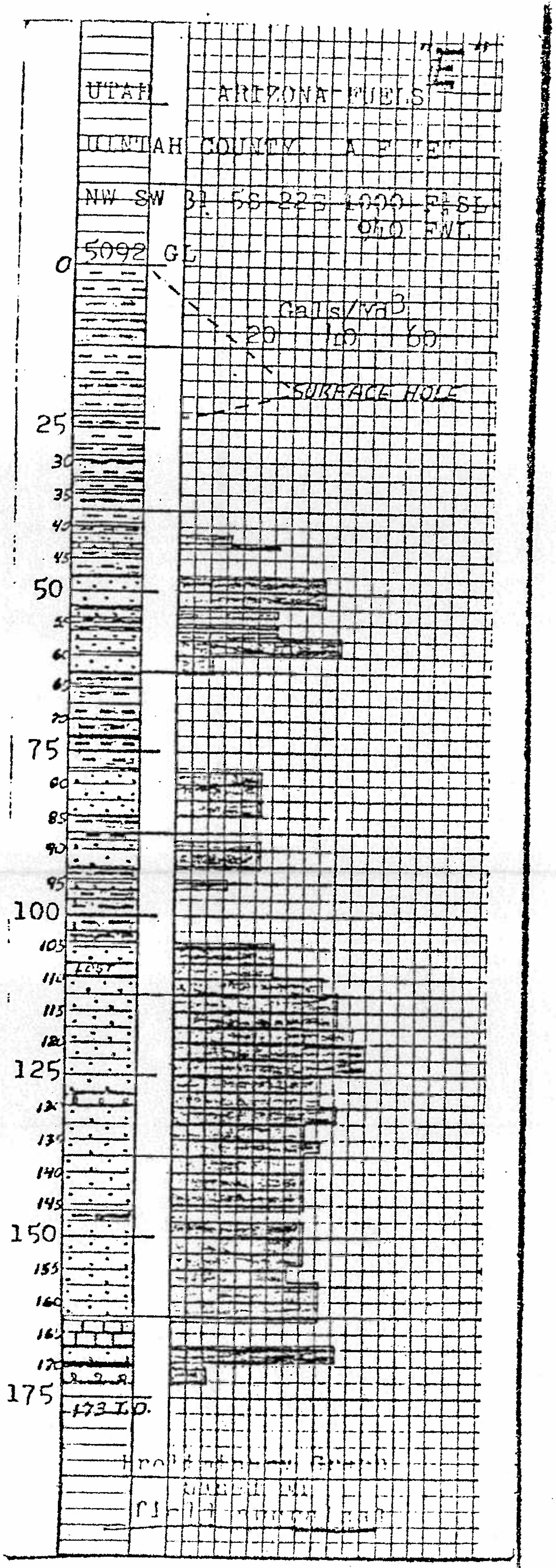
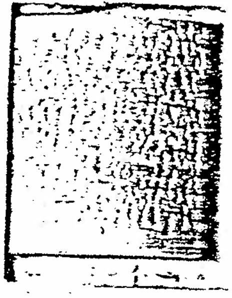
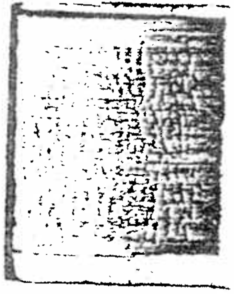







UTAH ARIZONA FUELS
UINTAH COUNTY A F 1E
NW SW 31 5S 22E 1000 FSL
910 FWL
5092 GL
Gals/Yd3
20 40 60
SURFACE HOLE
0
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
LOST
110
115
120
125
130
135
140
145
150
155
160
165
170
175
173 T.D.





5-7-75 Asphalt Ridge WELL FILE

Coring on "E" hole

PD 93 Feet — like "E" hole ore deep.

DRILLED & CSGd to 43'

Depth	Class o.s	Lithology
23- 29		shale gl. gry.
29- 33.2		sh rd. brn
33.2-34.2		sh gy.
34.2 -39.1		sh dk rd & rd brn cly
39.1- 41.6		sh gy grn
41.6 - 42.6	II OA	oil slt dk brsh tite
42.6-43.3	III	os
43.3 - 47.8		sh gy grn
47.8- 52.3	IV OA	os
52.3 - 53.1		sh gy grn & gy
53.1- 54.1	III	os
54.1 - 55.0		sh gy grn
55.0 - 55.7	III	os
55.7 - 56.0		sh gy grn
56.0- 56.8	III	os
56.8 - 59.1	IV +	os v/rich
59.1 - 60.0	IV +	os sltly cgl
60.0 - 62.9	II − OA	os I-III shly
62.9- 70		sh lt gy grn
70- 73		sh dull rd. & brn
73.0 - 78.3		sh med lt gy grn
76.3 - 84.7	III − OA	os
84.7 - 88.6		sh gy. grn
88.6 - 93.0	III	sh & os

intends to keep coring to find depth of good ore body 125'± will move to 'C' hole next. — Snow

Williams moving on site perm. in trailer — CREW working on ob removal 2-12 hour shifts

WELL FILE

5-8-75 Asphalt Ridge

moved to "C," core hole drlg to set 5ft pipe

"E" core hole TD 173

TOP of ore 105' to 169' 65' good rich ore

Depth	Feet	grade	Lithology
92.7 – 94.3	1.6		Shale gy, grn
94.3 – 96.1	1.8	II	os
96.1 – 104.3	8.2		sh gy grn
104.3 – 107.5	3.2	III	os fria.
st 107.5 – 109.5	2.0	AA	AA
109.5 – 111.5	2.0	IV	os
111.5 – 117.6	6.1	IV +	os
117.6 – 120.5	2.9	V −	os
120.5 – 125.0	4.5	V	os
125.0 – 128.1	3.1	IV	os
128.1 – 129.5	1.4	III	o cgl
129.5 – 132.1	2.6	IV +	os
132.1 – 135.1	3.0	IV −	os
135.1 – 136.5	1.4	IV	os
136.5 – 146.0	9.5	IV −	os & o cgl
146.0 – 147.4	1.4		sh gy grn
147.4 – 154.2	6.8	IV −	os
154.2 – 156.8	2.6	III +	os
156.8 – 158.5	1.7	IV	os
158.5 – 163.2	4.7	III +	os
163.2 – 167.0	3.8		ls lt gy
167.0 – 169.3	2.3	IV +	os
169.3 – 170.5	1.2		ls lt gy
170.5 – 173 TD	2.5	II	o cgl

105' TOP Vss + 4987 predrlg estm +5000'
overburden 105' predrlg estm. 85'

MISC – CAT RAN OUT OF FUEL

COMMENTS: DELIV. NOT ON TIME OVERALL SUPERV.

TAR SAND ANALYSIS

BURMAH OIL & GAS COMPANY
ARIZONA FUELS COMPANY

CORE HOLE NO. F

ASPHALT RIDGE FIELD

UINTAH COUNTY, UTAH

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4893
Well CORE HOLE NO. F
Core Type DIAMOND 2.125
Date Report 7-14-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
County UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

SAND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-S
SHALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
LIME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Sample No.	Depth	Weight Percent Oil	Weight Percent Water	Weight Percent Sand	Grain Density	Natural Density
1	14.0-16.5	1.7	1.8	96.5		
2	16.5-19.0	1.8	2.3	95.9	[illegible] unsampled intervals	
3	19.0-21.5	1.4	2.1	96.5		
4	21.5-24.0	0.3	4.2	95.5		
5	24.0-26.5	2.7	3.0	94.3		
6	26.5-29.0	1.5	2.4	96.1		
7	29.0-31.5	0.4	2.4	97.2		
8	31.5-34.0	0.1	2.7	97.2		
9	34.0-36.5	0.1	1.9	98.0		
10	36.5-39.0	1.2	2.3	96.5		
11	39.0-41.5	0.8	2.2	97.0		
12	41.5-44.0	6.7	1.6	91.7		
13	44.0-46.5	11.7	0.9	87.4		
14	46.5-49.0	0.4	2.5	97.1		
15	49.0-51.5	1.5	2.3	96.2		
16	51.5-54.0	2.3	1.7	96.0		
17	54.0-56.5	0.4	1.6	98.0		
18	56.5-59.0	6.1	2.5	91.4		
19	59.0-61.5	2.0	0.5	97.5		
20	61.5-64.0	0.9	2.0	97.1		
21	64.0-66.5	2.6	1.4	96.0		
22	66.5-69.0	5.2	2.7	92.1	2.65	1.97
23	69.0-71.5	1.1	3.1	95.8		
24	71.5-74.0	0.8	3.1	96.1	2.66	2.40
25	74.0-76.5	0.7	0.4	98.9		
26	76.5-79.0	0.7	3.4	95.9		
27	79.0-81.5	4.0	3.2	92.8		
28	81.5-84.0	0.0	2.2	97.8		
29	84.0-86.5	6.3	2.7	91.0	2.63	2.32
30	86.5-89.0	3.5	1.6	94.9		
31	89.0-91.5	4.6	2.4	93.0		
32	91.5-94.0	0.6	0.4	99.0		
33	94.0-96.5	0.4	1.9	97.7		
34	96.5-99.0	0.2	0.5	99.3	2.66	2.52

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

REPLY TO
BOX 47547
CABLE
CORELAB

RECEIVED
JAN 22 1976
E. W. EHRING

January 19, 1976

Burmah Oil & Gas
P. O. Box 94143
Houston, Texas 77018

Attention: Mr. Ted Ehring

Subject: Tar Sand Analysis

Dear Mr. Ehring,

Attached is a report covering 9 samples which were re-sampled from Core Hole "F". These results were obtained in same manner as the other core holes and this procedure is briefly outlined below:

> Representative samples were selected from 2½ foot intervals. These samples were crushed and placed in a Dean Stark apparatus where oil and water both were removed. The volume of water was measured directly as it was distilled from the sample while oil volumes were calculated by difference in weight before and after extraction. Saturations of oil and water by weight percent were reported. Sand content by weight percent was also determined.

We appreciate this opportunity to be of service.

Very truly yours,

Roy G. Gallop
Roy G. Gallop

cc: Mr. Gene Dalton
Mr. Parley R. Peterson

UNITED STATES CANADA SOUTH AMERICA EUROPE AFRICA AUSTRALIA ASIA

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY
ARIZONA FUELS COMPANY
Formation
File RP-2-4893
Well CORE HOLE NO. "F"
Core Type DIAMOND 2.125
Date Report 12-2-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts RG
County UINTAH
State UTAH
Elev.
Location SEC. 31-T5S-R22E

Lithological Abbreviations

SAND-SD
SHALE-SH
[illegible]
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-
VERY-V/
WITH-W/

MPLE UMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

			Weight Percent				
Sample No.	Depth		Oil x 432	Water	Sand	Grain Density	Natural Densit
1	14.0-16.5	20.7	4.8	1.2	94.1	2.64	2.03
2	16.5-19.0	29.8	6.9	0.6	92.6	2.60	2.02
3	19.0-21.5	34.1	7.9	1.0	91.1	2.60	2.00
4	21.5-24.0	38.0	8.8	1.7	89.6	2.64	2.08
5	24.0-26.5	30.2	7.0	0.9	92.1	2.62	2.16
11	39.0-41.5	42.3	9.8	0.8	89.4	2.63	2.07
12	41.5-44.0	43.6	10.1	0.7	89.2	2.63	2.07
13	44.0-46.5	51.8	12.0	0.6	87.4	2.59	2.06
18	56.5-59.0	13.0	3.0	0.6	96.4	2.60	2.18

Analysis of Resampled Intervals

CL-811-1

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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JUL 31 [illegible]
E. W. [illegible]

Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4893
Well CORE HOLE NO. F
Core Type DIAMOND 2.125
Date Report 7-14-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
County UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

SAND-SD
SHALE-SH
LIME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

MPLE MBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

done [illegible]

Sample No.	Depth	Gal/Yd³	Weight Percent Oil	Weight Percent Water	Weight Percent Sand	Grain Density	Natural Density
1	14.0-16.5	7.3	1.7	1.8	96.5		
2	16.5-19.0	7.8	1.8	2.3	95.9		
3	19.0-21.5	6.0	1.4	2.1	96.5		
4	21.5-24.0	1.3	0.3	4.2	95.5		
5	24.0-26.5	11.7	2.7	3.0	94.3		
6	26.5-29.0	6.5	1.5	2.4	96.1		
7	X 29.0-31.5	1.7	0.4	2.4	97.2		
8	X 31.5-34.0	.4	0.1	2.7	97.2		
9	X 34.0=36.5	.4	0.1	1.9	98.0		
10	36.5-39.0	5.2	1.2	2.3	96.5		
11	X 39.0-41.5	3.5	0.8	2.2	97.0		
12	41.5-44.0	28.9	6.7	1.6	91.7		
13	44.0=46.5	50.5	11.7	0.9	87.4		
14	X 46.5-49.0	1.7	0.4	2.5	97.1		
15	49.0=51.5	6.5	1.5	2.3	96.2		
16	51.5-54.0	9.9	2.3	1.7	96.0		
17	X 54.0-56.5	1.7	0.4	1.6	98.0		
18	56.5=59.0	26.4	6.1	2.5	91.4		
19	59.0-61.5	8.6	2.0	0.5	97.5		
20	X 61.5-64.0	3.9	0.9	2.0	97.1		
21	64.0-66.5	11.2	2.6	1.4	96.0		
22	66.5-69.0	22.5	5.2	2.7	92.1	2.65	1.97
23	X 69.0-71.5	4.8	1.1	3.1	95.8		
24	X 71.5=74.0	3.5	0.8	3.1	96.1	2.66	2.40
25	X 74.0-76.5	3.0	0.7	0.4	98.9		
26	X 76.5=79.0	3.0	0.7	3.4	95.9		
27	79.0-81.5	17.3	4.0	3.2	92.8		
28	X 81.5-84.0	0	0.0	2.2	97.8		
29	84.0-86.5	27.2	6.3	2.7	91.0	2.63	2.32
30	86.5=89.0	15.1	3.5	1.6	94.9		
31	89.0-91.5	19.9	4.6	2.4	93.0		
32	91.5-94.0	2.6	0.6	0.4	99.0		
33	94.0=96.5	1.7	0.4	1.9	97.7		
34	96.5-99.0	.9	0.2	0.5	99.3	2.66	2.52

Revised per Core
Analysis Report
dated 12-2-75

STATE UTAH ELEV. 5082'

COUNTY UINTAH

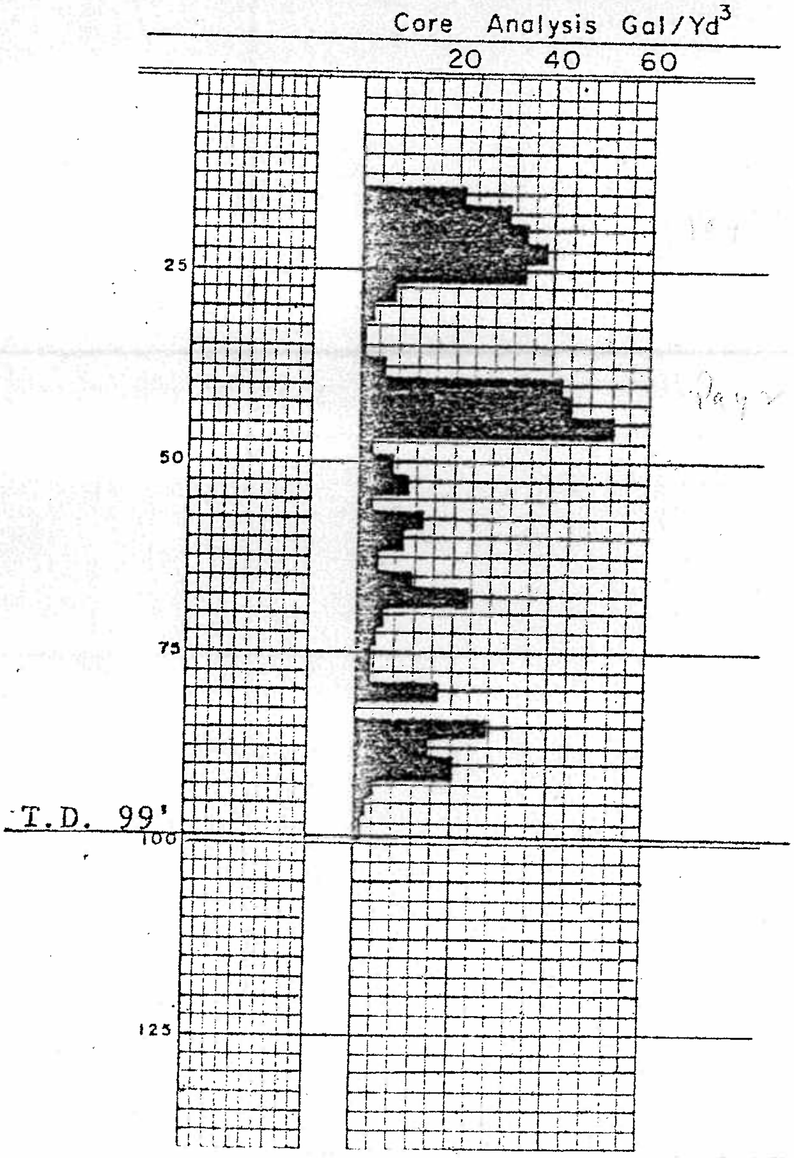
COMPANY ARIZONA FUELS CORPORATION

FARM BOAG-SOHIO WELL NO. CH "F"

LOCATION 525' F.1/4 S.L., 830' F.W.L.,
Sec. 31, T-5-S, R-22-E, S.L.B.M.

TD. 99' TOOLS Longyear 44

2-1/2" Wireline Core



4-23-75

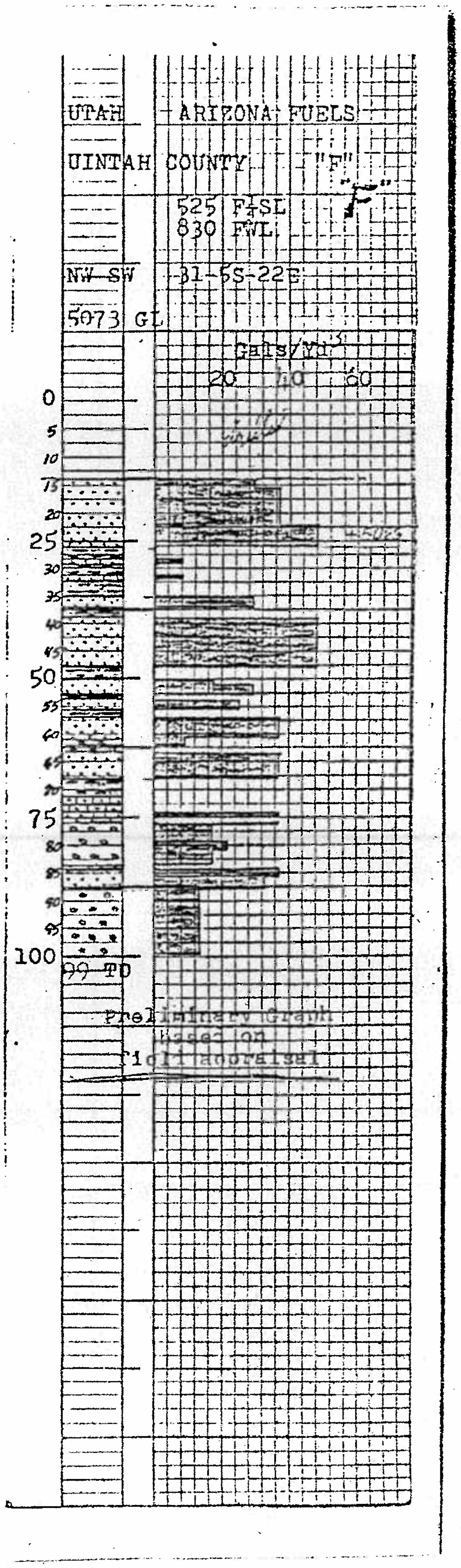
CORE HOLE "F" – Evaluation VISUAL by [illegible]

525' S & 830 E FWL Elev 5073'

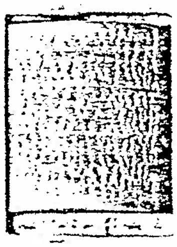
14' SFC PIPE

	DEPTH	FT BARREN	TARSO	CLASS	LITHOLOGY
	14-15½		1.5	III	
7' good	15½-22.3		6.8	IV	
	22.3-26.0		3.7	V	
5 WASTE	26.0-35.5	9.5			green shale
	35.5-37		1.5	III	
	37. – 38.7	1.7			
	38.7-48		9.3	V	slightly cgl.
	48-50.3	2.3			green shale
	50.3-51.2		.9	II +	
	51.2-52.8		1.6	III +	
	52.8-53.5	.7			green shale
	53.5-55.3		1.8	III	
	55.3-56.6	1.3			green shale
	56.6-61.0		4.4	IV	sltly cgl.
	61.0-61.8		.8	II	oil cgl.
	61.8-63.3	1.5			grn. shale
	63.3-67.7		4.4	IV	
	67.7-71.2	3.5			gray grn shale
	71.2-74.0	1.8			limestone sandy
	74.0-74.7		.7	IV	
	74.7-76.2	1.5			ls, sdy, lite
	76.2-76.6		.4	V	
	76.6-79.2		2.6	I +	cgl
	79.2-80.8		1.6	III –	cgl
	80.8-83.2		2.4	II +	
	83.2-84.0	.8 –			gy ls, sdy lite
	84.0-85.27		1.7	IV	
	85.7-87.8		2.1	IV –	
	87.8-94.0		6.2	II	cgl.
			Σ 52.3		

87.8 - 99.0 TD II Cgl



Preliminary Graph
Based on
Field appraisal



4F "F"
5070

	DEPTH	BARREN	I	II	III	IV	V		
	14.0-15.5				$\overset{+}{1.5}$				
	15.5-22.3					6.8			
	22.3-26.0						3.7		
		SH, 94-9mm 9.5							
	35.5-37.0				$\overset{+}{1.5}$				
		" 1.7							
	38.7-48.0						9.3		
		" 2.3							
	50.3-51.2			$\overset{+}{.9}$					
	51.2-52.8				$\overset{+}{1.6}$				
		" .7							
	53.5-55.3				1.8				
		" 1.3							
	56.6-61.0					4.4			
OC	61.0-61.8			$\overset{-}{.8}$					
		SH, 94-9mm 1.5							
	63.3-67.7					4.4			
		SH + LS 6.3							
	74.0-74.7					.7			
		LS 1.5							
	76.2-76.6					.4			
OC	76.6-79.2			$\overset{+}{2.6}$					
"	79.2-80.8				$\overset{-}{1.6}$				
"	80.8-83.2			$\overset{+}{2.4}$					
		LS .8							
OS	84.0-85.7					1.7			
"	85.7-87.8					$\overset{-}{2.1}$			
OC	87.8-99.0	T.D.		11.2					
									17.9 8.0 20.5 13.0 59.4
		25.6		17.9	8.0	20.5	13.0		59.4 25.6 85.0

TAR SAND ANALYSIS
FOR

BURMAH OIL & GAS COMPANY
ARIZONA FUELS COMPANY

CORE HOLE NO. "H"

ASPHALT RIDGE FIELD

UINTAH COUNTY, UTAH

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4853
Well CORE HOLE NO. "H"
Core Type DIAMOND 2.125
Date Report 5-16-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WJ
County UINTAH State UTAH Elev. Location NW SW SEC. 31-T5S-R22E

Lithological Abbreviations

AND-SD
HALE-SH
IME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

		Weight Percent				
Sample No.	Depth	Oil	Water	Sand	Natural Density	Grain Density
1	10.0-12.5	8.5	1.0	90.5		
2	12.5-15.0	4.3	0.8	94.9		
3	15.0-17.5	8.4	0.7	90.9	2.17	2.59
4	17.5-20.0	4.2	2.2	93.6		
5	20.0-22.5	0.6	1.6	97.8		
6	22.5-25.0	7.5	1.5	91.0		
7	25.0-27.5	7.0 0.9	1.6	97.5 32.8		
8	27.5-30.0	6.8 1.2	2.3	96.5 34		
9	30.0-32.5	2.0	1.3	96.7		
10	32.5-35.0	7.2	1.8	91.0		
11	35.0-37.5	1.8	1.4	96.8	2.23	2.57
12	37.5-40.0	0.5	0.4	99.1		
13	40.0-42.5	7.5	1.7	90.8		
14	42.5-45.0	1.4	0.4	98.2		
15	45.0-47.5	1.3	0.9	97.8	2.54	2.57
16	47.5-50.0	0.4	0.4	99.2		
17	50.0-52.5	0.5	0.2	99.3		
18	52.5-55.0	0.5	0.2	99.3		
19	55.0-57.5	0.2	1.2	98.6	2.38	2.57
20	57.5-60.0	1.5	0.9	97.6		
21	60.0-62.5	0.2	0.2	99.6		
22	62.5-65.0	0.3	0.2	99.5		
23	65.0-67.5	3.4	1.0	95.6	2.63	2.71
24	67.5-70.0	1.5	1.0	97.5		

CL-611-1

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Petroleum Reservoir Engineering
DALLAS, TEXAS

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L. W. EHRING

Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Well CORE HOLE NO. "H"
Field ASPHALT RIDGE
County UINTAH State UTAH Elev.
Formation
Core Type DIAMOND 2.125
Drilling Fluid WATER BASE MUD
Location NW SW SEC. 31-T5S-R22E
File RP-2-4853
Date Report 5-16-75
Analysts WW

Lithological Abbreviations

SAND-SD
SHALE-SH
LIME-LM
DOLOMITE-DOL
CHERT-CH
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VUGGY-VGY
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LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

43?

Sample No.	Depth	Gal/Yd³	Weight Percent Oil	Weight Percent Water	Weight Percent Sand	Natural Density	Grain Density
1	10.0-12.5	36.72	8.5	1.0	90.5		
2	12.5-15.0	18.58	4.3	0.8	94.9		
3	15.0-17.5	36.29	8.4	0.7	90.9	2.17	2.59
4	17.5-20.0	18.14	4.2	2.2	93.6		
5	X 20.0-22.5	2.59	0.6	1.6	97.8		
6	22.5-25.0	32.40	7.5	1.5	91.0		
# 7	25.0-27.5	32.80	~~0.9~~ 7.6	~~1.6~~ 0.9	~~97.5~~ 91.5	1.99	2.59
# 8	27.5-30.0	38.0	~~1.2~~ 8.8	~~2.3~~ 0.5	~~96.5~~ 90.7	2.00	2.60
9	30.0-32.5	8.64	2.0	1.3	96.7		
10	32.5-35.0	31.10	7.2	1.8	91.0		
11	35.0-37.5	7.78	1.8	1.4	96.8	2.23	2.57
12	X 37.5-40.0	2.16	0.5	0.4	99.1		
13	40.0-42.5	32.40	7.5	1.7	90.8		
14	42.5-45.0	6.05	1.4	0.4	98.2		
15	45.0-47.5	5.62	1.3	0.9	97.8	2.54	2.57
16	47.5-50.0	1.73	0.4	0.4	99.2		
17	50.0-52.5	2.16	0.5	0.2	99.3		
18	52.5-55.0	2.16	0.5	0.2	99.3		
19	55.0-57.5	.86	0.2	1.2	98.6	2.38	2.57
20	57.5-60.0	6.48	1.5	0.9	97.6		
21	60.0-62.5	.86	0.2	0.2	99.6		
22	62.5-65.0	1.30	0.3	0.2	99.5		
23	65.0-67.5	14.69	3.4	1.0	95.6	2.63	2.[illegible]
24	67.5-70.0	6.48	1.5	1.0	97.5		

~~5575'~~
5092'
100'

F 1/4 SL 70'
FWL 545'

+ See corrected copy

CL-811-1

[illegible]

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ~~ARIZONA FUELS COMPANY~~
Formation
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GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-S
VERY-V/
WITH-W/

AMPLE UMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

Sample No.	Depth		Weight Percent			Natural Density	Grain Density
			Oil	Water	Sand		
7	25.0-27.5	32.8	7.6	0.9	91.5	1.99	2.59
8	27.5-30.0	38.0	8.8	0.5	90.7	2.00	2.60

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SEP 15 1975
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STATE UTAH ELEV. 5092'

COUNTY UINTAH

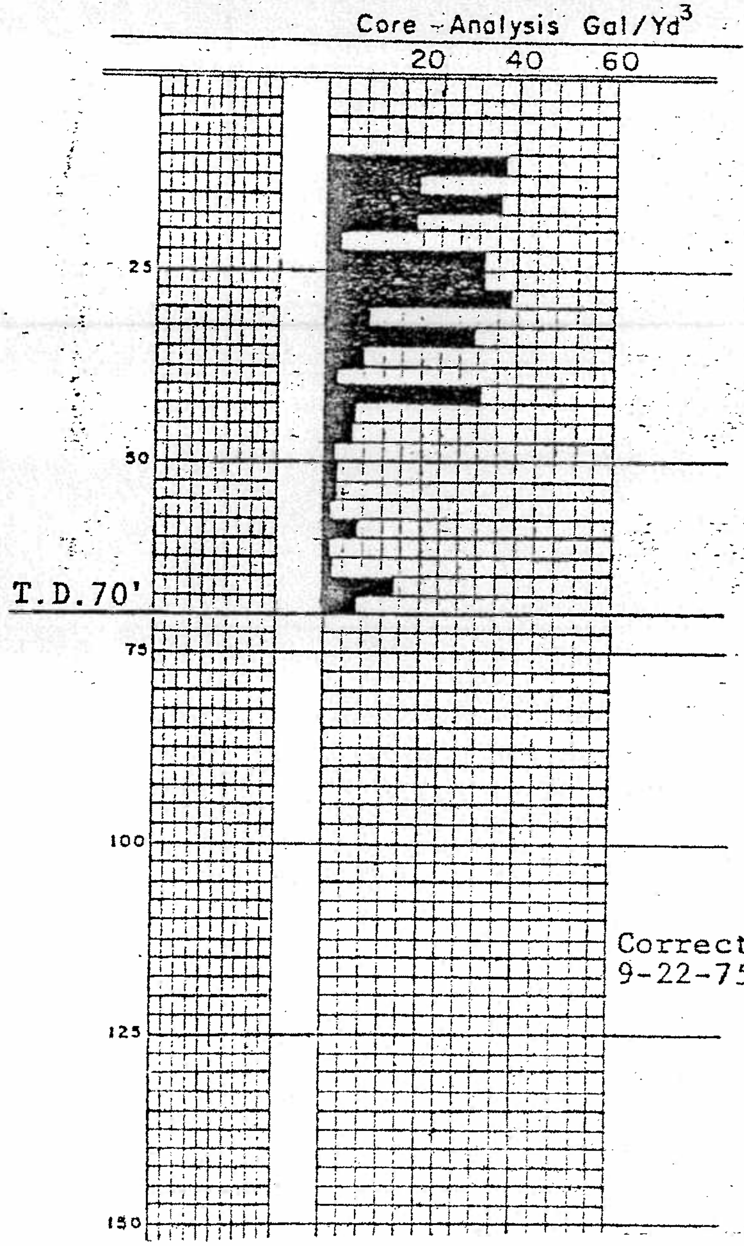
COMPANY ARIZONA FUELS CORPORATION

FARM BOAG-SOHIO WELL NO. CH-"H"

LOCATION 70' F.1/4 S.L., 545' F.W.L., Sec. 31, T-5-S, R-22-E, S.L.B.& M.

TD. 100' TOOLS Longyear 44

2-1/2" Wireline Core



Corrected
9-22-75

STATE UTAH ELEV. 5092'

COUNTY UINTAH

COMPANY ARIZONA FUELS CORPORATION

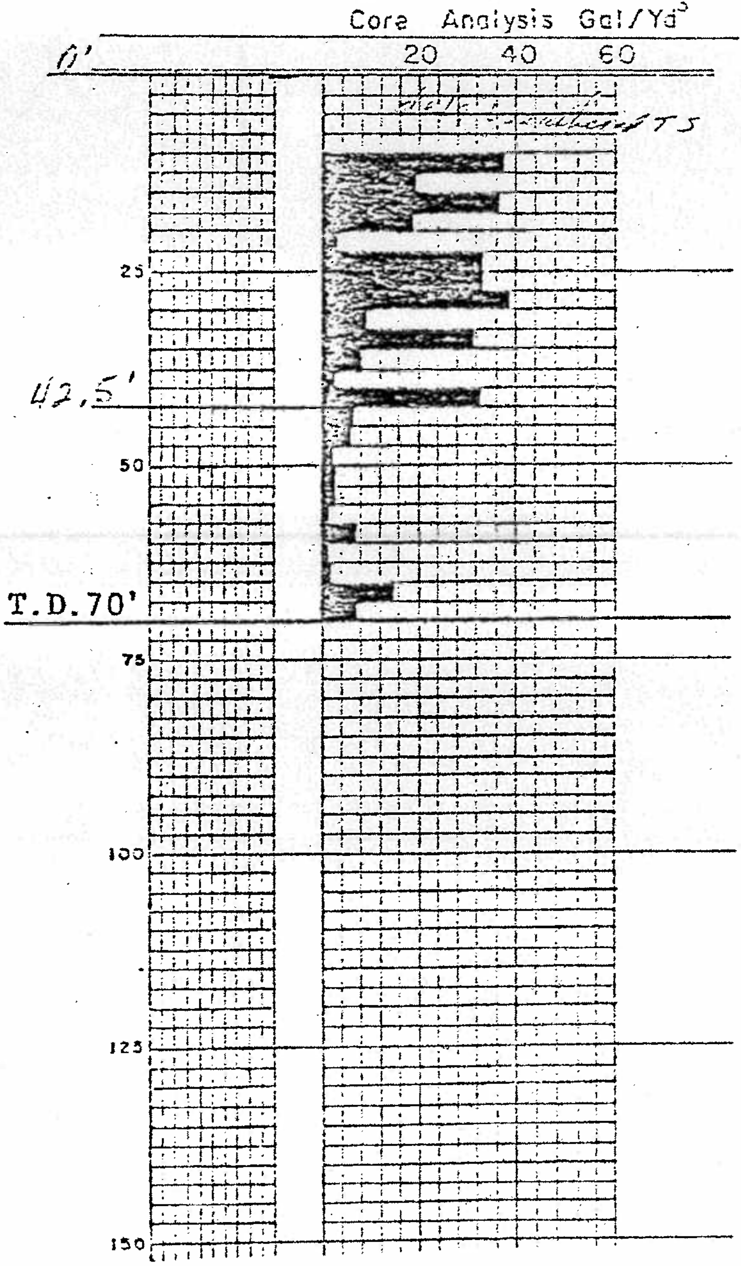
FARM BOAG-SOHIO WELL NO. CH-"H"

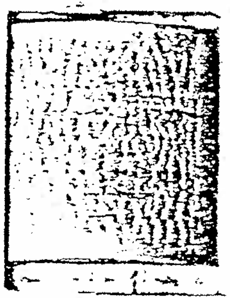
LOCATION 70' F.1/4 S.L., 545' F.W.L.,

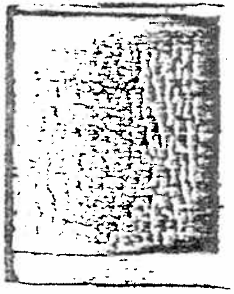
Sec. 31, T-5-S, R-22-E, S.L.B.& M.

TD. 100' TOOLS Longyear 44

2-1/2" Wireline Core







Corrected Copy

Core hole H

70 FS ⊄ —— FE WL 5075 ELEV ?

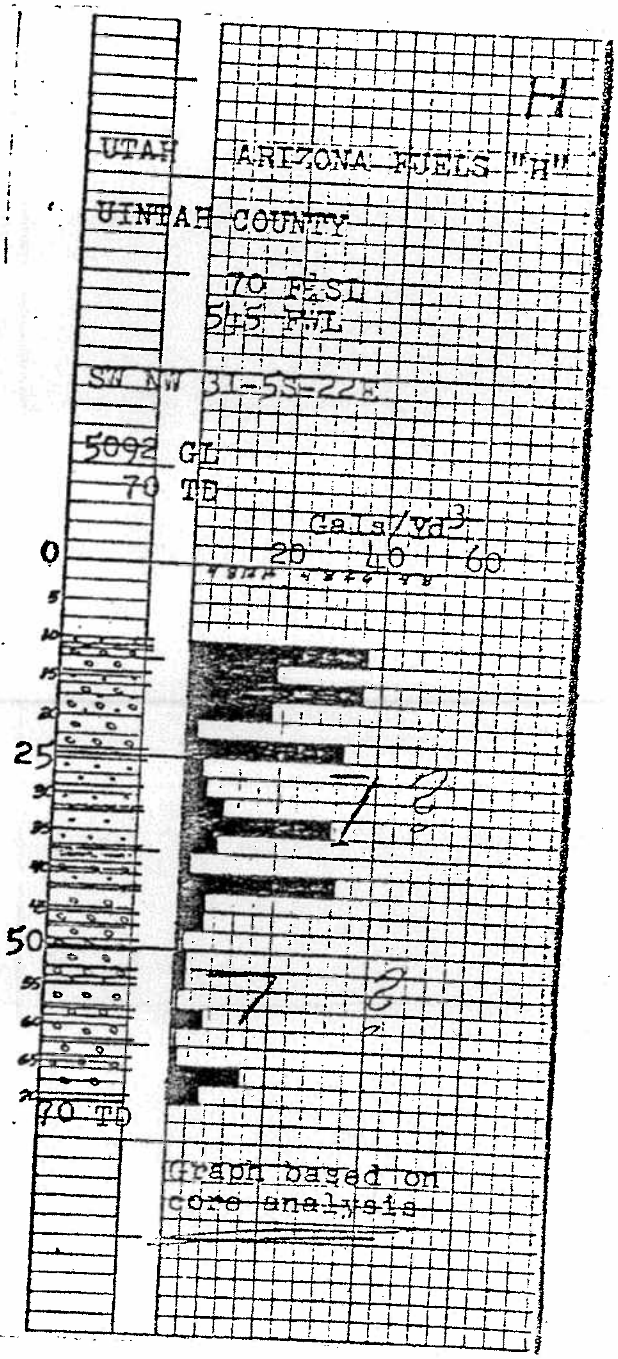
drld rubble w/ some oil sd to 10'
started coring at 10'

Logged by Peterson

DEPTH	FT	GRADE	LITH
10-10.8		II	os
10.8-11.5			Ccgl some os
11.5-14.2		IV -	ocgl.
14.2-16.2		III +	os
16.2-20.2	4.0	III OA	ocgl & os
20.0-24.0	4.0	II	ocgl
24-25.8	1.8	V	os
258-28.8	3.0	III	os
28.8-31.7		IV	os
31.7-32.3		Barren	Ls
32.3-36.9	4.6	IV	os base of good os.
36.9-38.9	2.0	Barren	gry shale
38.9-40.5		II	ocgl II-
40.5-42.0		IV+	os + cly.
42.0-42.6		III	ocgl
42.6-45.5		Barren	Ccgl
45.5-47.		I	ocgl.

To 63

To 70.


H
UTAH ARIZONA FUELS "H"
UINTAH COUNTY
70 FSL
545 FWL
SW NW 31-5S-22E
5092 GL
70 TD
Gals/yd3
20
40
60
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
70 TD
7 8
7 8
Graph based on core analysis

"H"

WELL	CORE #	DEPTH	BARREN	I	II	III	IV	V	GAL/YD^3	
5075	1	10.0-10.8	os				.8			
	"		CGL .7							
		11.5-14.2	oc				$\overset{-}{2.7}$			
		14.2-16.2	os			$\overset{+}{2.0}$				
		16.2-20.0	oc			$\overset{-}{3.8}$				
		20.0-24.0	oc		4.0					
		24.0-25.8	os					1.8		
		25.8-28.8	os			3.0				
		28.8-31.7	os				29			
			LS .6							
+5038	—	32.3-34.9	os				4.6			
			SH 2.0							
		38.9-40.5	oc		1.4					
		40.5-42.0	os				$\overset{+}{1.5}$			
+5033		42.0-42.4	oc			.6				
			CGL 2.9							
		45.5-47.0	oc	$\overset{+}{1.5}$						
		47.0-50.2	oc		$\overset{+}{3.2}$					
			CGL 3.5							
		53.7-54.7	os				1.0			
		54.7-58.0	oc		$\overset{-}{3.3}$					
		58.0-59.0	oc		$\overset{+}{1.0}$					
			CGL 3.0							
		62.0-64.0	oc	$\overset{+}{2.0}$						
		64.0-66.0	oc		$\overset{-}{2.0}$					12.4
		66.0-69.0	oc			3.0				13.5 1.8
		69.0-70.0	oc	$\overset{+}{1.0}$						27.7
		T.O.	12.7	4.5	15.1	12.4	13.5	1.8		4.5 15.1 19.6

TAR SAND ANALYSIS
FOR

BURMAH OIL AND GAS COMPANY
ARIZONA FUELS COMPANY

CORE HOLE NO. 1

ASPHALT RIDGE FIELD

UINTAH COUNTY, UTAH

RECEIVED

JUN 23 1975

E. W. EHRING

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 1

CORE ANALYSIS RESULTS

ompany BURMAH OIL & GAS COMPANY
ARIZONA FUELS COMPANY
Formation
File RP-2-4356
Vell CORE HOLE NO. I
Core Type DIAMOND 2.125
Date Report 6-1-75
ield ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts UN
ounty UINTAH
State UTAH
Elev.
Location SEC. 31-T5S-R22E

Lithological Abbreviations

AND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL
HALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
IME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

PLE BER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

mple No.	Depth	Weight Percent			Grain Density	Natural Density
		Oil	Water	Sand		
1	24.0-26.5	3.2	0.8	96.0		
2	26.5-29.0	2.8	1.5	95.7		
3	29.0-31.5	0.1	1.1	98.8		
4	31.5-33.0	0.2	0.7	99.1		
5	33.0-35.5	0.7	0.6	98.7		
6	35.5-38.0	6.5	1.0	92.5		
7	38.0-40.5	3.3	0.8	95.9		
8	40.5-43.0	0.0	0.7	99.3		
9	43.0-45.5	4.7	2.6	92.7		
10	45.5-48.0	8.2	0.9	90.9		
11	48.0-50.5	8.5	0.9	90.6	2.55	2.01
12	50.5-53.0	5.8	0.7	93.5		
13	53.0-55.5	3.8	1.4	94.8		
14	55.5-58.0	8.5	1.3	90.2		
15	58.0-60.5	2.8	1.2	96.0		
16	60.5-63.0	8.2	0.3	91.5		
17	63.0-65.5	7.6	0.4	92.0		
18	65.5-68.0	6.2	2.0	91.8		
19	68.0-69.0	8.5	0.8	90.7		
20	69.0-70.5	7.0	1.2	91.8		
21	70.5-73.0	9.2	1.1	89.7		
22	73.0-75.5	0.6	0.8	98.6	2.60	2.24
23	75.5-78.0	7.7	0.4	91.9		
24	78.0-80.5	10.1	0.4	89.5		
25	80.5-83.0	8.9	0.9	90.2		
26	83.0-85.5	2.4	1.3	96.3		
27	85.5-88.0	9.4	0.9	89.7		
28	88.0-90.5	11.2	0.6	88.2		
29	90.5-93.0	5.3	2.6	92.1		
30	93.0-95.5	5.3	0.6	94.1		

CL-511-1

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company	BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY	Formation		File	RP-2-4356
Well	CORE HOLE NO, I	Core Type	DIAMOND 2.125	Date Report	6-1-75
Field	ASPHALT RIDGE	Drilling Fluid	WATER BASE MUD	Analysts	WH
County	UINTAH State UTAH Elev.	Location	SEC. 31-T5S-R22E		

Lithological Abbreviations

SAND-SD
SHALE-SH
LIME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
ANHYDRITE-ANHY
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-S
VERY-V/
WITH-W/

MPLE MBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

ample No.	Depth	Weight Percent Oil	Water	Sand	Grain Density	Natural Density
31	95.5-98.0	7.9	0.7	91.4		
32	98.0-00.5	3.3	0.8	95.9		
33	100.5-03.0	8.9	0.9	90.2	2.57	2.05
34	103.0-05.5	5.4	0.9	93.7		
35	105.5-08.0	3.2	0.8	96.0		
36	108.0-10.5	0.0	1.4	98.6		
37	110.5-13.0	0.6	1.5	97.9		
38	113.0-15.5	9.8	0.7	89.5		
39	115.5-18.0	0.3	0.2	99.5		
40	120.5-23.0	0.2	0.3	99.5		
41	123.0-25.5	0.8	0.2	99.0		
42	125.5-28.0	0.1	1.8	98.1		
43	128.0-30.0	0.3	1.8	97.9		
44	130.0-32.0	9.1	0.4	90.5	3.18	2.93 (Pyritic
45	132.0-134.0	0.3	0.1	99.6		

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

RECEIVED
JUN 16 1975
E. W. EHRING

Page No. 1

CORE ANALYSIS RESULTS

Company [illegible] OIL & GAS COMPANY
ARIZONA FUELS COMPANY
Formation ______
File RP-2-4856

Well CORE HOLE NO. I
Core Type DIAMOND 2.125
Date Report 6-1-75

Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW

County UINTAH
State UTAH
Elev. ______
Location SEC. 31-T5S-R22E

Lithological Abbreviations

SAND - SD	DOLOMITE - DOL	ANHYDRITE - ANHY	SANDY - SDY	FINE - FN	CRYSTALLINE - XLN	BROWN - BRN	FRACTURED - FRAC	SLIGHTLY - SL
SHALE - SH	CHERT - CH	CONGLOMERATE - CONG	SHALY - SHY	MEDIUM - MED	GRAIN - GRN	GRAY - GY	LAMINATION - LAM	VERY - V/
LIME - LM	GYPSUM - GYP	FOSSILIFEROUS - FOSS	LIMY - LMY	COARSE - CSE	GRANULAR - GRNL	VUGGY - VGY	STYLOLITIC - STY	WITH - W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS

			Weight Percent				
Sample No.	Depth	Gal/Yd.³	Oil	Water	Sand	Grain Density	Natural Density
1	24.0-26.5	13.8	3.2	0.8	96.0		
2	26.5-29.0	12.1	2.8	1.5	95.7		
3	29.0-31.5	.4	0.1	1.1	98.8		
4	31.5-33.0	[illegible]	0.2	0.7	99.1		
5	33.0-35.5	3.2	0.7	0.6	98.7		
6	35.5-38.0	[illegible]	6.5	1.0	92.5		
7	38.0-40.5	14.8	3.3	0.8	95.9		
8	40.5-43.0	0	0.0	0.7	99.3		
9	43.0-45.5	20.3	4.7	2.6	92.7		
10	45.5-48.0	35.4	8.2	0.9	90.9		
11	48.0-50.5	36.7	8.5	0.9	90.6	2.55	2.01
12	50.5-53.0	25.1	5.8	0.7	93.5		
13	53.0-55.5	16.4	3.8	1.4	94.8		
14	55.5-58.0	[illegible]	8.5	1.3	90.2		
15	58.0-60.5	12.1	2.8	1.2	96.0		
16	60.5-63.0	35.4	8.2	0.3	91.5		
17	63.0-65.5	32.9	7.6	0.4	92.0		
18	65.5-68.0	26.8	6.2	2.0	91.8		
19	(68.0-69.0	[illegible]	8.5) 33.45	0.8	90.7		
20	(69.0-70.5	[illegible]	7.0)	1.2	91.8		
21	70.5-73.0	[illegible]	9.2	1.1	89.7		
22	73.0-75.5	[illegible]	0.6	0.8	98.6	2.60	2.24
23	75.5-78.0	[illegible]	7.7	0.4	91.9		
24	78.0-80.5	43.6	10.1	0.4	89.5		
25	80.5-83.0	[illegible]	8.9	0.9	90.2		
26	83.0-85.5	10.4	2.4	1.3	96.3		
27	85.5-88.0	40.6	9.4	0.9	89.7		
28	88.0-90.5	[illegible]	11.2	0.6	88.2		
29	90.5-93.0	[illegible]	5.3	2.6	92.1		
30	93.0-95.5	[illegible]	5.3	0.6	94.1		

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 2

CORE ANALYSIS RESULTS

Company BURMAH OIL & GAS COMPANY ARIZONA FUELS COMPANY
Formation
File RP-2-4856
Well CORE HOLE NO. I
Core Type DIAMOND 2.125
Date Report 6-1-75
Field ASPHALT RIDGE
Drilling Fluid WATER BASE MUD
Analysts WW
County UINTAH State UTAH Elev. Location SEC. 31-T5S-R22E

Lithological Abbreviations

SAND-SD
SHALE-SH
LIME-LM
DOLOMITE-DOL
CHERT-CH
GYPSUM-GYP
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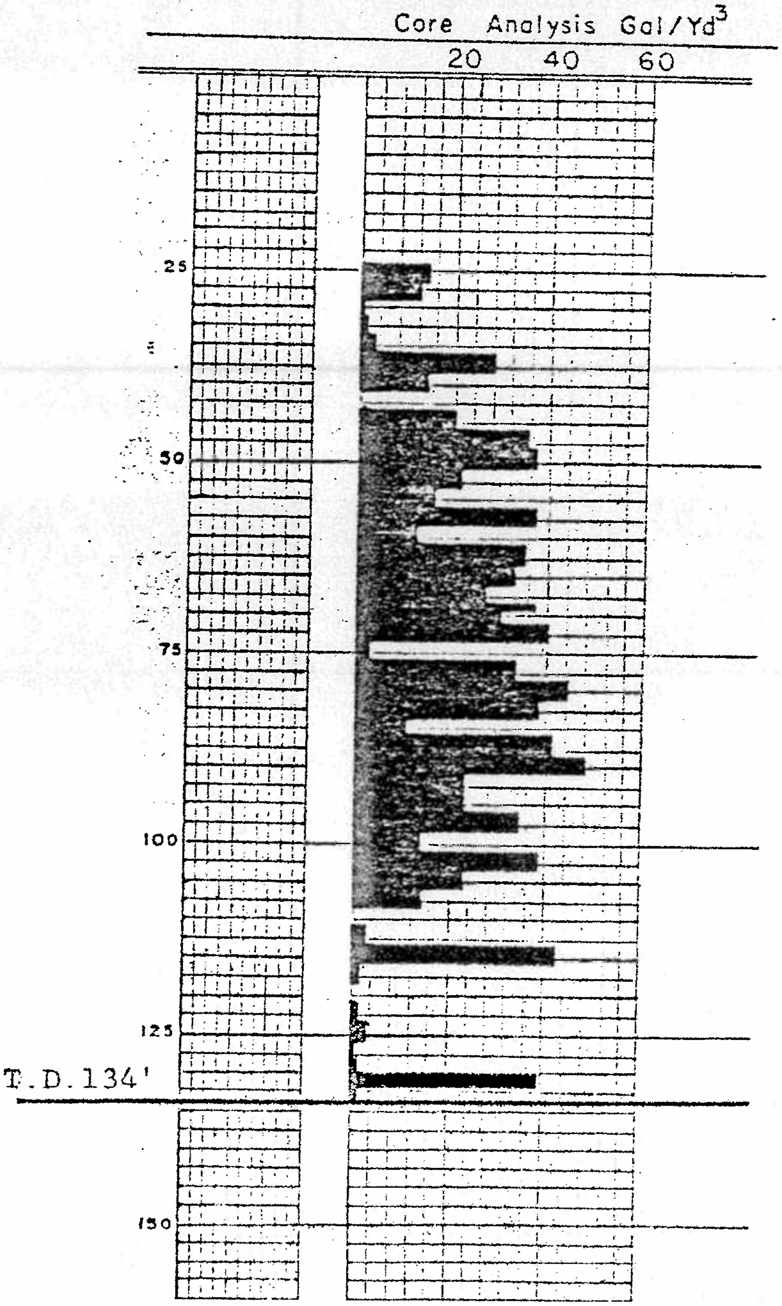
CONGLOMERATE-CONG
FOSSILIFEROUS-FOSS
SANDY-SDY
SHALY-SHY
LIMY-LMY
FINE-FN
MEDIUM-MED
COARSE-CSE
CRYSTALLINE-XLN
GRAIN-GRN
GRANULAR-GRNL
BROWN-BRN
GRAY-GY
VUGGY-VGY
FRACTURED-FRAC
LAMINATION-LAM
STYLOLITIC-STY
SLIGHTLY-SL
VERY-V/
WITH-W/

MPLE MBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER	

ample No.	Depth		Weight Percent Oil	Water	Sand	Grain Density	Natural Density
31	95.5-98.0	34.1	7.9	0.7	91.4		
32	98.0-00.5	14.3	3.3	0.8	95.9		
33	100.5-03.0	38.4	8.9	0.9	90.2	2.57	2.05
34	103.0-05.5	23.5	5.4	0.9	93.7		
35	105.5-08.0	13.5	3.2	0.8	96.0		
36	108.0-10.5	0	0.0	1.4	98.6		
37	110.5-13.0	2.6	0.6	1.5	97.9		
38	113.0-15.5	42.5	9.8	0.7	89.5		
39	115.5-18.0	1.3	0.3	0.2	99.5		
40	120.5-23.0	.9	0.2	0.3	99.5		
41	123.0-25.5	2.5	0.8	0.2	99.0		
42	125.5-28.0	.4	0.1	1.8	98.1		
43	128.0-30.0	1.3	0.3	1.8	97.9		
44	130.0-32.0	39.5	9.1	0.4	90.5	3.18	2.93 (Pyritic)
45	132.0-134.0	1.3	0.3	0.1	99.6		

STATE UTAH ELEV. 5139'
COUNTY UINTAH
COMPANY ARIZONA FUELS CORPORATION
FARM BOAG-SOHIO WELL NO. CH "I"
LOCATION 15' F.1/4 S.L., 81' F.W.L.,
Sec. 31, T-5-S, R-22-E, S.L.B.& M.
TD. 134' TOOLS Longyear 44
2-1/2" Wireline Core



STATE UTAH ELEV. 5139'

COUNTY UINTAH

COMPANY ARIZONA FUELS CORPORATION

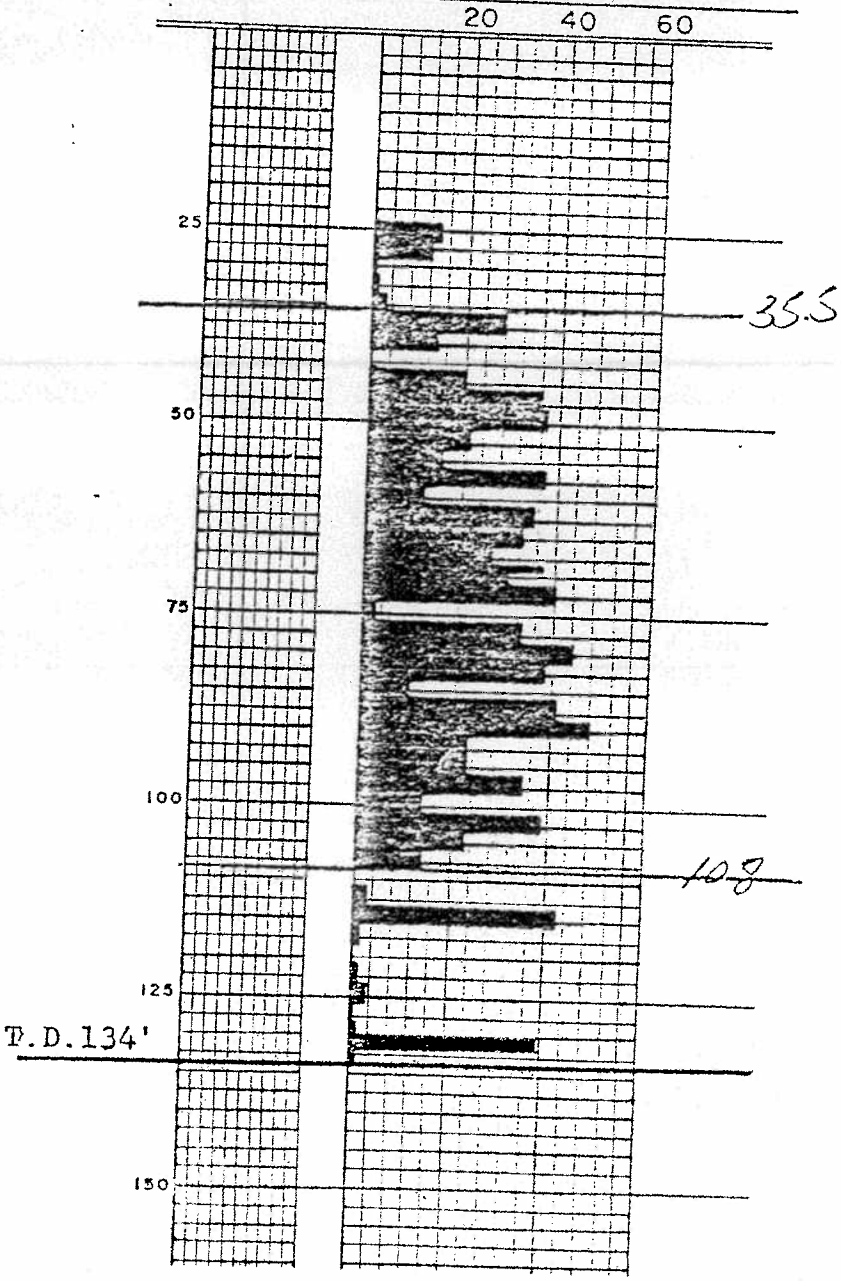
FARM BOAG-SOHIO WELL NO. CH "I"

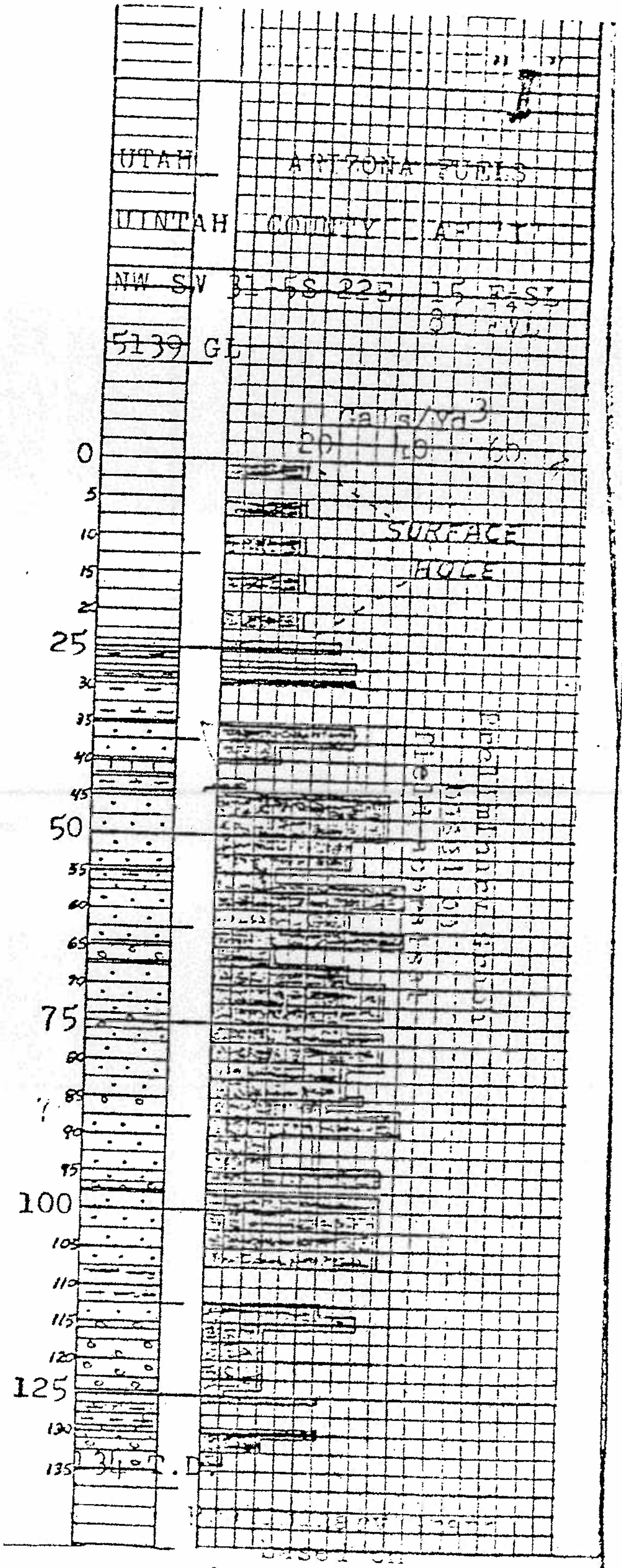
LOCATION 15' F.1/4 S.L., 81' F.W.L.,
Sec. 31, T-5-S, R-22-E, S.L.B.& M.

TD. 134' TOOLS Longyear 44

2-1/2" Wireline Core

Core Analysis Gal/Yd^3





based on
field appraisal

CH I – 124 [illegible] – 124

[illegible] [illegible]

Depth	FT	GRADE	LITE	
24-25.2	1.2	III+	os	5139
25.2-26.3	1.1	3	g sh	− 36
26.3-27.9	1.6	II−	os	+5105
27.9-28.8	.9	3	g sh	
28.8-29.7	.9	III	os	
29.7-35.5	5.8	B	g sh − o str	
35.5-38.4	2.9	III	os	
38.4-40.5	2.1	I	os	Good Rck.
40.5-44.0	3.5	6	ls & sh	
44.0-50.4	6.4	IV	os	
50.4-54.2	3.8	III	os	
54.2-56.5	2.3	B II oA	ls − os	
56.5-59.1	2.6	IV	os	
59.1-62.8		III	os	
62.8-64.8	4.0	IV	os	
64.8-66.8	2.0	II	o cgl	
66.8-69.1		III+	os	
69.1-74.0		IV	os	
74.0-76.1		III+ oA	o cgl	
76.1-81.4		IV	os	
81.4-84.2		III+	o cgl	
84.2-85.4		IV−	os	
85.4-86.5		III	o cgl	lost c̄ St
86.5-89.8		IV+	os	Rich
89.8-94.2		II est	o cgl	lost 1FT 92-93
94.2-96.7		IV	os	
96.7-97.7		3	cgl	
97.7-103.2		IV	os	
03.2-107.5		IV−	os	
07.5-111.8		B	sh − o str	
11.8-113.4		III oA	60% os/sh	
13.4-115.7		IV	os	
15 —			o/cgl iu	

24

file

4-30-75 [illegible]

I - 134 TD.

MOVED TO E Running sfc [illegible] drlg.

116 - 119	II	o cgl
119 - 121	LOST	[illegible] pbl. o. cgl
121 - 122.5	II	o cgl
122.5 - 124	Lost	prob o cgl
124 - 124.8	I+	Ln o cgl
124.8 126.4	III	os
126.4 - 129.0	B Sh	Sh gy limey
129.0 - 130.8	III	os
130.8 - 131.5	II	ocgl
131.5 - 132.5	Lost	prob grit o cgl
132.5 - 134.0 TD.	I+	o cgl tite

Expect crew to break Thurs prob [illegible] E hole — back Tues.

Out crew/did not.

Building rd to SITE

			Elev.
A1	442 S -	346 FWL	5114
E -	1000 S -	940 FWL	5092
F -	525 S -	830 FWL	5073
H -	70 S -	545 FWL	5092
2A1	109 S	358 FWL	5135
1A	315 S	965 FWL	5127
3A	682 S	1210 FWL	5097
B1	77 S	935 FWL	5141
C1	422 S	1207 FWL	5139
D1	111 S	1197 FWL	5114
SOHIO F-1	662 S	695 FWL	5082
I	15 S	81 FWL	5139

Believe B1 & C1 South distance transposed with

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV 5017'

TOTAL DEPTH 378.0'

INTERVAL CORED 10.0'-378.0' DATE 11-12-57

CLAIM Contested F

HOLE NO. CF-1

LOCATION 550' South and 550' West of the Northeast Corner, SW/4, SW/4, Section 31, T5S, R22E.

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
1	0-10			0-10.0 Plug bit through Alluvium.										
2	10-20	10.0	Duchesne River	10.0-19.3 Shale, light gray, soft, in places iron stained.										
3	20-30	1.3												
4	30-40	5.6												
5	40-50	7.8		19.3-42.2 Sandstone, buff, fine, grains sub-rounded, mainly quartz, argillaceous, friable, in places iron stained.										
6	50-60	10.0		42.2-58.1 Shale, greenish gray, soft, calcareous.										
7	60-70	10.0		58.1-60.7 Sandstone, gray, fine, grains sub-rounded, mainly quartz, a few dark minerals, friable, porous, water wet.										
8	70-80	10.0												
9	80-90	10.0	"	60.7-81.7 Shale, gray, calcareous, arenaceous in places.										
				81.7-89.9 Shale, reddish brown mottled greenish gray, calcareous, soft.										
10	90-100	10.0		89.9-92.7 Shale, greenish gray, soft, calcareous.										
11	100-110	10.0												
12	110-120	10.0		92.7-113.1 Shale, reddish brown, silty, calcareous.										
13	120-130	10.0	"	113.1-121.4 Shale, greenish gray, soft, arenaceous, calcareous.										
				121.4-124.1 Shale, reddish brown, soft, calcareous.										
14	130-140	10.0		124.1-135.7 Shale, greenish gray, arenaceous, soft, calcareous.										
15	140-150	10.0		135.7-144.2 Sandstone, black, very fine, grains sub-rounded, mainly quartz, a few clay particles, well saturated with oil.	1	136							20.48	11.23
					2	138							22.08	11.95
					3	140							42.80	24.60
					4	142							34.10	18.27
					5	144							39.00	22.20
					6	147							22.48	11.72

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV. 5017'

TOTAL DEPTH 378.0'

INTERVAL CORED 10.0'-378.0' DATE 11-12-57

CLAIM Contested F

HOLE NO. CF-1

LOCATION 550' South and 550' West of NE Corner, SW/4, SW/4, Section 31, T5S, R22E.

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River	144.2-146.0 Shale, greenish gray, soft, calcareous, has a few oil saturated sand streaks.										
16	150-160	10.0	2'	146.0-148.3 Sandstone, dark gray, fine to medium fine, grains sub-rounded, mainly quartz, a few dark minerals, abundant clay particles, fair oil saturation.									?	
			"	148.3-154.1 Shale, greenish gray, soft, silty, calcareous.										
17	160-170	10.0		154.1-164.7 Shale, reddish brown mottled greenish gray, silty, calcareous.										
				164.7-168.4 Shale, greenish gray, calcareous.										
18	170-180	10.0	2'	168.4-170.6 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, poor sorting, friable, fair oil saturation.	7	170							15.20	8.57
				170.6-171.1 Shale, greenish gray, calcareous.										
			X	171.1-172.1 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, argillaceous, friable, light oil saturation.										
				172.1-174.1 Shale, greenish gray, silty, calcareous.										
			2'	174.1-176.2 Sandstone, gray, very fine, grains sub-angular, mainly quartz, light oil saturation.	8	175							13.63	8.03
19	180-190	10.0	"	176.2-176.7 Shale, greenish gray, hard, calcareous.										
				176.7-181.5 Shale, reddish brown, silty, calcareous.										
				181.5-188.7 Shale, greenish gray, calcareous.										
20	190-200	10.0		188.7-190.0 Shale, reddish brown, calcareous.										
				190.0-191.2 Shale, greenish gray, calcareous.										
21	200-210	10.0		191.2-191.7 Shale, reddish brown, calcareous.										
				191.7-202.5 Shale, greenish gray, soft, calcareous.										
			X	202.5-203.1 Sandstone, dark gray, very fine, grains sub-rounded, mainly quartz, friable, fair oil saturation.										
				203.1-203.5 Shale, greenish gray, soft, calcareous.										

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV. 5017'

TOTAL DEPTH 378.0'

INTERVAL CORED 10.0'-378.0' DATE 11-12-57

CLAIM Contested F

HOLE NO. CF-1

LOCATION 550' South and 550' West of NE Corner, SW/4, SW/4, Section 31, T5S, R22E.

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE OIL	RESID. LIQ. SAT. % PORE SPACE WATER	RESID. LIQ. SAT. % BULK VOLUME OIL	RESID. LIQ. SAT. % BULK VOLUME WATER	RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
22	210-220	10.0	Duchesne River 4'	203.5-208.2 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, fair sorting, friable, fair oil saturation.	9 10 11	204 206 208							20.16 10.71 11.28	11.17 6.41 6.52
				208.2-215.5 Shale, greenish gray, soft, calcareous.										
			1'	215.5-217.0 Sandstone, gray, very fine, grains sub-angular, mainly quartz, fair sorting, light oil saturation, water wet.	12	216							11.74	6.96
				217.0-218.5 Shale, greenish gray, calcareous.										
23 24	220-230 230-240	10.0 10.0	18	218.5-237.3 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, a few dark minerals, friable, light to fair oil saturation, has a few shale seams, water wet.	13 14 15 16 17 18 19	219 221 223 225 227 229 235							14.86 15.03 12.66 9.83 8.77 5.63 8.71	9.32 8.60 10.48 5.34 5.36 2.96 5.08
25	240-250	6.1	"	237.3-240.0 Shale, light gray, hard, calcareous.										
			2'	240.0-242.1 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, well sorted, friable, light oil saturation, water wet.	20	241							12.37	7.44
			40'	242.1-244.2 Shale, light gray, hard, calcareous.										
				244.2-247.5 Sandstone, dark gray, fine, grains sub-angular, mainly quartz, fair sorting, friable, light oil saturation, water wet.	21	245							7.84	4.94
26	250-260	8.1	"	247.5-248.5 Shale, light gray, hard, calcareous.										
				248.5-256.4 Sandstone, gray, very fine, grains sub-angular, mainly quartz, well sorted, friable, light oil saturation, water wet.	22 23 24	249 251 253							7.82 4.18 3.91	4.43 2.80 2.74
				256.4-260.0 Shale, light gray, hard, calcareous.										
27	260-270	9.5		260.0-263.9 Sandstone, gray, very fine, grains sub-angular to angular, mainly quartz, well sorted, friable, light oil saturation, water wet.										

351.52 ÷ 20 = 17.58 avg

O.B. 135'

waste 67'

202'

Ratio 5/1

7½

135

167

SOHIO PETROLEUM COMPANY
ASPHALT RIDGE PROJECT
CORE HOLE DATA

GROUND ELEV 5017'
TOTAL DEPTH 378.0'
INTERVAL CORED 10.0'-378.0 DATE 11-12-57

CLAIM Contested F
HOLE NO. CF-1
LOCATION 550' South and 550' West of NE Corner, SW/4, SW/4, Section 31, T5S, R22E.

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River	263.9-265.3 Conglomerate, gray, pebbles to 1" in diameter, sub-rounded, gray limestone, matrix fine sand and calcareous clay, matrix has light oil saturation.										
28	270-280	8.9		265.3-266.4 Shale, light gray, hard, calcareous.										
				266.4-271.4 Sandstone, gray, medium fine, grains sub-angular, mainly quartz, fair sorting, friable, light oil saturation, water wet.	25	267							4.56	2.70
29	280-290	4.8		271.4-272.9 Shale, light gray, hard, calcareous.										
				272.9-286.8 Sandstone, gray, fine, grains sub-angular, mainly quartz, well sorted, porous, light oil saturation, water wet.	26	276							8.54	5.02
30	290-300	10.0		286.8-293.6 Shale, light gray, silty, calcareous.										
31	300-310	9.8												
32	310-320	9.6												
33	320-330	9.3												
34	330-340	8.1												
				293.6-339.5 Conglomerate, dark gray, pebbles to 3" in diameter, sub-rounded, gray chert and gray limestone, matrix clay and fine sand, light oil saturation in matrix.	27	301							2.36	0.97
					28	306							5.05	2.32
					29	310							4.02	1.86
					30	314							5.22	2.87
					31	323							6.13	3.13
					32	325							7.69	4.71
					33	328							1.95	0.90
35	340-350	4.8		339.5-340.1 Shale, light gray, hard, calcareous.										
36	350-360	8.3												
37	360-370	8.4												
38	370-378	6.2	"	340.1-378.0 Conglomerate, gray, pebbles to 3" in diameter, sub-rounded, gray limestone and gray chert, matrix clay and fine sand, non porous.										

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV 5138'

TOTAL DEPTH 296.0'

INTERVAL CORED 18.0'-296.0' DATE 11-19-57

CLAIM Contested G

HOLE NO. CG-1

LOCATION 620' North & 692' East of the Southwest Corner, NW/4, SE/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
1	0-18			0-18.0 Plug bit.										
2	18-30	6.5	Duchesne River 6	18.0-24.4 Conglomerate, dark gray, pebbles to 1½" in diameter, sub-rounded, gray limestone and gray chert, matrix fine sand and clay, matrix has light to fair oil saturation.									?	
			3'	24.4-27.1 Conglomerate, dark gray, pebbles to ½" in diameter, sub-angular, gray limestone and gray chert, matrix coarse sand, matrix has good oil saturation.	1	25							32.25	17.76
					2	27							17.47	9.67
3	30-40	9.3	4'	27.1-31.2 Conglomerate, dark gray, pebbles to 2" in diameter, sub-rounded, gray limestone, matrix fine sand and clay, matrix has light to fair oil saturation.	3	29							9.82	4.71
					4	31							21.40	10.69
				31.2-31.8 Shale, light gray, hard, calcareous.										
			7'	31.8-39.0 Sandstone, black, fine to medium fine, grains angular to sub-angular, mainly quartz, a few dark minerals, fair sorting, good oil saturation.	5	33							30.80	14.77
					6	35							35.08	19.80
					7	37							15.46	8.28
4	40-50	4.9	"		8	39							3.20	1.56
5	50-60	8.6	15'	39.0-55.5 Conglomerate, dark gray, pebbles to 2" in diameter, sub-rounded, gray limestone, matrix fine sand and clay, matrix has fair to good oil saturation.	9	43							5.58	2.90
					10	52							10.33	5.06
				55.5-55.9 Shale, light gray, hard, calcareous.										
			4'	55.9-60.1 Sandstone, black, medium, grains angular to sub-angular, quartz, gray chert, a few to abundant shale particles, fair to good oil saturation.	11	57							22.18	13.77
					12	59							17.61	8.66
					13	60							4.43	2.02
6	60-70	9.7												
7	70-80	9.8												
8	80-90	10.0												
9	90-100	10.0	" 31'	60.1-91.8 Conglomerate, dark gray, pebbles to 2" in diameter, sub-rounded, gray limestone, matrix fine sand and clay, matrix has fair to good oil saturation.	14	65							9.22	4.77
					15	67							19.03	9.24
					16	69							13.26	6.80
					17	72							22.16	12.57

SOHIO PETROLEUM COMPANY
ASPHALT RIDGE PROJECT
CORE HOLE DATA

GROUND ELEV 5138'

TOTAL DEPTH 296.0'

INTERVAL CORED 18.0'-296.0 DATE 11-19-57

CLAIM Contested G

HOLE NO. CG-1

LOCATION 620' North & 692' East of the Southwest Corner, NW/4, SE/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River		18	74							22.18	10.52
					19	77							5.13	2.52
					20	79							10.29	4.78
			59		21	82							2.06	1.01
			11'	Total	22	84							9.48	4.68
					23	86								
10	100-110	10.0			24	90							20.50	10.44
11	110-120	9.3											3.81	1.81
12	120-130	9.9	40'											
13	130-140	9.8							344.81 ÷	22 =			15.8 avg	
14	140-150	10.0		91.8-149.7 Shale, greenish, gray, soft, calcareous, silty.										
15	150-160	10.0	#	149.7-153.7 Shale, reddish brown, silty, soft, calcareous.										
				153.7-156.3 Shale, greenish gray, soft, silty, calcareous.										
			2'	156.3-158.5 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, argillaceous, friable, fair oil saturation.	25	157							12.32	7.02
16	160-170	10.0												
17	170-180	10.0		158.5-171.8 Shale, greenish gray, soft, calcareous, silty.										
18	180-190	10.0		171.8-183.2 Shale, light gray, hard, calcareous, silty, a few oil saturated sand streaks.										
			1'	183.2-184.1 Sandstone, black, very fine, grains sub-angular, mainly quartz, a few clay particles, good oil saturation.	26	184			243 92 151				30.35	17.98
				184.1-185.2 Shale, light gray, hard, calcareous.					34'?	Po				
			2'	185.2-187.3 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, argillaceous, light to fair oil saturation.	27	186			127	08 ÷ w Ratio	4.7/1		15.67	7.90

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV. 5138'

TOTAL DEPTH 296.0'

INTERVAL CORED 18.0'-296.0' DATE 11-19-57

CLAIM Contested G

HOLE NO. CG-1

LOCATION 620' North & 692' East of the Southwest Corner, NW/4, SE/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
19	190-200	10.0	Duchesne River											
20	200-210	10.0		187.3-205.1 Shale, greenish gray, hard, calcareous, arenaceous.	28	205							26.23	13.87
21	210-220	10.0	6'	205.1-211.7 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, argillaceous, fair oil saturation.	29 30 31	207 209 211							38.15 22.22 25.70	21.84 12.41 13.58
				211.7-212.3 Shale, light gray, hard, calcareous.										
			1'	212.3-213.4 Sandstone, black, very fine, grains sub-angular, mainly quartz, good oil saturation.	32	213							36.95	22.24
				213.4-214.2 Shale, greenish gray, calcareous, silty.										
			Mesaverde 6'	214.2-220.0 Sandstone, black, very fine, grains sub-angular, mainly quartz, a few dark minerals, sparse clay particles, good oil saturation.	33 34 35	215 217 219							31.95 38.30 36.20	18.04 22.26 20.64
22	220-230	10.0												
23	230-240	10.0		220.0-234.8 Shale, dark gray, calcareous, abundant carbonaceous material.										
24	240-250	10.0	8'	234.8-242.6 Sandstone, black, very fine, grains sub-angular, mainly quartz, a few dark minerals, fair to good oil saturation.	36 37 38 39	235 237 239 241							7.06 14.20 23.62 29.50	4.16 8.25 13.58 17.05
				242.6-244.7 Shale, dark gray, calcareous, abundant carbonaceous material.	40	243							10.46	6.04
			X	244.7-248.7 Sandstone, gray (salt & pepper), fine, grains sub-angular, mainly quartz, friable, very light oil saturation, water wet, looks as if oil has been flushed away at some time.										
25	250-260	10.0	"	248.7-252.0 Shale, dark gray, calcareous, abundant carbonaceous shale, several oil saturated sand streaks.										
				252.0-258.1 Sandstone, gray (salt & pepper), medium, grains sub-angular, mainly quartz, a few dark minerals, friable, very light oil saturation, water wet, looks as if oil has been flushed away at some time.										

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV 5138'

TOTAL DEPTH 296.0'

INTERVAL CORED 18.0'-296.0' DATE

CLAIM Contested G

HOLE NO. CG-1

LOCATION 620' North & 692' East of the Southwest Corner, NW/4, SE/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
26	260-270	10.0	Mesaverde											
27	270-280	9.7		258.1-276.1 Shale, dark gray, calcareous, abundant carbonaceous material.										
28	280-290	8.0												
29	290-296	4.8	"	276.1-296.0 Sandstone, gray (salt & pepper), grains sub-angular, mainly quartz, abundant, dark minerals, well sorted, porous, friable, water wet.										

Telegram of 1957 in Misc. Correspondence File and Colored Sample log from Sam Arcuri in BDAG STUDY File indicate top of ss ore at depth 76'

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SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV. 5073'

TOTAL DEPTH 441.0'

INTERVAL CORED 10.0'-441.0' DATE 7-19-57

CLAIM Patent F

See p. 2

HOLE NO. F-1

LOCATION NW/4, SW/4, Section 31 T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON.
									OIL	WATER	OIL	WATER		
			Duchesne	81.4-82.1 Shale, light gray, calcareous.	16	82		113.80					29.50	14.46
			River 7.5	82.1-89.6 Sandstone, black, medium to coarse, grains sub-rounded, mainly quartz, porous, well saturated with oil.	17 18 19	84 86 88		1237.00 240.50 918.00					23.55 32.40 37.10	13.34 20.09 21.85
9	90-100	9.2	8	89.6-98.2 Conglomerate, dark gray, pebbles rounded to 2" in diameter, mainly gray chert, gray limestone and gray shale, well saturated with oil.	20 21 22 23	90 94 96 98		10.72 2.42 .68 3.18					42.60 19.31 6.33 18.90	21.60 10.17 3.34 10.51
10	100-110	9.9	5.7	98.2-103.9 Sandstone, black, medium fine, grains sub-angular, mainly quartz, porous, fair to good oil saturation.	24 25 26	100 102 103.5		245.00 No plug " "					26.45 13.57 36.90	14.70 6.34 20.70
				103.9-105.3 Shale, light gray, calcareous.										
			3.5	105.3-109.2 Sandstone, dark gray, medium fine, grains sub-rounded, fair sorting, mainly quartz, a few dark minerals, porous, fair to good oil saturation.	27 28	106 108		17.30 79.50			avg. 26.31		4.04 28.60	2.19 14.64
				109.2-110.0 Shale, light gray, calcareous.	29	110		82.50					26.20	16.00
11	110-120	8.5	" " 3.5	110.0-113.6 Sandstone, black, very fine, grains sub-angular, mainly quartz, poor sorting, good oil saturation.	30	112		24.30					19.58	12.27
				113.6-114.6 Shale, gray, calcareous.										
12	120-130	6.6	X	114.6-127.0 Conglomerate, gray, pebbles to 2" in diameter, pebbles rounded, mainly gray chert, gray limestone and gray shale, many pebbles fractured with fractures filled with oil, light to fair oil saturation.of matrix.	31 32	120 126		21.30 1.81				X	5.64 1.81	2.49 0.87
				127.0-128.5 Sandstone, dark gray, fine, grains sub-angular, mainly quartz, fair sorting, slightly porous, well saturated with oil.	33	128		17.29					15.74	8.40
				128.5-128.9 Shale, light gray, calcareous.										
13	130-140	10.0	" " ? 10	128.9-139.1 Conglomerate, gray, pebbles to 6", pebbles rounded, gray chert, gray limestone, quartz, matrix fine sandstone, fair to good oil saturation.	34 35 36 37 38	130 132 134 136 138		187.00 No plug 0 2.36 No plug					12.26 13.39 22.35 15.82 12.72	6.43 6.24 12.50 8.04 6.18

2 4 3

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV 5073'

TOTAL DEPTH 441.0'

INTERVAL CORED 10.0'-441.0' DATE 7-19-57

CLAIM Patent F

HOLE NO. F-1

LOCATION Center NW/4, SW/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
14	140-150	9.5	Duchesne	139.1-141.0 Shale, light gray, calcareous.										
			1.5'	141.0-142.6 Sandstone, black, medium fine, grains sub-rounded, well sorted, mainly quartz, porous, well saturated with oil.	39	142		No plug					28.62	15.13
				142.6-143.6 Shale, light gray, calcareous.										
15	150-160	9.8	? 8'	143.6-152.2 Conglomerate, gray, pebbles to 3" in diameter, pebbles rounded, gray chert, gray limestone, quartz, matrix fine sand, fair to good oil saturation.	40 41 42 43 44	144 146 148 150 152		0 155.00 No plug " " " "					30.55 25.15 8.94 7.14 4.84	14.64 13.26 4.34 3.42 2.24
				152.2-152.7 Shale, light gray, calcareous.										
			1'	152.7-153.9 Conglomerate, gray, pebbles to 1" in diameter, gray chert, gray limestone, quartz, matrix fine sand, good oil saturation.										
				153.9-154.5 Shale, light gray, calcareous.										
			3'	154.5-157.4 Conglomerate, gray, pebbles to 3" in diameter, pebbles rounded, gray chert, gray limestone, matrix fine sand, fair to good oil saturation.	45	156		" "					14.87	8.16
				157.4-158.1 Shale, light gray, calcareous.	46	158		0					20.09	10.03
			? 2'	158.1-160.0 Conglomerate, gray, pebbles to 2" in diameter, sub-rounded, gray chert, gray limestone, matrix fine sand, fair to good oil saturation.	47	160		896.00					34.50	20.05
16	160-170	9.5	" " 2.8	160.0-162.8 Sandstone, black, fine, grains sub-rounded, mainly quartz, well saturated with oil.	48	162		1.61					28.70	16.15
17	170-180	9.8												
18	180-190	9.5												
19	190-200	8.2	? 31'	162.8-194.2 Conglomerate, gray, pebbles to 3" in diameter, pebbles rounded, mainly gray limestone with some gray chert and gray shale, matrix fine sand and in places clay, matrix is well saturated with oil, many pebbles are fractured with oil filling fractures.	49 50 51 52 53 54 55	164 166 168 170 172 176 178		No plug 0 0 6.26 No plug 2.33 18.50					15.78 9.95 17.35 2.17 0.71 3.14 10.45	7.85 4.98 9.22 1.06 0.35 1.56 4.94

3.

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV. 5073'

TOTAL DEPTH 441.0'

INTERVAL CORED 10.0'-441.0' DATE 7-19-57

CLAIM Patent F

HOLE NO. F-1

LOCATION Center NW/4, SW/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River		56	180		No plug					2.69	1.43
					57	182		25.70					7.45	3.66
					58	184		82.50					23.85	11.80
					59	186		5.57					12.79	6.41
					60	188		87.60					25.50	13.15
					61	190		No plug					9.90	4.27
					62	192		65.00					21.60	10.10
					63	194		193.00					37.00	21.50
			4'	194.2-198.2 Sandstone, black, medium, grains rounded, fair sorting, mainly quartz, fair porosity, good oil saturation.	64	196		No plug					36.80	20.30
					65	198		" "					30.40	17.90
20	200-210	9.5	10'	198.2-208.3 Conglomerate, gray, pebbles to 3" in diameter, pebbles rounded, mainly gray limestone, matrix fine sandstone, matrix well saturated with oil, pebbles fractured with fractures filled with oil.	66	200		" "					15.90	7.82
					67	202		" "					15.50	7.11
					68	204		" "					11.40	5.84
					69	206		23.90					20.80	10.00
					70	208		No Plug					36.20	18.00
			1'	208.3-209.1 Sandstone, black, fine, grains sub-rounded, mainly quartz, fair sorting, well saturated with oil.										
21	210-220	10.0	" " 7 7'	209.1-216.1 Conglomerate, gray, pebbles to 6" in diameter, pebbles rounded, mainly gray limestone, matrix medium sand, matrix well saturated with oil.	71	210		" "					14.30	6.88
					72	212		21.80					28.20	14.10
					73	215		77.60					23.60	12.80
22	220-230	10.0	5'	216.1-221.0 Sandstone, black, medium fine, grains subrounded, fair sorting, mainly quartz, a few dark minerals, fair porosity, well saturated with oil.	74	217		16.35			avg 19.698		41.40	22.10
					75	219		4.99					40.40	22.80
					76	221		29.00					56.10	24.30
			5.5'	221.0-226.5 Conglomerate, gray, pebbles to 3" in diameter, pebbles rounded, mainly gray limestone, matrix medium sand, matrix well saturated with oil.	77	223		51.50					9.71	4.87
					78	225		No plug					28.50	12.75
23	230-240	9.7												
24	240-250	10.0	" "	226.5-244.7 Conglomerate, gray, pebbles to 4" in diameter, pebbles rounded, gray chert, gray shale, gray limestone, matrix is calcareous clay.										

over all avg 22.296

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

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CLAIM Patent F

HOLE NO. F-1

LOCATION Center NW/4, SW/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River	244.7-250.0 Shale, gray, calcareous, abundant pyrite.										
25	250-260	10.0		250.0-259.1 Shale, greenish gray, highly arenaceous, calcareous. 259.1-260.2 Sandstone, light gray, medium fine, grains sub-rounded, mainly quartz, argillaceous, slightly porous, water wet.										
26	260-270	9.0		260.2-264.5 Shale, light gray, arenaceous, calcareous.										
27	270-280	9.3												
28-	280-290	9.7	" "	264.5-283.2 Sandstone, light gray, medium, grains sub-angular, fair sorting, mainly quartz, a few dark minerals, friable, fair porosity. 283.2-284.3 Conglomerate, gray, pebbles to 3/8", pebbles sub-rounded, mainly gray chert and quartz, matrix is medium sandstone and calcareous clay.										
29	290-300	9.6												
30	300-310	8.3												
31	310-320	10.0												
32	320-330	10.0												
33	330-340	9.8												
34	340-350	9.7		284.3-349.5 Shale, greenish gray, calcareous.										
35	350-360	9.6	" "	349.5-360.0 Shale, reddish brown mottled greenish gray, calcareous										
36	360-370	9.7												
37	370-380	8.5												
38	380-390	9.6		360.0-389.4 Shale, light gray to greenish gray, calcareous, arenaceous. 389.4-390.0 Sandstone, gray, very fine, grains sub-angular, mainly quartz, abundant clay pebbles, fair oil saturation.										
39	390-400	9.7		390.0-392.4 Shale, greenish gray, calcareous.										

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

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CLAIM Patent F

HOLE NO. F-1

LOCATION Center NW/4, SW/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River	392.4-395.7 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, abundant shale seams, fair oil saturation.	79 80	393 395		28.20 5.24					14.72 7.94	7.49 3.68
40	400-410	10.0		395.7-405.1 Shale, light gray, calcareous.										
				405.1-406.7 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, abundant shale seams and pebbles, fair oil saturation.										
				406.7-408.2 Shale, greenish gray, calcareous.										
				408.2-409.6 Sandstone, dark gray, very fine, grains sub-rounded, mainly quartz, abundant shale seams, fair oil saturation.	81	409		343.00					29.58	17.24
41	410-420	9.7		409.6-410.7 Shale, greenish gray, calcareous.										
				410.7-412.5 Sandstone, dark gray, very fine, grains sub-rounded, a few shale partings, fair oil saturation.	82	411		972.00					24.05	12.22
				412.5-414.4 Shale, greenish gray, calcareous, silty.										
				414.4-415.1 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, fair oil saturation.										
				415.1-416.8 Shale, light gray, calcareous.										
				416.8-418.3 Shale, dark gray, soft, micaceous.										
42	420-430	10.0	" "											
43	430-441	10.0		418.3-434.3 Shale, light gray, calcareous.										
				434.3-435.3 Conglomerate, gray, pebbles to ½", pebbles sub-rounded, mainly gray chert, gray limestone, matrix gray calcareous clay.										
				435.3-438.0 Shale, light gray, calcareous.										
				438.0-441.0 Conglomerate, gray, pebbles to ½", pebbles sub-rounded, mainly gray chert, matrix gray calcareous clay and fine sandstone, has light oil saturation in upper 0.5.										

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV. 5088'

TOTAL DEPTH 210.0'

INTERVAL CORED 10.0'-210.0' DATE 7-26-57

CLAIM Patent F

HOLE NO. F-2

LOCATION Center NE/4, SW/4
Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
1	0-10	9.6	Duchesne	0-2.2 Sandstone, black, fine, grains sub-rounded, mainly	1	1		Frac.				↓	32.60	18.41
			River 2'	quartz, abundant gray chert, fair sorting, fair porosity,										
				a few clay pebbles, fair oil saturation.										
				2.2-4.4 Siltstone, buff, argillaceous, calcareous.										
				4.4-10.3 Sandstone, black, very fine, mainly quartz, a	2	5		"					15.81	9.53
			6'	few dark minerals, fair to good oil saturation.	3	7		233.00					25.60	16.05
					4	9		60.10					42.30	20.85
2	10-20	9.7		10.3-11.5 Shale, light gray, calcareous.										
3	20-30	9.5		11.5-26.1 Sandstone, black, medium fine, grains sub-	5	12		90.50					33.40	18.90
			14'	rounded, fair sorting, mainly quartz, a few dark minerals,	6	14		Frac.					28.30	16.50
				fair porosity, well saturated with oil.	7	16		749.00					31.00	18.10
					8	18		1175.00					32.40	17.31
					9	20		211.00					38.90	18.50
					10	22		48.90					33.00	15.10
					11	24		26.80					29.20	16.50
					12	26		35.30					16.50	9.10
				26.1-29.1 Shale, light gray, calcareous.										
4	30-40	9.8	" "											
5	40-50	9.8		29.1-42.1 Conglomerate, dark gray, pebbles to 2", sub-	13	30		5.60					13.30	5.40
			? 13'	rounded, mainly gray chert and gray limestone, matrix	14	32		97.00					29.80	14.20
				fine sand, matrix well saturated with oil, longer	15	34		224.00					13.95	6.40
				pebbles are fractured with fractures oil filled.	16	36		Frac.					12.72	5.81
					17	38		101.00					26.70	11.60
					18	40		0					22.20	8.82
					19	42		42.00					42.80	24.30
				42.1-42.8 Shale, light gray, calcareous, sparse pyrite.										
				42.8-47.3 Sandstone, black, fine, grains sub-angular,	20	44		62.90					34.60	20.80
			4'	fair sorting, mainly quartz, a few dark minerals, fair	21	46		32.40					37.70	19.70
				porosity, good oil saturation.							avg	25.81		
6	50-60	9.8	" "											
7	60-70	9.7	? 20'	47.3-67.1 Conglomerate, dark gray, pebbles to 3", pebbles	22	48		112.90					42.30	24.20
				rounded, gray chert, gray limestone, gray shale, matrix	23	50		212.50					19.48	8.55
				fine sand, matrix well saturated with oil	24	52		0					21.75	12.95

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

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CLAIM Patent F

HOLE NO. F-2

LOCATION Center NE/4, SW/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River		25	54		0					15.15	9.31
					26	56		0					42.70	21.15
					27	58		0					16.41	7.52
					28	60		0					11.90	5.85
					29	62		No core					15.95	8.36
					30	64		465.00					13.89	7.95
					31	66		0					16.11	7.21
				67.1-69.5 Shale, greenish gray, calcareous, arenaceous.										
8	70-80	9.6	3.8'	69.5-73.3 Sandstone, black, medium fine, grains subrounded, mainly quartz, a few gray chert, fair sorting, fair porosity, good oil saturation, several shale partings.	32	70		436.00					19.55	9.83
					33	72		0.49					23.80	10.65
9	80-90	9.7	" " ? 9.6	73.3-82.9 Conglomerate, dark gray, pebbles to 3", pebbles rounded, mainly gray limestone and gray chert, matrix fine sand with a few clay pebbles, matrix well saturated with oil.	34	74		333.00					12.95	6.02
					35	76		0					16.65	8.85
					36	78		No core					11.50	5.07
					37	80		1.29					12.20	5.61
					38	82		0					15.80	7.20
				82.9-83.7 Shale, light gray, calcareous.										
10	90-100	9.8												
11	100-110	9.9												
12	110-120	9.8												
13	120-130	9.7												
14	130-140	9.8												
15	140-150	10.0												
16	150-160	10.0												
17	160-170	9.8												
18	170-180	3.0	" " ? 93	83.7-177.0 Conglomerate, dark gray, pebbles to 2", pebbles rounded, gray limestone, gray chert, gray shale, matrix fine sand, matrix well saturated with oil, larger pebbles are fractured with fractures filled with oil.	39	84		0					9.19	4.32
					40	86		0					23.00	12.39
					41	88		0					19.60	9.74
					42	90		8.25			avg - 11.52		17.60	9.04
					43	92		No core					14.60	8.48
					44	94		" "					13.49	7.65

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

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CLAIM Patent F

HOLE NO. F-2

LOCATION Center NE/4, SW/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River		77	160		**					14.30	6.50
					78	162		**					9.05	3.80
					79	164		**					30.90	13.95
					80	166		**					4.25	1.92
					81	168		**					14.25	6.74
					82	170		**					9.40	4.31
					83	172		**					17.50	8.02
19	180-190	9.2		177.0-183.3 Sandstone, gray, fine to medium fine, grains sub-angular, mainly quartz, fair sorting, porous, light oil saturation.	84	180		**					4.17	2.44
					85	182		**					5.65	3.30
				183.3-188.2 Conglomerate, gray, pebbles to 2" in diameter, pebbles sub-rounded, gray limestone, gray chert and gray shale, matrix greenish gray calcareous clay.										
20	190-200	6.9												
21	200-210	10.0	" "	188.2-210.0 Shale, greenish gray, soft.										
				** No perms. taken 100-182 because of conglomeratic nature of core.							over all avg	17.20 T		

SOHIO PETROLEUM COMPANY

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LOCATION Center NE/4, SW/4, Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River		45	96		No core					9.20	4.96
					46	98		" "					17.85	7.95
					47	100		**					11.70	5.60
					48	102		**					10.70	5.50
					49	104		**					11.40	4.77
					50	106		**					6.59	3.05
					51	108		**					6.76	3.29
					52	110		**					7.30	3.40
					53	112		**					2.88	1.31
					54	114		**					7.29	3.36
					55	116		**					5.77	2.68
					56	118		**					4.00	1.76
					57	120		**					24.40	10.65
					58	122		**					12.99	7.33
					59	124		**					22.65	9.04
					60	126		**					16.10	9.34
					61	128		**					9.75	3.79
					62	130		**					5.34	2.32
					63	132		**					10.60	5.27
					64	134		**					17.80	9.00
					65	136		**					16.01	7.28
					66	138		**					0.98	0.45
					67	140		**					12.70	5.64
					68	142		**					1.36	0.53
					69	144		**					12.20	5.05
					70	146		**					7.11	2.96
					71	148		**					0.69	0.35
					72	150		**					1.54	0.68
					73	152		**					2.56	1.20
					74	154		**					13.88	6.74
					75	156		**					3.42	1.63
					76	158		**					16.71	7.81

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV. 5067'

TOTAL DEPTH 382.0'

INTERVAL CORED 50.0'-382.0' DATE 11-12-57

CLAIM Patent F

HOLE NO. F-3

LOCATION

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
1	0-50			0-50.0 Plug bit through shale.										
2	50-60	8.7	Duchesne River	50.0-57.2 Shale, greenish gray, calcareous, soft, arenaceous.										
3	60-70	10.0		57.2-69.1 Sandstone, buff, fine, grains sub-angular, mainly quartz, argillaceous, friable, iron stained, slightly porous.										
4	70-80	10.0		69.1-76.2 Shale, greenish gray, soft.										
5	80-90	9.8		76.2-83.8 Shale, reddish brown, soft, calcareous.										
				83.8-88.3 Shale, greenish gray, silty, calcareous.										
6	90-100	10.0		88.3-98.2 Shale, reddish brown, soft, calcareous.										
				98.2-100.4 Shale, greenish gray, silty, calcareous.										
7	100-110	10.0		100.4-108.9 Shale, reddish brown, soft.										
8	110-120	9.9		108.9-116.3 Shale, greenish gray, silty, arenaceous, calcareous.										
				116.3-117.7 Sandstone, gray, fine, grains sub-rounded, mainly quartz, poor sorting, a few shale particles, light oil saturation.										
				117.7-120.5 Shale, greenish gray, soft, calcareous.										
9	120-130	10.0	" 1'	120.5-121.6 Sandstone, black, very fine, grains sub-rounded, mainly quartz, good oil saturation.	1	121							28.55	16.17
				121.6-122.3 Shale, greenish gray, soft, calcareous.										
			2.5'	122.3-125.0 Sandstone, black, very fine, grains sub-rounded, well sorted, mainly quartz, good oil saturation.	2	124							44.30	26.10
				125.0-126.9 Shale, greenish gray, soft, has a few oil saturated sand streaks.										
10	130-140	10.0												
11	140-150	10.0	18	126.9-145.0 Sandstone, black, fine, grains sub-rounded, poorly sorted, mainly quartz, soft, well saturated with oil.	3	128							32.80	20.02
					4	130							42.60	24.85
					5	132							26.10	16.80
					6	134							31.90	19.92
					7	136							45.50	26.20

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

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CLAIM Patent F

HOLE NO. F-3

LOCATION Center SE/4 SW/4 Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE OIL	RESID. LIQ. SAT. % PORE SPACE WATER	RESID. LIQ. SAT. % BULK VOLUME OIL	RESID. LIQ. SAT. % BULK VOLUME WATER	RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
			Duchesne River		8	138							40.02	23.05
					9	140							40.06	23.55
					10	142							41.30	25.90
12	150-160	10.0												
13	160-170	10.0	18'	145.0-163.2 Sandstone, black, medium fine to medium, in places conglomeratic, grains sub-angular to sub-rounded, mainly quartz, a few dark minerals, a few clay particles, soft, well saturated with oil.	11	146							36.42	19.90
					12	148							29.15	15.92
					13	150							30.08	18.66
					14	152							34.80	20.50
					15	154							38.30	22.06
					16	156							39.75	23.10
					17	158							28.24	16.08
					18	160							39.25	22.80
					19	162							31.25	17.46
14	170-180	10.0	8'	163.2-171.2 Conglomerate, dark gray, pebbles to 2" in diameter, sub-rounded, gray limestone and gray chert, matrix fine sand and calcareous clay, matrix has good oil saturation.	20	164							21.25	11.46
					21	166							30.45	16.24
					22	168							14.49	7.07
			1'	171.2-172.2 Sandstone, dark gray, medium fine, grains sub-angular, mainly quartz, argillaceous, good oil saturation.										
				172.2-173.3 Shale, greenish gray, soft.										
				173.3-174.2 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, argillaceous, friable, fair oil saturation.										
				174.2-177.3 Shale, greenish gray, soft, silty.										
				177.3-178.0 Conglomerate, dark gray, pebbles to 1" in diameter, gray limestone and gray chert, sub-rounded, matrix fine sand and calcareous clay, matrix has good oil saturation.										
15	180-190	10.0	"	178.0-185.9 Shale, greenish gray, calcareous, soft.										

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV. 5067'

TOTAL DEPTH 382.0'

INTERVAL CORED 50.0'-382.0 DATE 11-12-57

CLAIM Patent F

HOLE NO. F-3

LOCATION Center SE/4, SW/4
Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
16	190-200	10.0	Duchesne											
17	200-210	10.0	River											
18	210-220	10.0		185.9-216.7 Sandstone, black, very fine, grains sub-angular to sub-rounded, mainly quartz, a few dark minerals, a few shale particles and seams, soft, well saturated with oil.	23	186							22.77	13.16
			31'		24	188							27.28	15.61
					25	190							32.60	19.12
					26	192							22.85	13.48
					27	194							29.60	16.86
					28	196							30.05	17.43
					29	198							30.20	18.39
					30	200							32.50	19.36
					31	202							14.14	8.82
					32	204							38.75	21.68
					33	206							35.70	21.90
					34	208							48.60	29.20
					35	210							48.70	28.30
					36	212							48.00	28.03
					37	214							37.12	21.78
					38	216							39.30	23.28
				216.7-218.8 Shale, greenish gray, soft, calcareous.										
19	220-230	10.0	"	218.8-224.9 Sandstone, black, very fine to fine, grains sub-angular, mainly quartz, a few dark minerals, a few clay particles and partings, soft, has good oil saturation.	39	220							26.20	15.33
			6'		40	222							42.25	23.70
					41	224							29.76	18.56
20	230-240	10.0		224.9-232.2 Shale, greenish gray, soft.										
			3'	232.2-235.3 Sandstone, dark gray, fine, grains sub-angular, mainly quartz, a few shale partings and abundant shale particles, friable, fair oil saturation.	42	234							22.20	12.70
21	240-250	10.0	"	235.3-241.6 Shale, greenish gray, soft.										
			X	241.6-242.3 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, fair sorting, light oil saturation.										
				242.3-250.0 Shale, greenish gray, soft.	43	250							22.37	13.88

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

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CLAIM Patent F

HOLE NO. F-3

LOCATION Center SE/4, SW/4 Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
22	250-260	10.0	Duchesne River 6.5'	250.0-256.9 Sandstone, black, medium to coarse, grains sub-angular, mainly quartz, a few dark minerals, a few clay particles, good oil saturation. 256.9-258.0 Shale, greenish gray, soft.	44 45 46	252 254 256							32.30 37.55 26.72	19.24 21.40 15.07
23	260-270	9.2	12'	258.0-269.9 Conglomerate, dark gray, pebbles to 3" in diameter, gray limestone, sub-angular to sub-rounded, matrix fine sand, matrix has good oil saturation.	47 48 49 50 51	260 262 264 266 268							27.92 38.60 13.60 13.60 17.31	16.38 21.58 6.92 7.33 9.63
24	270-280	9.8												
25	280-290	8.9		269.9-285.9 Shale, greenish gray, soft, calcareous, arenaceous, has a few conglomerate pebbles at 278-279. 285.9-286.2 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, fair oil saturation. 286.2-287.7 Shale, light gray, hard, calcareous.										
26	290-300	9.1	" 4' 4'	287.7-292.3 Sandstone, black, fine, grains angular to sub-angular, mainly quartz, well sorted, a few shale particles, good oil saturation. 292.3-296.6 Conglomerate, dark gray, pebbles to 2" in diameter, gray limestone and gray chert, sub-rounded, matrix fine sand, good oil saturation. 296.6-297.6 Shale, light gray, hard, calcareous.	52 53 54 55	288 290 292 296							32.55 18.42 5.39 10.62	19.67 10.43 3.32 5.34
27	300-310	9.5	" 10' 1'	297.6-308.6 Conglomerate, dark gray, pebbles to 3" in diameter, sub-rounded, gray limestone and gray chert, matrix fine sand and clay, good oil saturation in matrix. 308.6-309.7 Sandstone, dark gray, fine, grains sub-angular, mainly quartz, a few shale particles, fair to good oil saturation.	56 57 58 59 60	298 300 302 304 308							8.64 7.38 7.87 15.43 16.55	4.18 3.66 4.01 8.96 8.87
28	310-320	9.8												
29	320-330	5.9												

SOHIO PETROLEUM COMPANY
ASPHALT RIDGE PROJECT
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CLAIM Patent F

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LOCATION Center SE/4, SW/4 Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
30	330-340	8.3	Duchesne											
31	340-350	9.7	River											
32	350-360	9.6		④ 309.7-355.6 Conglomerate, dark gray, pebbles to 1½" in diameter, sub-rounded, gray limestone and gray chert, matrix fine sand and clay, matrix has fair to good oil saturation.	61	310		1772.01 ÷ 61 = 29.05 avg					14.06	7.08
					62	313							6.14	3.16
					63	315							1.81	0.89
					64	325							4.02	2.15
					65	337							1.49	0.77
					66	348							1.67	0.82
					67	351							7.37	3.93
				355.6-357.6 Shale, light gray, hard, calcareous.										
33	360-370	9.5												
34	370-380	9.7												
35	380-382	2.0	"	357.6-382.0 Conglomerate, dark gray, pebbles to 2", sub-rounded, gray limestone, gray chert, matrix clay and fine sand, non porous, has spotty oil saturation in more porous parts.										

40
~~34~~' Congl.
92' Sand
~~128~~'
132'

310'
120
170'
125
65'

120' Overburden
65' waste
185'

Ratio 1.5/1

SOHIO PETROLEUM COMPANY

SIEVE ANALYSIS

Well F-3

Date 1-20-58

th	Screen Depth	Original Weight	Retained on 20 Mesh	Retained on 40 Mesh	Retained on 60 Mesh	Retained on 100 Mesh	Retained on 200 Mesh	Pa[illegible]
	Weight	53.4954	6.6134	3.4110	6.4307	22.0812	11.8404	3.2365
121'	%	100.00	12.36	6.38	12.03	41.11	22.08	6.04
	Weight	49.5578	0.6057	8.0252	22.7355	15.2660	2.3445	0.7553
142'	%	97.76	0.12	16.16	45.80	30.80	4.73	0.15
	Weight	55.1373	8.2908	20.9377	12.6370	8.3269	3.7200	1.5236
162'	%	100.00	14.89	37.90	22.80	14.92	6.73	2.76
	Weight	50.5203	2.6342	27.7848	12.1040	3.5009	3.2464	1.5727
186'	%	100.00	5.11	54.69	23.80	6.90	6.40	3.10
	Weight	51.0402	0.1109	0.9446	15.2426	22.8220	9.3037	2.7336
203'	%	100.00	0.21	1.84	29.80	44.58	18.22	5.35
	Weight	54.6529	3.7698	5.4162	15.1719	18.3995	7.8917	4.1466
224'	%	100.00	6.89	9.86	27.70	33.55	14.42	7.58
	Weight	50.1785	3.7937	2.1269	5.0943	17.3023	16.5570	5.5714
250'	%	97.53	7.34	4.10	9.85	33.46	32.00	10.78
	Weight	50.8030	17.5786	15.5825	8.9159	4.4684	2.9007	1.5405
268'	%	100.00	34.45	30.52	17.45	8.72	5.71	3.15
	Weight	49.9685	0.4634	7.3762	20.9031	14.0639	5.5880	1.6149
288'	%	100.00	0.92	14.76	41.80	28.12	11.18	3.22
	Weight	49.3472	29.7160	8.8259	5.2965	3.0340	1.5107	0.9208
308'	%	97.81	58.20	17.87	10.74	6.08	3.06	1.86
	Weight	48.9942	34.9334	6.8062	3.7994	1.9356	1.2464	0.5168
335'	%	100.00	71.30	13.79	7.64	3.84	2.43	1.00
	Weight	52.9498	7.6864	17.1878	12.5122	7.2598	5.0574	3.4219
351'	%	100.00	14.51	32.23	23.62	13.66	9.52	6.46

SOHIO PETROLEUM COMPANY
ASPHALT RIDGE PROJECT
CORE HOLE DATA

GROUND ELEV. 5024'
TOTAL DEPTH 358.0'
INTERVAL CORED 30.0'-358.0' DATE 11-16-57

CLAIM Patent F
HOLE NO. F-4
LOCATION Center SW/4, SE/4
Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
1	0-30			0-30.0 Plug bit, no core, probably Alluvium.										
2	30-40	7.7	Duchesne River	30.0-41.8 Shale, greenish gray, calcareous, soft.										
3	40-50	9.0		41.8-44.1 Sandstone, buff, fine, grains sub-angular, mainly quartz, argillaceous, iron stains, friable, non porous. 44.1-49.3 Shale, greenish gray, soft, calcareous.										
4	50-60	9.1	2.5'	49.3-52.0 Sandstone, dark gray, fine, grains sub-angular, mainly quartz, poor sorting, friable, a few clay particles, fair oil saturation.	1	51						✓	18.66	5.38
				52.0-56.4 Shale, greenish gray, soft, silty, calcareous.										
5	60-70	9.7												
6	70-80	9.8												
7	80-90	8.9	25'	56.4-81.3 Sandstone, black, very fine, grains sub-angular, mainly quartz, several shale seams, and sparse clay particles, friable, fair to good oil saturation.	2	57							11.78	7.67
					3	59							16.07	10.12
					4	61							9.83	6.06
					5	63							33.45	18.18
					6	65							37.82	20.19
					7	67							17.87	10.23
					8	69							10.38	5.91
					9	71							21.08	11.84
					10	73							8.21	4.69
					11	75							19.60	11.80
					12	77							10.36	5.71
					13	79							25.00	15.20
					14	81							29.30	17.03
			7.5	81.3-88.9 Conglomerate, dark gray, pebbles to 2" in diameter, sub-rounded, gray limestone, gray chert, matrix fine sand, matrix has good oil saturation.	15	84							31.30	17.74
					16	86							46.10	26.90
					17	88							35.50	18.87
8	90-100	10.0		88.9-91.5 Shale, greenish gray, soft, calcareous.										

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

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LOCATION Center SW/4, SE/4 Section 31, T5S, R22E

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INTERVAL CORED 30.0'-358.0 DATE 11-16-57

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River	91.5-94.9 Sandstone, black, very fine, grains sub-rounded, mainly quartz, a few shale seams, good oil saturation.	18	92							38.60	21.78
					19	94							43.20	22.95
			3'	94.9-95.4 Shale, greenish gray, calcareous.	20	96							17.64	8.71
9	100-110	10.0	7'	95.4-102.4 Sandstone, black, very fine, grains sub-rounded, to sub-angular, fair sorting, mainly quartz, well saturated with oil.	21	98							39.90	19.41
					22	100							41.60	20.45
					23	102							43.40	24.50
			3'	102.4-105.1 Conglomerate, dark gray, pebbles to 1" in diameter, sub-angular, gray limestone, gray chert, matrix fine sand, matrix well saturated with oil.	24	104							31.25	17.86
10	110-120	10.0		105.1-111.2 Shale, greenish grey, silty, calcareous.										
				111.2-112.9 Sandstone, dark gray, very fine, argillaceous grains sub-angular, mainly quartz, friable, fair oil saturation.	25	112							12.13	7.08
				112.9-116.4 Shale, greenish gray, silty, calcareous.										
11	120-130	10.0												
12	130-140	10.0	28'	116.4-144.7 Sandstone, black, very fine to fine, grains sub-rounded, mainly quartz, fair sorting, soft, well saturated with oil.	26	118							26.78	14.48
13	140-150	10.0			27	120							46.30	24.60
					28	122							45.80	27.85
					29	124							50.07	26.30
					30	126							55.70	28.58
					31	128							57.90	28.60
					32	130							56.30	28.63
					33	132							40.06	24.35
					34	134							20.05	11.94
					35	136							29.32	17.57
					36	138							30.16	18.79
					37	140							33.65	21.90
					38	142							37.74	17.47
					39	144							21.25	13.12

SOHIO PETROLEUM COMPANY
ASPHALT RIDGE PROJECT
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									OIL	WATER	OIL	WATER		
			Duchesne	144.7-145.8 Shale, greenish gray, calcareous.										
			River	145.8-146.4 Sandstone, black, very fine, grains sub-										
			X	angular, mainly quartz, good oil saturation.										
				146.4-149.5 Shale, greenish gray, calcareous, silty.										
14	150-160	10.0	3'	149.5-152.7 Conglomerate, dark gray, pebbles sub-	40	150							24.98	13.59
				rounded, gray limestone, gray chert, matrix fine sand,	41	152							16.33	8.71
				matrix well saturated with oil.										
15	160-170	10.0												
16	170-180	10.0		152.7-176.8 Sandstone, dark gray, very fine, grains	42	162							11.38	6.52
			24'	sub-angular, mainly quartz, a few shale particles,	43	164							8.34	4.75
				friable, fair to good oil saturation.	44	166							14.33	8.05
					45	168							27.18	15.57
					46	170							26.42	15.88
					47	172							33.58	18.52
					48	174							11.76	7.14
					49	176							22.95	13.33
17	180-190	9.7	" 7'	176.8-183.6 Conglomerate, dark gray, pebbles to 1" in	50	178							16.72	9.47
				diameter, sub-rounded, gray limestone, gray chert,	51	182							30.65	17.89
				matrix fine sand, matrix well saturated with oil.										
				183.6-188.2 Sandstone, black, coarse, conglomerate in	52	184							26.20	14.02
			5'	places, grains angular, quartz, chert, poorly sorted,	53	186							38.24	21.56
				a few clay particles, good oil saturation.	54	188							35.22	18.70
18	190-200	10.0	7'	188.2-195.2 Conglomerate, dark gray, pebbles to 3" in	55	190							35.75	17.67
				diameter, sub-rounded, gray limestone, gray chert,	56	192							13.13	6.37
				matrix fine sand, matrix well saturated with oil.										
				195.2-195.5 Shale, greenish gray, calcareous.										
			5'	195.5-200.5 Sandstone, black, medium to coarse,	57	196							23.15	11.39
				conglomeratic in places, grains sub-rounded, quartz,	58	198							31.60	17.83
				gray chert, friable, good oil saturation.	59	200							32.65	18.49
19	200-210	10.0	"	200.5-201.6 Shale, greenish gray, soft, calcareous.										

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

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									OIL	WATER	OIL	WATER		
			Duchesne River 2'	201.6-204.0 Sandstone, black, very fine, grains sub-angular, mainly quartz, a few clay particles, good oil saturation.	60	202							27.10	15.82
					61	204							9.85	5.33
			3'	204.0-206.5 Conglomerate, dark gray, pebbles to 2" in diameter, sub-rounded, gray limestone, gray chert, matrix fine sand, matrix has good oil saturation.	62	206							28.75	15.29
				206.5-207.1 Shale, greenish gray, soft, calcareous.										
			2'	207.1-209.0 Sandstone, black, very fine, grains sub-angular, mainly quartz, one shale seam, friable, good oil saturation.	63	208							26.06	15.84
20	210-220	10.0												
21	220-230	10.0	" 13	209.0-222.3 Conglomerate, dark gray, pebbles to 3" in diameter, rounded, gray limestone, matrix coarse sand, matrix well saturated with oil.	64	212							7.26	3.72
					65	216							4.94	2.53
					66	218							5.86	2.89
					67	221							7.93	4.03
				222.3-223.6 Shale, greenish gray, soft, calcareous.										
			6'	223.6-230.0 Sandstone, black, very fine, grains sub-angular, mainly quartz, abundant clay particles, soft, good oil saturation.	68	224							20.23	12.22
					69	226							19.33	11.51
					70	228							23.57	12.47
					71	230							25.68	16.53
22	230-240	10.0	5'	230.0-235.1 Conglomerate, dark gray, pebbles to 3" in diameter, sub-rounded, gray limestone, matrix fine sand and clay, matrix has good oil saturation.	72	231							2.97	1.38
					73	233							19.06	9.44
					74	235							26.68	15.26
			2'	235.1-237.6 Sandstone, black, very fine, grains angular to sub-angular, mainly quartz, abundant clay particles, good oil saturation.	75	237							22.63	12.25
23	240-250	10.0	"											
24	250-260	10.0												
25	260-270	10.0	23'	237.6-260.8 Conglomerate, dark gray, pebbles to 3" in diameter, sub-rounded to rounded, gray limestone, matrix fine sand and clay, matrix has good oil saturation.	76	239							15.97	8.93
					77	241							19.56	10.48
					78	243							16.62	9.75
					79	245							26.50	15.63

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HOLE NO. F-4
LOCATION Center SW/4 SE/4 Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River		80	247							26.55	15.43
					81	249							27.14	15.38
					82	253							18.88	8.92
					83	255							6.22	3.08
					84	257							23.58	13.62
			7'	260.8-267.4 Sandstone, black, fine, grains sub-angular, mainly quartz, a few dark minerals, friable, good oil saturation.	85	261							8.85	4.35
					86	263							22.57	11.15
					87	265							26.00	12.48
					88	267							10.23	4.84
			2'	267.4-269.5 Conglomerate, black, pebbles to 3/8", pebbles angular to sub-angular, gray limestone and gray chert, matrix coarse sand, matrix has good oil saturation.	89	269							7.53	3.73
26	270-280	10.0	" 6'	269.5-275.0 Sandstone, black, medium fine, grains angular to sub-angular, mainly quartz, abundant dark minerals, abundant clay particles, good oil saturation.	90	271							10.10	5.04
					91	273							30.95	18.08
					92	275							23.74	14.68
			5'	275.0-280.0 Conglomerate, dark gray, pebbles to 2" in diameter, sub-rounded, gray limestone and gray chert, matrix coarse sand and clay, matrix has good oil saturation.	93	277							11.90	6.05
					94	279							7.72	4.08
27	280-290	10.0												
28	290-300	9.8	78.5' Congl.					2300.16 ÷ 94 =					24.46 avg	
29	300-310	10.0	124.5' Sand											
30	310-320	10.0	203'	280.0-311.4 Conglomerate, dark gray, pebbles to 3" in diameter, sub-rounded to rounded, gray limestone, gray chert, matrix fine sand and clay, matrix has light to fair oil saturation.	95	283							5.64	2.81
					96	285							2.98	1.57
					97	287							5.32	2.73
					98	289							2.53	1.39
					99	291		49' OB					5.46	2.69
					100	293		29' waste					2.93	1.37
					101	295							4.27	2.08
					102	297		78'					7.23	3.59

250
49
31

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV. 5024'

TOTAL DEPTH 358.0'

INTERVAL CORED 30.0'-358.0 DATE 11-16-57

CLAIM Patent F

HOLE NO. F-4

LOCATION Center SW/4, SE/4 Section 31, T5S, R22E

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD.	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River		103	299							6.34	3.14
					104	305							8.36	3.96
					105	307							4.68	2.29
					106	309							6.14	3.09
					107	311							9.22	4.28
				311.4-316.3 Shale, greenish gray, silty, calcareous.	108	313							4.41	2.02
				316.3-318.0 Sandstone, dark gray, very fine, grains sub-rounded, mainly quartz, well sorted, friable, fair oil saturation.	109	317							26.08	14.92
31	320-330	9.9		318.0-327.4 Conglomerate, dark gray, pebbles to 2" in diameter, sub-rounded, gray limestone, gray chert, matrix calcareous clay and fine sand, matrix has light oil saturation.	110	319							11.61	6.63
					111	327							15.47	9.26
				327.4-328.6 Sandstone, dark gray, fine, grains sub-rounded, mainly quartz, fair sorting, friable, fair oil saturation.										
32	330-340	9.7	"	328.6-332.3 Conglomerate, dark gray, pebbles to 1½" in diameter, sub-rounded to rounded, gray limestone, matrix calcareous clay and fine sand, matrix has light oil saturation.	112	329							1.59	0.79
					113	330							10.52	5.17
				332.3-337.7 Shale, greenish gray, silty, calcareous.										
33	340-350	9.8		337.7-349.7 Sandstone, light gray, very fine, grains sub-angular, mainly quartz, friable, water wet.										
34	350-358	8.0	"	349.7-352.2 Conglomerate, gray, pebbles to 1" in diameter, sub-angular, gray limestone and gray chert, matrix calcareous clay, hard, non porous.										
				352.2-358.0 Shale, greenish gray, calcareous.										

SOHIO PETROLEUM COMPANY

SIEVE ANALYSIS

Well F-4

Date 1-20-58

th	Screen Depth	Original Weight	Retained on 20 Mesh	Retained on 40 Mesh	Retained on 60 Mesh	Retained on 100 Mesh	Retained on 200 Mesh	Passe
51'	Weight	55.7205	8.8718	11.2067	11.4774	11.7327	8.3057	4.3638
	%	100.00	15.82	20.05	20.50	21.00	14.83	7.80
71'	Weight	45.9761	7.8996	4.2765	4.8437	14.2364	10.2744	4.6253
	%	100.00	17.11	9.26	10.50	30.85	22.25	10.03
92'	Weight	59.1298	2.2915	3.4718	13.3730	22.4834	11.0528	6.4940
	%	100.00	3.87	5.87	22.60	38.00	18.70	10.96
112'	Weight	49.1893	11.8574	3.9875	3.7299	8.1621	14.1138	7.6028
	%	99.98	24.05	8.00	7.48	16.50	28.60	15.35
132'	Weight	52.2834	0.1696	4.0488	24.6432	17.1951	5.0533	1.2353
	%	100.00	0.22	7.74	47.18	32.86	9.65	2.35
152'	Weight	50.5905	14.8122	14.8068	10.9902	5.2939	3.0391	1.8853
	%	99.97	29.22	29.20	21.65	10.38	5.90	3.62
172'	Weight	53.8308	3.3986	23.0351	12.4261	7.6138	4.4648	3.0235
	%	100.00	6.29	42.67	23.06	14.13	8.28	5.57
192'	Weight	47.0140	22.2465	10.7269	6.7213	4.1964	2.1483	1.0958
	%	100.00	47.24	22.74	14.23	8.92	4.55	2.32
212'	Weight	43.6047	25.9564	5.6333	4.8930	3.3875	2.5391	1.2867
	%	99.88	59.40	12.90	11.22	7.74	5.69	2.93
231'	Weight	40.4779	32.0257	2.6086	1.6051	1.8550	1.8423	0.7521
	%	98.96	79.25	6.44	3.96	4.57	4.56	0.18
253'	Weight	55.9380	12.2544	20.2239	13.1519	5.7462	3.0163	1.6334
	%	100.00	21.82	36.40	23.43	10.16	5.32	2.87
273'	Weight	52.0670	1.6164	1.3399	4.5974	22.7476	17.7371	3.8905
	%	99.76	3.09	2.55	8.84	43.70	34.10	7.48

MCW Energy Group

Temple Mountain Mine

Asphalt Ridge, Uintah County, Utah

Seep and Spring Survey

June 2015

Prepared for:

Utah Department of Environmental Quality

Division of Water Quality

Prepared by:

Donald Clark, PhD

Chief Geologist

MCW Energy Group

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Suite 300
Century City, CA 90067

Mobile: (718) 869-3763

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APPENDICES

1.0 Introduction: In early 2015, MCW Energy Group filed a Utah Ground Water Discharge Permit Application with the Utah Department of Environmental Quality - Division of Water Quality, for operating an oil sands processing facility in Maeser, Utah and an oil sands mining operation (Temple Mountain Mine) south of Vernal, Utah. On May 6, 2015, members of the Division of Water Quality (DWQ) performed a site visit and inspection to both the oil sands processing facility and the Temple Mountain Mine site, which will be used to supply oil sands ore to the existing oil sands processing facility. As a result of this site visit, the DWQ requested that a seep and spring inventory be performed at the Temple Mountain Mine site and that further water quality analyses be performed on the intermittent stream that is located to the east of the mine pit area.

The following seep and spring inventory and stream water quality analyses is the result of this request and will be part of a Ground Water Discharge Permit application that will be submitted to the state of Utah for the Temple Mountain Mine site.

2.0 Site Description:

2.1 Location: The Temple Mountain Mine site is located within Township 5 South, Range 22 East, Section 31 approximately 7 miles south of Vernal, Utah (Fig. 1). The site is located directly on Asphalt Ridge, just west of Route 45, approximately two miles north of the Green River. The entrance to the mine site is on Route 45.

2.2 Overall Site Description: The Temple Mountain Mine site is located in a semi-arid region that receives approximately 8.78 inches of precipitation annually (Table 1). The overall landscape is consistent with this low amount of precipitation and is composed of sparsely vegetated rolling hills with both rock outcrops and deeply cut dry stream beds.

2.3 Geology: Asphalt Ridge is an exposed hogback ridge, approximately 15 miles long, with a northwest-southeast orientation (Blackett, 1996). The major bitumen bearing formations along the ridge are the Rim Rock Sandstone of the Cretaceous Mesaverde Group, the Eocene Uinta Formation and the Oligocene Duchesne River Formation (Fig. 2). The Rim Rock Sandstone is a marine sandstone. The Uinta Formation is a fluvial formation and is composed of interbedded sandstones, mudstones and shale, with lenses of conglomerates. The Duchesne River Formation is also fluvial in origin and composed of interbedded sandstones, shales and conglomerates. The conglomerates and sandstones are channel deposits whereas the shales are floodplain deposits. An angular unconformity separates the Uinta and Duchesne River formations from the underlying Rim Rock Sandstone. The oil that is found in the oil bearing formations is thought to have originated from the Green River Formation and migrated upward along the Tertiary-Cretaceous angular unconformity and into the reservoir rocks. The Rim Rock Sandstone dips from 8 to 30 degrees to the south-southwest, whereas the Duchesne River Formation dips 9 to 20 degrees to the south-southwest. Bitumen saturation within clastic beds of the Duchesne River and Uinta Formations varies both laterally and vertically due to lithology which affects both permeability and porosity. The most permeable and therefore the most saturated lithologies tend to be medium to coarse grained sandstones.

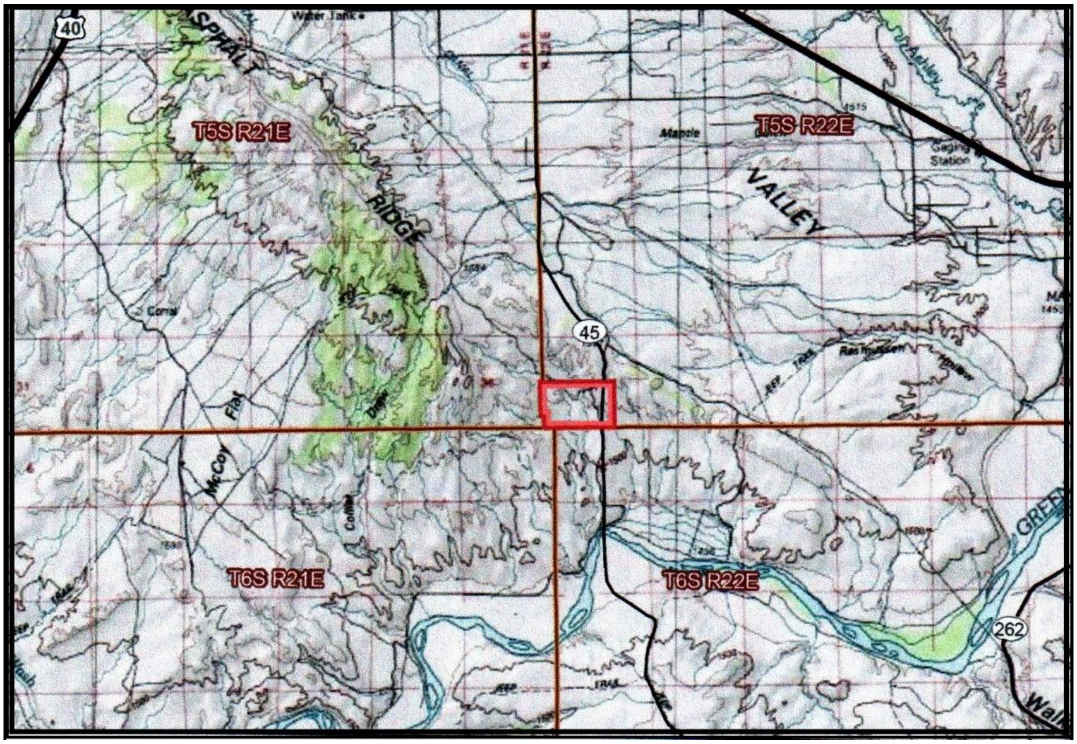

Figure 1. The red box marks the location of the Temple Mountain Mine site on Asphalt Ridge. The surface geology is composed primarily of the Oligocene Duchesne River formation and recent alluvial material.

Source: Stantec, 2015.

Table 1: Average monthly precipitation (inches) for Vernal, Utah.

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Avg. precipitation:	**0.43**	**0.51**	**0.67**	**0.87**	**1.06**	**0.67**
Month	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Avg. precipitation:	**0.63**	**0.75**	**0.91**	**1.26**	**0.55**	**0.47**
Average annual precipitation - rainfall:	**8.78**					

Source http://www.usclimatedata.com/climate/vernal/utah/united-states/usut0261

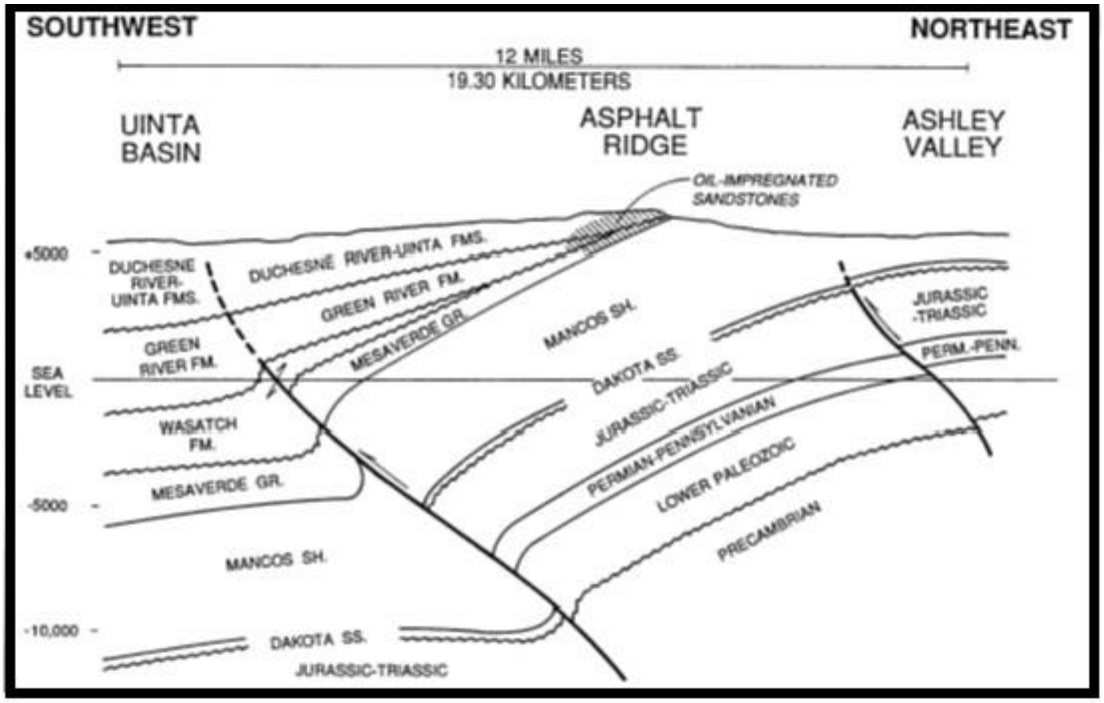

Figure 2. Generalized Cross Section of Asphalt Ridge.

Source: (Blackett, 1996)

3 Inventory Methodology:

3.1 Inventory Boundary: The boundary for the seep and spring survey covered the entire mine area of the Temple Mountain Mine site and was approximately the same as the boundary of the 2008 Ecological Baseline Report compiled by the URS Corporation (Figs. 3 and 4) (URS Corporation, 2008).

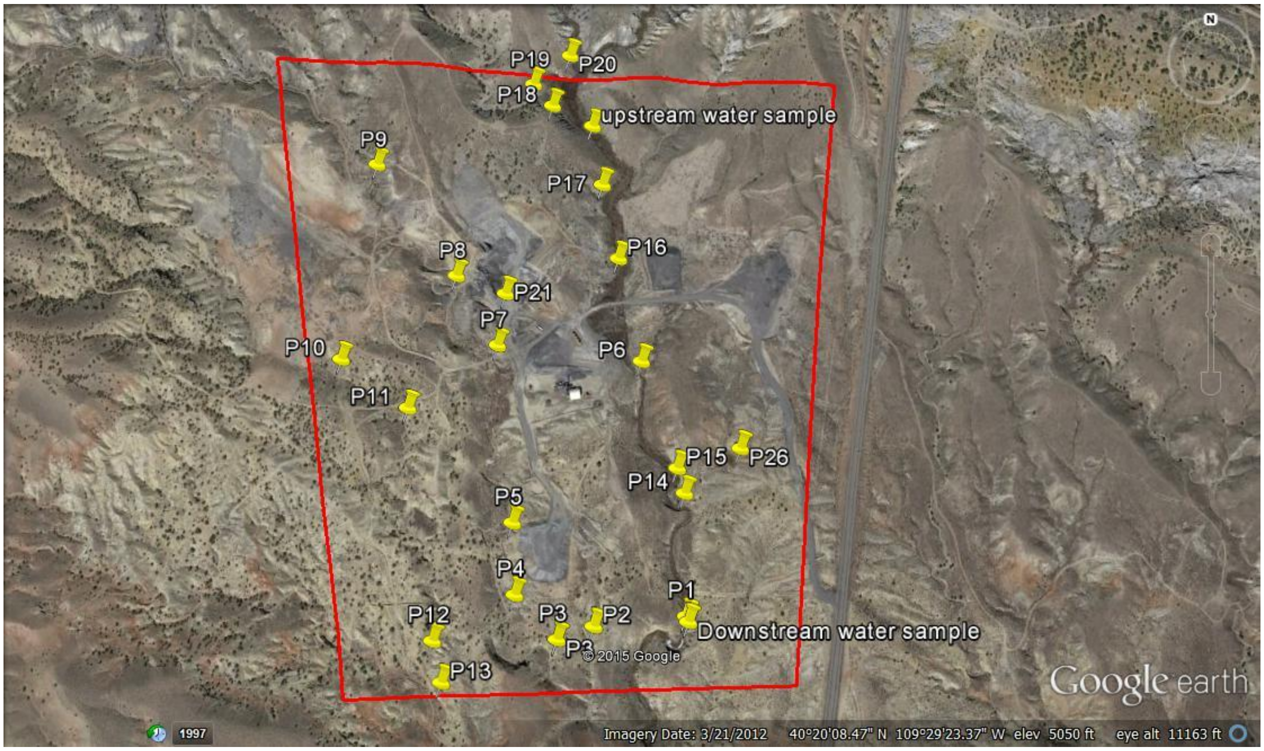

Figure 3. The boundary of the June 2015 Seep and Spring Survey. The yellow pins indicate the location of pictures that were taking during the survey and the locations where the water samples were taken from the intermittent stream that runs through the Temple Mountain Mine site.

Source: Google Earth, 2012.

3.2 Preliminary Recognizance: Prior to engaging in actual field work, previous hydrological/geological/environmental reports were read and both topographic maps and satellite imagery were examined to determine the locations of erosional features and concentrations of vegetation that may indicate the possible presence of seeps and springs within the boundary area. Recent precipitation records were also examined to determine if rainfall prior to the survey was within, or outside the normal range for this time of year. Recent rainfall below, or above the monthly average may decrease or increase, respectively, the number of seeps or springs encountered during the survey.

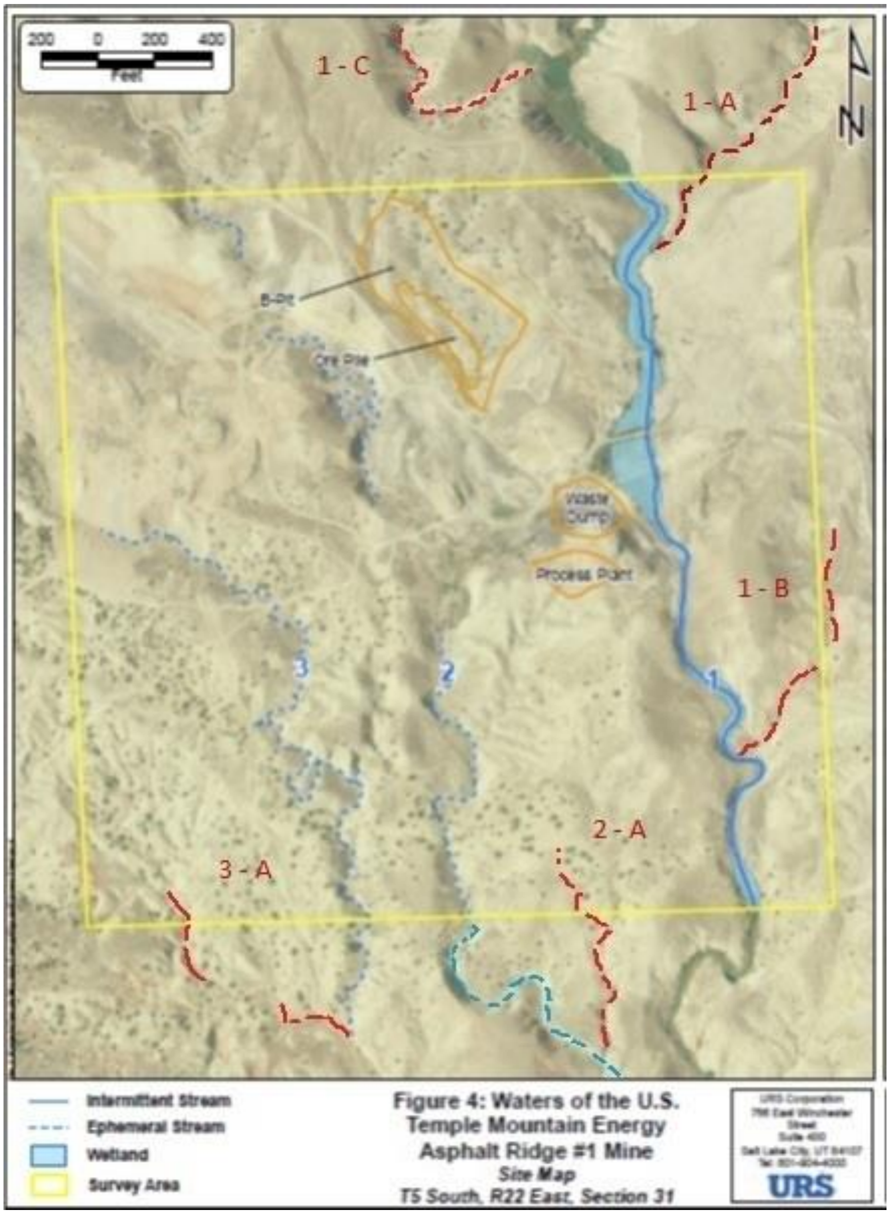

Figure 4. The intermittent stream (1) and ephemeral streams (2) and (3) (in blue) on the Temple Mountain Mine Site as identified in the 2008 Ecological Baseline Report compiled by the URS Corporation. The ephemeral tributaries (1-A, 1-B, 1-C, 2-A, 3-A) were identified in the current seep and spring test (in red).

Source: Modified from URS Corporation, 2008.

3.3 Field Work: Dry stream beds and erosional features were traced by foot to determine is any springs or seeps were present, but not visible in satellite imagery. Stands of vegetation were also examined to determine if the vegetation was hydrophytic and if there was a seep or spring associated with the vegetation. A hand held GPS and topographic map were brought into the field to mark the location of any seeps or springs that were discovered during the course of the field work. A hand held water testing probe (Hach – Pocket Pro Tester) was used to determine the field pH, Conductivity, TDS, Salinity and Temperature of any water encountered during field work. American West Analytical Services (AWAL) supplied pretreated sample bottles, coolers and the Chain of Custody documentation for any water samples taken during the survey. All water samples were stored at 4^{oc}, or less prior to laboratory analysis. A one gallon and five gallon bucket and a stop watch were also brought into the field to measure stream flow rate. Pictures were taken of the stream beds and erosional features to record whether seeps and springs were present, or absent at these locations. Field work was conducted from June, 23rd through June 25th, 2015.

4 Inventory Results:

4.1 Preliminary Recognizance: An Ecological Baseline Report was submitted to the State of Utah as part of the TME Asphalt Ridge LLC NOI (application #M0470089) in 2008 (URS Corporation, 2008). This report indicated that this site had one intermittent and two ephemeral streams on the property (Fig. 4). The intermittent steam is located just to the east of the open pit mining area and has a wet land associated with it that is filled with hydrophytic vegetation, primarily Reed Canary Grass (*Phalaris arundinacea)*, Broadleaf Cattail *(Typha latifolia)*, Salt Cedar (*Tamarix ramosissima)*, and Russian Olive (*Elaeagnus angustifolia)*. This stream continues to and flows into the Green River. The 2008 URS report noted that the stream did not have a flowing water connection with the Green River during the time that the field work for the report was done, which was in September of 2007.

The source of the water for the intermittent stream is from an underground spring located north of the Temple Mountain Mine site (Figs. 4 and 5). No springs were identified on the Temple Mountain Mine site that contributed to the flow of water in the intermittent stream.

Figure 5. Satellite imagery of the headwaters of the intermittent stream that flows through the Temple Mountain Mine site. The springs feeding the stream flow out of the earth just south of P24 and P25. This area is to the north of the survey boundary.

Source: Google Earth, 2012.

An ephemeral stream, identified as stream (2) in the 2008 Ecological Baseline Report, is located near the center of the Temple Mountain Mine site (URS Corporation, 2008) (Fig. 4). URS Corporation (2008) defined this stream as having the following characteristics "Portions of the stream consist of a shallow, well established channel cut in the soil and rock while other sections of the stream tend to disperse and flow overland and not within a defined channel. The broad overland flow typically begins just downgradient of an historically disturbed area or dirt road that has diverted the stream flow in the past. The channel is established again when the overland flow is concentrated and directed into a small valley."

URS Corporation (2008) observed and concluded the following about this ephemeral stream when they were performing their field work in September of 2007, "During fieldwork this channel was dry and most likely will only carry water during heavy rain events or during the spring melt and runoff."

A second ephemeral stream, identified as stream (3) by URS Corporation (2008), is located on the west side of the site (Fig. 4). The URS Corporation (2008) description of stream (3) was very similar to their description of stream (2). "Some sections of this stream do not have a well-defined channel, particularly the northern section. This portion of the stream is not well defined, however, as it flows to the south the channel becomes more apparent. This stream was dry during the time of the site visit and most likely only carries water during heavy rain events or during the spring melt and runoff."

The intermittent stream (stream 1), identified by URS Corporation (2008), and the ephemeral stream in the middle of the property (stream 2) join together just south of the survey area and continue to the Green River. The ephemeral stream on the west side of the property (stream 3) and the intermittent stream (stream 1) join together just before emptying into the Green River approximately two miles to the south of the mine site. It should be noted that during the time that URS did its field work, September 2007, there was no flowing water contact between the intermittent stream and the Green River. This is significant since URS Corporation (2008) noted that a significant amount of rain fell in this area the weekend before their fieldwork. This may indicate that the intermittent stream turns into an ephemeral stream before reaching the Green River and that flowing water does not reach the Green River except under conditions of excessive rain.

Satellite imagery showed thick vegetation along the entire length of the intermittent stream to the east of the open pit mine and relatively closely spaced individual shrubs/small trees on the southwest corner of the survey boundary area (Fig. 3). The remainder of the survey boundary area was largely devoid of significant vegetation.

The only standing water seen in satellite imagery was to the east of the intermittent stream at 40^{o}20'3.77" N 109^{o}29'16.09 W (Fig. 6). This standing water appeared, in satellite imagery, to be contained by a man made earthen dam.

Precipitation records for the three months prior to the survey indicated that rainfall during the months of April and June was approximately half the normal average for these months, whereas the rainfall during the month of May was approximately three times the monthly average (Tables 1 and 2). Given the fact that meteoric water percolating into the ground surface at higher elevations may form seeps and springs at lower elevations, the total rainfall during these three months may be more important than individual monthly rainfall amounts due to the time (lag time) it takes for water to flow through the ground. The higher total rainfall for these three months combined (4.14 inches in 2015 versus 2.60 inches for a normal year) would increase the likelihood of detecting a seep or spring during the survey, if one existed on the Temple Mountain Mine site.

Figure 6. Satellite imagery of standing water east of the intermittent stream that flows through the Temple Mountain Mine site. The water appears to be contained by a man made dam that blocks the downstream flow of water from the north and northeast to the southwest. The mine access road is to the right.

Source: Google Earth, 2012.

Table 2: Monthly precipitation for Vernal, Utah, 2015.

Month	**Apr**	**May**	**Jun**
Precipitation (inches):	**0.41**	**3.37**	**0.36**

Source: http://weather-warehouse.com/WeatherHistory/PastWeatherData_VernalArpt_Vernal_UT_April.html

Stantec (2015) reported that only four of seventeen test wells that were drilled on the Temple Mountain Mine site recorded any water. Of these four wells only one, well CF-1 in the south western portion of the lease area, recorded any water close to the surface. Well CF-1 recorded a water saturated zone between 58.1 and 60.7 feet. The lack of groundwater close to the surface in these seventeen well logs strongly suggests that there is a low probability that there will be seeps, or springs on the Temple Mountain Mine site.

4.2 Field Work: No seeps or springs were identified within the survey boundary of the Temple Mountain Mine site (Fig. 3).

The intermittent stream that runs to the east of the open pit mine is fed by at least four individual springs to the north of the survey boundary (Fig. 5). Two tributaries come together to form a west branch of the intermittent stream and two tributaries come together to form an east branch of the stream. The west branch and the east branch come together to form the intermittent stream north of the survey boundary. Thick hydrophytic vegetation, especially near the northern portion of the boundary, may hide additional springs (Photograph P18, Appendix A).

The only hydrophytic vegetation encountered during the inventory was the hydrophytic vegetation associated with the intermittent stream, primarily Reed Canary Grass (*Phalaris arundinacea)*, Broadleaf Cattail *(Typha latifolia)*, Salt Cedar (*Tamarix ramosissima)*, and Russian Olive (*Elaeagnus angustifolia)* and the hydrophytic vegetation associated with the standing water in the ephemeral tributary (1-B) that flows into the intermittent stream, primarily Reed Canary Grass (*Phalaris arundinacea)* and Broadleaf cattail *(Typha latifolia)* (Fig 4, Photographs P26a and b - Appendix A).

The standing water identified in satellite imagery was a pond that formed due to the construction of an earthen dam over a section of the ephemeral tributary (1-B) that flows into the intermittent stream on the eastern portion of the Temple Mountain Mine site (Figs. 4 and 6 and Photographs P26a and b - Appendix A). The water was several feet below its high water mark and a delta, that formed where the ephemeral stream entered the pond, was subaerially exposed. The low current water level, the exposure of a normally subaqueous delta and the lack of any springs feeding the pond indicates that this pond was filled by meteoric water from the ephemeral stream and not spring water.

The intermittent steam on the property is in direct contact with and cuts through the oil sands bedrock for a considerable distance just east of the open pit mining area (photographs P6 and P16a – Appendix A). The surface exposure of the oil sands bedrock on the Temple Mountain Mine site prevents the water from infiltrating into the ground. The steep dip (approximately 9° - 20° SSW) of the oil sands, relative to the southerly dip of the ground surface, causes them to dip below the ground surface south of the Temple Mountain Mine site which allows for the infiltration of the stream water into the ground. This causes the connection between the stream and the Green River to be lost, except under conditions of prolonged and excessive rain or snow melt. During this survey, the intermittent stream bed was dry starting approximately half way to the Green River and all the way to the Green River (Fig. 7 and photographs P22 and P23 – Appendix A).

In addition to the intermittent and ephemeral streams identified by the URS Corporation (2008), this survey identified several additional ephemeral streams that are tributaries to the three streams identified by URS (Fig. 4). The intermittent stream has three ephemeral tributaries associated with it that had no flowing water at the time the survey was conducted, from June 23rd to June 25th. The ephemeral tributary stream channels had no springs or seeps associated with them indicating that they were formed due to snow runoff and rainfall. The tributary identified as 1 – B was dammed and had the standing water identified in satellite imagery and was discussed above.

5 Intermittent Stream Analysis

5.1 Water Quality: Field measurements of various water quality parameters (pH, Conductivity, TDS, Salinity and Temperature) were taken from both upstream and downstream locations on June 23rd (Fig. 3 and Tables 3 and 4).

Stantec (2015) reported that levels of cadmium in the stream water exceeded the numerical standard (Table 5). In addition to high levels of cadmium, high levels of calcium and sulfate were detected as well as high conductivity and low pH.

Additional water samples were taken for laboratory analysis from both the upstream and downstream locations where the field measurements were taken on the evening of June 25th and delivered to American West Analytical Laboratory the morning of June 26th (Fig. 3).

Table 3. Field measurements of various water quality parameters from the upstream reach of the intermittent stream in the survey area.

Parameter	**Value**	**Temperature**	**Numeric Standard**
pH	**3.30**	25.1^{oc}	**6.5 – 9.0(1)**
Salinity	820 mg/L	24.9^{oc}	
Conductivity	1660 uS/cm	24.6^{oc}	
TDS	**1170 mg/L**	24.8^{oc}	1200 mg/L(2) **500 mg/L(3)**

(1) – R317-6-2, Utah Administrative Code – Groundwater Quality Standards
(2) – R317-2-14, Utah Administrative Code – Numerical Criteria
(3) – US EPA National Secondary Drinking Water Regulations

Table 4. Field measurements of various water quality parameters from the downstream reach of the intermittent stream in the survey area.

Parameter	**Value**	**Temperature**	**Numeric Standard**
pH	**3.41**	25.9^{oc}	**6.5 – 9.0(1)**
Salinity	790 mg/L	26.6^{oc}	
Conductivity	1560 uS/cm	26.4^{oc}	
TDS	**1110 mg/L**	26.5^{oc}	1200 mg/L(2) **500 mg/L(3)**

(1) – R317-6-2, Utah Administrative Code – Groundwater Quality Standards
(2) – R317-2-14, Utah Administrative Code – Numerical Criteria
(3) – US EPA National Secondary Drinking Water Regulations

Table 5. Selected compounds from an upstream water analysis from the intermittent stream in the survey area.

Compound	**Upstream Sample**	**Numeric Standard**
Cadmium	**0.014 mg/L**	**0.010 mg/L(1)** **0.005 mg/L(2)**
Calcium	180 mg/L	
Magnesium	66 mg/L	
Sodium	21 mg/L	
Sulfate	**1,100 mg/L**	**250 mg/L(3)**
Conductivity	1500 umhos/cm	
pH@25^{oc}	**3.13**	**6.5 – 9.0(1)**

(1) – R317-6-2, Utah Administrative Code – Groundwater Quality Standards

(2) – US EPA National Primary Drinking Water Regulations

(3) – US EPA National Secondary Drinking Water Regulations

Source: Stantec, 2015

The intermittent stream water has very low levels of hydrocarbons and organic material associated with hydrocarbons despite being in direct contact with the oil sands (Table 6 and Appendix B and C). The analytical testing showed virtually no difference in the levels of hydrocarbons and organic material associated with hydrocarbons in the water from the sample taken upstream versus the sample taken downstream.

The low pH of the intermittent stream water, combined with the high levels of iron is most likely the result of the weathering of pyrite (FeS_2) and the resultant acid mine drainage (AMD). There are several basic chemical reactions for the weathering of pyrite, all of which lead to low pH and elevated levels of sulfate and iron in the water (Lehigh University, 2015; Thorsten, 2013).

The overall reaction is …

$4\ FeS_2 + 15\ O_2 + 14\ H_2O => 4\ Fe(OH)_3 + 8\ H_2SO_4$

The reaction for the oxidation of pyrite by oxygen is…

$2\ FeS_2 + 7\ O_2 + 2\ H_2O => 2\ Fe^{2+} + 4\ SO_4^{2-} + 4\ H^+$

The reaction for the oxidation of pyrite by ferric iron is…

$FeS_2 + 14\ Fe^{3+} + 8\ H_2O => 15\ Fe^{2+} + 2\ SO_4^{2-} + 16\ H^+$

Table 6. Analytical results from both upstream and downstream water samples from the intermittent stream running through the Temple Mountain Mine site.

Compound	**Upstream Sample**	**Downstream Sample**	**Numeric Standard**
Calcium	175 mg/L	212 mg/L	
Magnesium	57.1 mg/L	64.2 mg/L	
Iron	**7.21 mg/L**	**2.36 mg/L**	**0.3 mg/L**$^{(3)}$
Potassium	5.56 mg/L	15.7 mg/L	
Sodium	18.3 mg/L	29.8 mg/L	
Chloride	7.05 mg/L	7.02 mg/L	
Oil & Grease	< 6.40 mg/L	< 6.37 mg/L	
pH @ 25° C	**3.04 pH units**	**3.52 pH units**	**6.5 – 9.0**$^{(1)}$
Sulfate	**893 mg/L**	**960 mg/L**	**250 mg/L**$^{(3)}$
Total Dissolved Solids	**1,220 mg/L**	**1,410 mg/L**	**1200 mg/L**$^{(2)}$ **500 mg/L**$^{(3)}$
Total Organic Carbon	6.75 mg/L	6.67 mg/L	
Benzene	< 2.00 µg/L	< 2.00 µg/L	
C5&C6 Aliphatic hydrocarbons	< 20.0 µg/L	< 20.0 µg/L	
C7&C8 Aliphatic hydrocarbons	< 20.0 µg/L	< 20.0 µg/L	
C9&C10 Aliphatic hydrocarbons	< 20.0 µg/L	< 20.0 µg/L	
C9&C10 Alkyl Benzenes	< 20.0 µg/L	< 20.0 µg/L	
Ethylbenzene	< 2.00 µg/L	< 2.00 µg/L	
Naphthalene	< 2.00 µg/L	< 2.00 µg/L	
Toluene	< 2.00 µg/L	< 2.00 µg/L	
TPH C6-C10 (GRO)	< 20.0 µg/L	< 20.0 µg/L	
Xylenes, Total	< 2.00 µg/L	< 2.00 µg/L	
Diesel Range Organics (DRO) (C10-C28)	< 0.625 mg/L	< 0.556 mg/L	

(1) – R317-6-2, Utah Administrative Code – Groundwater Quality Standards

(2) – R317-2-14, Utah Administrative Code – Numerical Criteria

(3) – US EPA National Secondary Drinking Water Regulations

Fig. 7. Satellite imagery of the intermittent stream south of the Temple Mountain Mine site. P22 is approximately half way between the lease and the Green River. P23 is just before the Green River. There was no flowing water between P22 and P23 at the time of the survey.

Source: Google Earth 2012.

A particularly strong qualitative indicator of AMD is the yellowish brown precipitation of ferric hydroxide or yellowboy ($Fe(OH)_3$) on rocks and vegetation in streams with AMD. Several sections of the stream had such a yellowish brown precipitate (photographs P6b, P24a and P25 – Appendix A).

The precipitation of ferric hydroxide is pH dependent water (Lehigh University, 2015; Thorsten, 2013). Ferric hydroxide precipitates out of the water if the pH is ~3.5 and above. Below pH ~3.5, little or no ferric hydroxide will precipitate. The pH of the stream water increased from 3.04 upstream to 3.5 downstream (Table 6). Iron content also decreased from upstream to downstream, strongly suggesting that ferric hydroxide is precipitating out of the stream water as it flows downstream where the pH of the water rises. The rise in pH is due to the increased amount of alkaline compounds that the stream water absorbs from the surface sediments as it moves downstream.

The stream originates from springs just north of the mine site. This area of Utah has an annual rainfall of about 8 inches with monthly precipitation rarely exceeding an inch (Table 1).

This is a small stream with flowrates of approximately 67 gallons/minute and increases in stream water pH, due to the dilutive effects of precipitation and the addition of increased amounts of alkaline compounds from overland flow, are very likely during periods of rain or snow melt. If the increase in pH is significantly above 3.5, higher quantities of ferric hydroxide will precipitate out of the stream water during periods of rain or snow melt.

Several significant areas of pyrite weathering were seen in the Duchesne River Formation just above the headwaters of the intermittent stream where the springs are located (photograph P24b and P24c – Appendix A). Similar lenses of pyrite rich sediments beneath the surface may be responsible for the high concentrations of sulfate and iron in the stream water and the low pH of the stream water.

The elevated levels of cadmium in the water may be due to the presence of phosphate bearing rocks in northeastern Utah (Hyatt and Budd, 2003). Cadmium is present in elevated levels in phosphate rocks and is often found in phosphate fertilizers. Hyatt and Budd (2003) reported that samples of the Permian Phosphoria Rock Complex taken from the Vernal – Bush Creek section had cadmium levels that ranged from 1 to 4 ppm and averaged 2.6 ppm (from 49 samples). This may be the source of the cadmium in the stream water.

5.2 Stream Flow Rate: A small water fall allowed the stream flow to be measured using the bucket method (Fig. 3 and photograph P15 – Appendix A). The stream flow was measured at 67.11 gallons per minute (average of 6 measurements).

Summary and Conclusions: Multiple factors contribute to the absence of any seeps or springs on the Temple Mountain Mine sight. This is an arid area with approximately 8 inches of rain per year. This low amount of rainfall and the high evaporation rates doesn't allow for a significant buildup of groundwater which would lead to the formation of seeps and springs. Adding to the low amounts of groundwater are the surface exposures of oil sands, which act as very effective barriers to the downward infiltration of water, as evidenced by the presence of the intermittent stream along the east side of the mine site, but its disappearance south of the mine site due to the relatively steep dip of the oil sands to the south, versus the dip of the topography of the land. Further evidence of insufficient groundwater to form seeps and seeps and springs is the low number of wells in the boundary area with any groundwater close to the surface. Higher than average total rainfall during three months prior to the survey failed to produce any seeps or springs, adding to the conclusion that this area does not have any perennial seeps and springs and is not prone to having seasonal seeps or springs. The only springs and seeps are to the north of the property, which is the source of the water for the intermittent stream that runs through the survey area.

The AMD from Asphalt Ridge is not as severe as the AMD that is produced from abandoned mines and tailings piles, especially the coal mines in the Appalachian Mountain region. It should be remembered though, that the AMD from abandoned mines and tailings and overburden piles is worse due to the fact that the water is passing through material that has been mined and crushed, dramatically increasing the surface area for the chemical reactions that breakdown the sulfate minerals that cause AMD. The AMD from Asphalt Ridge, although not as severe as that found in other locations, still deteriorates the stream water quality, so that it does not pass the EPA's National Secondary Drinking Water Regulations. The National Secondary Drinking Water Regulations are non-enforceable guidelines regulating contaminants that may cause negative cosmetic effects (skin or tooth discoloration) to the water user or produce unpleasant aesthetics in drinking water, such as an unpleasant taste, odor, or color.

Cadmium concentrations in drinking water are regulated by the EPA's National Primary Drinking Water Regulations. National Primary Drinking Water Regulations are legally enforceable standards that apply to public water systems. Cadmium concentrations in groundwater are regulated by the Utah Administrative Code. Cadmium is regulated due to the fact that ingesting excessive levels can cause kidney damage. The cadmium in the intermittent steam is three times higher than the Maximum Contaminant Level (MCL) set by the EPA for drinking water and just above the level set for groundwater by the State of Utah. Considering the fact that the cadmium in the stream water is most likely sourced from the phosphate rock in the area, it will undoubtedly always be found in the intermittent steam water. Whether this level continues to stay above the EPA's and Utah's maximum levels can only be determined with continued testing. Due to the fact that the cadmium levels in the intermittent stream are not associated with oil sands, mining activity at the Temple Mountain Mine site will have no effect on these levels

The absence of seeps and springs on the Temple Mountain Mine site means that future mining activity will have no effect on the quantity or quality of the water emanating from seeps and springs in this area.

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Appendix A

Photographs of the Temple Mountain Mine Site

Photograph P1. Intermittent stream near the southern boundary of the survey area. 355^o orientation. The hydrophytic vegetation is primarily Reed canary grass (*Phalaris arundinacea)*, Broadleaf cattail *(Typha latifolia)*, Salt Cedar (*Tamarix ramosissima)*, and Russian Olive (*Elaeagnus angustifolia)*. Elevation – 4989 feet. See figure 3 for location of picture.

Photograph P2a. Ephemeral tributary stream 2 - A near the southern boundary of the survey area. 160^o orientation. This ephemeral stream is a tributary of ephemeral stream 2 (identified by the URS Corporation (2008) in figure 4). Elevation 4991 feet. See figure 3 for location of picture.

Photograph P2b. Ephemeral tributary stream 2 - A near the southern boundary of the survey area. 355^{o} orientation. This ephemeral stream is a tributary of ephemeral stream 2 (identified by the URS Corporation (2008) in figure 4). Elevation 4991 feet. See figure 3 for location of picture.

Photograph P3a. Ephemeral stream 2 (identified by the URS Corporation (2008) in figure 4) near the southern boundary of the survey area. 147^{o} orientation. No seeps or springs were seen beneath the prominent ledges along the stream bank. Elevation 4980 feet. See figure 3 for location of picture.

Photograph P3b. Ephemeral stream 2 (identified by the URS Corporation (2008) in figure 4) near the southern boundary of the survey area. 312^o orientation. No seeps or springs were seen along the steep erosion cuts of the stream bank. Elevation 4984 feet. See figure 3 for location of picture.

Photograph P4. Ephemeral stream 2 (identified by the URS Corporation (2008) in figure 4) near the southern boundary of the survey area. 350^o orientation. No seeps or springs were seen along this reach of stream. The pile to the right is a waste pile of mining overburden. Elevation 4998 feet. See figure 3 for location of picture.

Photograph P5. Ephemeral stream 2 (identified by the URS Corporation (2008) in figure 4) near the lower middle section of the survey area. 350° orientation. No seeps or springs were seen along this reach of stream. The waste pile of mining overburden is to the immediate right of this picture location. Elevation 5006 feet. See figure 3 for location of picture.

Photograph P6a. Intermittent stream 1 (identified by the URS Corporation (2008) in figure 4) near the middle section of the survey area. 170^o orientation. The stream cuts directly into oil sands bedrock. No springs or seeps were seen next to, or feeding the stream bed. The vegetation was very close to the stream along this reach, strongly suggesting that the stream was the only source of water at this location. Elevation 5042 feet. See figure 3 for location of picture.

Photograph P6b. Intermittent stream 1 (identified by the URS Corporation (2008) in figure 4) near the middle section of the survey area. The rocks and vegetation were colored yellowish brown at this location suggesting that iron oxide or ferric hydroxide was the cause of this coloration. Elevation 5042 feet. See figure 3 for location of picture.

Photograph P7. Ephemeral stream 2 (identified by the URS Corporation (2008) in figure 4) near the middle section of the survey area. 180^{o} orientation. No seeps or springs were seen along this reach of stream. The steam along this reach had a less defined channel and had more of an overland flow character. Elevation 5035 feet. See figure 3 for location of picture.

Photograph P8. Ephemeral stream 2 (identified by the URS Corporation (2008) in figure 4) near the upper middle section of the survey area. 336^o orientation. This picture shows where two cut banks are in the process of forming a dry oxbow lake. Elevation 5050 feet. See figure 3 for location of picture.

Photograph P9. Ephemeral stream 2 (identified by the URS Corporation (2008) in figure 4) near the upper section of the survey area. 316^o orientation. No seeps or springs were seen along the steep uphill slopes to the east of this stream and the steep erosional cut was completely dry. Steep sided erosional features are characteristics of desert environments where short and intense rain events lead to rapid erosion with little erosion occurring at other times due to low amounts of rainfall and/or water flow from natural springs. Elevation 5085 feet. See figure 3 for location of picture.

Photograph P10a. Ephemeral stream 3 (identified by the URS Corporation (2008) in figure 4) near the western most border of the survey area. 276^{o} orientation. No seeps or springs were visible along the base of the steep slope to the right of the photograph. Elevation 5050 feet. See figure 3 for location of picture.

Photograph P10b. Ephemeral stream 3 (identified by the URS Corporation (2008) in figure 4) near the western most border of the survey area. 130^{o} orientation. No seeps or springs were visible beneath the ledges along this reach of the ephemeral stream. Elevation 4980 feet. See figure 3 for location of picture.

Photograph P11. Ephemeral stream 3 (identified by the URS Corporation (2008) in figure 4) near the western most border of the survey area. 130° orientation. No seeps or springs were visible beneath the ledges along this reach of the ephemeral stream. Elevation 5027 feet. See figure 3 for location of picture.

Photograph P12. Ephemeral stream 3 (identified by the URS Corporation (2008) in figure 4) near the southwestern most border of the survey area. 33^{o} orientation. No seeps or springs were visible uphill of the location from where this photo was taken. Elevation 4969 feet. See figure 3 for location of picture.

Photograph P13. Ephemeral stream 3 (identified by the URS Corporation (2008) in figure 4) near the southwestern most border of the survey area. 145° orientation. No seeps or springs were visible at the base of the steep slope to the left in this picture. This picture was taken just downstream of where ephemeral tributary 3 – A intersects ephemeral stream 3. Elevation 4960 feet. See figure 3 for location of picture.

Photograph P14. Ephemeral tributary stream 1-B where it intersects intermittent stream 1 (identified by the URS Corporation (2008) in figure 4) near the eastern border of the survey area. 33^o orientation. No seeps or springs were visible beneath the ledges seen along this tributary. Elevation 5014 feet. See figure 3 for location of picture.

Photograph P15. Intermittent stream 1 (identified by the URS Corporation (2008) in figure 4) near the eastern border of the survey area. Stream flow was measured using the bucket method at this location. Elevation 5020 feet. See figure 3 for location of picture.

Photograph P16a. Intermittent stream 1 (identified by the URS Corporation (2008) in figure 4) near the eastern border of the survey area. 95° orientation. The stream cuts into and is directly on top of oil sands bedrock at this location. Elevation 5079 feet. See figure 3 for location of picture.

Photograph P16b. Intermittent stream 1 (identified by the URS Corporation (2008) in figure 4) near the eastern border of the survey area. The rust coloring is iron hydroxide from the weathering of pyrite nodules in the oil sands bedrock at this location. The overall equation of this reaction is…

FeS_2 (*solid*) + $15O_2$ + $14H_2O$ > $16H^+$ (*aqueous*) + $8SO_4^{2-}$ (*aqueous*) + $4Fe(OH)_3$ (*s*) (Thorsten, 2013).

Elevation 5079 feet. See figure 3 for location of picture.

Photograph P18. Ephemeral stream 1 (identified by the URS Corporation (2008) in figure 4) near the northern border of the survey area. 33^o orientation. Thick vegetation prevented the identification of any seeps or springs in this area. The continuation of the vegetation up two separate tributaries strongly suggests that the majority of the stream water originated upstream of this location. Elevation 5120 feet. See figure 3 for location of picture.

Photograph P19. Ephemeral tributary stream 1-C at the intersection of intermittent stream 1 (identified by the URS Corporation (2008) in figure 4) near the northern border of the survey area. 240° orientation. No seeps or springs were seen along the steep sided slopes of this ephemeral tributary stream. Elevation 5137 feet. See figure 3 for location of picture.

Photo P21. Side wall of the open pit mine showing exposed oil sands ore. No seeps or springs were evident on the sidewalls or floor of the mine despite being approximately 500 feet from the intermittent stream and at a lower elevation (approximately 5000 feet as opposed to the 5080 feet elevation of the stream).

Photo P22. The intermittent stream bed is dry approximately halfway between the Temple Mountain Mine site and the Green River. The stream runs dry due to the fact that the steeply dipping oil sands beds dip below the water which allows the stream water to infiltrate the soil.

Photo P23. The intermittent stream bed is dry where it meets the Green River. 350° orientation

Photograph P24a. Western headwaters of intermittent stream 1 (identified by the URS Corporation (2008) in figure 4) north of the border of the survey area. 225^{o} orientation. The springs appeared to flow from the base of the steep sided slopes surrounding the stream. A red to yellowish red staining was clearly evident around the perimeter of the head of the stream which may be the result of ferric hydroxide precipitation from the weathering of pyrite within the Duchesne River Formation. Elevation 5225 feet. See figure 5 for location of picture.

Photograph 24b. Heavily weathered pyrite containing sediments of the Duchesne River Formation just above the headwaters in Photograph 24a. A similar lens of pyrite rich sediments beneath the surface may be responsible for the high concentrations of sulfate and iron in the water and the low pH of the water.

Photograph 24c. Heavily weathered pyrite containing sediments of the Duchesne River Formation just above the headwaters in Photograph 24a.

Photograph P25. Eastern headwaters of intermittent stream 1 (identified by the URS Corporation (2008) in figure 4) north of the border of the survey area. 225° orientation. The single spring appeared to flow from the base of the steep sided slope surrounding the stream. A black to dark reddish brown staining was clearly evident along the upper reach of this stream which may be the result of ferric hydroxide precipitation. Significantly, there is no vegetation growing along the upper reach of this stream which strongly suggests that the water chemistry is prohibiting the growth of vegetation. It also suggests that there is a second spring supplying additional water to this stream, just below this reach, that allows vegetation to grow. Elevation 5240 feet. See figure 5 for location of picture.

Photograph P26a and b. Standing water in ephemeral tributary stream 1-B (see figures 3, 4 and 6). Standing water was due to a manmade earthen dam. Hydrophytic vegetation (cattails and reed canary grass) present. The high-water mark around the perimeter of the pond and the subaerially exposed delta indicate that the water level is down approximately 2 feet. Below average rainfall during June resulted in the lowering of the water level due to evaporation exceeding precipitation.

MCW Energy Group

Technology Overview

Asphalt Ridge, Uintah County, Utah

October 15, 2015

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Introduction: As a non-convention hydrocarbon resource, oil sands hold billions of barrels of oil all over the world. The world's largest oil sands deposits are found in western Canada, where over 170 billion barrels of bitumen are found close to the surface. The oil sands of western Canada are being developed using hot water (Clark hot water extraction) and steam (Steam Assisted Gravity Drainage - SAGD). Both of these technologies consume tremendous amounts of water and energy (natural gas for heating water and producing steam), emit excessive amounts of greenhouse gases and, in the case of hot water extraction, produce huge tailings ponds that are polluted with the oil that is not fully extracted from the sands. In addition to multiple environmental issues, the shortcomings and inefficiencies of these technologies result in exceptionally poor economics on a per barrel production basis.

MCW Energy Group recognized the inherent shortcomings of the hot water and steam based oil extraction technologies and developed a new technology to overcome these shortcomings that uses solvents, instead of water, to recover the oil from the oil sands.

1.1 MCW Energy Group Technology Overview: MCW Energy Group's (MCW) proprietary technology uses a chemical solvent, instead of water, to extract the oil from oil sands. MCW's solvent is composed of multiple individual components (multiple light hydrocarbons and alcohols) which, when combined, are capable of dissolving and recovering over 99% of the bitumen, heavy oil and other lighter hydrocarbons that are found in oil sands. This solvent contains no chlorinated compounds, or dense non aqueous phase liquids (DNAPL). MCW's technology is able to extract the oil at much lower operating temperatures (50^{oc} to 60^{oc}) than either the Clark hot water extraction, or SAGD processes. The components of MCW Energy Group's unique solvent form an azeotropic mixture that boils at a relatively low temperature (70^{oc} – 75^{oc}). This guarantees a high level of energy efficiency during the oil extraction process. MCW's proprietary design also includes exceptionally efficient heat exchange systems and distillation/rectification systems. This energy efficiency makes MCW's extraction facilities extremely economical to operate. By comparison, the Clark hot water extraction and SAGD technologies are far less energy efficient and ultimately far less economical to operate than MCW's oil extraction facilities.

MCW's oil extraction process takes place in a completely closed loop system that continuously recirculates the solvent after it has separated the bitumen and heavy oils from the oil sands. As mentioned above, the closed loop system is capable of recovering over 99% of the bitumen and oil from the oil sands making this technology very environmentally friendly. Unlike the tailings pond sands produced by the Clark hot water extraction technology, the processed sands from MCW's technology are virtually solvent and hydrocarbon free, which enables it to be either used in mine remediation operations, or sold for use as a construction aggregate. Independent laboratory analysis of the synthetic leachate produced from the MCW processed sands show extremely low levels of hydrocarbons (Appendix A).

1.2 How MCW's Technology Works. During the first stage of the oil extraction process, crushed oil sands ore is premixed with MCW's solvent in a special mixing vessel located at the top of the facility tower (Fig. 1). The resultant slurry then passes vertically downward through a pug mill that further crushes any clumps of oil sands ore allowing greater contact area between the solvent and the oil sands which helps make the recovery operation more efficient. The slurry is then fed into the primary oil recovery vessel located at the base of the facility tower, where more solvent is added to the slurry and the majority of the oil is recovered from the oil sands. The slurry is then pumped into MCW's patented, pseudo-boiling layer fluidized bed extraction column (Fig. 2). The patented design of the extraction column is a key reason for the exceptionally high rate of oil extraction, over 99%. The solids (mainly clean sand and clay) settle to the bottom of the extraction column while the solvent/oil mixture leaves the top of the extraction column and is deposited into a surge tank.

The solvent/oil mixture is then pumped from the surge tank to the distillation column (Fig. 2). As mentioned above, the solvent/oil mixture is heated under relatively low heat conditions and the light hydrocarbon and alcohol solvent is separated from the oil by distillation. The distillation process is designed to allow some of the lighter hydrocarbons in the solvent to remain in the solvent/oil mixture in order to give the customer an oil with the specific API to meet their needs. This can range from light API oil (>31.1^{o}) medium API oil (22.3^{o} – 31.1^{o}), to heavy API oil (<22.3^{o}), depending upon the needs of the end user (purchaser). After separating the solvents from the oil, the oil is pumped into the onsite storage tanks and/or delivery trucks and shipped to the customer. All the solvent vapors produced by the distillation process are collected and then condensed in a chiller and returned to the closed-loop system where they are used to recover more oil from incoming oil sands ore (Fig. 1).

During the final stage of the operation, the clean sand is transferred from the extraction column into the drying vessel to begin the drying process (Fig. 3). The sand is heated by steam lines within the drying vessel in order to vaporize any remaining solvent in the sand. The vaporized solvent is recovered from the drying vessel, condensed in the chiller and recycled in the closed loop system. Over 99% of the solvent is recovered and recycled from the processed sand. The clean, dry sand can then be sold as a construction aggregate or used in mine remediation.

Figure 1. Conveyor belt loading oil sands ore into the premixing vessel at the top of MCW's oil sands extraction facility in Maeser, Utah, USA. The gray, horizontal structure immediately below the conveyor belt is the chiller used to condense all the vaporized solvent that is collected from the sand drying vessel. The condensed solvent is recycled through the closed loop system and reused.

Figure 2. MCW patented, pseudo-boiling fluidized bed extraction column in the foreground. The extraction column increases oil recovery to over 99%. The distillation column used for separating the solvent from the oil is in the background. All vaporized solvent is collected, condensed (see chiller in figure 1) and recycled in the closed loop system.

It is important to note that MCW has tested its technology on oil sands from different locations around the world that have very different hydrocarbon chemical compositions. MCW has found that the efficiency and consistency of their technology is not affected by differences in the chemical composition of the oil/bitumen in the oil sands. An example of the technology's efficiency and consistency, despite dramatic differences in oil/bitumen chemistry, are the results of extensive testing on oil sands samples sourced from both Utah and China (Table 1, Appendix B and C). In both cases, MCW's recovery efficiency exceeded 99%.

Figure 3. MCW oil sands drying vessel in Maeser, Utah. The post processed sands are heated with steam to vaporize any remaining solvent in the sand. All vaporized solvent is collected, condensed and returned to the closed loop system to start the process over again. This process recovers over 99% of the solvent for reuse.

1.3 Energy Returned Over Energy Invested: By using solvents instead of hot water or steam, MCW's technology immediately realizes a dramatic reduction in the energy required to produce a barrel of oil from oil sands. MCW's process also employs multiple energy saving technologies to reduce energy requirements even further. A third party consultant, Chapman Petroleum Engineering, performed an extensive energy analysis of MCW's technology and determined that the combined effect of all the energy saving features of MCW's technology is a 45:1 EROEI (energy returned over energy invested) ratio (Chapman, 2011 – Appendix D). To be conservative, Chapman reduced this ratio to 22:1 to account for any unforeseen energy losses. A 22:1 EROEI compares very favorably to EROEI values of 4:1 for SAGD and 6:1 for Clark hot water extraction.

Table 1. Chemical comparison between oil sands samples sourced from Utah, USA and China

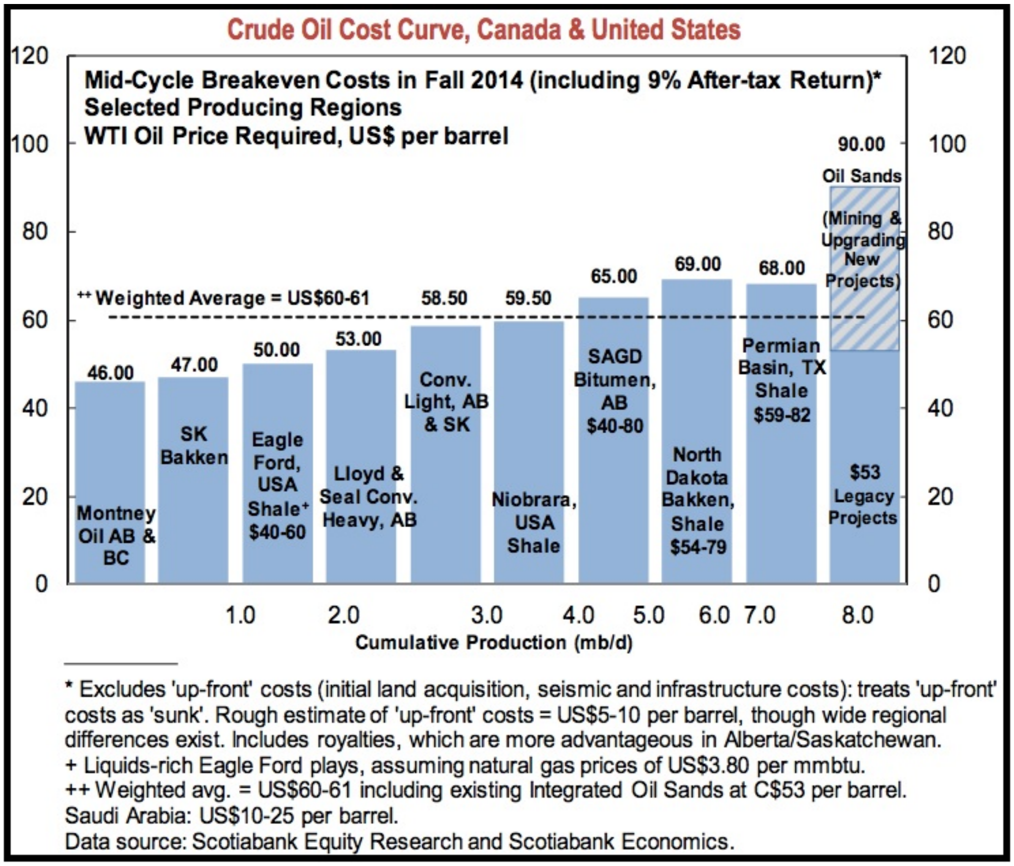
Location	**Saturated Hydrocarbons**	**Aromatic Hydrocarbons**
Utah (Asphalt Ridge)[1]	29.3%	28.4%
China[2]	61.06%	5.34%
China[3]	78.87%	4.43%

1 - Oblad, et al. (1975)
2 - Zhi-Nong Gao, Li-Bo Zeng and Fei Niu (2005) - 5 sample average
3 - MCW testing (Appendix B) - 3 sample average

2.0 MCW Extraction Costs: Based upon conservative and reasonable assumptions, the Monte Carlo simulations performed by Chapman (2011- Appendix D) determined, with a 90% confidence level, that MCW's technology processing costs will range from $22.84 to $38.87 per barrel. A second study performed by Chapman Petroleum Engineering (2012 - Appendix E) again estimated that the production costs for MCW's solvent based extraction process would range between $24.51 and $34.04 per barrel.

A recent, confidential third party analysis of MCW's technology, including a multi-day site visit at the company's 250 barrel per day plant in Maeser, Utah, confirmed that production costs for a light-sweet crude oil are $33.40 per barrel and $31.30 per barrel for oil sands having 4.75% and a 10% (weight percent) oil, respectively. A follow up report from the same third party estimated that production costs for a larger plant (2500 barrels per day) would be in the mid $20 per barrel range with significant room to reduce those costs further.

In response to the falling price of oil, Scotiabank published a comparison of the per barrel breakeven costs between various conventional Canadian light and heavy oil plays, US based tight shale plays and Canadian oil sands projects (Fig. 4) (Scotiabank, 2014). The mid-cycle breakeven costs for legacy oil sands projects are approximately $53 per barrel, $40 to $80 per barrel for SAGD and $90 per barrel for mining and upgrading new projects. In comparison to these production costs, MCW's production costs are very competitive.


Crude Oil Cost Curve, Canada & United States

* Excludes 'up-front' costs (initial land acquisition, seismic and infrastructure costs): treats 'up-front' costs as 'sunk'. Rough estimate of 'up-front' costs = US$5-10 per barrel, though wide regional differences exist. Includes royalties, which are more advantageous in Alberta/Saskatchewan.
\+ Liquids-rich Eagle Ford plays, assuming natural gas prices of US$3.80 per mmbtu.
++ Weighted avg. = US$60-61 including existing Integrated Oil Sands at C$53 per barrel.
Saudi Arabia: US$10-25 per barrel.
Data source: Scotiabank Equity Research and Scotiabank Economics.

Figure 4. Comparison of breakeven costs for various tight shale plays and Canadian oil sands projects.

Source: Scotiabank Commodity Price Index, November 28, 2014.

Direct evidence of the poor economics of both the hot water and SAGD technologies comes in the form of the multiple oil sands operations that have shut down in Canada due to poor economic returns. For example, Total and partners Suncor and Occidental Petroleum shut down the Joslyn oil sands project in Canada in 2014 after spending $11 billion on the project (Globe and Mail, May 29, 2014). Mr. Andre Goffart, head of Total's Canadian division, stressed that the "*Joslyn decision is due to the project's costs, saying its technology and execution plans must improve*". The Joslyn operation first used SAGD before switching to hot water extraction. Clearly this is an acknowledgement by three major oil companies that hot water and SAGD technologies are not economically competitive in the current oil price environment.

3.0 Summary and Conclusion: The inherent shortcomings of both the Clark hot water and SAGD technologies cannot be overcome, no matter how they are modified. Their reliance on using energy in the form of heat to create hot water and steam will always have a very strong negative affect on the economics of extracting oil from oil sands. No better evidence of this is the closing of the Joslyn oil sands operation by Total, Suncor and Occidental petroleum after spending a total of $11 billion dollars on the project. Andre Goffart's public statement that the "*Joslyn decision is due to the project's costs, saying its technology and execution plans must improve*" certainly confirms the fact that new technology is needed for oil sands extraction.

By abandoning the conventional energy based methods of oil sands extraction and developing a new, proprietary solvent based technology, MCW has simultaneously addressed both the environmental problems (excessive water use, water pollution from tailings ponds, excessive energy consumption and excessive greenhouse gas emissions) and poor economics associated with hot water and SAGD extraction technologies and in doing so, has developed the "new technology" that Andre Goffart was referring to.

Recent third party analysis of MCW's technology and plant operations confirm that oil can be produced in the low $30 per barrel range and lower still if a larger plant is built, due to the efficiencies of economies of scale. This production cost is very competitive in the present oil price environment.

Additionally, the solvents used in MCW's technology (light hydrocarbons found in naturally occurring natural gas condensate liquids and alcohols) and the trace quantities of hydrocarbon compounds found in the SPLP leachate test are light non-aqueous phase liquids (LNAPL). LNAPLs are much less harmful to the ground water (they float on water due to their lower density) and the environment in general than dense non-aqueous phase liquids (DNAPL). DNAPLs are significantly more damaging to the environment, are more difficult and much more expensive to clean up if groundwater remediation is required, not only because they sink in the water column and impact deeper and larger volumes of water, but also because they are generally non-petroleum and more likely chlorinated compounds. Most chlorinated compounds are listed as hazardous wastes.

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TEST REPORT

DATE: September 29, 2013
Sample Origin: Asphalt Ridge, Utah
Contact: Rob Cowley/435-671-2430
Project: Analysis of the bitumen extracted from the Asphalt Ridge native oil sands ore using MCW patented extraction technology and solvent composition.
Product: Asphalt Ridge oil sands sample.
MCW Reference Number : CA-CU-092913/ES

Experimental Design Summary:

25 Lbs native oil sands ore sample has been received in MCW laboratory from Asphalt Ridge oil sands mine in Utah. Testing was performed by extracting bitumen from the oil sands sample using MCW proprietary/patented oil from oil sands extraction method. Saturation of the oil sands with bitumen has been determined by weight. Afforded bitumen/hydrocarbons were tested on API gravity and were analyzed using MS-GC and FTIR analysis methods. Every test has been repeated 3 times.

Table 1: Observations

Original Sample	**Sticky solid black oil sands sample, with specific hydrocarbon odor**
Processed Bitumen	**Thick dark viscous heavy oil with strong hydrocarbon odor**
Processed solid phase	**Clean off white sand**

Table 2 Solid phase saturation with hydrocarbons analysis before processing

Test Number	Bitumen (% by weight)	API Gravity
1	12.22	11.6
2	12.37	11.8
3	12.28	11.7

Table 3 Solid phase saturation with hydrocarbons analysis after processing

Test Number	Bitumen (% by weight)	API Gravity
1	Less than 0.1	N/A
2	Less than 0.1	N/A
3	Less than 0.1	N/A

Table 4 Analysis of the Hydrocarbons/Bitumen afforded from the oil sands

Test Number	Viscosity, CP 225 F	Viscosity, CP 320 F	Pour point, F	S (Sulfur), wt%
1	448	75	111	0.37
2	445	76	109	0.33
3	446	76	112	0.34

CONCLUSIONS

1. MCW oil from oil sands extraction technology process can be successfully applied to produce bitumen/heavy oil from the native oil sands ore with efficiency of 99.9%.

2. Analyzed samples of the Asphalt Ridge, Utah oil sands have hydrocarbon saturation in the range of 12.2% to 12.4%

3. Analyzed samples of the tailing sands afforded after hydrocarbons extraction from the native oil sands of Asphalt Ridge, Utah have shown residual bitumen/hydrocarbons content less than 0.1% by weight.

4. Asphalt Ridge bitumen has API gravity in the range of 11.6 to 11.8 and it is flow able at the temperatures higher than 120 F. It is comparable to the oil sands from Athabasca oil sands region in Alberta, Canada

5. Asphalt Ridge oil sands contains between 0.34% to 0.37% of sulfure that is a significantly less sulfur compare to the Athabasca oil sands reserves in Alberta, Canada.

Chief Technology Officer ______Signed_____________ Date: September 29, 2013
Vladimir Podlipskiy,

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REPORT ON OIL SANDS SAMPLE #1 FROM CHINA

DATE: **June 23, 2014**
Sample Origin: KYD, China
Contact: Elton Zeng

Project: ***Analysis of the oil sands samples from China on the oil content and applicability of MCW oil from oil sands extraction process for commercial oil production in China***

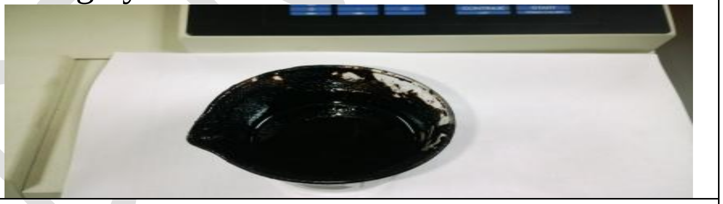
Product: Oil sands from China. Sample #1.
MCW Reference Number: ***CA-CU-06142014/ES1***

Experimental Design Summary:

34 Lbs native oil sands ore sample has been received in MCW laboratory from China. Part of the sample # 1 has been grinded and treated with MCW patented solvent composition used in oil from oil sands extraction process in MCW production plant built in Utah, USA. Heavy oil/bitumen has been extracted, separated on different fractions and analyzed on the hydrocarbon content, type, and distribution. Saturation of the native oil sands ore with the hydrocarbons (% weight) has been determined. Afforded oil/bitumen (hydrocarbons) were analyzed using GC and FTIR/IR analysis methods. Density/API Gravity and viscosity of the afforded hydrocarbons have been determined. Combustion elemental analysis has been performed to determine the content of carbon, hydrogen, nitrogen and sulfur

in the afforded hydrocarbons. ICPMS tests have been performed to determine the heavy metal content/distribution in the afforded hydrocarbon materials. Additional testing has been performed to determine the BTU value/energy per pound for the hydrocarbon material extracted from the native oil sands ore. Processed solid tailings after the extraction were analyzed on the hydrocarbons content. Every test has been repeated 3 times. The following results have been obtained and analyzed.

Table 1: Observations

Original Sample # 1 of the oil sands from China	Large sticky solid black oil sands rocks with specific hydrocarbon odor 
Extracted hydrocarbons (Heavy Oil/Bitumen) afforded from original oil sands from China, sample # 1 using MCW process and solvent composition	Thick black viscous heavy/gummy liquid with strong hydrocarbon odor 
Asphaltene/Asphalt afforded from the hydrocarbon mixture extracted from the native oil sands ore of the sample # 1 from China	Solid powder with the specific asphalt odor 
Clean sand after hydrocarbon extraction from original oil sands from China, sample # 1	Clean dry sand after extraction. Rocks of the original oil sands before extraction have shown for the comparison. 

Total hydrocarbons content in the native oil sands ore has been determined before and after the extraction process with MCW solvent composition. The following data have been obtained.

Table 2 Total hydrocarbons content in the sample # 1 prior to the extraction

Test Number	Hydrocarbons (% by weight)
1	30.5%
2	28.6%
3	29.2%

Table 3 Total hydrocarbons content in the sample # 1 tailing after the extraction

Test Number	Hydrocarbons (% by weight)
1	Less than 0.1
2	Less than 0.1
3	Less than 0.1

Total hydrocarbons extracted from the native oil sands ore have been separated on two main fractions/compositions Asphaltene and Maltenes. The following data have been obtained.

Table 4 Hydrocarbons composition in the sample # 1 after the extraction

Test Number	Maltenes (% by weight)	Asphaltene (% by weight)
1	70.82	29.28
2	70.16	29.84
3	69.78	30.22

Additional analysis of the Maltenes hydrocarbon types have been performed and the following data have been obtained.

Table 5 Maltenes analysis results by hydrocarbon types (%wt)

Test No	Saturated Hydrocarbons	Unsaturated Hydrocarbons	Aromatic Hydrocarbons	Other Hydrocarbons
1	78.6	6.8	4.2	10.4
2	79.1	6.7	4.5	9.7
3	78.9	7.2	4.6	9.3

Viscosity and API Gravity/Density of the total hydrocarbons fraction extracted from the native oil sands ore have been determined and the following results have been obtained.

Viscosity @ 98 C	**49.52 CsT**
Density	**1.06 g/ml**
API Gravity	**1.99**

Heavy metal elemental analysis (ICPMS) has been performed on the total hydrocarbons fraction extracted from the native oil sands ore. The following data have been obtained**.**

Barium	***14.35***	***PPM***
Iron	***109.00***	***PPM***
Lead	***0.19***	***PPM***
Molybdenum	***7.40***	***PPM***
Nickel	***15 .00***	***PPM***
Strontium	***1.50***	***PPM***

Combustion elemental analysis has been performed on the total hydrocarbons fraction extracted from the native oil sands ore. The following data have been obtained (% wt)**.**

Carbon	***84.75***
Hydrogen	***10.12***
Nitrogen	***0.84***
Sulfur	***4.05***

The heating value/energy of the total hydrocarbons fraction extracted from the native oil sands ore has been determined in the closed bomb colorimeter. The following result has been obtained: ***17,900 BTU/Lbs***

CONCLUSIONS

1. Oil sands # 1 sample from China has extremely high concentrations of the hydrocarbons averaging almost 30% by weight.
2. The majority of the hydrocarbons are Maltenes with straight saturated hydrocarbon chains. Unsaturated and aromatic hydrocarbons are present in moderate rates and significant amount of Asphaltene is present.
3. MCW solvent composition and oil from oil sands extraction process are very effective when applied to produce hydrocarbons from the oil sands ore (sample # 1) from China. The efficiency of the extraction process has been 99.9% of total hydrocarbons obtained/extracted. Very high concentrations of the hydrocarbons in the native ore are making the process even more energy efficient compare to the oil sands production in Utah, USA. Expected energy return can be as high as 1 to 45 times energy invested vs. energy obtained.
4. In addition due to the very high level of the saturated hydrocarbons and Asphaltene in the hydrocarbons extracted from the sample # 1, this material is a very attractive source for the commercial hydrocarbon production. Afforded Maltenes and Asphaltene can be utilized in both oil refinery and high quality asphalt manufacturing processes. In addition the testing results have shown that with slight modification of MCW production process there is a possibility of obtaining both Maltenes and Asphaltene as two separate products of the extraction without additional separation. This approach allows using Maltenes for the oil refinery business and using the Asphaltene straight for the high quality asphalt manufacturing. MCW technology is fully compatible with Chinese sample #1 oil sands type and composition. Commercial development of this reserves would be very effective, energy efficient and economically viable. .

Vladimir Podlipskiy,
Chief technology Officer
June 23, 2014

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September 23, 2011

MCW Energy Group Ltd.
9701 Wilshire Blvd., 10th Floor
Beverly Hills, CA
90212

Attention: Alex Blyumkin

Dear Sir:

Re: Evaluation of Oil Sands Extraction Process – September 1, 2011
NW Asphalt Ridge Area, Utah, USA

In accordance with your authorization, we have prepared this excerpt of the September 14, 2011 Chapman Petroleum evaluation of a proprietary oil sands extraction process, for MCW Energy Group Ltd. (the "Company"), in order to determine the expected value of the Company's technology and business development plan. This evaluation has been conducted in accordance with the APEGGA Practice Standards, and utilizing our September 1, 2011 forecast prices and costs.

Our analysis has included a review of the available technical data including process component performance, ore characteristics at proposed mine site, mining and extraction costs, labor costs, and power costs etc. We have also considered the availability of product markets, and transmission facilities within economic reach of the area.

In forming our opinion of this prospect we have relied to some extent on the information presented by the Company, which, together with our independent analysis and judgment, was sufficient for us to confidently establish the nature of the project and uncertainty involved.

An economic analysis has been performed for the Company's business development plan. The plan calls for a total of 750 STB/d of processing capacity to be built by 2013. This analysis has been utilized predominantly for formulating and supporting our recommendation on the viability of the technology and project proposal. Values established do not necessarily infer the "fair market value" of this development plan. All monetary values presented in this report are expressed in terms of United States dollars.

Based on our analysis, after consideration of risks, we have concluded that the potential of this process is of sufficient merit to justify the business development plan being proposed, and we therefore recommend and support the Company's participation.

All data gathered and calculations created in support of this report are stored permanently in our files and can be made available or presented on request. We reserve the right to make revisions to this report in light of additional information made available or which becomes known subsequent to the preparation of this report. Due to the risks involved in exploring for oil and gas reserves, our assessment of the project cannot be considered a guarantee that any wells drilled will be successful.

Prior to public disclosure of any information contained in this report, or our name as author, our written consent must be obtained, as to the information being disclosed and the manner in which it is presented. This report may not be reproduced, distributed or made available for use by any other party without our written consent and may not be reproduced for distribution at any time without the complete context of the report, unless otherwise reviewed and approved by us.

We consent to the submission of this report, in its entirety, to securities regulatory agencies and stock exchanges, by the Company.

It has been a pleasure to perform this evaluation and the opportunity to have been of service is appreciated.

Yours very truly,

Chapman Petroleum Engineering Ltd.

[Original Signed By:]

C.W. Chapman

C. W. Chapman, P. Eng.,
President

[Original Signed By:]

Roy A. Collver

Roy A. Collver, P. Eng.
Petroleum Engineer

rac/lml/5441
attachments

Oil Sands Extraction Process
Economic Model and Forecast

Process Capital Costs

Average capital required to develop processing capacity is estimated at approximately \$10,000-\$12,000 per STB/d. The overall costs expected to develop the modeled plant sizes are shown in Table 1.

Process Energy and Costs – Assumptions

A probabilistic approach has been taken to determining the energy and cost requirements of the process in order to characterize the risks associated with different factors affecting the efficiency and profitability of the process.

The initial analysis focused on a 250 STB/d pilot scale operation that would be able to be moved from area to area as new ore becomes available.

Several key assumptions were made during this analysis, and they are listed below:

1. The process plant described in this analysis would be sized to handle approximately 26.5 m^3 of crushed ore per hour.

2. The process plant would operate on a 10 hour work day, and be operated every day of the year.

3. Every m^3 of raw crushed ore would consist of approximately 15% extractable hydrocarbon by volume, a conservative estimate considering higher grade ore (>20% hydrocarbon by vol.) is expected.

4. Approximately 4 parts of solvent will be needed for every part of hydrocarbon extracted.

5. A negligible amount (and value) of the solvent will be lost in the final hydrocarbon stream.

6. Electrical energy is available in sufficient quantity, at an expected price of 4.8 cents per kwh.

7. The power requirements of the process, in terms of the caloric energy of the liquid output products compared to the energy required to process the crushed ore, were doubled in the economic analysis to be approximately 20:1 to account for unexpected efficiency losses.

8. The total yearly operation of the plant for the schedule as described will require 24 workers at an average of $64,000 per year in total employment costs.

9. The costs of obtaining crushed ore will range approximately $10-$20 per m^3.

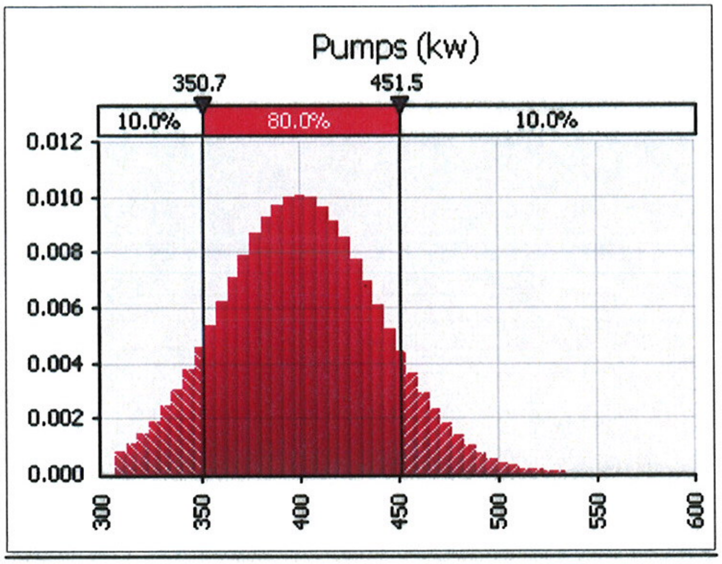
10. The equivalent of approximately 2.5% of the value of the final bitumen products will be lost due to lost solvent to the spent ore.

Energy Consumption Analysis

The following details the energy requirements estimated for a 250 STB/d ($27m^3$/hour) processing plant utilizing this process, and the probability density functions associated with the uncertainty on each component's power usage.

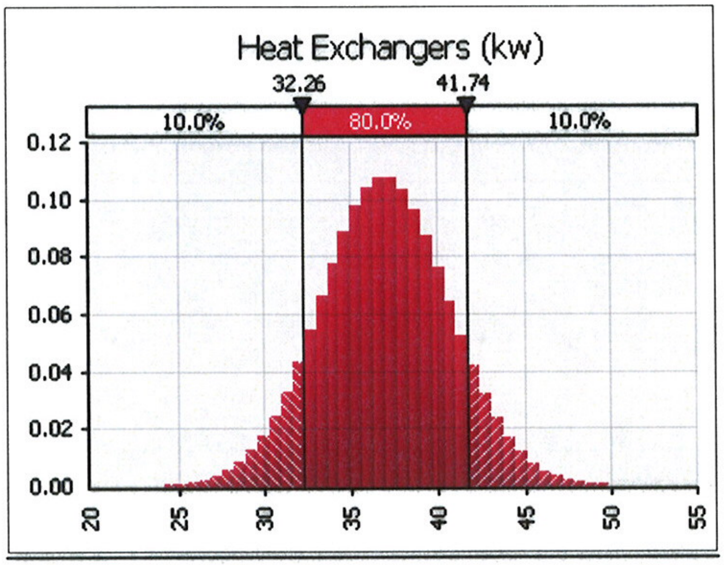
1. **Pumps** – There are 7 pumps for moving hot process water through the system, and one fixed displacement hydraulic pump for moving steam to the evaporator. The total power requirement of all the pumps is expected to be approximately 400 kw, to move approximately 2 tons of steam/hot process water through the system.

   Pump Power Req. PDF



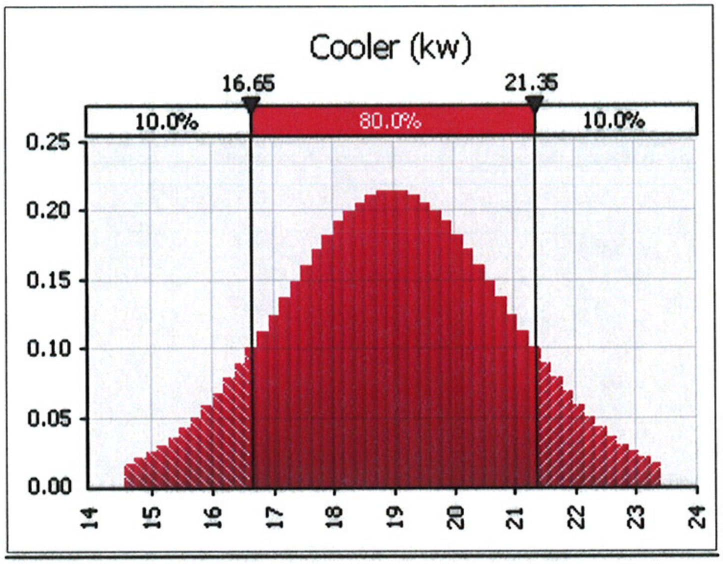
2. **Heat Exchangers –** There is one "tube and shell" style heat exchanger at the solvent heater, before the solvent enters the extractor (stage 8 on Figure 1.) The total power requirements of the heat exchanger are expected to be approximately 37 kw, which will be provided by hot process water that has cooled after the evaporator.

Heat Exchanger Power Req. PDF



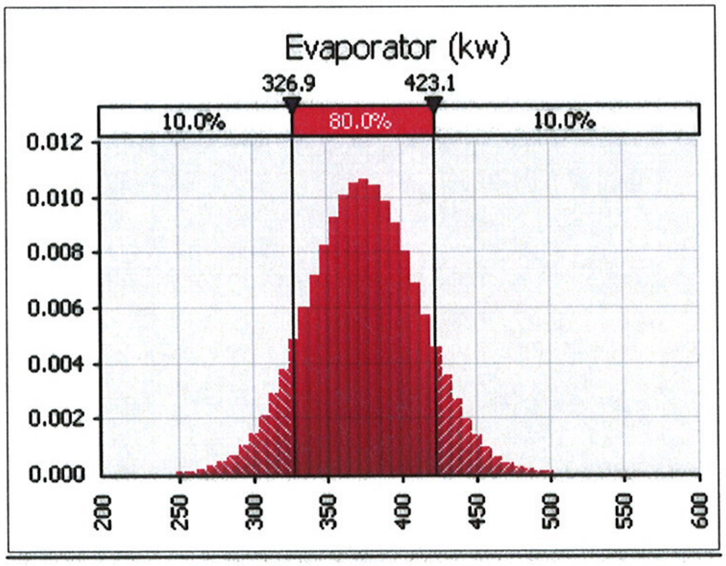
3. **Coolers –** There is one cooler to cool the solvent as it leaves the condenser (Stage 7 on Figure 1). The total power requirements of the cooler are expected to be approximately 19 kw.

Cooler Power Req. PDF



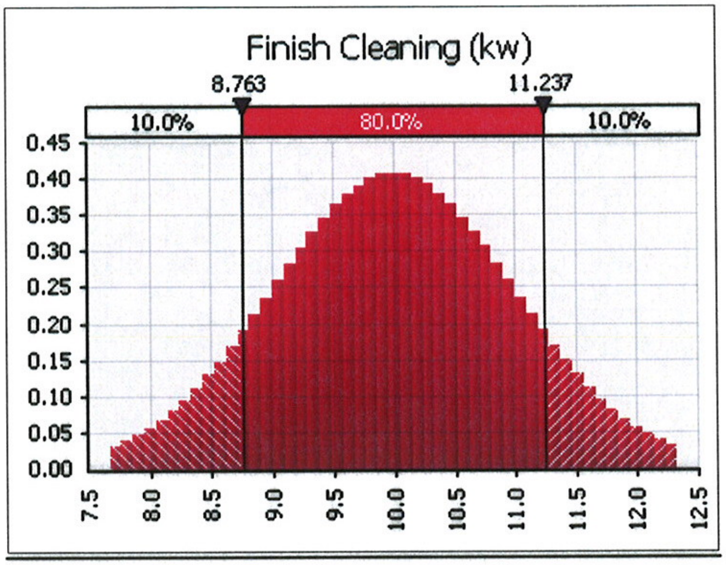
4. **Evaporator** – There is one evaporator to vaporize the solvent and hydrocarbon mixture before it enters the distillation column (stage 5 on Figure 1). The total power requirements of the evaporator are expected to be approximately 375 kw, which will be provided by steam heated by a central boiler.

Evaporator Power Req. PDF



5. **Final Cleaning –** Electric heaters will help to dry the spent ore of remaining solvent. It is expected the heaters will have fairly low power requirements, of approximately 10 kw.

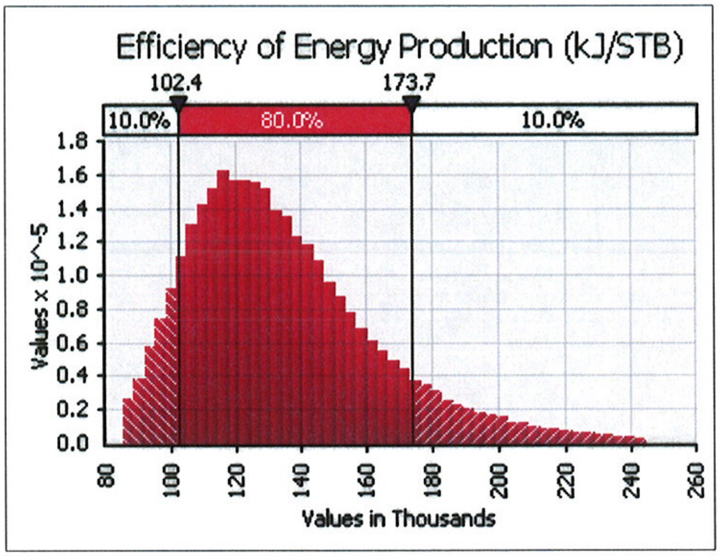
Final Cleaning Power Req. PDF

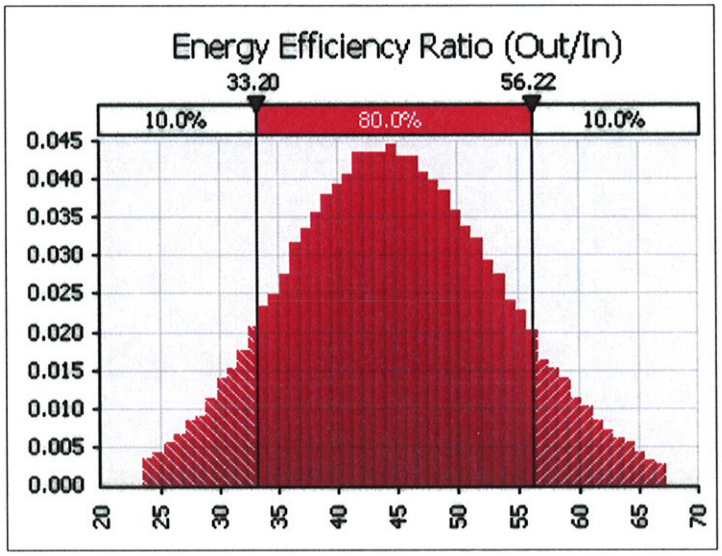


6. **Additional Operating & Contingency –** Approximately 60 kw of additional power requirements were allotted to the process for the general operation of the plant facility, as well as unexpected power requirements. The additional operating and contingency amount was expressed a definite value rather than a probability density function.

Energy Consumption Conclusions

The above probability density functions were used in a Monte Carlo simulation to generate the range of energy consumptions expected for this process.





Figures and above shows the outputs of the Monte Carlo simulation for the total energy required to generate one barrel of finished product (crude bitumen), and the ratio of energy input to energy output in liquids. Further detailed results are shown in Appendix B.

The results of the energy analysis show that this process has an expected energy requirement of 134 MJ per STB of bitumen generated, representing an energy efficiency of approximately 45 to 1 in terms of energy output to energy input (1 STB of bitumen is approximately 5,883 MJ). The reasons for this exceptional efficiency are that the process relies on the effectiveness of the solvent and fluid bed reactor to mix solvent and extract hydrocarbons. All other competing processes (that are currently commercial) utilize vast amounts of energy in the form of steam to heat the bitumen and reduce its viscosity. On this basis, this process would be expected to be economically successful and substantially better than existing competitive processes.

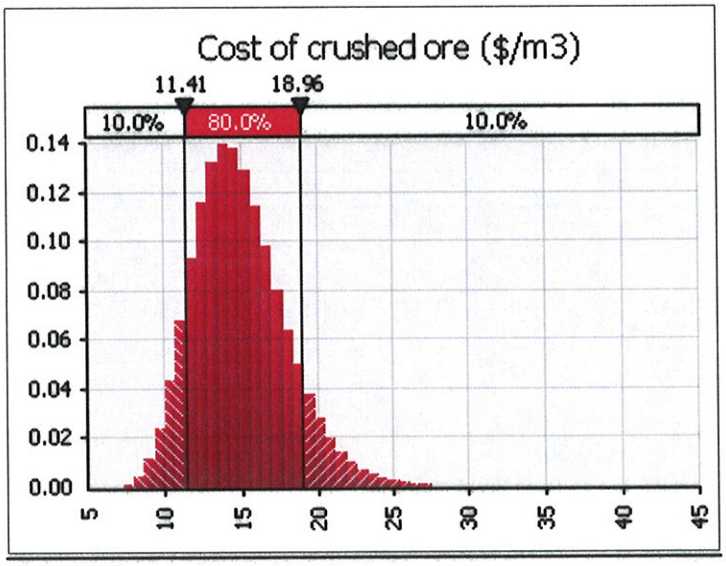
Costs Per STB Analysis

The proceeding analysis of expected energy requirements was incorporated into a statistical model of the overall processing costs per STB of hydrocarbon generated. For the sake of being conservative, the energy requirements of the process were doubled, bringing the expected energy output to input ratio to approximately 22 to 1.

The following details the significant costs associated with this process and the probability density functions that characterize the uncertainty in that variable.

1. **Raw Ore Costs –** It is assumed that the Company will have access to raw crushed oil sands ore in the Asphalt Ridge area of Utah at an average cost of between \$10-\$20/m^3. These costs are considered to be quite reasonable considering that the average costs of operators in the Athabasca oil sands are considered closer to \$10 per STB.

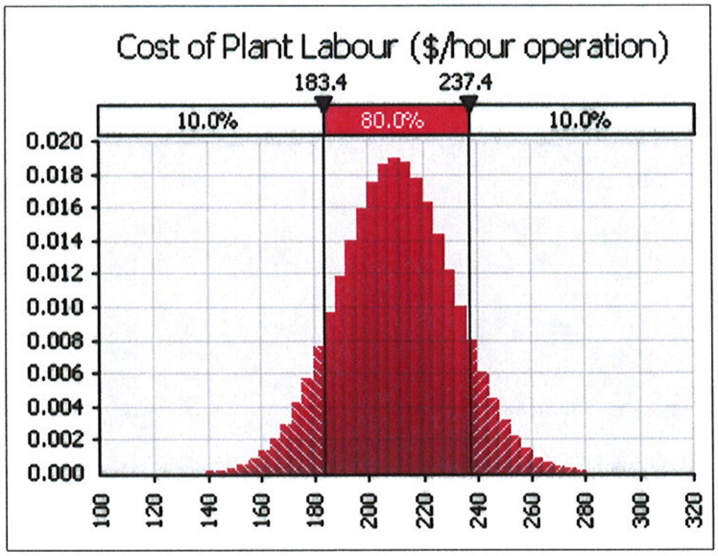
Raw Ore Costs (\$/m$^{3)}$ PDF



2. **Tons of Raw Ore Processed –** The total amount of raw ore processed per hour was expected to be constant at 27 tons, or 26.52 m^3/h.

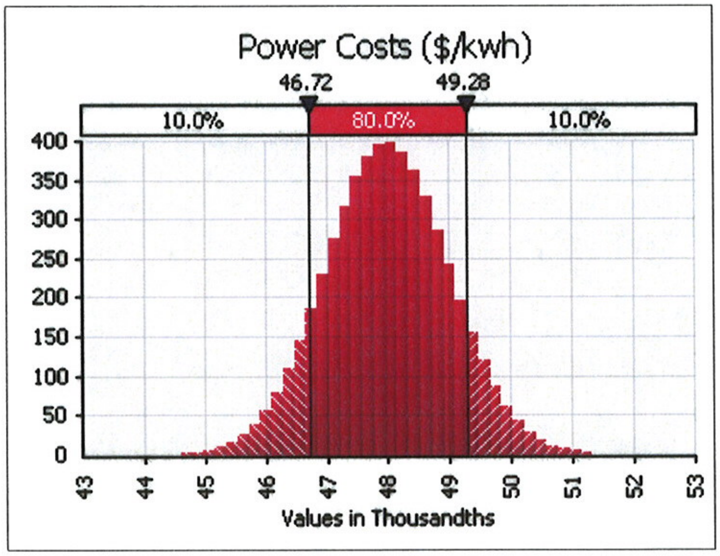
3. **Labour Costs –** It is assumed that the plant will be in operation for 10 hours per day, 365 day per year. That is expected to require 2 crews of six workers, who will on average cost $64,000 per year to employ.

Labour Costs ($/plant op hour) PDF



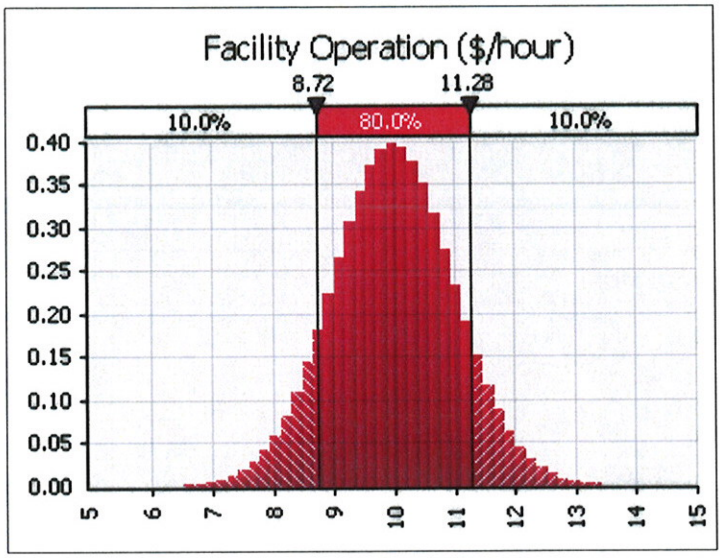
4. **Power Costs –** All power costs were based on the preceeding energy consumption analysis, and assuming an average price of electrical power of $0.048/kwh.

Power Cost ($/kwh) PDF



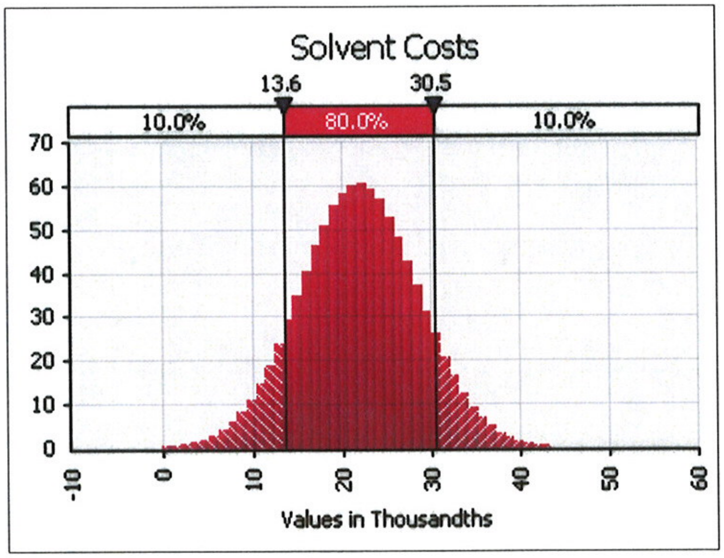
5. **Facility Operation –** An additional $10/hour was added for the costs of operating the facility, administration, custodial etc.

Facility Operation ($/h) PDF

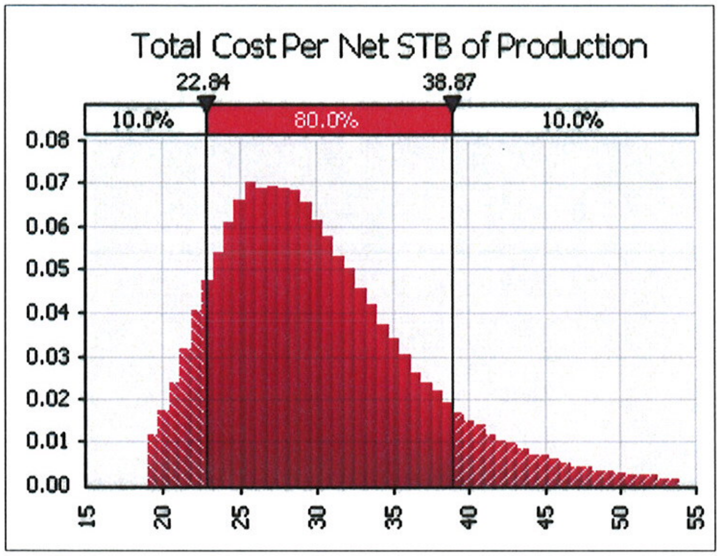


6. **Solvent Losses –** Solvent losses to the spent ore were accounted for as follows. The amount of solvent lost per STB of bitumen produced was estimated, and the cost of that solvent was also estimated (approximately 1.1 * WTI price). The value being lost as solvent in the spent ore was then deducted from the value of the bitumen output stream (Approximately 0.8 * WTI price). The PDF below shows the percentage of the bitumen value which is lost in solvent costs per STB of production.

Solvent Losses % PDF



Based on the probability density functions described above, the following range of processing costs in $ per STB was generated, as shown in Figure below.



Cost Per STB Conclusions

The overall cost per STB is conservatively expected to be in the rage of approximately $25-$40/STB. Comparatively, existing oil sands mining and extraction processes cost approximately $20/STB to produce non-upgraded bitumen, and approximately $40/STB to produce upgraded bitumen. This process is expected to be competitive with the existing hot water processes for water wet reservoirs (i.e.: Athabasca Oil Sands), and far superior for oil wet reservoirs (i.e.: Utah Asphalt Ridge).

Economic Analysis

The results of the energy analysis show that this process has an expected energy requirement of 130 MJ per STB of bitumen generated, representing an energy efficiency of approximately 45 to 1 in terms of energy output to energy input. For the cost per STB analysis, this ratio was reduced to 22 to 1, to conservatively account for unexpected energy requirements that could arise.

The ranges of processing costs were built into a statistical model predicting the value of this process to the company for their predicted development scenario.

The company plans to construct one 250 STB/d moveable pilot scale plant in the beginning of 2011 in order to demonstrate the economics of the process. At that point, the Company plans to construct 500 STB/d plants in areas with plentiful mineable oil sands ore. For the purposes of the economic forecast the value of constructing one 250 STB/d facility and one 500 STB/d facility was considered, assuming a fifteen year production life for each. It was assumed that the 500 STB/d plant would commence production in early 2013.

Per STB operating costs were further escalated by 2% per year for the first 25 years of the forecast, as is common in industry cost and economic evaluations.

Prices were estimated using the Chapman Petroleum Engineering September 1, 2011 WTI price forecast, as shown in Table 2, reduced by a factor of 0.8 based on our experience with the pricing of non-upgraded bitumen.

Probability density functions were generated for the project net present value, at 0%, 5%, 10%, 15%, and 20% discounting factors, as shown in Table 3.

Economic Conclusions

The results of the cost per STB analysis show that this process could reasonably expect to have overall processing costs of $30.10 per STB of crude bitumen generated, representing a netback of approximately $49.00 per STB. The results of the Monte Carlo simulation show there is a 90% confidence level that the per STB processing costs will fall between $22.84 and $38.87 per STB, based on conservative and reasonable assumptions of the major cost items and their variability, using the input probability distributions shown in cost analysis discussion.

The cash flows of a likely plant development scenario were modeled using the standard Chapman Petroleum Engineering September 1, 2011 price forecast, as shown in Table 2. The forecast shows bitumen sales prices approximately in the $80-$90/STB range going forward, and therefore this process is expected to be profitable.

The results of these analyses are shown in Table 3, Summary of Process Economics. Line 1 describes a 250 STB/d capacity plant costing $3,000,000, whereas line 2 shows the economics of a 500 STB/d capacity plant costing $5,000,000. The total value is a forecast assuming one 250 STB/d plant will be constructed in 2012, and another 500 STB/d plant will be constructed in 2013. The cashflow forecast for the anticipated development is shown in Table 3a, and the individual plant forecasts (250 STB/d and 500 STB/d) follow in Tables 3b and 3c.

Analysis of the statistical data used in this report shows that the primary factor influencing the cost per STB, and thus the economics of any implementation of this process, is the yield percentage of the raw oil sands. This one factor has far more impact on the potential value than any others. In addition, the actual cost the Company pays for the raw ore is important, but this factor is expected to be within manageable limits and mostly based on the depth of the mined sands.

Based on these analyses, and our experience in the economics of oil and gas projects, this process is expected to be commercially viable under a fairly wide range of conditions.

The Company intends to initially demonstrate this technology with a 250 STB/d a plant in early 2012, and then to add another 500 STB/d plant in early 2013.

The 15% discounted cashflow has been utilized as the best estimate of the net present value of the Company's technology and business plan, which our economic model shows to be 58.2 Million US$.

Table 1

Summary of Anticipated Capital Expenditures
Oil Sands Extraction Plant

September 1, 2011

MCW Energy Group Ltd.

Ashpahlt Ridge, Utah

Description	Date	Operation	Capital Interest %	Gross Capital M$	Net Capital M$
Oil Sands Extraction Plant	Dec-2011	Build 250 STB/d capacity fluidized bed oil sands processing plant	100.0000	3,000	3,000
Oil Sands Extraction Plant	Dec-2012	Build 500 STB/d capacity fluidized bed oil sands processing plant	100.0000	5,000	5,000
		Total Best Estimate		8,000	8,000

Note: **M$ means thousands of dollars.**

The above capital values are expressed in terms of current dollar values without escalation.

Unless details are known, drilling costs have been split 70% Intangible and 30% Tangible for tax purposes

Table 2

CHAPMAN PETROLEUM ENGINEERING LTD.

CRUDE OIL
HISTORICAL, CONSTANT, CURRENT AND FUTURE PRICES

September 1, 2011

Date	WTI [1] $US/STB	Alberta Par Price [2] $CDN/STB	Alberta Heavy [3] $CDN/STB	Sask. Light [4] $CDN/STB	Sask. Heavy [5] $CDN/STB	B.C. Light [6] $CDN/STB	Bank of Canada Average Noon Exchange rate $US/$CDN
HISTORICAL PRICES							
2001	25.98	39.66	25.41	35.57	31.84	n/a	0.65
2002	26.09	40.63	32.20	37.67	34.57	n/a	0.64
2003	30.84	43.57	32.65	40.13	37.64	n/a	0.72
2004	41.48	52.89	37.52	48.96	45.74	n/a	0.77
2005	56.62	69.16	43.25	62.04	56.53	n/a	0.83
2006	65.91	72.88	50.40	66.77	61.23	n/a	0.88
2007	72.35	75.57	53.17	71.42	64.55	n/a	0.94
2008	99.70	102.98	83.88	98.02	92.45	n/a	0.94
2009	61.64	76.77	53.04	72.56	64.37	n/a	0.88
2010	79.42	80.56	66.58	77.02	72.79	n/a	0.97
2011 (8 mos)	98.16	104.03	76.15	93.03	83.28	n/a	1.03
CONSTANT PRICES							
the first-day-of-the-month price for the preceding 12 months [7]	92.06	95.21	73.21	86.34	78.36	92.83	1.01
CURRENT YEAR FORECAST							
2011 (4 mos)	**99.00**	98.00	81.34	93.10	88.45	95.55	1
FUTURE FORECAST							
2012	**100.00**	101.04	83.86	95.99	91.19	98.51	0.98
2013	**100.00**	101.04	83.86	95.99	91.19	98.51	0.98
2014	**100.00**	101.04	83.86	95.99	91.19	98.51	0.98
2015	**100.00**	101.04	83.86	95.99	91.19	98.51	0.98
2016	**100.00**	101.04	83.86	95.99	91.19	98.51	0.98
2017	**102.00**	103.08	85.56	97.93	93.03	100.50	0.98
2018	**104.00**	105.12	87.25	99.87	94.87	102.49	0.98
2019	**106.00**	107.16	88.95	101.81	96.71	104.48	0.98
2020	**108.12**	109.33	90.74	103.86	98.67	106.59	0.98
2021	**110.28**	111.53	92.57	105.96	100.66	108.74	0.98
2022	**112.49**	113.78	94.44	108.09	102.69	110.94	0.98
2023	**114.74**	116.08	96.35	110.28	104.76	113.18	0.98
2024	**117.03**	118.42	98.29	112.50	106.87	115.46	0.98
2025	**119.37**	120.81	100.27	114.77	109.03	117.79	0.98
2026	**121.76**	123.25	102.29	117.08	111.23	120.16	0.98
Constant thereafter							

Notes:

[1] West Texas Intermediate quality (D2/S2) crude landed in Cushing, Oklahoma.

[2] Equivalent price for Light Sweet Crude (D2/S2) landed in Edmonton, Alberta is estimated from WTI US$ exchange to C$ and transportation differential of $1.00 CDN/STB.

[3] Bow River at Hardisty, Alberta (905 kg/m3, 2.1% sulphur).

[4] Light Sour Blend at Cromer, Saskatchewan (850 kg/m3, 1.2% sulphur).

[5] Midale at Cromer, Saskatchewan (880 kg/m3, 2.0% sulphur).

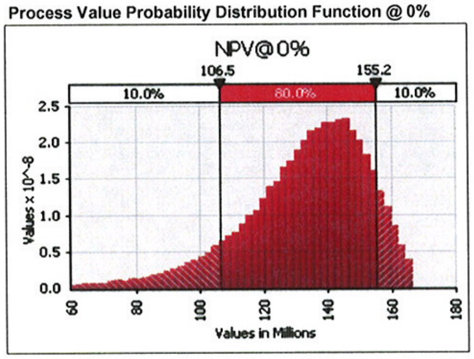
[6] B.C. Light at Taylor, British Columbia (825 kg/m3, 0.5% sulphur).

Table 3a

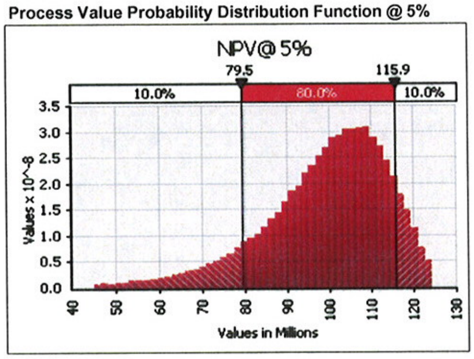
Total Oil Sands Processing Forecast
MCW Energy Group Ltd.

	Facility Capital		Price	Yearly Income	Processing		Net	Net Present Value ($)				
Year	(M$)	Rate	($/STB)	($)	Costs $/STB	Costs	Cashflow	0%	5%	10%	15%	20%
2012	3,000	250	80	7305000	30.10	2,748,506	1,556,494	1,556,494	1,494,481	1,437,656	1,385,371	1,337,098
2013	5,000	750	80	21915000	30.70	8,410,429	8,504,571	8,504,571	7,776,892	7,141,134	6,582,233	6,088,174
2014		750	80	21915000	31.32	8,578,638	13,336,362	13,336,362	11,614,533	10,180,275	8,975,536	7,955,927
2015		750	80	21915000	31.94	8,750,210	13,164,790	13,164,790	10,919,154	9,135,732	7,704,404	6,544,645
2016		750	80	21915000	32.58	8,925,215	12,989,785	12,989,785	10,260,954	8,194,807	6,610,423	5,381,370
2017		750	81.6	22353300	33.23	9,103,719	13,249,581	13,249,581	9,967,784	7,598,821	5,863,158	4,574,165
2018		750	83.2	22791600	33.90	9,285,793	13,505,807	13,505,807	9,676,709	7,041,609	5,196,993	3,885,518
2019		750	84.8	23229900	34.58	9,471,509	13,758,391	13,758,391	9,388,269	6,521,182	4,603,641	3,298,487
2020		750	86.5	23695593.75	35.27	9,660,939	14,034,654	14,034,654	9,120,744	6,047,386	4,083,548	2,803,933
2021		750	88.22	24166766.25	35.97	9,854,158	14,312,608	14,312,608	8,858,456	5,606,503	3,621,236	2,382,887
2022		500	89.99	16434423.75	36.69	6,700,828	9,733,596	9,733,596	5,737,508	3,466,203	2,141,478	1,350,445
2023		0	91.79	0	37.43	0	0	0	0	0	0	0
								128,146,639	**94,815,483**	**72,371,307**	**56,768,022**	**45,602,649**

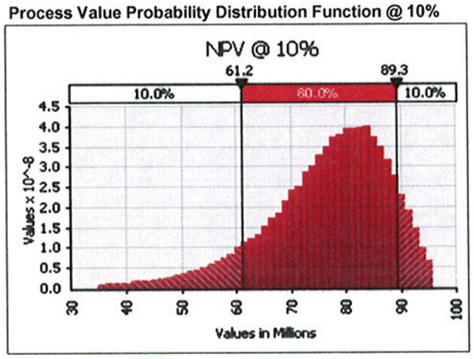
Process Value Probability Distribution Function @ 0%



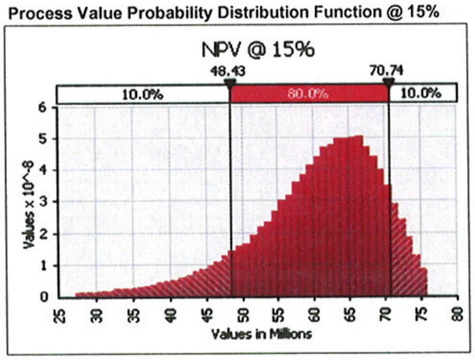
Process Value Probability Distribution Function @ 5%



Process Value Probability Distribution Function @ 10%



Process Value Probability Distribution Function @ 15%



Process Value Probability Distribution Function @ 20%

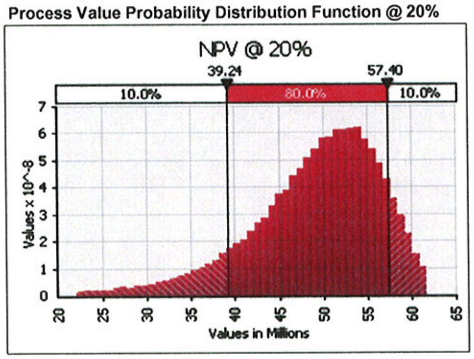
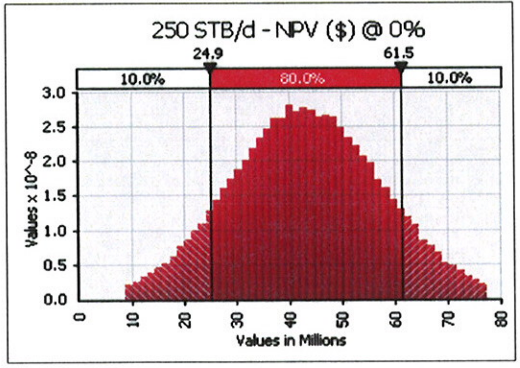


Table 3b

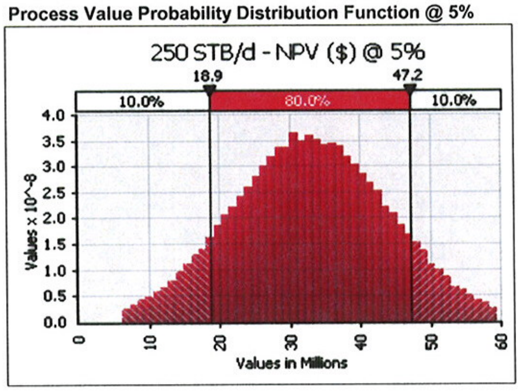
250 STB/d Oil Sands Processing Plant
MCW Energy Group Ltd.

Year	Facility Capital (M$)	Rate (STB/d)	Price ($/STB)	Yearly Income ($)	Processing Costs ($/STB)	Costs ($)	Net Cashflow ($)	Net Present Value ($) 0%	5%	10%	15%	20%
2012	3,000	250	80	7305000	30.10	2,748,506	1,556,494	1,556,494	1,494,481	1,437,656	1,385,371	1,337,098
2013		250	80	7305000	30.70	2,803,476	4,501,524	4,501,524	4,116,359	3,779,848	3,484,018	3,222,509
2014		250	80	7305000	31.32	2,859,546	4,445,454	4,445,454	3,871,511	3,393,425	2,991,845	2,651,976
2015		250	80	7305000	31.94	2,916,737	4,388,263	4,388,263	3,639,718	3,045,244	2,568,135	2,181,548
2016		250	80	7305000	32.58	2,975,072	4,329,928	4,329,928	3,420,318	2,731,602	2,203,474	1,793,790
2017		250	81.6	7451100	33.23	3,034,573	4,416,527	4,416,527	3,322,595	2,532,940	1,954,386	1,524,722
2018		250	83.2	7597200	33.90	3,095,264	4,501,936	4,501,936	3,225,570	2,347,203	1,732,331	1,295,173
2019		250	84.8	7743300	34.58	3,157,170	4,586,130	4,586,130	3,129,423	2,173,727	1,534,547	1,099,496
2020		250	86.5	7898531.25	35.27	3,220,313	4,678,218	4,678,218	3,040,248	2,015,795	1,361,183	934,644
2021		250	88.22	8055588.75	35.97	3,284,719	4,770,869	4,770,869	2,952,819	1,868,834	1,207,079	794,296
								42,175,343	**32,213,040**	**25,326,275**	**20,422,369**	**16,835,252**

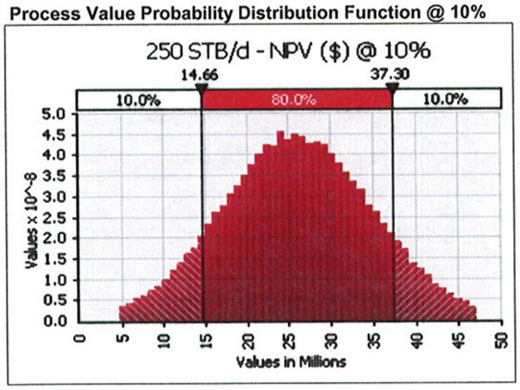
Process Value Probability Distribution Function @ 0%



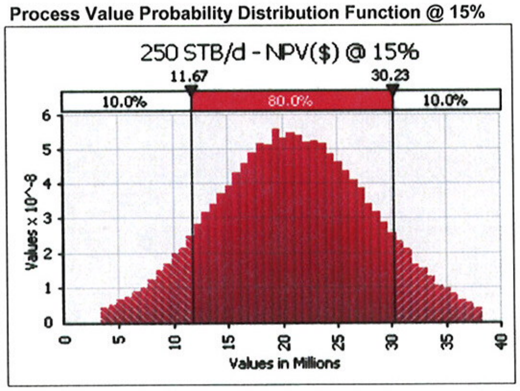
Process Value Probability Distribution Function @ 5%



Process Value Probability Distribution Function @ 10%



Process Value Probability Distribution Function @ 15%



Process Value Probability Distribution Function @ 20%

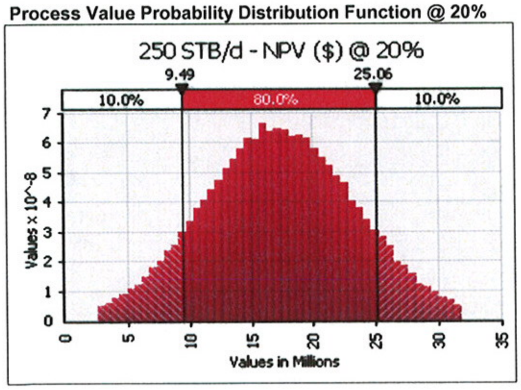
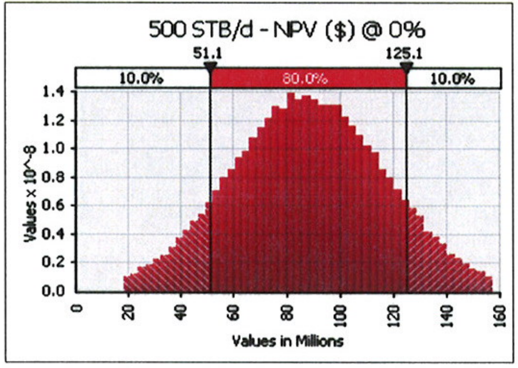


Table 3c

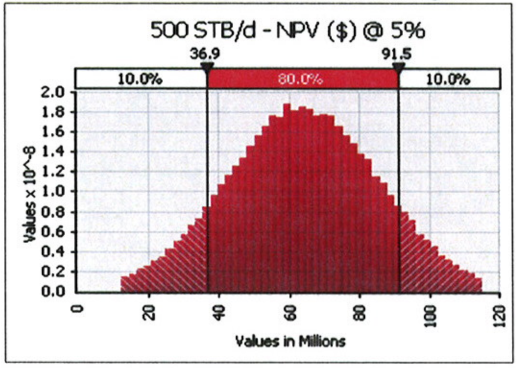
500 STB/d Oil Sands Processing Plant
MCW Energy Group Ltd.

Year	Facility Capital (M$)	Rate	Price ($/STB)	Yearly Income ($)	Processing Costs $/STB	Costs	Net Cashflow	Net Present Value ($) 0%	5%	10%	15%	20%
2012		0	80	0	30.10	0	0	0	0	0	0	0
2013	5000	500	80	14610000	30.70	5,606,953	9,003,047	9,003,047	8,232,717	7,559,696	6,968,036	6,445,019
2014		500	80	14610000	31.32	5,719,092	8,890,908	8,890,908	7,743,022	6,786,850	5,983,690	5,303,951
2015		500	80	14610000	31.94	5,833,474	8,776,526	8,776,526	7,279,436	6,090,488	5,136,270	4,363,096
2016		500	80	14610000	32.58	5,950,143	8,659,857	8,659,857	6,840,636	5,463,204	4,406,949	3,587,580
2017		500	81.6	14902200	33.23	6,069,146	8,833,054	8,833,054	6,645,189	5,065,880	3,908,772	3,049,443
2018		500	83.2	15194400	33.90	6,190,529	9,003,871	9,003,871	6,451,139	4,694,406	3,464,662	2,590,345
2019		500	84.8	15486600	34.58	6,314,339	9,172,261	9,172,261	6,258,846	4,347,455	3,069,094	2,198,992
2020		500	86.5	15797062.5	35.27	6,440,626	9,356,436	9,356,436	6,080,496	4,031,591	2,722,365	1,869,289
2021		500	88.22	16111177.5	35.97	6,569,439	9,541,739	9,541,739	5,905,637	3,737,669	2,414,158	1,588,591
2022		500	89.99	16434423.75	36.69	6,700,828	9,733,596	9,733,596	5,737,508	3,466,203	2,141,478	1,350,445
								90,971,295	**67,174,627**	**51,243,441**	**40,215,474**	**32,346,751**

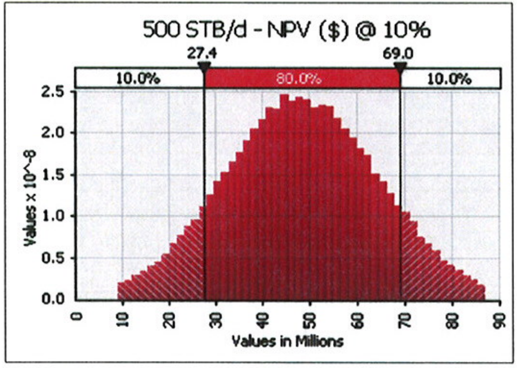
Process Value Probability Distribution Function @ 0%



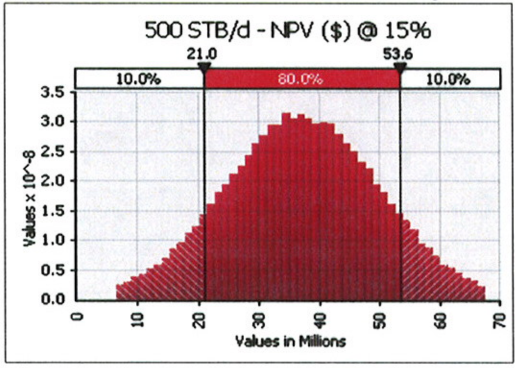
Process Value Probability Distribution Function @ 5%



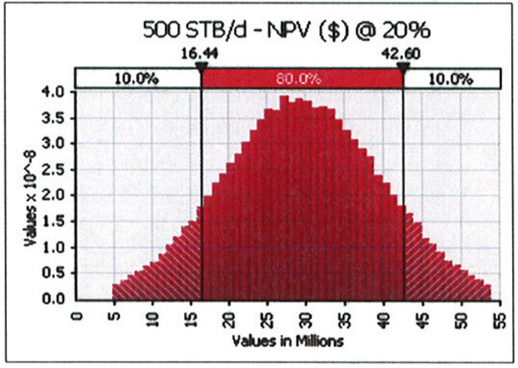
Process Value Probability Distribution Function @ 10%



Process Value Probability Distribution Function @ 15%



Process Value Probability Distribution Function @ 20%



5576

EVALUATION OF PROSPECTIVE RESOURCES

NW ASPHALT RIDGE AREA
UTAH, USA

Prepared for

MCW ENERGY GROUP LTD.

April 1, 2012
(March 31, 2012)

Chapman Petroleum Engineering Ltd.

445, 708 - 11th Avenue S.W., Calgary, Alberta T2R 0E4 • Phone: (403) 266-4141 • Fax: (403) 266-4259 • www.chapeng.ab.ca

April 4, 2012

MCW Energy Group Ltd
9701 Wilshire Blvd., 10th Floor
Beverly Hills, CA
90212

Attention: Alex Blyumkin

Dear Sir:

Re: Evaluation of Prospective Resources – April 1, 2012
NW Asphalt Ridge Area, Utah, USA

In accordance with your authorization, we have performed an evaluation of the prospective resources on the NW Asphalt Ridge Prospect, in Utah, USA, for MCW Energy Group Ltd. (the "Company"), in order to determine the feasibility of the Company participating in the exploration and development of this prospect under the terms proposed and determine the magnitude of the prospective resources and the economic value before and after the consideration of risk. This evaluation has been conducted in accordance with NI 51-101, Sec 5.9, pertaining to disclosure of resources, utilizing forecast prices and costs.

Our analysis has included a review of the available technical data including the geological and geophysical interpretation presented by the Company, the proposed ownership terms, information from relevant nearby wells or analogous reservoirs and the proposed program for the prospect. We have reviewed this material with respect to the estimated resources and productivity that would be expected of a successful program, the anticipated capital costs (including drilling, completion and equipment), the average operating costs in the area and expected product prices. We have also considered the availability of product markets, and transmission facilities within economic reach of the area.

In forming our opinion of this prospect we have relied to some extent on the information presented by the Company, which, together with our independent analysis and judgment, was sufficient for us to confidently establish the nature of the prospect and risks involved.

An economic analysis has been performed for the Company's interest position. This analysis has been utilized predominantly for formulating and supporting our recommendation on the project and the values established do not necessarily infer the "fair market value" of these prospective resources. All monetary values presented in this report are expressed in terms of United States dollars.

Based on our analysis, after consideration of risk, we have concluded that the potential of this prospect is of sufficient merit to justify the work program being proposed, and we therefore recommend and support the Company's participation.

All data gathered and calculations created in support of this report are stored permanently in our files and can be made available or presented on request. We reserve the right to make revisions to this report in light of additional information made available or which becomes known subsequent to the preparation of this report. Due to the risks involved in exploring for oil and gas reserves, our assessment of the project cannot be considered a guarantee that any wells drilled will be successful.

Prior to public disclosure of any information contained in this report, or our name as author, our written consent must be obtained, as to the information being disclosed and the manner in which it is presented. This report may not be reproduced, distributed or made available for use by any other party without our written consent and may not be reproduced for distribution at any time without the complete context of the report, unless otherwise reviewed and approved by us.

We consent to the submission of this report, in its entirety, to securities regulatory agencies and stock exchanges, by the Company.

It has been a pleasure to perform this evaluation and the opportunity to have been of service is appreciated.

Yours very truly,

Chapman Petroleum Engineering Ltd.

[Original Signed By:]

C.W. Chapman

C. W. Chapman, P. Eng.,
President

[Original Signed By:]

Roy A. Collver

Roy A. Collver, P. Eng.
Petroleum Engineer

rac/lml/5576
attachments

CERTIFICATE OF QUALIFICATION

I, C. W. CHAPMAN, P. Eng., Professional Engineer of the City of Calgary, Alberta, Canada, officing at Suite 445, 708 – 11th Avenue S.W., hereby certify:

1. THAT I am a registered Professional Engineer in the Province of Alberta and a member of the Australasian Institute of Mining and Metallurgy.

2. THAT I graduated from the University of Alberta with a Bachelor of Science degree in Mechanical Engineering in 1971.

3. THAT I have been employed in the petroleum industry since graduation by various companies and have been directly involved in reservoir engineering, petrophysics, operations, and evaluations during that time.

4. THAT I have in excess of 25 years in the conduct of evaluation and engineering studies relating to oil & gas fields in Canada and around the world.

5. THAT I participated directly in the evaluation of these assets and properties and preparation of this report for MCW Energy Group Ltd. dated April 4, 2012 and the parameters and conditions employed in this evaluation were examined by me and adopted as representative and appropriate in establishing the value of these oil and gas properties according to the information available to date.

6. THAT I have not, nor do I expect to receive, any direct or indirect interest in the properties or securities of MCW Energy Group Ltd. its participants or any affiliate thereof.

7. THAT I have not examined all of the documents pertaining to the ownership and agreements referred to in this report, or the chain of Title for the oil and gas properties discussed.

8. A personal field examination of these properties was considered to be unnecessary because the data available from the Company's records and public sources was satisfactory for our purposes.

[Original Signed By:]

C.W. Chapman

C. W. Chapman, P.Eng.
President

CERTIFICATE OF QUALIFICATION

I, ROY A. COLLVER, of the City of Calgary, Alberta, Canada, officing at Suite 445, 708 – 11th Avenue S.W., hereby certify:

1. THAT I am a registered Professional Engineer in the Province of Alberta, and a member of APEGGA.
2. THAT I graduated from Queen's University in Kingston, Ontario with a Bachelor of Science degree in Engineering Physics in 2005.
3. THAT I participated directly in the evaluation of these assets and properties and preparation of this report for MCW Energy Group Ltd., dated April 4, 2012 and the parameters and conditions employed in this evaluation were examined by me and adopted as representative and appropriate in establishing the value of these oil and gas properties according to the information available to date.
4. THAT I have not, nor do I expect to receive, any direct or indirect interest in the properties or securities of MCW Energy Group Ltd., its participants or any affiliate thereof.
5. THAT I have not examined all of the documents pertaining to the ownership and agreements referred to in this report, or the chain of Title for the oil and gas properties discussed.
6. A personal field examination of these properties was considered to be unnecessary because the data available from the Company's records and public sources was satisfactory for our purposes.

[Original Signed By:]

Roy A. Collver

Roy A. Collver, P. Eng.
Petroleum Engineer

EVALUATION OF
PROSPECTIVE RESOURCES

NW ASPHALT RIDGE AREA
UTAH, USA

Prepared for

MCW ENERGY GROUP LTD.

April 1, 2012
(March 31, 2012)

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SCOPE OF REPORT

Authorization

This report has been authorized by Mr. Alex Blyumkin, COO of MCW Energy Group Ltd. The technical analysis of this property has been performed during the month of April 2012.

Purpose

The purpose of this report was to independently determine the feasibility of the Company undertaking the exploration and development of the prospective resources in the NW Asphalt Ridge area, Utah, USA, and determine the magnitude of the prospective resources and the economic value before and after the consideration of risk.

Definitions

The following definitions, extracted from Section 5.2 of the Canadian Oil and Gas Evaluation Handbook, Volume 1 – Second Edition (COGEH-1) published by the Petroleum Society of CIM, and the Calgary chapter of the Society of Petroleum Evaluation Engineers (SPEE), as specified by Canadian Securities Regulations NI 51-101. These definitions relate to the subdivisions in the resources classification framework of Figure 1 which follows and use the primary nomenclature and concepts contained in the 2007 SPE-PRMS.

Total Petroleum Initially-In-Place (PIIP) is that quantity of petroleum that is estimated to exist originally in naturally occurring accumulations. It includes that quantity of petroleum that is estimated, as of a given date, to be contained in known accumulations, prior to production, plus those estimated quantities in accumulations yet to be discovered (equivalent to "total resources").

Discovered Petroleum Initially-In-Place (equivalent to "discovered resources") is that quantity of petroleum that is estimated, as of a given date, to be contained in known accumulations prior to production. The recoverable portion of discovered petroleum initially in place includes production, reserves, and contingent resources; the remainder is unrecoverable.

a) Production

Production is the cumulative quantity of petroleum that has been recovered at a given date.

b) Reserves

Reserves are estimated remaining quantities of oil and natural gas and related substances anticipated to be recoverable from known accumulations, as of a given date, based on the analysis of drilling, geological, geophysical, and engineering data; the use of established technology; and specified economic conditions, which are generally accepted as being reasonable. Reserves are further classified according to the level of certainty associated with the estimates and may be subclassified based on development and production status.

c) Contingent Resources

Contingent resources are those quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations using established technology or technology under development, but which are not currently considered to be commercially recoverable due to one or more contingencies. Contingencies may include factors such as economic, legal, environmental, political, and regulatory matters, or a lack of markets. It is also appropriate to classify as contingent resources the estimated discovered recoverable quantities associated with a project in the early evaluation stage. Contingent Resources are further classified in accordance with the level of certainty associated with the estimates and may be subclassified based on project maturity and/or characterized by their economic status.

d) Unrecoverable

Unrecoverable is that portion of Discovered or Undiscovered PIIP quantities which is estimated, as of a given date, not to be recoverable by future development projects. A portion of these quantities may become recoverable in the future as commercial circumstances change or technological developments occur; the remaining portion may never be recovered due to the physical/chemical constraints represented by subsurface interaction of fluids and reservoir rocks.

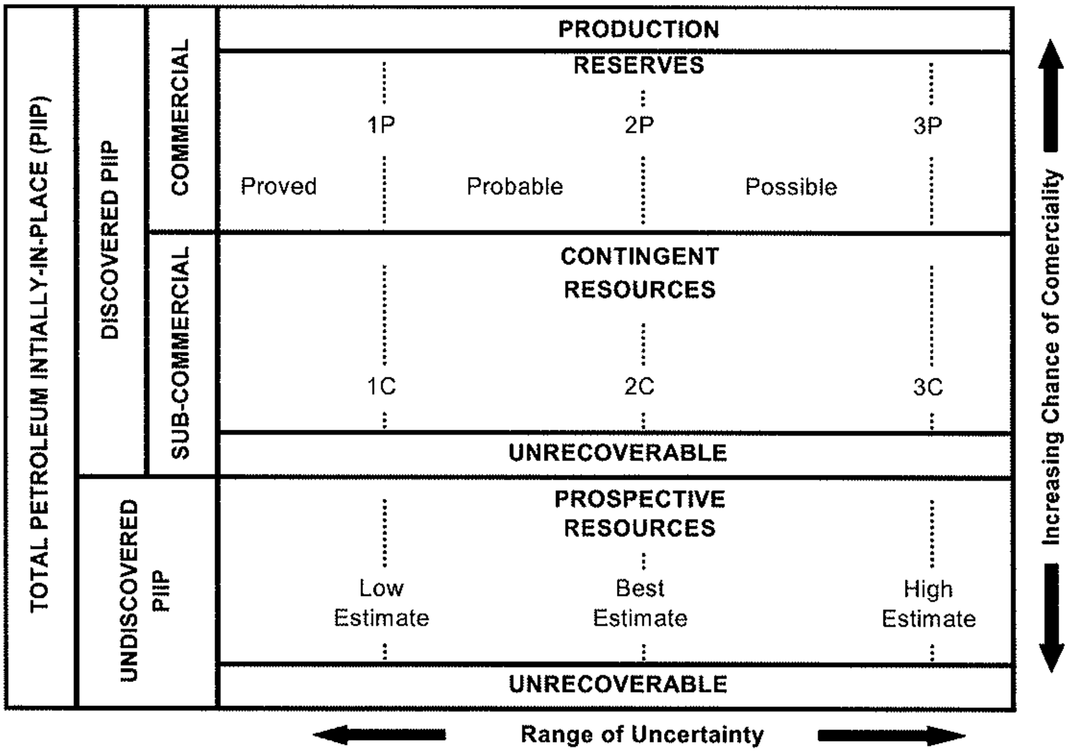
Undiscovered Petroleum Initially In Place (equivalent to "undiscovered resources") is that quantity of petroleum that is estimated, on a given date, to be contained in accumulations yet to be discovered. The recoverable portion of undiscovered petroleum initially in place is referred to as "prospective resources", the remainder as "unrecoverable".

a) *Prospective Resources*

Prospective resources are those quantities of petroleum estimated, as of a given date, to be potentially recoverable from undiscovered accumulations by application of future development projects. Prospective resources have both an associated chance of discovery and a chance of development. Prospective resources are further subdivided in accordance with the level of certainty associated with recoverable estimates assuming their discovery and development and may be subclassified based on project maturity.

There is no certainty that any portion of the resources will be discovered. If discovered, there is no certainty that it will be commercially viable to produce any portion of the resources.

Figure 1 – Resources classification framework (SPE-PRMS, Figure 1.1).



Not to scale

Barrels of Oil Equivalent

If at any time in this report reference is made to "Barrels of Oil Equivalent" (BOE), the conversion used is 6 Mscf : 1 STB (6 Mcf : 1 bbl).

BOEs may be misleading, particularly if used in isolation. A BOE conversion ratio of 6 Mcf : 1 bbl is based on an energy equivalency conversion method primarily applicable at the burner tip and does not represent value equivalency at the well head.

Abandonment and Restoration

Abandonment and restoration costs, net of salvage, have been included in the cash flows for the final event of any particular well. The abandonment cost does not impact the economic limit and is included in the final year of production automatically by the economic software.

Attachment 1 - Product Price Forecast
CHAPMAN PETROLEUM ENGINEERING LTD.
International Price - Crude Oil & Natural Gas
HISTORICAL, CONSTANT, CURRENT AND FUTURE PRICES

April 1, 2012

Date	WTI [1] $US/STB	Brent Spot (ICE) $US/STB[2]	AECO Spot Gas [3] C$/MMBTU	Henry Hub Gas[4] $US/MMBTU	Nymex C1 $US/MMBTU	Bank of Canada Average Noon Exchange Rate $US/$CDN	Ashpalt Ridge Bitumen Sales US$/STB
HISTORICAL PRICES							
2001	25.98	24.36	5.44	N/A	N/A	0.65	20.78
2002	26.09	24.09	4.13	N/A	N/A	0.64	20.87
2003	30.84	28.40	7.03	N/A	N/A	0.71	24.67
2004	41.48	38.03	6.60	5.91	6.18	0.77	33.18
2005	56.62	55.28	8.82	8.92	9.01	0.83	45.30
2006	65.91	66.09	6.55	6.75	6.98	0.88	52.73
2007	72.35	72.74	6.47	6.97	7.11	0.94	57.88
2008	99.70	98.33	8.17	8.98	8.90	0.94	79.76
2009	61.64	62.52	3.99	3.94	3.91	0.88	49.31
2010	79.42	80.22	4.02	4.39	4.42	0.97	63.54
2011	95.03	109.67	3.63	3.99	4.03	1.01	76.02
2011 (3mos)	102.87	110.63	2.15	2.45	2.51	1.00	82.30
CONSTANT PRICES (The first-day-of-the-month price for the preceding 12 months)							
	97.67	111.11	3.35	3.67	3.74	**1.01**	78.14
FORECAST PRICE							
2012	**104.00**	108.40	2.50	2.60	2.54	**1**	83.20
2013	**102.00**	106.20	3.58	3.97	3.90	**1**	81.60
2014	**100.00**	104.00	4.12	4.65	4.58	**1**	80.00
2015	**100.00**	104.00	4.93	5.67	5.60	**1**	80.00
2016	**102.00**	106.20	5.42	6.29	6.22	**1**	81.60
2017	**102.00**	106.20	5.85	6.83	6.76	**1**	81.60
2018	**104.04**	108.44	6.18	7.24	7.17	**1**	83.23
2019	**106.12**	110.73	6.39	7.51	7.45	**1**	84.90
2020	**108.24**	113.07	6.72	7.92	7.85	**1**	86.59
2021	**110.41**	115.45	6.93	8.20	8.13	**1**	88.33
2022	**112.62**	117.88	7.04	8.33	8.26	**1**	90.09
2023	**114.87**	120.36	7.20	8.54	8.47	**1**	91.89
2024	**117.17**	122.88	7.37	8.74	8.67	**1**	93.73
2025	**119.51**	125.46	7.47	8.88	8.81	**1**	95.61
2026	**121.90**	128.09	7.69	9.15	9.08	**1**	97.52
2027	**124.34**	130.77	7.91	9.42	9.35	**1**	99.47
Constant thereafter							

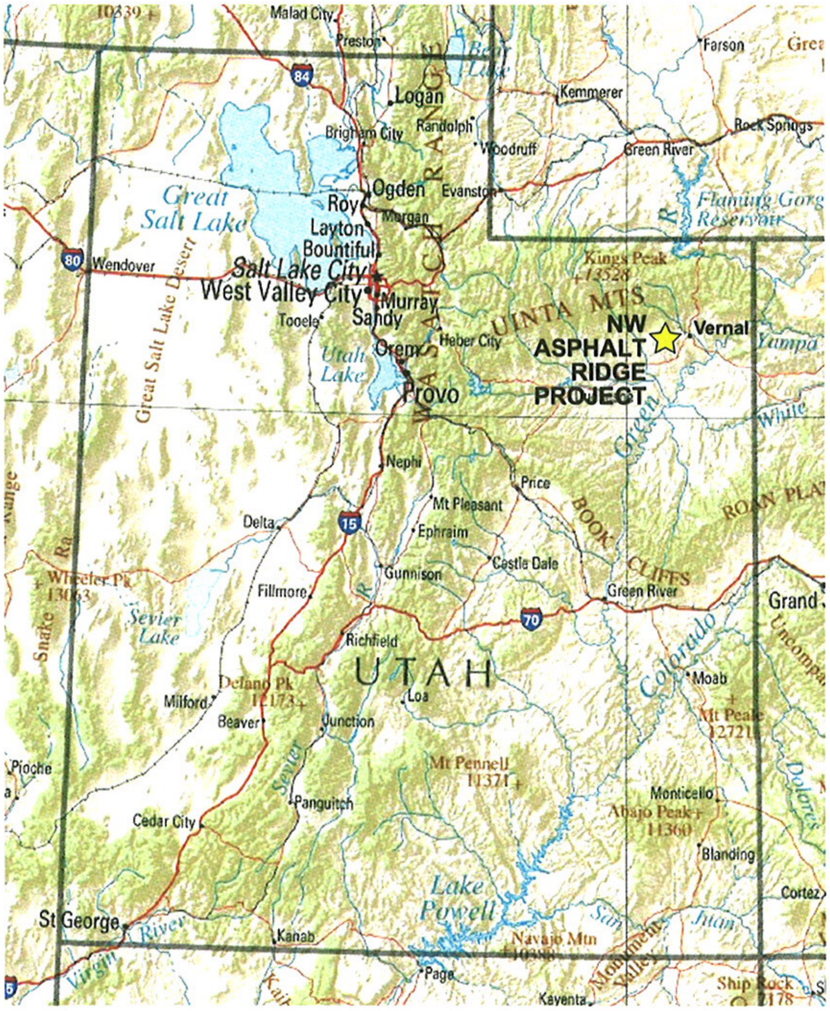
Notes:

[1] West Texas Intermediate quality (D2/S2) crude landed in Cushing, Oklahoma.

[2] The Brent Spot price is estimated based on historic data.

[3] The AECO C Spot price, which is the Alberta gas trading price

[4] Henry Hub is natural gas futures contracts traded on the New York Mercantile Exchange (NYMEX).



MCW ENERGY GROUP LTD.

NW ASPHALT RIDGE PROJECT

UINTAH COUNTY, UTAH, USA

ORIENTATION MAP

APR. 2012 JOB No. 5576

PROSPECT SYNOPSIS
PROSPECTIVE OIL SANDS RESOURCES
NW ASPHALT RIDGE, UTAH

This Prospect Synopsis contains the information required to be disclosed under NI 51-101, Sec. 5.9. More details regarding the prospects are presented in the Report Discussion which follows.

(a) The Company has a 100% percent working interest in 1138 acres,

(b) The subject exploration lands are located in the county Uintah, Utah, approximately 3 miles west of the town of Vernal,

(c) The expected product from a successful prospect is crude bitumen between 12 API gravity,

(d) The economic and risk analysis, justifying the participation in this project is presented in the Discussion of the report and a summary of the "before and after risk" values for the Forecast Prices and Costs Case is presented below:

Project Net Value, Thousands of Dollars

	Before Risk	After Risk
Undiscounted	1,018,936,333	243,126,000
Discounted @ 5%/year	449,853,667	106,546,000
Discounted @ 10%/year	252,232,667	59,117,000
Discounted @ 15%/year	162,431,000	37,565,000
Discounted @ 20%/year	113,850,000	25,906,000

This report was prepared by a "Qualified Reserves Evaluator and Auditor" who is independent of the Company.

NW ASPHALT RIDGE
UTAH, USA
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NW ASPHALT RIDGE AREA
UTAH, USA
DISCUSSION

Ownership

The Company controls 1138 Acres of land in this area, under Oil Sands Mineral Lease ML51484. The majority of the Company lands are considered to be prospective for active oil sands mining development.

The outline of the Company lease is shown on Figure 1. Exact company lands are contained within the outline shown on the map, and are described in more detail in Table 1.

Bitumen production is subject to a constant 8% royalty rate for the first 10 years of production, escalating thereafter at 1% per year until 12.5%. There is a minimum royalty payable $10 per acre of mineral lease.

Exploration History

The bituminous sands of Asphalt Ridge and Asphalt Ridge Northwest have been known to early people and settlers of the area for quite some time. The first known use of the material was for road paving and construction during the early 1920s. In the 1930s, the first hot water extraction plant was attempted to commercially produce the oil bearing sands.

In the 1950s, two companies (Knicker-bocker Investments and W.M. Barnes Engineering Company) acquired a large block of placer mining claims and began in earnest the first drilling and evaluation program of the area. The claims were then leased to SOHIO Oil Company, which continued to expand upon the earlier evaluation program.

During the 1970s and 1980s, interest in this resource was at a high, and many companies completed extensive exploration and testing efforts around Asphalt Ridge and NW Asphalt Ridge. The Laramie Energy and Technology Center (DOE) conducted 3 in-situ experiments on the NW Asphalt Ridge deposit. The tests were conducted on an initial 10 Acre block, and then subsequently an additional 16 Acre block, in sections 23 and 24 of T4S R20E, part of the SOHIO "D" tract. In addition to the experiments, researchers drilled and analyzed numerous core holes, and studied formation outcrops where they were available. Although the in-situ experiments were largely considered failures, they did increase the knowledge of the accumulation immensely, in an area which lies immediately adjacent to Company lands.

In the late 1990s and early 2000s another pilot study was attempted in the main Asphalt Ridge formation using a solvent extraction process. After many attempts, researchers moved to a modified hot water extraction, and processed over 15,000 tones of mined oil sands material in this manner. Although this was an encouraging test, the land and facilities were sold, and the project was suspended for a period of time.

As of April 2012, the Company has completed construction of their pilot extraction plant at the site of the future mine, and have begun testing of their process on ores and samples purchased from mines in the surrounding area.

Geology

The Unita Basin primarily located in northeast Utah and shown on the map illustrated in Figure 2a, contains a number of oil sand deposits located on the margins of the basin. The basin was formed in the Late Cretaceous and early Tertiary and presently has an asymmetric configuration, with a steeply dipping side to the north and a gently sloping side to the south.

The structural axis of the Unita Basin is generally parallel to Asphalt Ridge, a prominent cuesta approximately 12 miles in length located on the northeast flank of the basin. An outcrop map of the Asphalt Ridge and NW Asphalt Ridge deposits is illustrated in Figure 2b. As also shown in the regional cross-section illustrated in Figure 2c, Cretaceous and Tertiary sandstones form bitumen saturated outcrops along the northeast side of Asphalt Ridge as well as its subsurface extension, NW Asphalt Ridge.

Structurally, Asphalt Ridge is terminated on its northwest end by a series of major crosscutting northeast trending high angle faults as shown in Figure 2b. The NW Asphalt Ridge deposit is located on the downdropped block, a monocline dipping southeast . This fault zone has apparently acted as a barrier to oil migration. While both deposits are stratigraphically continuous, one of the major bitumen bearing sandstone is saturated in the Northwest deposit and unsaturated in the Asphalt Ridge deposit.

Along Asphalt Ridge, the bitumen deposit extends downdip in the subsurface for a distance ranging from one-third to thirds-thirds of a mile from the outcropping sandstones, as indicated by the cross hatched area shown in Figure 2b.

A schematic type section of the NW Asphalt Ridge deposit is illustrated in Figure 2d. It was created from lithologic descriptions of a number of core holes drilled as part of a DOE pilot project located on the NW Asphalt Ridge deposit and shown on Figure 2b. A major angular unconformity separates the marine sediments of the Cretaceous Mancos and Mesaverde groups from the fluvial sediments of the Tertiary Duchesne River Formation. The Mesaverde Group contains two bitumen saturated sandstones, the Asphalt Ridge Sandstone and the Rim Rock Sandstone separated by a tongue of Mancos Shale. Both were deposited in a shallow marine environment.

At NW Asphalt Ridge, the Asphalt Ridge Sandstone is approximately 150 ft thick while the Rim Rock Sandstone varies in thickness from 100 to 350 feet. Unconformably overlying the Mesaverde group, is the sandstone and conglomerate rich Duchesne River Formation. This formation is approximately 250 feet in thickness and the lower portion is saturated with bitumen at NW Asphalt Ridge. A core sample from the Asphalt Ridge Sandstone has a published analysis reporting 13.4% bitumen content with an API gravity of 14.3.

Prospective Resources

The total estimated volume of Bitumen recoverable on Company lands has been estimated to be 13 MMSTB in the Low case (20.2 MMSTB bitumen in place), 20 MMSTB in the Best case (30.4 MMSTB bitumen in place), and 30 MSTB in the high case (55.6 MMSTB in place). This reflects a bitumen density of between 125 MSTB to 325 MSTB per mineable acre, as indicated by published literature regarding this deposit.

Estimates of the approximate resource size and overburden profile are based on published literature and publicly available information regarding the characteristics of the Asphalt ridge deposit, and discussions with the Company.

Productivity Estimates

In all cases it has been assumed that the Company will commence mining of their lease and producing extracted bitumen at a rate of 500 STB/d in 2013. Future upgrades to the plant and mining operation are expected to increase capacity to 1000 STB/d in 2014, and 2000 STB/d in 2015 when the operation is on full production.

Product Prices

The expected product from a successful mining operation would 8-12 API gravity crude bitumen. The forecast price for this product stream has been estimated at 80% of the WTI price, based on analogy to Canadian oil sands operations.

The 2013 estimated bitumen price is $81.60/STB.

Operating Environment

The prospective lands are located 3 miles west of the town of Vernal, in Uintah County, Utah. There are extensive oil and gas operations in this area, and several experimental mining project have been attempted on the Asphalt Ridge deposit.

There are two roads running through the middle of the lease, and the majority of the area has relatively easy, year round, access.

Capital Expenditures

Total Capital expenditures required to fully establish production on this lease have been estimated at $12,941,420 ($12,941,420 net to the Company), as shown in Table 3a.

The net capital exposure required to test these prospective resources has been estimated to be $1,866,420 ($1,866,420 net to the Company), as shown in Table 3a. The capital exposure are the estimated remaining expenses before the Company can full demonstrate the ability of the project to operate economically.

Operating Costs

Operating costs were considered to be very significant to the overall project success, and were the main parameters varied between the low, best, and high cases. In all cases, it was assumed the mining operation would proceed as follows:

1. The overall cost of mining and obtaining ore will be approximately $19.50/tonne.
2. The process plant would operate on a 10 hour work day, and be operated every day of the year.
3. Every tone of raw crushed ore would consist of approximately 14% extractable hydrocarbon by weight.
4. Approximately 4 parts of solvent will be needed for every part of hydrocarbon extracted.
5. A negligible amount (and value) of the solvent will be lost in the final hydrocarbon stream.
6. Electrical energy is available in sufficient quantity, at an expected price of 5.65 cents per kwh[1].
7. The 500 STB/d plant will require 9 workers to operate, also earning an average of $15/hour.
8. The equivalent of approximately 0.3% of the value of the final bitumen products will be lost due to lost solvent in the spent ore.
9. An average 8% royalty has been included to account for state royalties and taxes.

A complete breakdown of the operating costs assumed in each of the low, best, and high cases is presented in Table 3b.

Economics and Risk

The results of the economic analysis, before and after income tax are summarized in Table 4, and the before risk cash flows are presented in Tables 4a, 4b and 4c, for the best, low and high estimates, respectively. The before risk analysis represents the results of an assumed successful exploration and development model having parameters which are considered to be reasonable based on the information available. This is the 100% probability of success (POS) case.

A risk analysis has been performed to determine the feasibility of the Company participating in this project and to determine the after risk value before income tax, utilizing the "Expected Value" technique applied to the arithmetic average of the best, low and high estimate results, a presentation of which is shown in Figure 3.

The net capital exposure (POS = 0%) for this project have been assumed to be the costs of a 24 well delineation plan, and establishing 500 STB/d of bitumen production from their mining operation and pilot extraction plant. Based on the risk analysis presented in Figure 3, the Company would require a minimum probability of success of 0.7% to participate in this project at a discount rate of 10%. As we have estimated a probability of success of 24%, the Company's participation in this project is considered feasible.

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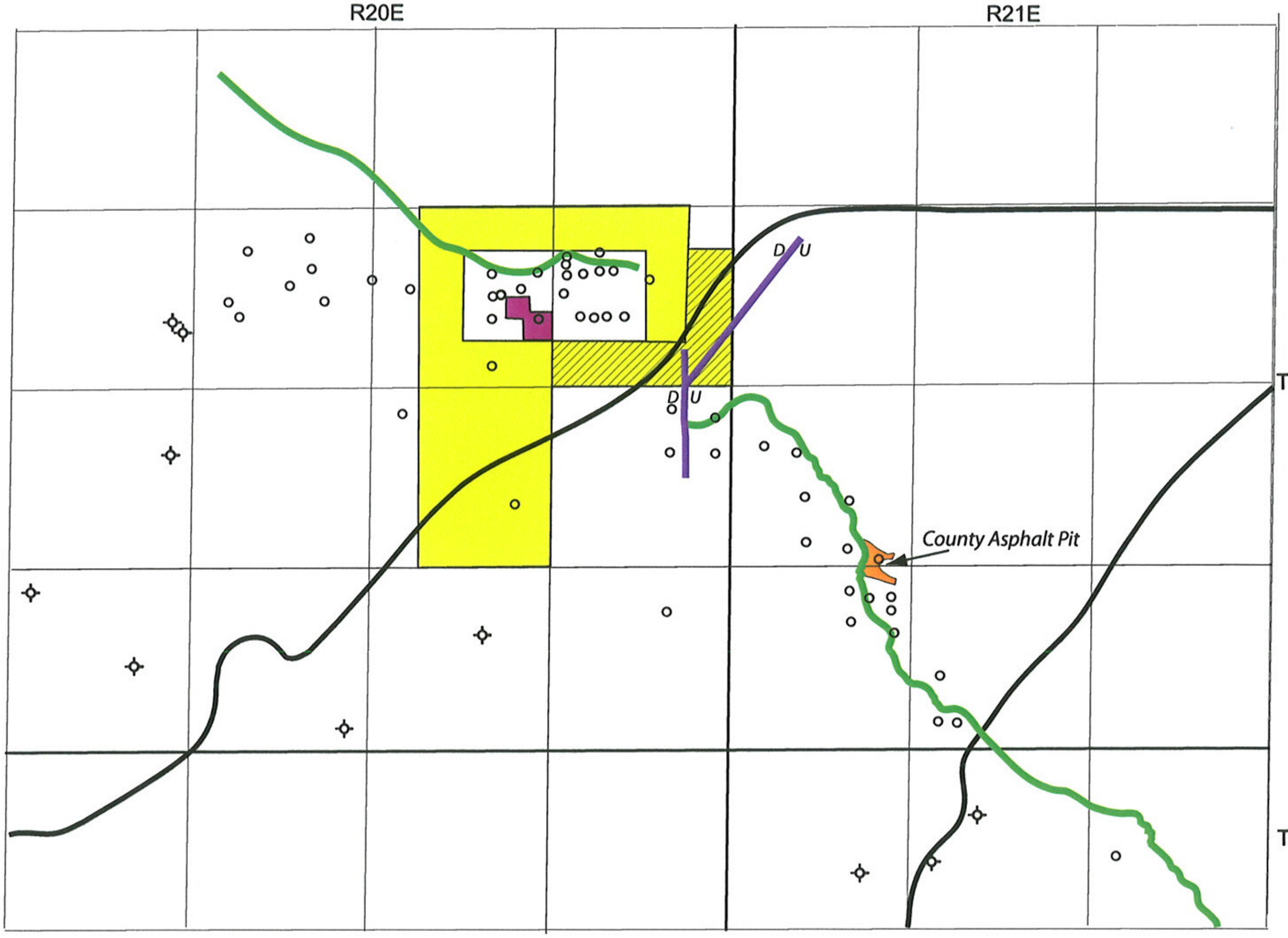
[1] Source – www.eia.gov

In establishing our probability of success, consideration has been given to both geological and commerciality factors. The geological factors include the four main geological components of a petroleum system needed for commercial production, source rocks available to generate hydrocarbons, reservoir rocks to accumulate hydrocarbons, a stratigraphic or structural trapping mechanism with a seal to hold hydrocarbons and a mechanism and proper geological timing allowing for hydrocarbons to migrate into the trap.

The predominant risk is the possibility that the ratio of overburden to formation thickness is not favorable enough to support mining development. In the context of an oil sands mining operation, this factor would fall under commerciality risk, in that the risk is in the per barrel production costs becoming excessive.



- 🟨 COMPANY LAND
- ▨ COMPANY LAND (100 ACRES NOT COMPLETELY DESCRIBED)
- ▬ HIGHWAYS
- ▬ FAULTS
- ▬ EDGE OF BITUMINOUS SANDSTONE OUTCROP
- ⌖ EXPLORATORY WELLS
- ○ CORE HOLES
- 🟪 DOE PILOT PROJECT

MCW ENERGY GROUP LTD.

NW ASPHALT RIDGE PROJECT

UINTAH COUNTY, UTAH, USA

LAND AND WELL MAP

APR. 2012 JOB No. 5576 FIGURE No. 1

Chapman Petroleum Engineering Ltd.

Table 1

Schedule of Lands, Interests and Royalty Burdens
April 1, 2012

MCW Energy Group Ltd.

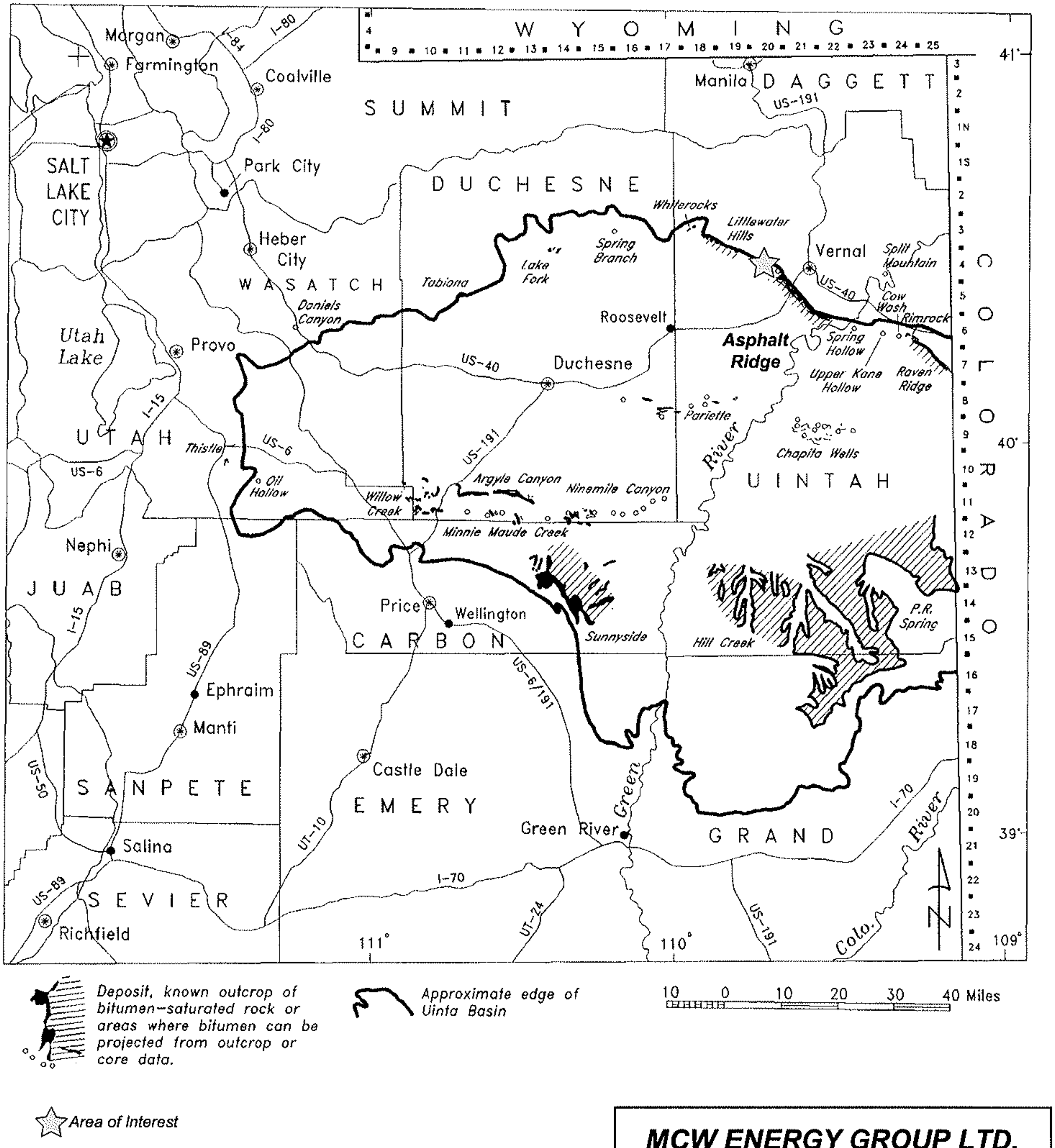
NW Asphalt Ridge, Utah

		Appraised Interest	Royalty Burdens	
	Gross	Working	Basic	Overriding
Description	Acres	%	%	%
ML 51484	1,138	100.0000	[1]	-
Sec 23				
N/2 of NE/4, E/2 of W/2,S/2 of S/4				
Sec 24				
Lots 2,3,4 , W/2 of E/2, N/2 of NW/4		[2]		
Sec 26				
E/2, E/2 of W/2				
	1138			

General Notes :

[1] State production royalties begin at 8% per year for 10 years, than increase at 1% per year to a total of 12.5%

[2] Lots 2,3, and 4 are of unknown size and position, but total 100 Acres. See Fig 1



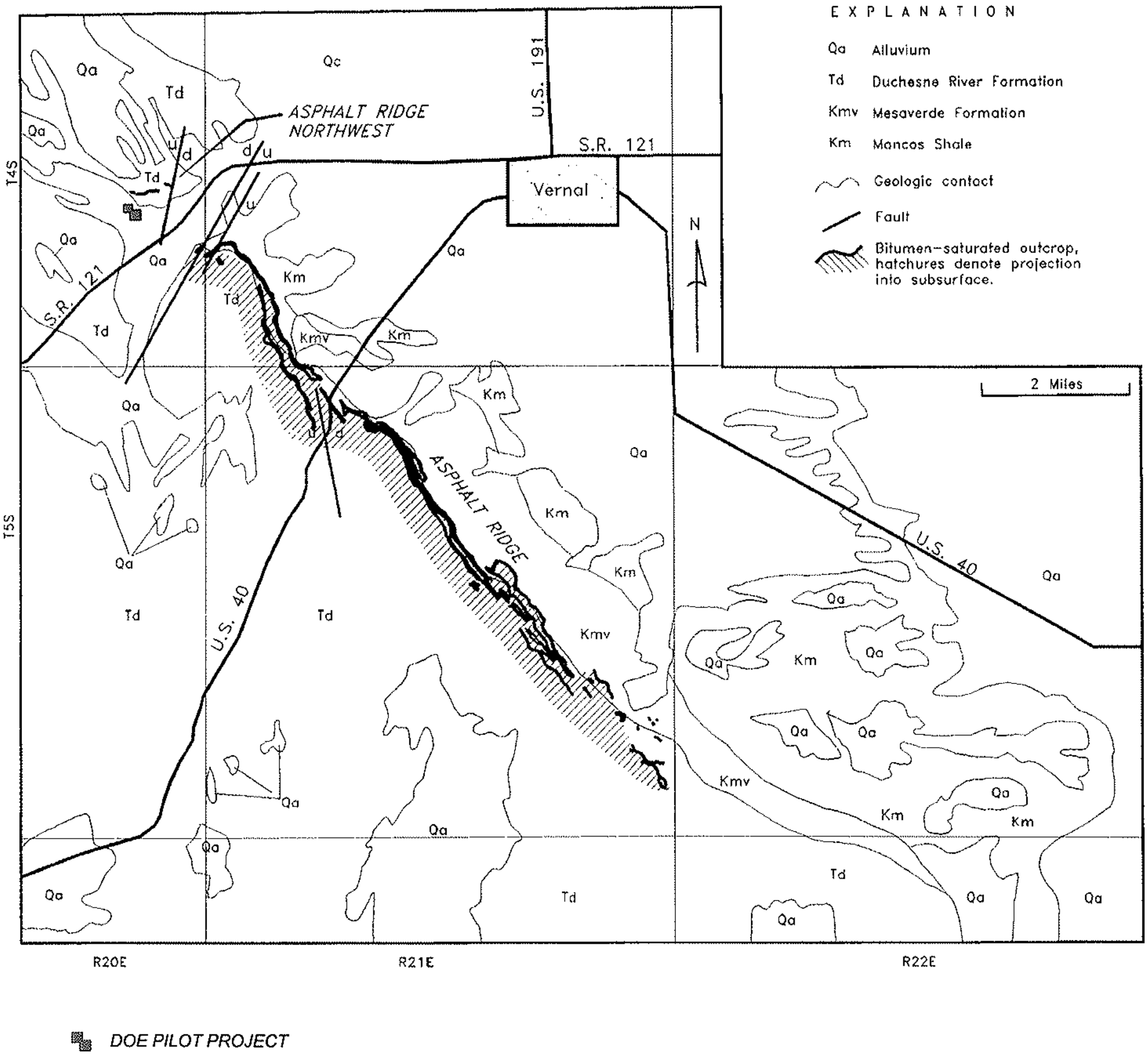
MCW ENERGY GROUP LTD.

NW ASPHALT RIDGE PROJECT

UINTAH COUNTY, UTAH, USA

OIL SAND DEPOSITS MAP

APR. 2012 JOB No. 5576 FIGURE No. 2a



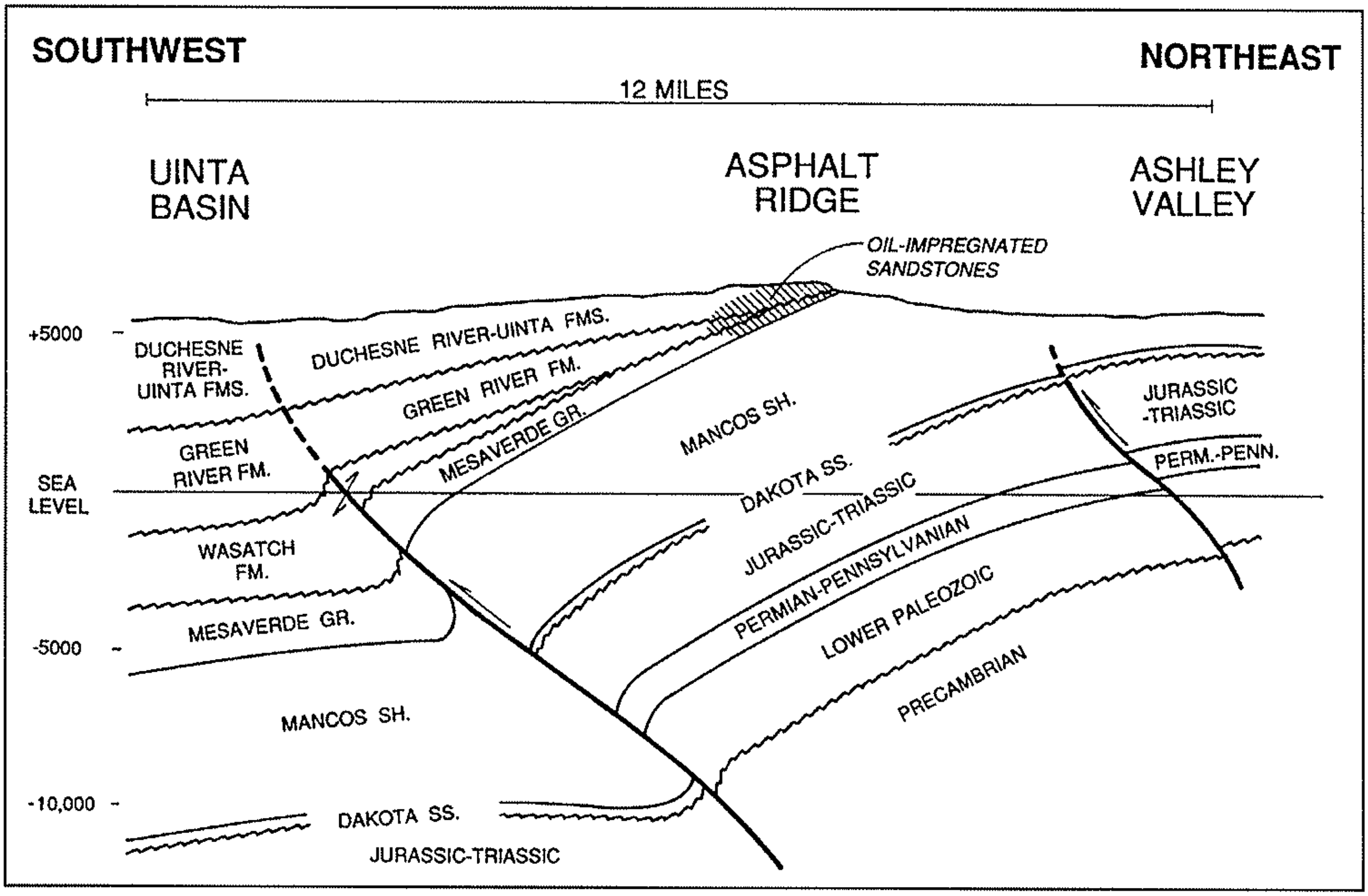
MCW ENERGY GROUP LTD.

NW ASPHALT RIDGE PROJECT

UINTAH COUNTY, UTAH, USA

OUTCROP MAP

APR. 2012 JOB No. 5576 FIGURE No. 2b



MCW ENERGY GROUP LTD.

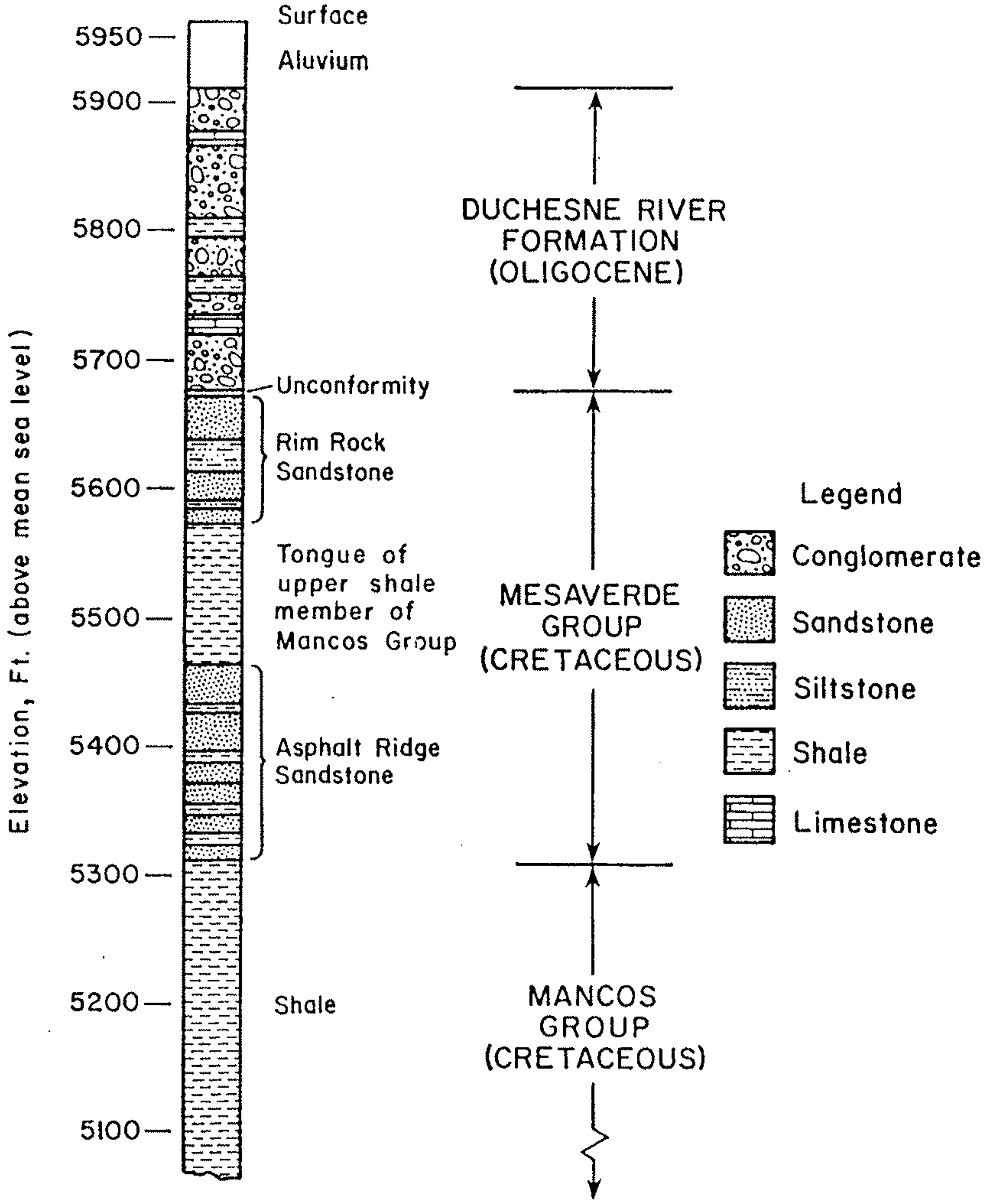
NW ASPHALT RIDGE PROJECT

UINTAH COUNTY, UTAH, USA

REGIONAL CROSS SECTION

APR. 2012 **JOB No. 5576** **FIGURE No. 2c**

Chapman Petroleum Engineering Ltd.



MCW ENERGY GROUP LTD.

NW ASPHALT RIDGE PROJECT

UINTAH COUNTY, UTAH, USA

GENERALIZED STRATIGRAPHIC SECTION

APR. 2012 JOB No. 5576 FIGURE No. 2d

Chapman Petroleum Engineering Ltd.

Table 2

Summary of Gross Prospective Resources
April 1, 2012

NW Asphalt Ridge, Utah

Description		Avg. Net Pay Thick. m	Overburd/Form Ratio	Overburden Volume m3	Oil Sands Volume m3	Development Area ha [1]	Bitumen Grade [3] % Vol	Recoverable Bitumen Resources STB	Original Bit. In Place STB [2]
Prospective Resources									
Best Estimate									
ML 51484	Rim Rock & Duchesne River	50.00	1.10	23,321,143	21,201,039	42	15.0%	20,000,000	217,112,003
	Total Best			**23,321,143**	**21,201,039**	**42**		**20,000,000**	**217,112,003**
Low Estimate									
ML 51484	Rim Rock & Duchesne River	35.00	1.50	22,147,514	14,765,009	42	14.0%	13,000,000	141,846,508
	Total Best			**22,147,514**	**14,765,009**	**42**		**13,000,000**	**141,846,508**
High Estimate									
ML 51484	Rim Rock & Duchesne River	80.00	0.90	26,832,565	29,813,961	37	16.0%	30,000,000	370,537,818
	Total Best			**26,832,565**	**29,813,961**	**37**		**30,000,000**	**370,537,818**

Table 3a

Summary of Anticipated Capital Expenditures
Exploration & Development

April 1, 2012

MCW Energy Group Ltd.

NW Asphalt Ridge, Utah

Description	Date	Operation	Capital Interest %	Gross Capital $	Net Capital $
Prospective Resources					
Dry and Abandoned					
Asphalt Ridge, Utah	2012	Surveying and lease preperation	100.0000	65,420	65,420
Asphalt Ridge, Utah	2012	24 cored delineation wells	100.0000	576,000	576,000
Asphalt Ridge, Utah	2012	2 Excavators + Salvage	100.0000	125,000	125,000
Asphalt Ridge, Utah	2012	2 Track Loaders + Salvage	100.0000	400,000	400,000
Asphalt Ridge, Utah	2012	Plant Start-up Costs	100.0000	500,000	500,000
Asphalt Ridge, Utah	2012	Infrastructure and Roads	100.0000	200,000	200,000
				1,866,420	**1,866,420**
Best/Low/High Estimate					
Asphalt Ridge, Utah	2012	Surveying and lease preperation	100.0000	65,420	65,420
Asphalt Ridge, Utah	2012	24 cored delineation wells	100.0000	576,000	576,000
Asphalt Ridge, Utah	2012	2 Excavators	100.0000	250,000	250,000
Asphalt Ridge, Utah	2012	2 Track Loaders	100.0000	800,000	800,000
Asphalt Ridge, Utah	2012	Infrastructure and Roads	100.0000	200,000	200,000
Asphalt Ridge, Utah	2013	2 Excavators	100.0000	250,000	250,000
Asphalt Ridge, Utah	2013	2 Track Loaders	100.0000	800,000	800,000
Asphalt Ridge, Utah	2013	Bitumen Extraction Plant Expansion	100.0000	2,500,000	2,500,000
Asphalt Ridge, Utah	2013	Infrastructure and Roads	100.0000	200,000	200,000
Asphalt Ridge, Utah	2013	4 Excavators	100.0000	500,000	500,000
Asphalt Ridge, Utah	2013	4 Track Loaders	100.0000	1,600,000	1,600,000
Asphalt Ridge, Utah	2013	Bitumen Extraction Plant Expansion	100.0000	5,000,000	5,000,000
Asphalt Ridge, Utah	2013	Infrastructure and Roads	100.0000	200,000	200,000
		Total		**12,941,420**	**12,941,420**

Note: **M$ means thousands of dollars.**
The above capital values are expressed in terms of current dollar values without escalation.
Unless details are known, drilling costs have been split 70% Intangible and 30% Tangible for tax purposes

Table 3b
Per STB Processing Cost Analysis - 500 STB/d plant
Janaury 1, 2012
MCW Energy Group Ltd.

***Assume 14% extractable oil

56	tons raw ore processed per hour
27.91625125	m3 of raw ore processed per hour
49.30576	STB of hydrobarbon produced per hour
197.22304	STB of solvent utilized per hour
0.0005	% of solvent lost to spent ore per STB of solvent used
0	% solvent lost to hydrocarbon stream per STB of solvent used

2 tons water steam generated per hour

Solvent Losses

0.09861152	Solvent lost to spent ore
0	Solvent lost to hydrocarbon stream
0.09861152	STB solvent lost per hour

10 Hour Standard Work Day
37 MJ/l energy density of bitumen

Energy Requirements	kw	
Pumps	800	400
Heat Exchangers	74	37
Cooler	38	19
Evaporator	750	375
Finish Cleaning	20	10
Operating + Contingency	120	60

Energy Production		
Total Bitumen Production (STB/h)	49.30576	
Lost Solvent in Spent Ore (STB/h)	- 0.09861152	
	49.2071485	
Total Energy Productin (litres)	7824.32	
Energy Production Per Hour (kJ/h)	289,499,840	
Total Energy Consumption Per Hour (kJ/h)	6,487,200	
Efficiency of Energy Production (%)	97.76%	43.62632
Efficiency of Energy Production (kJ/STB)	131,571	

Economic Analysis		
Cost of crushed ore ($/tonne)	19.5	
Cost of Plant Labour ($/hour operation)	135	
Power Costs ($/kwh)	0.0565	$/kwh Electricity price - www.eia.com
Facility Operation ($/hour)	10	
Solvent Costs	0.3%	

Solvent costs are shown as the equivalent percentage of the final product which would be given up to pay for the lost solvent costs

Cost Analysis		
Total Raw Ore Cost ($/h)	1092	
Total Labour Costs ($/h)	135	
Power Costs ($/h)	101.813	
Facility Operation ($/h)	10	
Solvent Loss Reduction Fraction	99.7%	
Total Production Per Hour	49.30576	
Total Production Per Hour Subtracting Solvent Loss	49.1701692	
Total Cost Per Hour	1338.813	
Total Best Estimate Cost Per Net STB of Production	**27.23**	**($/STB)**
Total Low Estimate Cost Per Net STB of Production	**34.04**	**($/STB)**
Total High Estimate Cost Per Net STB of Production	**24.51**	**($/STB)**

"net" means after deduction of the costs of solvent

Table 4
Summary of Company Prospective Resources and Economics
Before Income Tax
April 1, 2012
(as of March 31, 2012)

Forecast Prices & Costs

MCW Energy Group Ltd.

Asphalt Ridge, Uintah County, Utah, USA

Description	Resources Bitumen STB Gross	 Net	Cumulative Cash Flow (BIT) - US$ Undisc.	 Discounted at: 5%/year	 10%/year	 15%/year	 20%/year
BEFORE RISK							
Best Estimate Asphalt Ridge Oil Sands (Rim Rock,Duchesne River)	20,000,000	17,845,000	969,516,000	465,339,000	264,829,000	170,209,000	118,888,000
Low Estimate Asphalt Ridge Oil Sands (Rim Rock,Duchesne River)	13,000,000	11,720,000	508,333,000	299,596,000	191,491,000	130,721,000	94,010,000
High Estimate Asphalt Ridge Oil Sands (Rim Rock,Duchesne River)	30,000,000	26,596,000	1,578,960,000	584,626,000	300,378,000	186,363,000	128,652,000
Arithmetic Average Asphalt Ridge Oil Sands (Rim Rock,Duchesne River)	**21,000,000**	**18,720,333**	**1,018,936,333**	**449,853,667**	**252,232,667**	**162,431,000**	**113,850,000**
AFTER RISK							
Arithmetic Average After Risk Asphalt Ridge Oil Sands (Rim Rock,Duchesne River)	**5,040,000**	**4,492,880**	**243,126,000**	**106,546,000**	**59,117,000**	**37,565,000**	**25,906,000**

Gross resources are the total of the Company's working and/or royalty interest share before deduction of royalties owned by others.

Net resources are the total of the Company's working and/or royalty interest share after deducting the amounts attributable to royalties owned by others.

Columns may not add precisely due to accumulative rounding of values throughout the report.

Table 4a

```
EVALUATION OF: Asphalt Ridge, Utah - Prospect Best Estimate                 ERGO v7.43   P2 ENERGY SOLUTIONS          PAGE   1
==============                                                              GLOBAL  : 03-APR-2012 5576
                                                                            EFF:01-APR-2012 DISC:01-APR-2012 PROD:01-JAN-2013
                                                                            RUN DATE:  4-APR-2012 TIME: 14:12
                                                                            FILE: Outa1PB.DAX

WELL/LOCATION     - Asphalt Ridge Oil Sands (Rim Rock & Duchesne River)     UNIT FACTOR          -    100.0000 %
EVALUATED BY      -                                                         TOTAL RESERVES       -       20000 MSTB
COMPANY EVALUATED - MCW Energy Group Ltd.                                   PRODUCTION TO DATE   -         N/A
APPRAISAL FOR     -                                                         DECLINE INDICATOR    -    EXPONENTIAL
PROJECT           - FORECAST PRICES & COSTS                                 TOTAL CAPITAL COSTS  -      13162 -M$-

     INTEREST                                     ROYALTIES/TAXES

     AVG WI 100.0000%                             U.S.

                                                                Oil
                                                                MSTB
                                                  --------------------------------------
                                                               Pool       Company Share
                                                       # of  Price  -------------   -------------
                                                  Year Wells $/STB   STB/D   Vol   Gross    Net
                                                  ---- ---------------------------------------

                                                  2012   0   83.20     .0      0      0      0
                                                  2013   1   81.60  500.0    183    183    168
                                                  2014   1   80.00 1000.0    365    365    336
                                                  2015   1   80.00 2000.0    730    730    672

                                                  2016   1   81.60 2000.0    730    730    672
                                                  2017   1   81.60 2000.0    730    730    672
                                                  2018   1   83.23 2000.0    730    730    672
                                                  2019   1   84.90 2000.0    730    730    672
                                                  2020   1   86.59 2000.0    730    730    672

                                                  2021   1   88.33 2000.0    730    730    672
                                                  2022   1   90.10 2000.0    730    730    672
                                                  2023   1   91.90 2000.0    730    730    664
                                                  2024   1   93.74 1985.9    725    725    652
                                                  2025   1   95.61 1958.0    715    715    636

                                                  2026   1   97.52 1930.4    705    705    620
                                                  ---- ---------------------------------------

                                                  SUB                       9262   9262   8449
                                                  REM                      10738  10738   9396
                                                  TOT                      20000  20000  17845

     ================================================ COMPANY SHARE FUTURE NET REVENUE ================================================

                                                                                                                    Future Net Revenue
           Company Share                                                                                   ---------------------------------
        Future Revenue (FR)           Royalties    Wellhead Taxes  Oper Costs             Proc&              Undiscounted           10.0%
     ---------------------------   -------------  --------------  ------------ FR After Other Capital Aband  --------------   --------------
Year    Oil    SaleGas Products Total   State  Other    Sev  Ad-val Fixed Variabl Roy&Oper Income Costs  Costs  Annual    Cum    Annual    Cum
       -M$-    -M$-     -M$-    -M$-    -M$-   -M$-    -M$-   -M$-   -M$-   -M$-    -M$-    -M$-   -M$-   -M$-   -M$-    -M$-    -M$-    -M$-
------------------------------------------------------------------------------------------------------------------------------------------------

2012       0      0        0       0      0      0      0      0      0      0       0      0    1891     0   -1891   -1891   -1825   -1825
2013   14892      0        0   14892   1191      0      0      0      0   5069    8632      0   11271     0   -2639   -4531   -2342   -4167
2014   29200      0        0   29200   2336      0      0      0      0  10340   16524      0       0     0   16524   11993   13330    9163
2015   58400      0        0   58400   4672      0      0      0      0  21095   32633      0       0     0   32633   44626   23933   33096

2016   59568      0        0   59568   4765      0      0      0      0  21516   33286      0       0     0   33286   77912   22192   55288
2017   59568      0        0   59568   4765      0      0      0      0  21947   32856      0       0     0   32856  110768   19914   75202
2018   60759      0        0   60759   4861      0      0      0      0  22386   33513      0       0     0   33513  144281   18466   93668
2019   61974      0        0   61974   4958      0      0      0      0  22833   34183      0       0     0   34183  178464   17123  110790
2020   63212      0        0   63212   5057      0      0      0      0  23290   34865      0       0     0   34865  213329   15877  126667

2021   64479      0        0   64479   5158      0      0      0      0  23756   35565      0       0     0   35565  248894   14723  141390
2022   65770      0        0   65770   5262      0      0      0      0  24231   36277      0       0     0   36277  285171   13653  155043
2023   67084      0        0   67084   6038      0      0      0      0  24716   36331      0       0     0   36331  321502   12430  167473
2024   67945      0        0   67945   6794      0      0      0      0  25032   36118      0       0     0   36118  357620   11234  178707
2025   68327      0        0   68327   7516      0      0      0      0  25174   35637      0       0     0   35637  393258   10076  188783

2026   68713      0        0   68713   8246      0      0      0      0  25316   35151      0       0     0   35151  428409    9036  197819
------------------------------------------------------------------------------------------------------------------------------------------------

SUB   809892      0        0  809892  71619      0      0      0      0 296701  441571      0   13162     0  428409           197819
REM  1068169      0        0 1068169 133521      0      0      0      0 393540  541107      0       0     0  541107            67010
TOT  1878061      0        0 1878061 205141      0      0      0      0 690242  982679      0   13162     0  969516           264829

=========================== NET PRESENT VALUE (-M$-)===========================          ================ PROFITABILITY ===============
                                                                                                                               Before
Discount Rate               .0%     5.0%     8.0%    10.0%    12.0%    15.0%    20.0%         COMPANY SHARE BASIS                    Tax
---------------------------------------------------------------------------------         --------------------------------------------
FR After Roy & Oper.    982679   477799   338229   276656   230819   181463   129622         Rate of Return (%) ...........       253.0
Proc & Other Income.         0        0        0        0        0        0        0         Profit Index (undisc.) .......        73.7
Capital Costs ......     13162    12459    12072    11827    11591    11254    10734                      (disc. @ 10.0%) .        22.4
Abandonment Costs ..         0        0        0        0        0        0        0                      (disc. @  5.0%) .        37.3
Future Net Revenue .    969516   465339   326157   264829   219228   170209   118888         First Payout (years) .........         2.0
                                                                                             Total Payout (years) .........         2.0
=================================== COMPANY SHARE =====================================      Cost of Finding ($/BOE) ......         .66
                                                      Oper   FR After  Capital   Future     NPV @ 10.0% ($/STB ) .........       13.24
                           1st Year  Average Royalties  Costs  Roy&Oper   Costs    NetRev     NPV @  5.0% ($/STB ) .........       23.27
---------------------------------------------------------------------------------------
% Interest .........          100.0    100.0
% of Future Revenue.                            10.9    36.8     52.3       .7     51.6
```

Table 4b

```
EVALUATION OF: Asphalt Ridge, Utah - Prospect Low Estimate         ERGO v7.43    P2 ENERGY SOLUTIONS          PAGE   1
==============                                                     GLOBAL  : 03-APR-2012 5576
                                                                   EFF:01-APR-2012 DISC:01-APR-2012 PROD:01-JAN-2013
                                                                   RUN DATE:  4-APR-2012 TIME: 14:13
                                                                   FILE: Outa2PL.DAX

WELL/LOCATION      - Asphalt Ridge Oil Sands (Rim Rock & Duchesne River)     UNIT FACTOR          -    100.0000 %
EVALUATED BY       -                                                         TOTAL RESERVES       -      13000 MSTB
COMPANY EVALUATED  - MCW Energy Group Ltd.                                   PRODUCTION TO DATE   -        N/A
APPRAISAL FOR      -                                                         DECLINE INDICATOR    -    EXPONENTIAL
PROJECT            - FORECAST PRICES & COSTS                                 TOTAL CAPITAL COSTS  -      13162 -M$-

      INTEREST                                  ROYALTIES/TAXES

      AVG WI 100.0000%                          U.S.

                                                           Oil
                                                           MSTB
                                             -----------------------------------------
                                                           Pool        Company Share
                                                 # of   Price  ------------  -------------
                                             Year Wells  $/STB  STB/D   Vol   Gross    Net
                                             ---- -----------------------------------------

                                             2012    0  83.20     .0      0       0      0
                                             2013    1  81.60  500.0    183     183    168
                                             2014    1  80.00 1000.0    365     365    336
                                             2015    1  80.00 2000.0    730     730    672

                                             2016    1  81.60 2000.0    730     730    672
                                             2017    1  81.60 2000.0    730     730    672
                                             2018    1  83.23 2000.0    730     730    672
                                             2019    1  84.90 2000.0    730     730    672
                                             2020    1  86.59 2000.0    730     730    672

                                             2021    1  88.33 2000.0    730     730    672
                                             2022    1  90.10 2000.0    730     730    672
                                             2023    1  91.90 2000.0    730     730    664
                                             2024    1  93.74 1969.3    719     719    647
                                             2025    1  95.61 1909.1    697     697    620

                                             2026    1  97.52 1850.8    676     676    594
                                             ---- -----------------------------------------

                                             SUB                       9209    9209   8402
                                             REM                       3791    3791   3317
                                             TOT                      13000   13000  11720

    =================================================== COMPANY SHARE FUTURE NET REVENUE =====================================================

                                                                                                                    Future Net Revenue
               Company Share                                                                               --------------------------------
          Future Revenue (FR)          Royalties    Wellhead Taxes  Oper Costs             Proc&            Undiscounted         10.0%
        ----------------------------- -------------  ------------- ------------- FR After Other Capital Aband  --------------  --------------
Year     Oil    SaleGas Products Total   State  Other    Sev  Ad-val Fixed Variabl Roy&Oper Income Costs  Costs  Annual   Cum    Annual    Cum
        -M$-     -M$-    -M$-    -M$-    -M$-   -M$-    -M$-   -M$-   -M$-   -M$-    -M$-    -M$-   -M$-   -M$-   -M$-    -M$-    -M$-    -M$-
-----------------------------------------------------------------------------------------------------------------------------------------------

2012        0       0        0       0       0     0      0      0      0       0       0      0   1891      0   -1891   -1891   -1825   -1825
2013    14892       0        0   14892    1191     0      0      0      0    6337    7364      0  11271      0   -3907   -5798   -3467   -5292
2014    29200       0        0   29200    2336     0      0      0      0   12927   13937      0      0      0   13937    8139   11244    5952
2015    58400       0        0   58400    4672     0      0      0      0   26370   27358      0      0      0   27358   35497   20064   26016

2016    59568       0        0   59568    4765     0      0      0      0   26898   27905      0      0      0   27905   63402   18605   44620
2017    59568       0        0   59568    4765     0      0      0      0   27436   27367      0      0      0   27367   90769   16587   61208
2018    60759       0        0   60759    4861     0      0      0      0   27984   27914      0      0      0   27914  118683   15381   76589
2019    61974       0        0   61974    4958     0      0      0      0   28544   28472      0      0      0   28472  147156   14262   90851
2020    63212       0        0   63212    5057     0      0      0      0   29115   29040      0      0      0   29040  176196   13224  104075

2021    64479       0        0   64479    5158     0      0      0      0   29697   29624      0      0      0   29624  205820   12264  116339
2022    65770       0        0   65770    5262     0      0      0      0   30291   30217      0      0      0   30217  236037   11372  127711
2023    67084       0        0   67084    6038     0      0      0      0   30897   30150      0      0      0   30150  266187   10315  138026
2024    67377       0        0   67377    6738     0      0      0      0   31031   29608      0      0      0   29608  295795    9209  147235
2025    66623       0        0   66623    7329     0      0      0      0   30685   28610      0      0      0   28610  324405    8089  155324

2026    65879       0        0   65879    7906     0      0      0      0   30342   27632      0      0      0   27632  352037    7103  162427
-----------------------------------------------------------------------------------------------------------------------------------------------

SUB    804786       0        0  804786   71035     0      0      0      0  368552  365199      0  13162      0  352037           162427
REM    377131       0        0  377131   47141     0      0      0      0  173693  156296      0      0      0  156296            29065
TOT   1181917       0        0 1181917  118177     0      0      0      0  542246  521495      0  13162      0  508333           191491

============================== NET PRESENT VALUE (-M$-)===========================       ================ PROFITABILITY ===============

Discount Rate              .0%      5.0%      8.0%     10.0%     12.0%     15.0%     20.0%                                            Before
-------------------------------------------------------------------------------------       COMPANY SHARE BASIS                         Tax
FR After Roy & Oper.   521495    312056    239117    203318    174803    141975    104744      ----------------------------------------------
Proc & Other Income.        0         0         0         0         0         0         0      Rate of Return (%) ...........           205.5
Capital Costs ......    13162     12459     12072     11827     11591     11254     10734      Profit Index (undisc.) .......            38.6
Abandonment Costs ..        0         0         0         0         0         0         0                (disc. @ 10.0%) .            16.2
Future Net Revenue .   508333    299596    227045    191491    163212    130721     94010                (disc. @  5.0%) .            24.0
                                                                                             First Payout (years) .........             2.2
==================================== COMPANY SHARE ==================================        Total Payout (years) .........             2.2
                                                      Oper    FR After  Capital   Future     Cost of Finding ($/BOE) ......            1.01
                      1st Year  Average  Royalties   Costs   Roy&Oper    Costs    NetRev     NPV @ 10.0% ($/STB ) .........           14.73
-----------------------------------------------------------------------------------          NPV @  5.0% ($/STB ) .........           23.05
% Interest .........    100.0    100.0
% of Future Revenue.                         10.0     45.9      44.1       1.1      43.0
```

Table 4c

```
EVALUATION OF: Asphalt Ridge, Utah - Prospect High Estimate                                                    ERGO v7.43    P2 ENERGY SOLUTIONS        PAGE   1
==============                                                                                                 GLOBAL  : 03-APR-2012 5576
                                                                                                               EFF:01-APR-2012 DISC:01-APR-2012 PROD:01-JAN-2013
                                                                                                               RUN DATE:  4-APR-2012 TIME: 14:13
                                                                                                               FILE: Outa3PH.DAX

WELL/LOCATION      - Asphalt Ridge Oil Sands (Rim Rock & Duchesne River)                                       UNIT FACTOR          -     100.0000 %
EVALUATED BY       -                                                                                           TOTAL RESERVES       -        30000 MSTB
COMPANY EVALUATED  - MCW Energy Group Ltd.                                                                     PRODUCTION TO DATE   -          N/A
APPRAISAL FOR      -                                                                                           DECLINE INDICATOR    -    EXPONENTIAL
PROJECT            - FORECAST PRICES & COSTS                                                                   TOTAL CAPITAL COSTS  -        13162 -M$-

      INTEREST                                              ROYALTIES/TAXES

      AVG WI 100.0000%                                      U.S.

                                                                                 Oil
                                                                                 MSTB
                                                          ----------------------------------------------
                                                                               Pool        Company Share
                                                           # of    Price  -------------- ---------------
                                                     Year  Wells   $/STB   STB/D     Vol   Gross     Net
                                                     ---- ----------------------------------------------

                                                     2012      0   83.20      .0       0       0       0
                                                     2013      1   81.60   500.0     183     183     168
                                                     2014      1   80.00  1000.0     365     365     336
                                                     2015      1   80.00  2000.0     730     730     672

                                                     2016      1   81.60  2000.0     730     730     672
                                                     2017      1   81.60  2000.0     730     730     672
                                                     2018      1   83.23  2000.0     730     730     672
                                                     2019      1   84.90  2000.0     730     730     672
                                                     2020      1   86.59  2000.0     730     730     672

                                                     2021      1   88.33  2000.0     730     730     672
                                                     2022      1   90.10  2000.0     730     730     672
                                                     2023      1   91.90  2000.0     730     730     664
                                                     2024      1   93.74  1992.0     727     727     654
                                                     2025      1   95.61  1976.2     721     721     642

                                                     2026      1   97.52  1960.5     716     716     630
                                                     ---- ----------------------------------------------

                                                     SUB                           9282    9282    8467
                                                     REM                          20718   20718   18129
                                                     TOT                          30000   30000   26596

      ==================================================== COMPANY SHARE FUTURE NET REVENUE ====================================================

                  Company Share                                                                                                         Future Net Revenue
                                                                                                                                ------------------------------------
              Future Revenue (FR)            Royalties     Wellhead Taxes     Oper Costs                 Proc&                    Undiscounted             10.0%
          -------------------------------- ------------- -------------- ------------- FR After   Other  Capital   Aband  --------------  ------------------
Year        Oil  SaleGas  Products    Total   State    Other     Sev  Ad-val   Fixed  Variabl Roy&Oper  Income    Costs   Costs   Annual       Cum   Annual      Cum
           -M$-     -M$-      -M$-     -M$-    -M$-     -M$-    -M$-    -M$-    -M$-     -M$-     -M$-    -M$-     -M$-    -M$-     -M$-      -M$-     -M$-     -M$-
---------------------------------------------------------------------------------------------------------------------------------------------------------------------

2012          0        0         0        0       0        0       0       0       0        0        0       0     1891       0    -1891     -1891    -1825    -1825
2013      14892        0         0    14892    1191        0       0       0       0     4563     9138       0    11271       0    -2133     -4024    -1893    -3717
2014      29200        0         0    29200    2336        0       0       0       0     9308    17556       0        0       0    17556     13532    14163    10446
2015      58400        0         0    58400    4672        0       0       0       0    18987    34741       0        0       0    34741     48273    25478    35924

2016      59568        0         0    59568    4765        0       0       0       0    19367    35435       0        0       0    35435     83708    23625    59549
2017      59568        0         0    59568    4765        0       0       0       0    19755    35048       0        0       0    35048    118756    21243    80792
2018      60759        0         0    60759    4861        0       0       0       0    20150    35749       0        0       0    35749    154505    19698   100490
2019      61974        0         0    61974    4958        0       0       0       0    20553    36464       0        0       0    36464    190969    18265   118755
2020      63212        0         0    63212    5057        0       0       0       0    20964    37192       0        0       0    37192    228160    16936   135691

2021      64479        0         0    64479    5158        0       0       0       0    21383    37938       0        0       0    37938    266098    15706   151396
2022      65770        0         0    65770    5262        0       0       0       0    21811    38698       0        0       0    38698    304796    14564   165960
2023      67084        0         0    67084    6038        0       0       0       0    22247    38800       0        0       0    38800    343596    13275   179234
2024      68155        0         0    68155    6816        0       0       0       0    22602    38738       0        0       0    38738    382334    12049   191283
2025      68964        0         0    68964    7586        0       0       0       0    22870    38508       0        0       0    38508    420841    10888   202171

2026      69784        0         0    69784    8374        0       0       0       0    23143    38268       0        0       0    38268    459109     9837   212008
---------------------------------------------------------------------------------------------------------------------------------------------------------------------

SUB      811811        0         0   811811   71839        0       0       0       0   267700   472272       0    13162       0   459109              212008
REM     2060910        0         0  2060910  257614        0       0       0       0   683446  1119851       0        0       0  1119851               88370
TOT     2872721        0         0  2872721  329453        0       0       0       0   951146  1592122       0    13162       0  1578960              300378

============================== NET PRESENT VALUE (-M$-)=============================                ================= PROFITABILITY ================
                                                                                                                                                 Before
Discount Rate               .0%      5.0%      8.0%     10.0%     12.0%     15.0%     20.0%            COMPANY SHARE BASIS                              Tax
-----------------------------------------------------------------------------------------            ------------------------------------------------------
FR After Roy & Oper.   1592122    597085    392858    312204    255616    197618    139386            Rate of Return (%) ...........                 273.1
Proc & Other Income.         0         0         0         0         0         0         0            Profit Index (undisc.) .......                 120.0
Capital Costs ......     13162     12459     12072     11827     11591     11254     10734                         (disc. @ 10.0%) .                 25.4
Abandonment Costs ..         0         0         0         0         0         0         0                         (disc. @  5.0%) .                 46.9
Future Net Revenue .   1578960    584626    380786    300378    244026    186363    128652            First Payout (years) .........                   2.0
=================================== COMPANY SHARE ======================================            Total Payout (years) .........                   2.0
                                                       Oper    FR After   Capital     Future            Cost of Finding ($/BOE) ......                   .44
                        1st Year   Average  Royalties  Costs   Roy&Oper     Costs     NetRev            NPV @ 10.0% ($/STB ) .........                 10.01
-----------------------------------------------------------------------------------------            NPV @  5.0% ($/STB ) .........                 19.49
% Interest .........       100.0     100.0
% of Future Revenue.                           11.5     33.1       55.4        .5       55.0
```

Figure 3

MCW Energy Group Ltd.
Asphalt Ridge Oil Sands,Uintah County,Utah,USA
Prospect Analysis (Arithmetic Average)

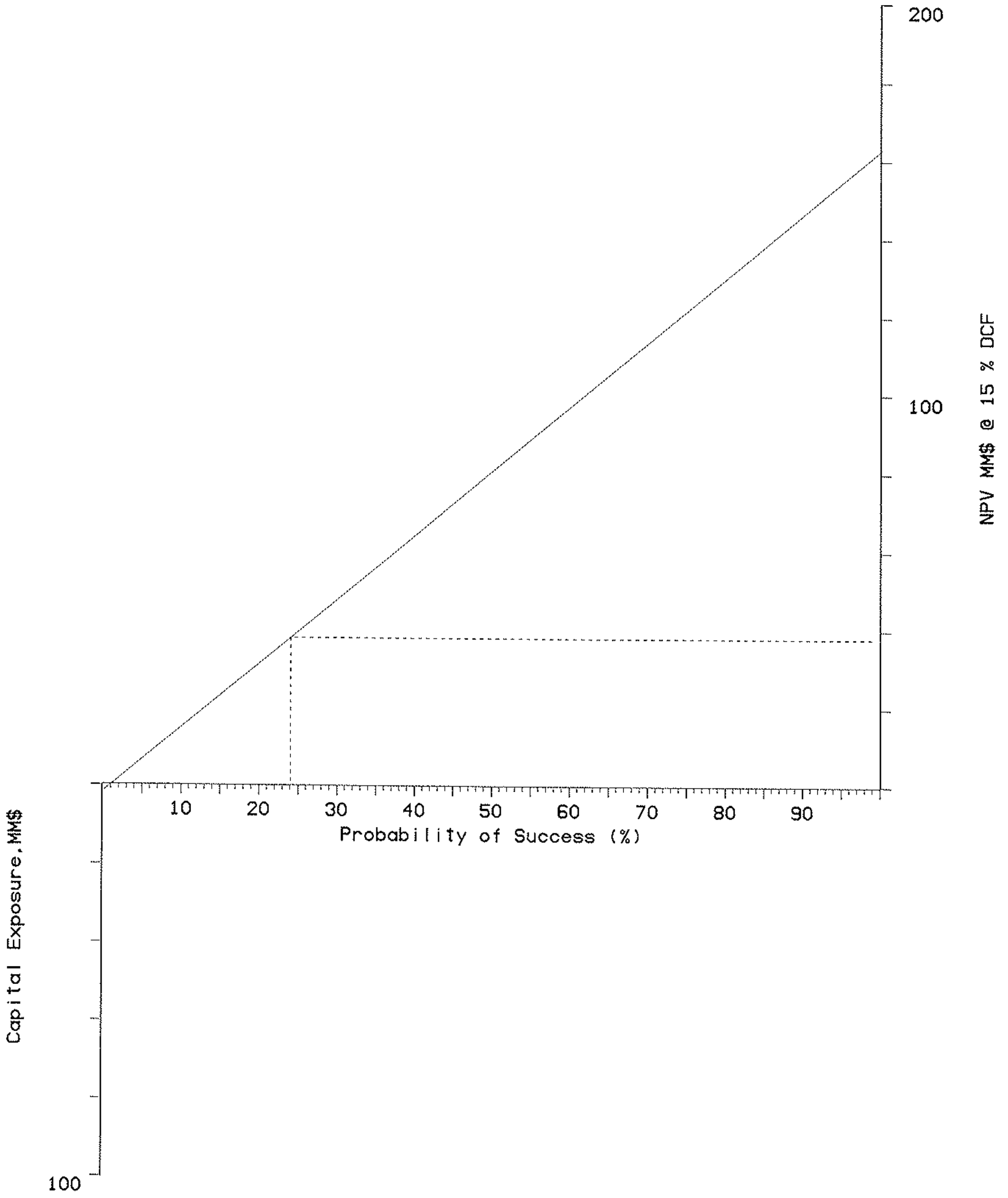


Figure 3
(cont'd)

MCW Energy Group Ltd.
Asphalt Ridge Oil Sands,Uintah County,Utah,USA
Prospect Analysis (Arithmetic Average)

ECONOMIC PARAMETERS

Net Capital Exposure, M$	**1,866**
Risk Components, POS	%
Source	100
Reservoir	60
Trap/Seal	100
Timing/Migration	100
Geological Success	**60**
Commerciality Factor	40
Commercial Success	**24**

TOTAL VALUES

Discount Rate, %	undisc.	5	10	15	20
Unrisked Value, M$	1,018,936	449,854	252,233	162,431	113,850
Risked Value, M$	243,126	106,546	59,117	37,565	25,906
Minimum Prob. of Success Req'd, %	0.2	0.4	0.7	1.1	1.6

MCW Energy Group

Temple Mountain Mine

Asphalt Ridge, Uintah County, Utah

Processed Oil Sands Disposal and Monitoring Program for the Temple Mountain Mine Site

October 2015

Prepared for:

Utah Department of Environmental Quality

Division of Water Quality

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1.0 Introduction: As a result of a site visit on May 6, 2015, the Division of Water Quality (DWQ) requested the following from MCW "**A plan to monitor tailings quality should be included with MCW's permit application. MCW should also conduct dry analyses on the tailings material (reported in mg/kg) for Total Organic Carbon and the petroleum parameters which were detected in the SPLP analysis**" and to "**have a monitor well immediately downgradient of the tailings disposal area to both define background water quality and demonstrate that water quality is not being degraded by the tailings disposal operation.**" This report addresses these requests and concerns.

Several factors need to be considered when designing a cap and liner system for the disposal and subsequent monitoring of oils sands after the oil has been extracted from it to ensure that the processed sands do not have a negative impact on the environment. These include...

- the efficiency of the oil recovery process;
- the permeability of the underlying bedrock;
- the quality and quantity of the groundwater beneath the mine area;
- the average monthly rainfall and evaporation and annual rainfall in the area;
- the water storage capacity of the processed sands and
- the residual hydrocarbon content of the processed sands and the hydrocarbon content of the leachate produced from the processed sands

Each of these factors will be evaluated individually below.

1.1 Efficiency of the oil recovery process: MCW's technology has been proven to recover over 99% of the oil/bitumen from the oil sands and over 99% of the light hydrocarbon and alcohol solvents used to extract the oil from the oil sands (Appendix A and B). This high extraction efficiency is an essential component to MCW's technology and compares very favorably to the 85% to 90% extraction efficiency of the hot water extraction technologies used for oil sands development in Alberta, Canada. This high recovery efficiency will produce a sand with an exceptionally low volume of potential ground water contaminates.

1.2 Permeability of underlying bedrock: Well logs from exploration wells drilled in the mine area reveal that the Duchesne River formation is composed predominantly of interbedded oil sands and shales (Temple Mountain Energy, 2013). The low permeability of the shale and oil sands will form a very effective barrier preventing any surface water, due to rainfall or snow melt, from percolating into the ground. It should be noted that the presence of the intermittent stream that flows from north to south on the property is due to the surface exposure of oil sands on the property, which prevents the stream water from percolating into the ground. The streams becomes an ephemeral stream just south of the mine site due to the steep dip of the oil sands relative to the topography of the land, which allows the water to percolate into the ground.

1.3 Quality and quantity of groundwater beneath the mine area: Stantec (2015) reported that, according to the State of Utah's definition of an aquifer (geologic formation, group of geologic formations or part of a geologic formation that contains sufficiently saturated permeable material to yield usable quantities of water to wells and springs (R317-6-1)), that no aquifer has been identified within 311 vertical feet of the bottom of the pit, near the center of the mine where Well F-1 was drilled (Fig. 1). Of the 17 wells that were drilled at the Temple Mountain Mine site, only 4 contained intervals that were described as "water wet" in well logs (Table 1). Many of these intervals were relatively thin intervals, between 1 and 8 feet, suggesting that these were isolated fluvial sandstone lenses as opposed to wide spread sand stone bodies. Thin sandstone lenses would have a low probability of yielding usable quantities of water to wells and springs. For well CF-1, the well with the highest number of intervals described as "water wet", the intervals between 215 and 285 feet below ground surface were also described as having light to fair oil saturation (SOHIO Petroleum Company, 1957) (Appendix C). This description suggests that the quality of any water from these intervals may not be suitable for domestic or agricultural use.

The lack of any seeps and/or springs on the property is also a very strong indication that this area has very little groundwater near the ground surface (Clark, 2015).

The water in the intermittent stream that flows through the property has high levels of sulfates, iron, cadmium and total dissolved solids (TDS) and a very low pH (3.04 - 3.5) (Clark, 2015). The cadmium level in the stream water (0.014 mg/L) is nearly three times higher than the Maximum Contaminant Level (0.005 mg/L) set by the EPA for drinking water and above the level set for groundwater by the State of Utah (0.010 mg/L). As noted above, just south of the mine area the water from the intermittent stream percolates into the ground and may be a source of groundwater south of the property. This stream water is clearly not a source of good quality ground water and will not create, or recharge an aquifer as defined by the state of Utah.

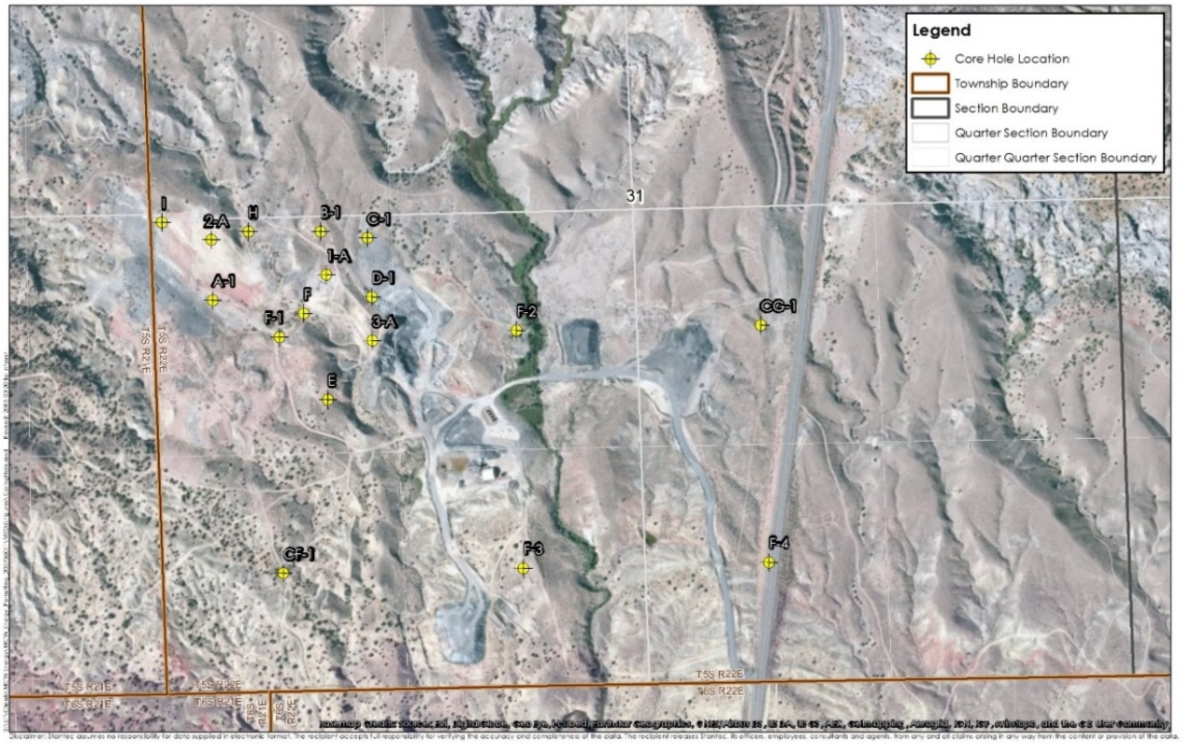

Figure 1. Map of core wells drilled at the Temple Mountain Mine Site.

Source: Stantec, 2015.

1.4 Average rainfall in the area: Historic rainfall records indicate that rainfall in this area of Utah is particularly low, both on a monthly and annual basis (Table 2). The low amount of precipitation combined with the impermeable nature of the geology of the area is the primary reason why so few well logs in this area recorded significant amounts of "water wet" internals, as discussed above. More importantly, the low amount of precipitation will dramatically minimize the chance that any leachate will be produced from the processed oil sands.

1.5 Water storage capacity of the tailings sand: It should be noted that the processed sands themselves have the capacity to hold a considerable amount of water, since they will be coming out of the sand dryer with just enough moisture to control dust. The capillary forces within the processed sands will be quite strong and hold a significant amount of water after a rain storm. If a standard water holding capacity chart is used as a measure of the storage capacity of the processed sands (using fine sand as the category of soil that the processed sands are equivalent to) then each vertical foot of processed sands should be able to hold 1.8 inches of rainwater via capillary forces (Table 3).

Table 1. Well log summary of wells drilled at the mine site with respect to ground water.

Feature	**F-1**	**F-2**	**CG-1**	**CF-1**	**F-3**	**F-4**
Maximum Depth of core (feet BGS[1])	441	210	296	378	382	358
Saturated Interval (feet BGS)	259.1 - 260.2		244.7 - 248.7	58.1 - 60.7		337.7 - 349.7
Saturated Interval (feet BGS)			252.0 - 258.1	215.5 - 217.0		
Saturated Interval (feet BGS)			276.1 - 296.0	218.5 - 237.3		
Saturated Interval (feet BGS)				240.0 - 242.1		
Saturated Interval (feet BGS)				244.2-247.5		
Saturated Interval (feet BGS)				248.5-256.4		
Saturated Interval (feet BGS)				260.0-263.9		
Saturated Interval (feet BGS)				266.4-271.4		
Saturated Interval (feet BGS)				272.9-285.8		
Maximum Thickness of Contiguous Saturated Intervals (feet)[2]	1.1	0.0	19.9	58.0	0.0	12.0

(1) BGS – below ground surface (2) <10 feet separating saturated intervals
Source: Stantec, 2015

Table 2: Average monthly precipitation (inches) for Vernal, Utah.

Month	**January**	**February**	**March**	**April**	**May**	**June**
Avg. Precipitation	0.43	0.51	0.67	0.87	1.06	0.67
Month	**July**	**August**	**September**	**October**	**November**	**December**
Avg. Precipitation	0.63	0.75	0.91	1.26	0.55	0.47

Average annual precipitation (rainfall): 8.78

Source: US Climate Data, 2015

Table 3. Water holding capacity measured in inches of water per foot of soil.

Soil Type	Total Available Water, in/ft
coarse sand	0.6
fine sand	1.8
loamy sand	2.0
sandy loam	2.4
sandy clay loam	1.9
loam	3.8
silt loam	4.2
silty clay loam	2.4
clay loam	2.2
silty clay	2.6
clay	2.4
peat	6.0

Source: Cornell University, 2015 - http://nrcca.cals.cornell.edu/soil/CA2/CA0212.1-3.php

Twenty feet of processed sands have the capability of holding 36 inches of water due to capillary attraction, this is significantly more than the 100-year 24-hour rain event in this area, 2.3 inches of rain (Western Regional Climate Center, 2015a) and significantly more than the annual average rainfall in this area, 8.87 inches (Table 2).

Precipitation is, of course, balanced with evaporation and the pan evaporation for Vernal, Utah is significantly higher than the precipitation both on an annual basis and during the months of April through October (Tables 2 and 4) (Western Regional Climate Center, 2015b). The high rate of evaporation, especially during the April through October time frame, will result in the net loss of any water held by capillary forces in the processed sands as they are used for mine remediation work and dramatically reduce the chance that any leachate will be created.

Table 4. Pan evaporation for Vernal Utah, average values from 1928-2005 (in inches).

Month	**January**	**February**	**March**	**April**	**May**	**June**
Pan Evaporation	0.00	0.00	0.00	5.07	6.41	7.48
Month	**July**	**August**	**September**	**October**	**November**	**December**
Pan Evaporation	6.64	6.34	4.89	2.92	0.00	0.00

Annual average - 39.75 inches

Source: Western Region Climate Center, 2015b

1.6 Prior testing of the processed sands: Prior analysis of the leachate from the processed sands produced by the Synthetic Precipitation Leaching Procedure (SPLP) revealed slightly elevated levels of TOC, but very low levels of other organic chemicals associated with oil/bitumen (Table 5 and Appendix D). Interestingly, the leachate from the processed sands had lower levels of Total Dissolved Solids (TDS) and lower levels of sulfate than the leachate produced from the overburden material at the mine site and had much lower levels of TDS and sulfate than the intermittent stream that flows through the eastern part of the mine site (Clark, 2015). The sulfate levels of the leachate produced from the overburden and the sulfate levels of the intermittent steam are in excess of the 250 mg/L level set by the US EPA National Secondary Drinking Water Regulations (US EPA, 2015). The TDS levels of the stream are in excess of the 500 mg/L level set by the US EPA National Secondary Drinking Water Regulations. The processed sands will not contribute to the high TDS, sulfate or cadmium levels that are naturally found in the water at the Temple Mountain Mine area. Additionally, the solvents used in MCW's technology (light hydrocarbon compounds and alcohols) and the trace quantities of hydrocarbon compounds found in the SPLP leachate test are light non-aqueous phase liquids (LNAPL) (Table 5). LNAPLs have far less potential to harm the ground water (they float on water due to their lower density) and the environment in general than dense non-aqueous phase liquids (DNAPL). DNAPLs are significantly more damaging to the environment, more difficult and much more expensive to clean up if groundwater remediation is required, not only because they sink in the water column and impact deeper and larger volumes of water, but also because they are generally non-petroleum and more likely chlorinated compounds. Most chlorinated compounds are listed as hazardous wastes. Absolutely no DNAPLs are used in MCW's solvent.

Blackett (1996) reported that the oil/bitumen in the Asphalt Ridge area all originated from the lacustrine rocks of the Green River formation, the API ranged from 8.2 to 12.9 and that the bitumen had a low sulfur content that ranged between 0.19 and 0.76. This is consistent with the results of MCW's extraction technology (Appendix A). All of the raw oil sands ore mined at the Temple Mountain Mine site will come from the Duchesne River formation. As noted above, the bitumen from this formation has been reported to be fairly consistent along Asphalt Ridge. This strongly suggests that the chemistry of the leachate produced from the processed sands by the SPLP analysis is a fairly good representative sample for the remaining oil sands that will be mined and processed from the Temple Mountain Mine (Table 5 and Appendix D).

It is important to note that MCW has tested its technology on oil sands from different locations with very different bitumen chemical compositions. MCW has found that the efficiency and consistency of the technology is not affected by differences in the chemical composition of the bitumen. An example of the technology's efficiency and consistency, despite major differences in bitumen chemistry, is the result of testing on oil sands samples from Utah and China (Table 6, Appendix A and B). MCW's recovery efficiency in both cases exceeded 99%.

The efficiency and consistency of MCW's technology, despite differences in bitumen chemistry, will ensure that the chemistry of the processed sands from the Temple Mountain Mine will be consistent, even if there are minor changes in bitumen chemistry from one area of the mine to the other. If the consistency of the chemistry of the tailings is confirmed by the results of the dry analyses on a quarterly basis, semiannual analyses should be sufficient thereafter.

Table 5. Analytical Results for Overburden and MCW Processed Sands

Compound	Native Overburden Analytical Results (mg/L)	MCW Processed Sands Analytical Result (mg/L)	Numeric Standard (mg/L) [1]
Arsenic	<0.050		0.05
Barium	<0.050		2.0
Cadmium	<0.010		0.005
Calcium	90	4.90	
Chromium (total)	<0.010		0.1
Lead	<0.050		0.015
Magnesium	16	<1.00	
Mercury	<0.0010		0.002
Potassium	3.8	<1.00	
Selenium	<0.050		0.05
Silver	<0.010		0.1
Sodium	28	1.94	
Alkalinity (as $CaCO_3$)	68	12.9	
Bicarbonate (as $CaCO_3$)		<10.0	
Carbonate (as $CaCO_3$)		<10.0	
Chloride	1.5	0.580	
Oil & Grease		<5.00	
Conductivity (µmhos/cm)	1300		
pH @ 25 °C (reported in Standard Units)	7.96	10.0	6.5-8.5
SGT-HEM/Non-Polar Material		<5.00	
Sulfate	280	4.77	
Total Dissolved Solids (TDS)	440	84.0	1200[2]
Total Recoverable Petroleum Hydrocarbon	3.9		10[3]
Total Organic Carbon (TOC)		31.4	
Diesel Range Organics (DRO)		0.898	
Gasoline Range Organics (GRO)		0.149	
SVOA SPLP by GC/MS Method 8270D/1312/3510C (19 compounds reported, all below detection limit)		<0.0100	
Benzene		<0.00100	0.005
C5&C6 Aliphatic hydrocarbons[4]		0.00778	
C7&C8 Aliphatic hydrocarbons[4]		<0.0200	
C9&C10 Aliphatic hydrocarbons[4]		<0.0200	
C9&C10 Alkyl Benzenes		0.0286	
Ethylbenzene		0.00522	0.7
Naphthalene		0.00472	
Toluene		0.0378	1
Xylenes, Total		0.0554	10

[1] Source: R317-6-2, Ground Water Quality Standards, [2] R317-2-14, Numeric Criteria, [3] Utah Tier 1, [4] EPA and Utah do not have standards for Aliphatic hydrocarbons; for comparison, Massachusetts has a maximum contaminant level (MCL) for aliphatic hydrocarbons of 0.3 mg/L

Source: Stantec, 2015

Table 6. Comparison between oil sands samples sourced from Utah, USA and China

Location	Saturated Hydrocarbons	Aromatic Hydrocarbons	Recovery Efficiency
Utah(Asphalt Ridge)[1]	29.3%	28.4%	99.9%
China[2]	61.06%	5.34%	
China[3]	78.87%	4.43%	99.9%

1 - Oblad, et al. (1975) MCW testing (Appendix A) - 3 sample average
2 - Zhi-Nong Gao, Li-Bo Zeng and Fei Niu (2005) - 5 sample average
3 - MCW testing (Appendix B) - 3 sample average

1.7 Dry analyses of processed sands: In accordance with the DWQ's request, MCW has conducted a dry analysis of the processed sands and will continue to do so on a quarterly basis for the first year of operation and semiannually thereafter (Table 7 and Appendix E). The levels of hydrocarbon compounds found in the processed sands are small fractions of the levels of these same compounds found in the bitumen (Appendix F). It should be noted that the hydrocarbon levels found in the processed sands are below Utah's Tier 1 screening levels (maximum contamination levels) for petroleum hydrocarbons from leaking underground storage tanks. In the case of leaking underground storage tanks, if the Tier 1 criteria are met (contamination levels for all constituents are found to be below the screening levels) the Utah Division of Environmental Response and Remediation (DERR) may deem that no further action is needed. The fact that the trace levels of hydrocarbons found in the processed sands are below Tier 1 screening levels combined with the fact that these processed sands will be encapsulated in low permeability clays and oil sands strongly suggests that using the processed sands for mine remediation poses an extremely low risk to the environment. Processing the oil sands using MCW's technology and recovering the hydrocarbons within them is essentially a remediation of these oil sands.

2.0 Processed sands disposal and monitoring program: During the initial stage of mining operations, the processed sands will be temporarily stored on a large, flat topped stockpile of oil sands ore before being used for mine remediation (outlined in red in Fig. 2). This ore pile will be processed once permanent storage of the processed sands commences. The permanent processed sand disposal area will be the mine floor, starting at the eastern most portion of the active mining area. An asphalt pad, adjacent to the mine, shall be used as a staging area for processed sands waiting to be disposed of on the mine floor (Appendix G and H).

Active mining will continue in a radial pattern to the west and south of the present disturbed mining area designated as Pit 1 (Figs. 3a to 3e). Mining activity in Pit 1 is anticipated to range from four years (for a 5000 barrel per day operation) to 8 years (for a 2500 barrel per day operation). The processed sands disposal area will follow the same direction as the mining area. Natural clay, or native oil sands found at the mine site, will be used both as a liner below the processed sands and as a component of the cap above the processed sands. Permeability tests were performed on five samples of the clay. In all tests, the permeability of the clay was lower than 3.5 x 10^{-7} cm/sec, the 5 sample average was 4.2 x 10^{-7} cm/sec (Appendix I). After mining activities in Pit 1 are completed, a continuation of mining activity in Pits 3 and 4 will be evaluated.

Table 7. Dry analyses of the hydrocarbon compounds found in the bitumen compared to the hydrocarbon compounds found in the processed sands from the mine site. All hydrocarbon compounds detected in the processed sands are below Utah's Tier 1 screening levels (maximum contamination levels) for petroleum hydrocarbons from leaking underground storage tanks.

Compound	**Bitumen**	**Processed Sands**	**Tier 1 screening levels**
Diesel Range Organics (DRO) (C10-C28)		4,750 mg/kg	5,000 mg/kg (1)
TPH (GRO) (C6-C10)	20,300,000 µg/kg	20,500 µg/kg	1,500,000 µg/kg (1)
C5&C6 Aliphatic hydrocarbons	472,000 µg/kg	< 1,000 µg/kg	
C7&C8 Aliphatic hydrocarbons	3,320,000 µg/kg	< 1,000 µg/kg	
C9&C10 Aliphatic hydrocarbons	6,810,000 µg/kg	< 1,000 µg/kg	
C9&C10 Alkyl Benzenes	354,000 µg/kg	20,300 µg/kg	
Ethylbenzene	248,000 µg/kg	< 100 µg/kg	23,000 µg/kg (1)
Naphthalene	33,400 µg/kg	< 100 µg/kg	51,000 µg/kg (1)
Toluene	6,680,000 µg/kg	132 µg/kg	25,000 µg/kg (1)
Benzene	45,700 µg/kg	< 100 µg/kg	900 µg/kg (1)
Xylenes, Total	2,370,000 µg/kg	< 100 µg/kg	142,000 µg/kg (1)

(1) – Source - Table 1-3: Tier 1 Screening Criteria - Guidelines for Utah's Corrective Action Process for Leaking Underground Storage Tank Sites - http://www.deq.utah.gov/ProgramsServices/programs/tanks/ust/releases/docs/2010/11Nov/correctiveActionProcessGuide.pdf

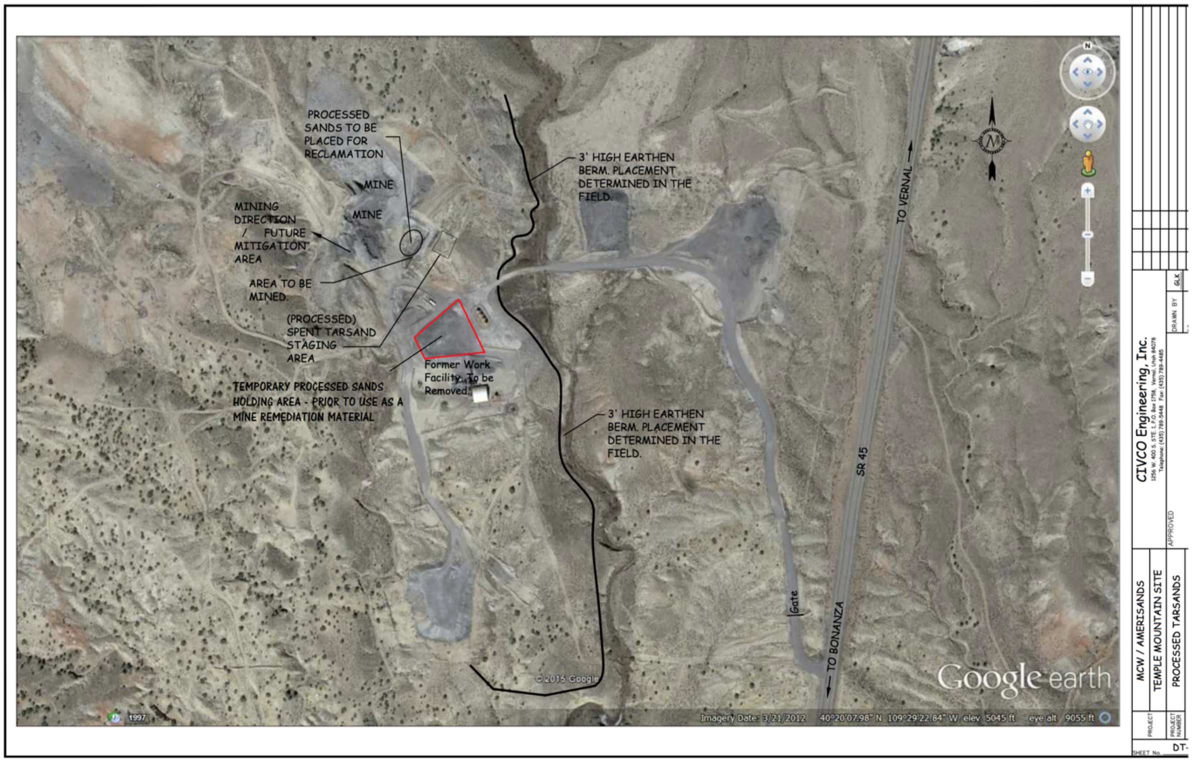

Figure 2. Aerial view of the active open pit and processed sand staging area (square box) and area where processed sands will start to be used for mine remediation (oval). Temporary storage of processed sands will be on a large flat topped oil sands stockpile (red box). A raised berm surrounds the perimeter of the temporary storage pad. The temporary storage area will be used until mine remediation activity starts.

2.1 Processed sands cap design: Despite the fact that the dry analysis of the processed oil sands indicated extremely low levels of remaining hydrocarbons, as an addition level of environmental protection the design of the cap will be based upon the recommendations of the EPA for covering hazardous waste landfills (Fig. 4) (EPA, 1989). This design includes the following features…

- A 30 cm (12 in.) minimum thickness gas vent layer composed of a coarse-grained, porous material (sand or gravel) located between the low-permeability soil liner and the underlying waste layer. Horizontal, perforated pipes will be connected to vertical risers located at high points to minimize water infiltration. The standpipes will be 30 cm (12 in.) or more in diameter.
- A 60 cm (24 in.) minimum thickness compacted soil component with a maximum in-place saturated hydraulic conductivity of 1 x 10^{-7} cm/ sec. The natural clays found at the mine site will be used for this layer. As expanded upon below, native oil sands may be used for this layer as well.

- A 40 mil thickness HDPE flexible membrane liner (FML) component installed directly over the compacted soil component.
- A 30 cm (12 in.) minimum thickness soil drainage (and FML protective bedding) layer with a minimum hydraulic conductivity of 1 x 10^{-2} cm/sec. The EPA indicated that this layer may not be necessary in arid regions, so this layer will not be used at this location.
- A 60 cm (24 in.) minimum thickness fill soil component above the drainage layer. Stockpiled original overburden and interburden material from the mining operation will be used for this layer. This fill layer shall be covered by a top layer composed of either a vegetated, or armored surface component to minimize erosion and, to the extent possible, promote drainage off the cover. Stockpiled top soil and gravel will be used for this layer. The top surface shall have a slope of at least 3 percent, but not more than 5 percent, to promote runoff while reducing erosion.
- Overburden material and surface soils will be temporarily stored to the south of the active mining area, or on the other side of Route 45 (in the area designated as Pit 3) before being used to cover the capped processed sands during mine remediation activities (Fig. 3a).

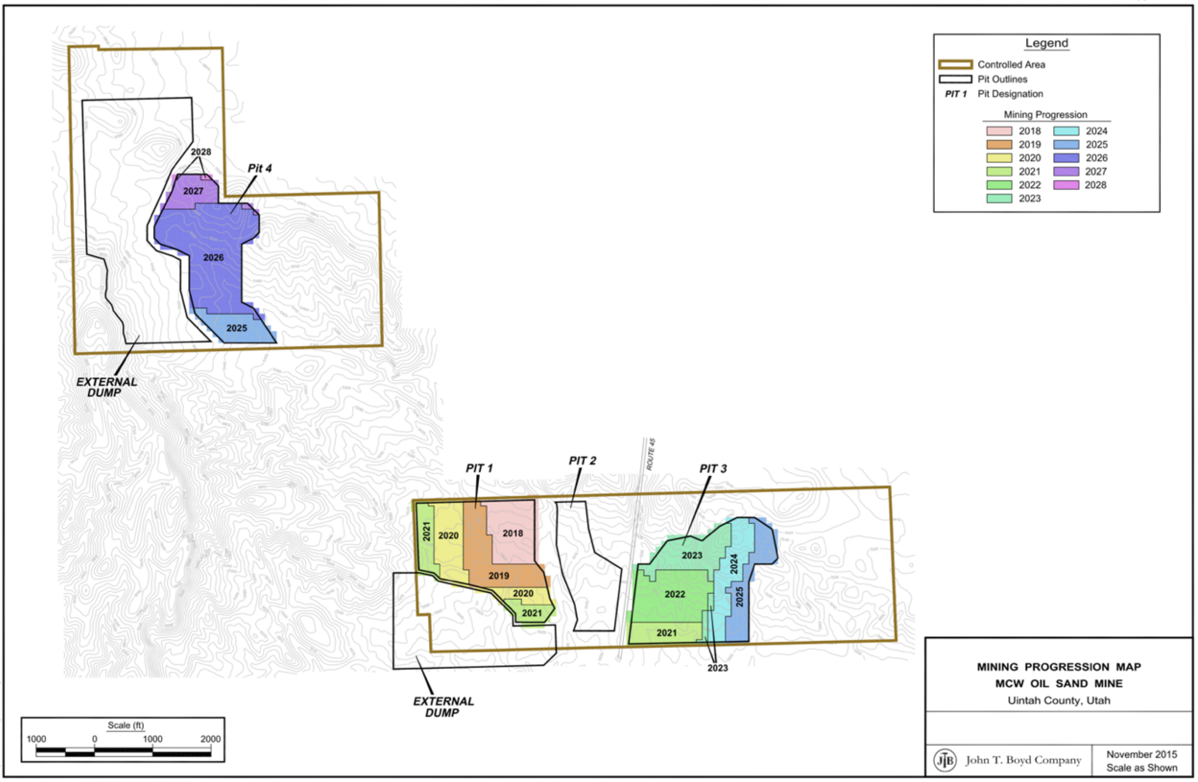

Figure 3a. Schematic of anticipated mining activity, beginning in area designated as Pit 1. The oil sands processing facility will be constructed in the northern portion of the area designated as Pit 2. Overburden material and surface soils will be stockpiled in the area marked external dump before being used to cover the processed sands. If additional room is needed to stockpile the overburden material, the area designated as Pit 3, across Route 45, will be used.

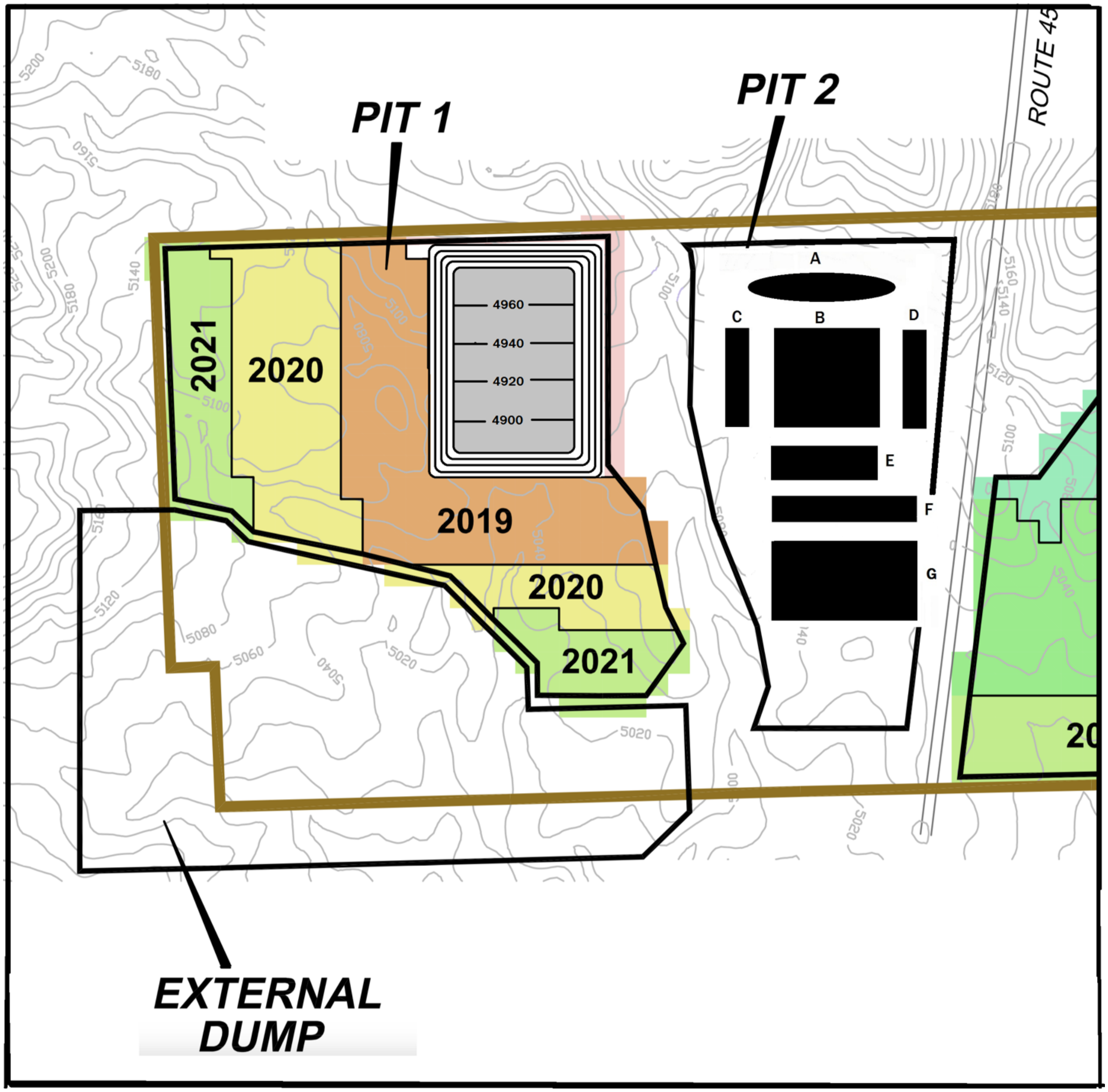

Fig. 3b. Anticipated open pit mining activity during 2018 (5000 barrel per day operation). Contour lines are estimates for the floor of the active mining area.

A – Raw oil sands ore stockpile
B – Oil sands processing facility
C – Solvent storage tanks
D – Solvent storage tanks
E – Bitumen storage tanks
F – Tanker truck loading area
G – Parking area, offices, work shop

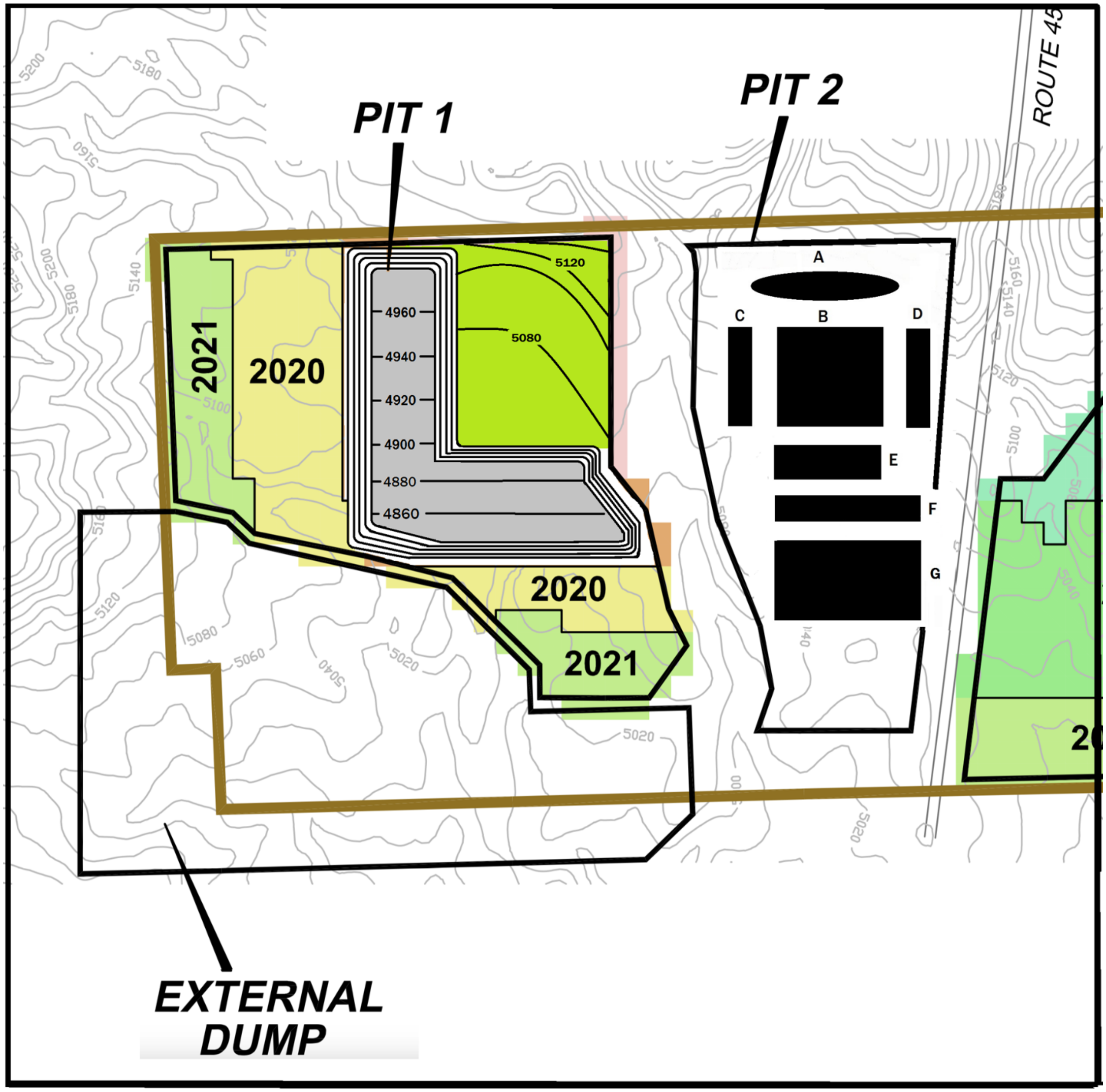

Fig. 3c. Anticipated open pit mining activity during 2019 (5000 barrel per day operation). Contour lines are estimates for the floor of the active mining area. Contour lines over the 2018 mining area are surface estimates after mine remediation activities are completed.

A – Raw oil sands ore stockpile
B – Oil sands processing facility
C – Solvent storage tanks
D – Solvent storage tanks
E – Bitumen storage tanks
F – Tanker truck loading area
G – Parking area, offices, work shop

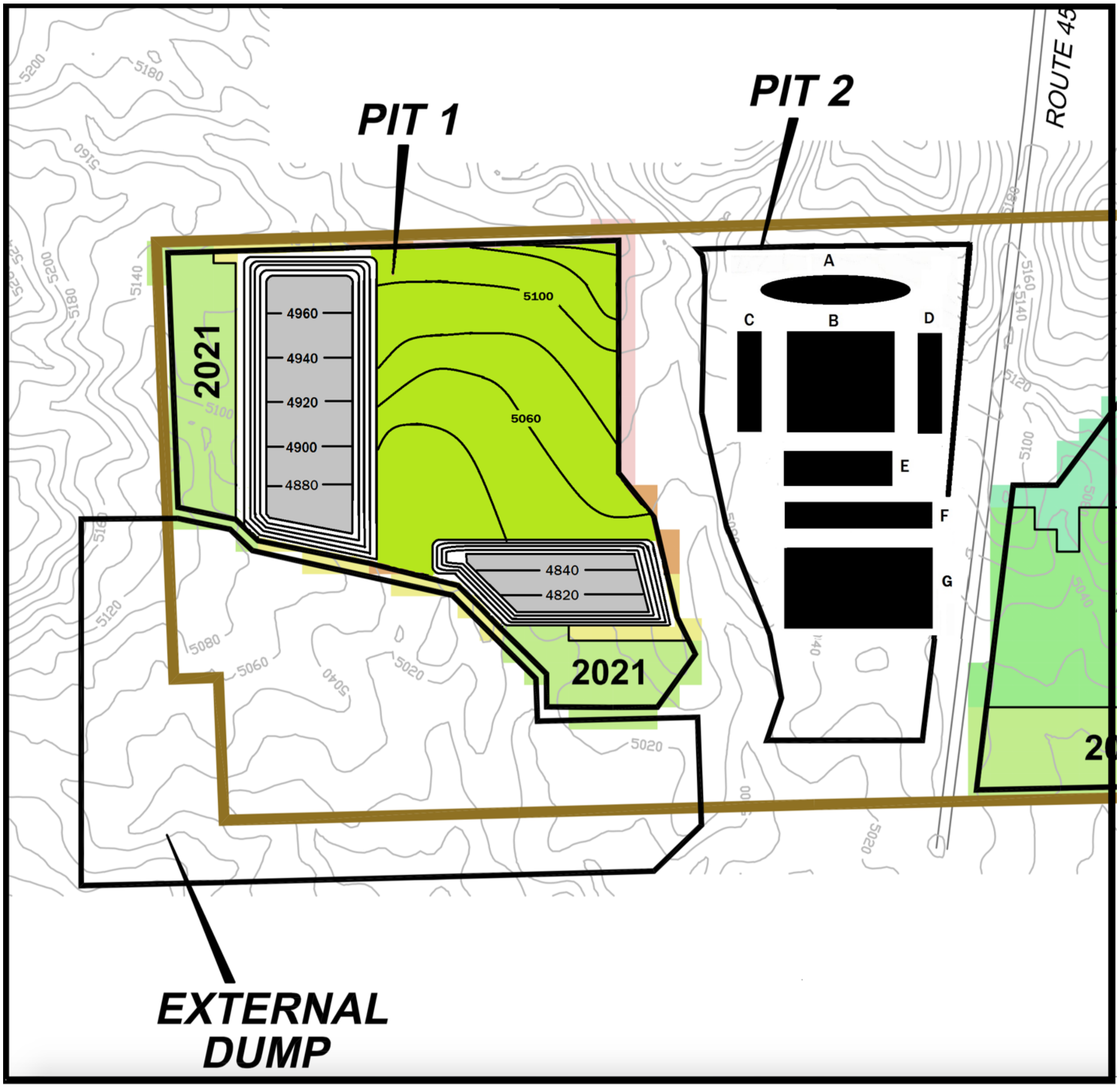

Fig. 3d. Anticipated open pit mining activity during 2020 (5000 barrel per day operation). Contour lines are estimates for the floor of the active mining area. Contour lines over the 2018 - 2019 mining area are surface estimates after mine remediation activities are completed.

A – Raw oil sands ore stockpile
B – Oil sands processing facility
C – Solvent storage tanks
D – Solvent storage tanks
E – Bitumen storage tanks
F – Tanker truck loading area
G – Parking area, offices, work shop

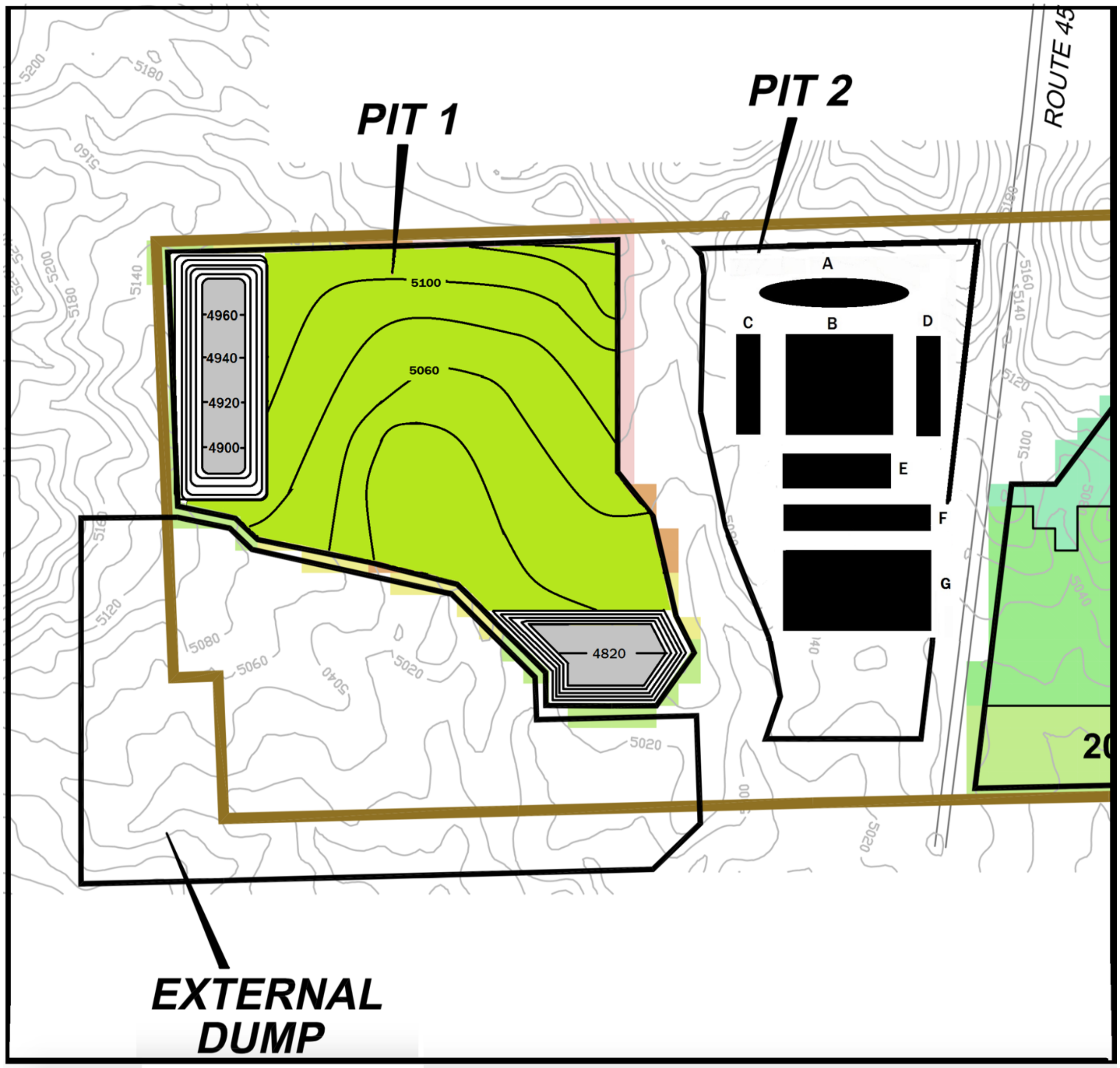

Fig. 3e. Anticipated open pit mining activity during 2021 (5000 barrel per day operation). Contour lines are estimates for the floor of the active mining area. Contour lines over the 2018 - 2020 mining area are surface estimates after mine remediation activities are completed.

A – Raw oil sands ore stockpile
B – Oil sands processing facility
C – Solvent storage tanks
D – Solvent storage tanks
E – Bitumen storage tanks
F – Tanker truck loading area
G – Parking area, offices, work shop

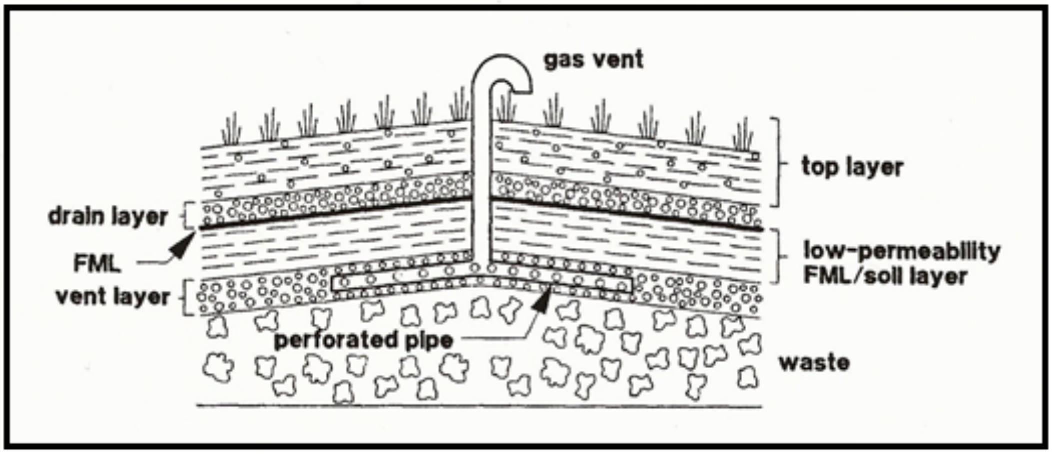

Fig 4. Schematic of the cap design for hazardous waste landfills. See body of text for detailed description of each layer.

Source: EPA, 1989.

As stated above, in addition to the natural clays found at the mine site, the oil sands mined at Temple Mountain can be used as a component of both the cap and the base.

Bowders, et al (2000) reviewed the benefits of using an asphalt barrier as a hydraulic barrier/cap for both hazardous waste and municipal landfills (Appendix H). Several of the benefits include very long life (>1,000 years), especially when buried with cover soils, and extremely low hydraulic conductivities when the proper weight percent of bitumen is used. Recommendations for using asphalt as a hydraulic cap include the following...

- bitumen weight percent of 7% or higher should be used to achieve a hydraulic conductivity of 10^{-7} cm/s or lower.
- the use of two layers of asphalt with a minimum thickness of 5 cm (~2 inches) each.
- an asphalt cement tack coat should be sprayed between the layers.
- the seams of the layers should be staggered.
- the fines content should be between 8% and 15% to ensure a dense graded mixture.
- the asphalt should be compacted so that the percentage of air is below 4%.

The presence of multiple shale and oil sands layers, recorded in SOHIO well logs below the proposed 200 foot maximum depth of the open pit, will act as a very effective natural seal below the processed sands (Temple Mountain Energy, 2013). Impermeable oil sands and shales extend downward for several thousand feet below the mine site.

2.2 Processed sands liner design: The liner shall be constructed of compacted clay and asphalt. The fine grained native clay found at the mine site has previously been tested and has a permeability of less than 10^{-7} cm/sec and is an excellent material for use as the main component of the compacted clay liner (Appendix I). The compacted clay liner shall include the following features based on the recommendations of US EPA (1989) and USDA/NRCS/Wisconsin, 2015.

- a minimum thickness of one foot.
- a maximum hydraulic conductivity of 1×10^{-7} cm/sec.
- soil plasticity indices ranging from 10% to 30%.
- shall containing at least 30 percent fines and up to 50 percent gravel, by weight.
- the moisture content shall be above the optimum moisture as determined by the standard proctor test or modified proctor test.
- loose lift (layer) thicknesses shall be 6 inches.
- compactors, weighing 25,000 or more pounds, with feet long enough to penetrate a loose lift of soil will be used to compact each lift.
- 5 to 20 passes will be made to ensure that clods are broken up (less than ½ inch in diameter) and that the clay is compacted properly.
- the clay liner shall be compacted to a minimum of 95% of standard proctor dry density or to a minimum of 90% of modified proctor dry density.
- Foundation surfaces shall be graded to remove surface irregularities and shall be scarified or otherwise acceptably scored or loosened to a minimum depth of 2 inches.

Six inches of compacted native asphalt will be used to cover the compacted clay. Although the compacted asphalt will provide a high degree of impermeability on its own, as indicated above, the main purpose of the asphalt will be to protect the integrity of the clay liner during remediation activities and to protect it from desiccation. It should be noted that the rock formations below the floor of the mine are composed of interbedded shale and oil sands, which naturally form a very impermeable barrier to water flow. It should also be noted that no aquifers were identified beneath the mine floor, or in the vicinity of this mine.

2.3. Quality control during the installation of the compacted clay low permeability layer: Quality control during the installation of the compacted clay layer are based on the guidelines of the US EPA (1989) and USDA/NRCS/Wisconsin, 2015 (Table 8). Clay liner construction shall be tested and documented by a third party engineering or testing firm at the specified minimum frequency shown in Table 8.

Table 8: Quality control testing performed during compacted clay installation.

Test	Frequency
Standard proctor test (ASTM D-698), or Modified Proctor Test (ASTM D-1557)	1 per 5,000 cubic yards of clay liner
Field density tests (ASTM D-2922, or D-2937, or D-2167, or D-1556)	1 test per 100 foot grid per1 foot thickness of clay liner
Atterberg Limit tests (ASTM D-4318)	1 per 5,000 cubic yards of clay liner
Grain size distribution (ASTM-D422)	1 per 5,000 cubic yards of clay liner
Permeability (ASTM D-5084)	1 per 5,000 cubic yards of clay liner

Source: USDA/NRCS/Wisconsin, 2015 Section IV, Technical Guide 300. Clay liner
US EPA, 1989.

2.4 Potential groundwater monitoring well location: Historical records indicate that 17 wells were drilled in this area as exploration wells for oil sands within the Duchesne River Formation (Fig. 1) (Stantec 2015). Well logs indicated that only four of these wells encountered intervals that were described as "water wet" (Table 1). Wells CG-1 and F-4 had thin intervals described as "water wet", but these wells are east of the mine site, so are not appropriate locations for a monitoring well since ground water will tend to travel in the down dip direction, which is 9^o to 20^o to the SSW in this area (Blackett, 1996). Well F-1 also had a very thin interval described as "water wet", but this core was taken from within the proposed open pit area, so is not an appropriate monitoring well location (Figs. 1). Well CF-1 is both down dip of the mine site (and therefore the processed sands that will be used for mine remediation) and also had the most intervals described as "water wet", so appears to be the most appropriate location for a monitoring well based upon currently available information and understanding of the geology of the area (Fig.1, Appendix C).

Stantec (2015) indicated that the interval described as "water wet" in well CF-1, at a depth of 58.1 - 60.7 feet, is likely an isolated sand lens as opposed to an aquifer of any areal extent. Drilling the proposed monitoring well, slightly offset to the original CF-1, will help to establish whether this shallow sandstone body extends over a larger area than just the immediate area where the original well was drilled. The intervals between 215 and 285 feet below ground surface that were described in the well log as "water wet" were also described as having light to fair oil saturation (SOHIO Petroleum Company, 1957 – Appendix C). This description suggests that the quality of any water from these intervals may not be suitable for either domestic or agricultural use.

2.5 Results from drilling the groundwater monitoring well: On October 1 and 2, 2015, the ground water monitoring well was drilled approximately 100 feet to the east of the location where well CF-1 was drilled (Fig. 2). The well first targeted the interval described as “water wet” in the CF-1 well log that was at a depth of 58.1 - 60.7 feet. This zone was dry. The intervals between 215 and 285 feet below ground surface that were described in the CF-1 well log as “water wet” were then targeted. The well was drilled to a depth of 275 feet and no “water wet” zones were encountered. The well was drilled using an air rotary drill rig. All the cutting that came to the surface were exceptionally dry, no traces of moisture were encountered (Fig. 5). It should be remembered that well CF-1 was drilled in 1957 and is not a good indicator of current subsurface conditions.

2.6 Collection lysimeter for monitoring water associated with disposal of processed sands: Due the fact there are no detectable amounts of groundwater beneath the mine site, the Division of Water Quality requested that a water collection lysimeter be designed and used to monitor the quality of any water/leachate that may form during mine remediation operations using processed sands as a backfill material (Appendix J). The collection lysimeter will be constructed beneath area mined in 2018 and will be constructed as soon as an appropriately sized area is free of active mining operations. The lysimeter will be monitored for the presence of any water/leachate on a regular basis. Any water/leachate that collects in the lysimeter will be sent to a state certified environmental laboratory for analysis.

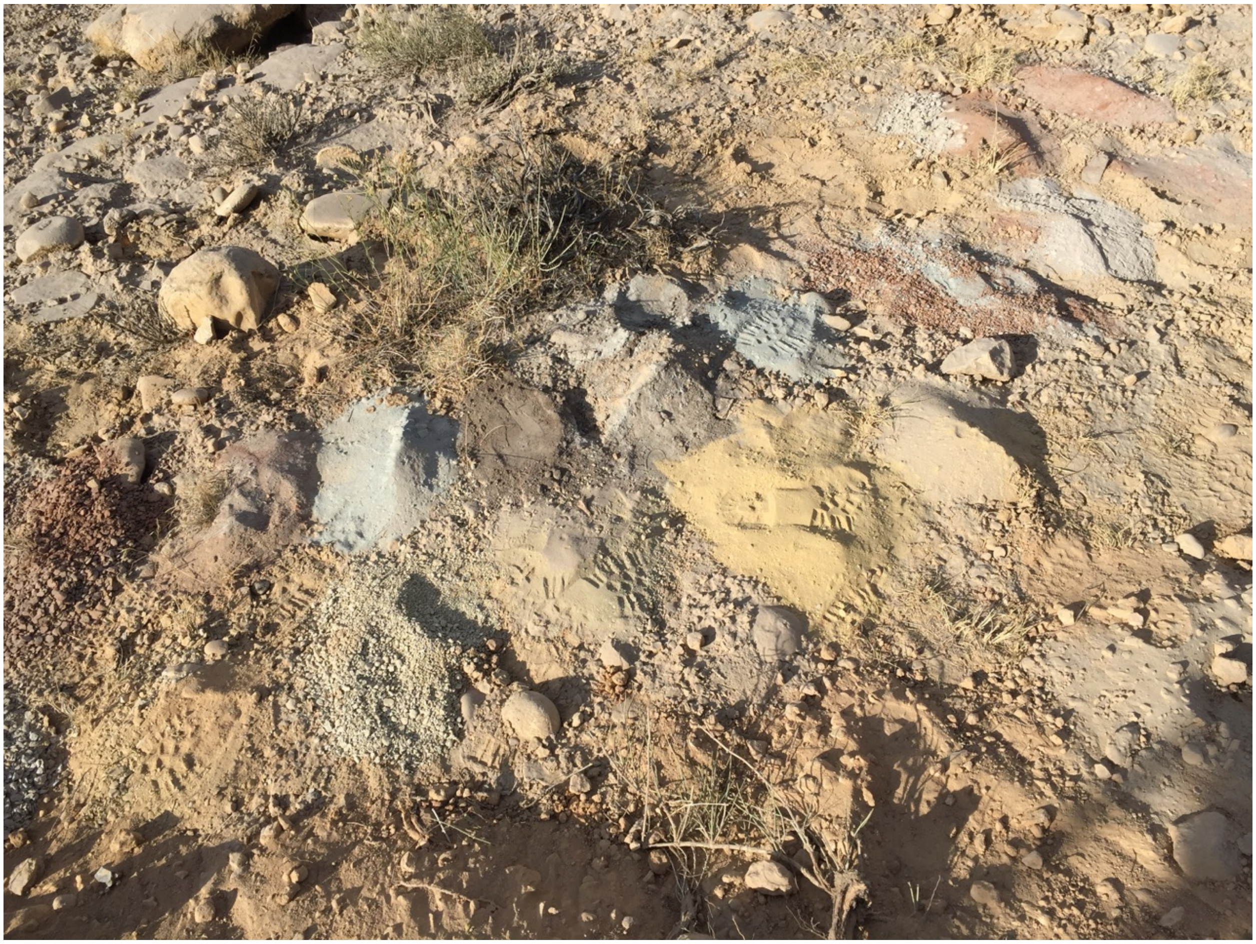

Figure 5. Cutting from the ground water monitoring well that was drilled approximately 100 feet to the east of well CF-1. Air rotary drilling produced cuttings that were exceptionally dry and easy to identify. The majority of cuttings were from interbedded red and gray shales. The black cuttings near the center of the picture are oil sands. No water was encountered at the two target zones at 58.1 - 60.7 feet and 215+ feet.

3.0 Summary and Conclusion: With the present knowledge of both surface and subsurface conditions including...

- the absence of an aquifer beneath the mine site;
- the absence of water in the potential ground water monitoring well that was drilled adjacent to well CF-1;
- the extensive thickness of impermeable beds (shale and oil sands) beneath the planned mine floor (>1,000 feet thick);
- the low volume of precipitation in this area of Utah;

- the high evaporation rates in this area of Utah;
- the poor quality of the intermittent stream water as a potential source of groundwater south of the mine site;
- the absence of any natural seeps or springs in the mine area;
- the low historical occurrence of groundwater in 17 well logs in the immediate mine area;
- encapsulating the processed sands in low permeability clay and/or native oil sands (for both the liner and cap);
- the construction of a collection lysimeter to monitor any leachate created from the processed sands;
- the low residual levels of hydrocarbons in the processed sands (below Utah's Tier 1 screening levels);
- conducting dry analyses of the processed sands on a regular basis;

The use of processed oil sands in mine remediation will have a *de minimis* effect on groundwater quality in this area.

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TEST REPORT

DATE: September 29, 2013
Sample Origin: Asphalt Ridge, Utah
Contact: Rob Cowley/435-671-2430
Project: Analysis of the bitumen extracted from the Asphalt Ridge native oil sands ore using MCW patented extraction technology and solvent composition.
Product: Asphalt Ridge oil sands sample.
MCW Reference Number : CA-CU-092913/ES

Experimental Design Summary:

25 Lbs native oil sands ore sample has been received in MCW laboratory from Asphalt Ridge oil sands mine in Utah. Testing was performed by extracting bitumen from the oil sands sample using MCW proprietary/patented oil from oil sands extraction method. Saturation of the oil sands with bitumen has been determined by weight. Afforded bitumen/hydrocarbons were tested on API gravity and were analyzed using MS-GC and FTIR analysis methods. Every test has been repeated 3 times.

Table 1: Observations

Original Sample	**Sticky solid black oil sands sample, with specific hydrocarbon odor**
Processed Bitumen	**Thick dark viscous heavy oil with strong hydrocarbon odor**
Processed solid phase	**Clean off white sand**

Table 2 Solid phase saturation with hydrocarbons analysis before processing

Test Number	Bitumen (% by weight)	API Gravity
1	12.22	11.6
2	12.37	11.8
3	12.28	11.7

Table 3 Solid phase saturation with hydrocarbons analysis after processing

Test Number	Bitumen (% by weight)	API Gravity
1	Less than 0.1	N/A
2	Less than 0.1	N/A
3	Less than 0.1	N/A

Table 4 Analysis of the Hydrocarbons/Bitumen afforded from the oil sands

Test Number	Viscosity, CP 225 F	Viscosity, CP 320 F	Pour point, F	S (Sulfur), wt%
1	448	75	111	0.37
2	445	76	109	0.33
3	446	76	112	0.34

CONCLUSIONS

1. MCW oil from oil sands extraction technology process can be successfully applied to produce bitumen/heavy oil from the native oil sands ore with efficiency of 99.9%.

2. Analyzed samples of the Asphalt Ridge, Utah oil sands have hydrocarbon saturation in the range of 12.2% to 12.4%

3. Analyzed samples of the tailing sands afforded after hydrocarbons extraction from the native oil sands of Asphalt Ridge, Utah have shown residual bitumen/hydrocarbons content less than 0.1% by weight.

4. Asphalt Ridge bitumen has API gravity in the range of 11.6 to 11.8 and it is flow able at the temperatures higher than 120 F. It is comparable to the oil sands from Athabasca oil sands region in Alberta, Canada

5. Asphalt Ridge oil sands contains between 0.34% to 0.37% of sulfure that is a significantly less sulfur compare to the Athabasca oil sands reserves in Alberta, Canada.

Chief Technology Officer ______Signed______________ Date: September 29, 2013
Vladimir Podlipskiy,

MCW
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REPORT ON OIL SANDS SAMPLE #1 FROM CHINA

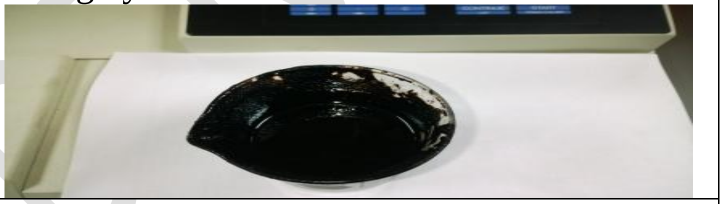
DATE:	**June 23, 2014**
Sample Origin:	KYD, China
Contact:	Elton Zeng
Project:	***Analysis of the oil sands samples from China on the oil content and applicability of MCW oil from oil sands extraction process for commercial oil production in China***
Product:	Oil sands from China. Sample #1.
MCW Reference Number:	***CA-CU-06142014/ES1***

Experimental Design Summary:

34 Lbs native oil sands ore sample has been received in MCW laboratory from China. Part of the sample # 1 has been grinded and treated with MCW patented solvent composition used in oil from oil sands extraction process in MCW production plant built in Utah, USA. Heavy oil/bitumen has been extracted, separated on different fractions and analyzed on the hydrocarbon content, type, and distribution. Saturation of the native oil sands ore with the hydrocarbons (% weight) has been determined. Afforded oil/bitumen (hydrocarbons) were analyzed using GC and FTIR/IR analysis methods. Density/API Gravity and viscosity of the afforded hydrocarbons have been determined. Combustion elemental analysis has been performed to determine the content of carbon, hydrogen, nitrogen and sulfur

in the afforded hydrocarbons. ICPMS tests have been performed to determine the heavy metal content/distribution in the afforded hydrocarbon materials. Additional testing has been performed to determine the BTU value/energy per pound for the hydrocarbon material extracted from the native oil sands ore. Processed solid tailings after the extraction were analyzed on the hydrocarbons content. Every test has been repeated 3 times. The following results have been obtained and analyzed.

Table 1: Observations

Original Sample # 1 of the oil sands from China	Large sticky solid black oil sands rocks with specific hydrocarbon odor 
Extracted hydrocarbons (Heavy Oil/Bitumen) afforded from original oil sands from China, sample # 1 using MCW process and solvent composition	Thick black viscous heavy/gummy liquid with strong hydrocarbon odor 
Asphaltene/Asphalt afforded from the hydrocarbon mixture extracted from the native oil sands ore of the sample # 1 from China	Solid powder with the specific asphalt odor 
Clean sand after hydrocarbon extraction from original oil sands from China, sample # 1	Clean dry sand after extraction. Rocks of the original oil sands before extraction have shown for the comparison. 

Total hydrocarbons content in the native oil sands ore has been determined before and after the extraction process with MCW solvent composition. The following data have been obtained.

Table 2 Total hydrocarbons content in the sample # 1 prior to the extraction

Test Number	Hydrocarbons (% by weight)
1	30.5%
2	28.6%
3	29.2%

Table 3 Total hydrocarbons content in the sample # 1 tailing after the extraction

Test Number	Hydrocarbons (% by weight)
1	Less than 0.1
2	Less than 0.1
3	Less than 0.1

Total hydrocarbons extracted from the native oil sands ore have been separated on two main fractions/compositions Asphaltene and Maltenes. The following data have been obtained.

Table 4 Hydrocarbons composition in the sample # 1 after the extraction

Test Number	Maltenes (% by weight)	Asphaltene (% by weight)
1	70.82	29.28
2	70.16	29.84
3	69.78	30.22

Additional analysis of the Maltenes hydrocarbon types have been performed and the following data have been obtained.

Table 5 Maltenes analysis results by hydrocarbon types (%wt)

Test No	Saturated Hydrocarbons	Unsaturated Hydrocarbons	Aromatic Hydrocarbons	Other Hydrocarbons
1	78.6	6.8	4.2	10.4
2	79.1	6.7	4.5	9.7
3	78.9	7.2	4.6	9.3

Viscosity and API Gravity/Density of the total hydrocarbons fraction extracted from the native oil sands ore have been determined and the following results have been obtained.

Viscosity @ 98 C	**49.52 CsT**
Density	**1.06 g/ml**
API Gravity	**1.99**

Heavy metal elemental analysis (ICPMS) has been performed on the total hydrocarbons fraction extracted from the native oil sands ore. The following data have been obtained**.**

Barium	***14.35***	***PPM***
Iron	***109.00***	***PPM***
Lead	***0.19***	***PPM***
Molybdenum	***7.40***	***PPM***
Nickel	***15 .00***	***PPM***
Strontium	***1.50***	***PPM***

Combustion elemental analysis has been performed on the total hydrocarbons fraction extracted from the native oil sands ore. The following data have been obtained (% wt)**.**

Carbon	***84.75***
Hydrogen	***10.12***
Nitrogen	***0.84***
Sulfur	***4.05***

The heating value/energy of the total hydrocarbons fraction extracted from the native oil sands ore has been determined in the closed bomb colorimeter. The following result has been obtained: ***17,900 BTU/Lbs***

CONCLUSIONS

1. Oil sands # 1 sample from China has extremely high concentrations of the hydrocarbons averaging almost 30% by weight.
2. The majority of the hydrocarbons are Maltenes with straight saturated hydrocarbon chains. Unsaturated and aromatic hydrocarbons are present in moderate rates and significant amount of Asphaltene is present.
3. MCW solvent composition and oil from oil sands extraction process are very effective when applied to produce hydrocarbons from the oil sands ore (sample # 1) from China. The efficiency of the extraction process has been 99.9% of total hydrocarbons obtained/extracted. Very high concentrations of the hydrocarbons in the native ore are making the process even more energy efficient compare to the oil sands production in Utah, USA. Expected energy return can be as high as 1 to 45 times energy invested vs. energy obtained.
4. In addition due to the very high level of the saturated hydrocarbons and Asphaltene in the hydrocarbons extracted from the sample # 1, this material is a very attractive source for the commercial hydrocarbon production. Afforded Maltenes and Asphaltene can be utilized in both oil refinery and high quality asphalt manufacturing processes. In addition the testing results have shown that with slight modification of MCW production process there is a possibility of obtaining both Maltenes and Asphaltene as two separate products of the extraction without additional separation. This approach allows using Maltenes for the oil refinery business and using the Asphaltene straight for the high quality asphalt manufacturing. MCW technology is fully compatible with Chinese sample #1 oil sands type and composition. Commercial development of this reserves would be very effective, energy efficient and economically viable. .

Vladimir Podlipskiy,
Chief technology Officer
June 23, 2014

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV 5017'

TOTAL DEPTH 378.0'

INTERVAL CORED 10.0'-378.0' DATE 11-12-57

CLAIM Contested F

HOLE NO. CF-1

LOCATION 550' South and 550' West of the Northeast Corner, SW/4, SW/4, Section 31, T5S, R22E.

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERMEABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD	RESIDUAL OIL SATURATION GALS./TON.
									OIL	WATER	OIL	WATER		
1	0-10			0-10.0 Plug bit through Alluvium.										
2	10-20	10.0	Duchesne River	10.0-19.3 Shale, light gray, soft, in places iron stained.										
3	20-30	1.3												
4	30-40	5.6												
5	40-50	7.8		19.3-42.2 Sandstone, buff, fine, grains sub-rounded, mainly quartz, argillaceous, friable, in places iron stained.										
6	50-60	10.0		42.2-58.1 Shale, greenish gray, soft, calcareous.										
7	60-70	10.0		58.1-60.7 Sandstone, gray, fine, grains sub-rounded, mainly quartz, a few dark minerals, friable, porous, water wet.										
8	70-80	10.0												
9	80-90	10.0	"	60.7-81.7 Shale, gray, calcareous, arenaceous in places. 81.7-89.9 Shale, reddish brown mottled greenish gray, calcareous, soft.										
10	90-100	10.0		89.9-92.7 Shale, greenish gray, soft, calcareous.										
11	100-110	10.0												
12	110-120	10.0		92.7-113.1 Shale, reddish brown, silty, calcareous.										
13	120-130	10.0	"	113.1-121.4 Shale, greenish gray, soft, arenaceous, calcareous. 121.4-124.1 Shale, reddish brown, soft, calcareous.										
14	130-140	10.0		124.1-135.7 Shale, greenish gray, arenaceous, soft, calcareous.										
15	140-150	10.0		135.7-144.2 Sandstone, black, very fine, grains sub-rounded, mainly quartz, a few clay particles, well saturated with oil.	1	136							20.48	11.23
					2	138							22.08	11.95
					3	140							42.80	24.60
					4	142							34.10	18.27
					5	144							39.00	22.20
					6	147							22.48	11.72

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									OIL	WATER	OIL	WATER		
			Duchesne River	144.2-146.0 Shale, greenish gray, soft, calcareous, has a few oil saturated sand streaks.										
			2'	146.0-148.3 Sandstone, dark gray, fine to medium fine, grains sub-rounded, mainly quartz, a few dark minerals, abundant clay particles, fair oil saturation.										
16	150-160	10.0	"	148.3-154.1 Shale, greenish gray, soft, silty, calcareous.									?	
17	160-170	10.0		154.1-164.7 Shale, reddish brown mottled greenish gray, silty, calcareous.										
18	170-180	10.0		164.7-168.4 Shale, greenish gray, calcareous.										
			2'	168.4-170.6 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, poor sorting, friable, fair oil saturation.	7	170							15.20	8.57
				170.6-171.1 Shale, greenish gray, calcareous.										
				171.1-172.1 Sandstone, dark gray, very fine, grains X sub-angular, mainly quartz, argillaceous, friable, light oil saturation.										
				172.1-174.1 Shale, greenish gray, silty, calcareous.										
			2'	174.1-176.2 Sandstone, gray, very fine, grains sub-angular, mainly quartz, light oil saturation.	8	175							13.63	8.03
19	180-190	10.0	"	176.2-176.7 Shale, greenish gray, hard, calcareous.										
				176.7-181.5 Shale, reddish brown, silty, calcareous.										
				181.5-188.7 Shale, greenish gray, calcareous.										
20	190-200	10.0		188.7-190.0 Shale, reddish brown, calcareous.										
				190.0-191.2 Shale, greenish gray, calcareous.										
21	200-210	10.0		191.2-191.7 Shale, reddish brown, calcareous.										
				191.7-202.5 Shale, greenish gray, soft, calcareous.										
				202.5-203.1 Sandstone, dark gray, very fine, grains X sub-rounded, mainly quartz, friable, fair oil saturation.										
				203.1-203.5 Shale, greenish gray, soft, calcareous.										

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

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HOLE NO. CF-1

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CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River 4'	203.5-208.2 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, fair sorting, friable, fair oil saturation.	9 10 11	204 206 208							20.16 10.71 11.28	11.17 6.41 6.52
22	210-220	10.0		208.2-215.5 Shale, greenish gray, soft, calcareous.										
			1'	215.5-217.0 Sandstone, gray, very fine, grains sub-angular, mainly quartz, fair sorting, light oil saturation, water wet.	12	216							11.74	6.96
				217.0-218.5 Shale, greenish gray, calcareous.										
23 24	220-230 230-240	10.0 10.0	18	218.5-237.3 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, a few dark minerals, friable, light to fair oil saturation, has a few shale seams, water wet.	13 14 15 16 17 18 19	219 221 223 225 227 229 235							14.86 15.03 12.66 9.83 8.77 5.63 8.71	9.32 8.60 10.48 5.34 5.36 2.96 5.08
25	240-250	6.1	"	237.3-240.0 Shale, light gray, hard, calcareous.										
			2'	240.0-242.1 Sandstone, dark gray, very fine, grains sub-angular, mainly quartz, well sorted, friable, light oil saturation, water wet.	20	241							12.37	7.44
			40'	242.1-244.2 Shale, light gray, hard, calcareous.										
				244.2-247.5 Sandstone, dark gray, fine, grains sub-angular, mainly quartz, fair sorting, friable, light oil saturation, water wet.	21	245							7.84	4.94
26	250-260	8.1	"	247.5-248.5 Shale, light gray, hard, calcareous.										
				248.5-256.4 Sandstone, gray, very fine, grains sub-angular, mainly quartz, well sorted, friable, light oil saturation, water wet.	22 23 24	249 251 253							7.82 4.18 3.91	4.43 2.80 2.74
				256.4-260.0 Shale, light gray, hard, calcareous.										
27	260-270	9.5		260.0-263.9 Sandstone, gray, very fine, grains sub-angular to angular, mainly quartz, well sorted, friable, light oil saturation, water wet.										

351.52 ÷ 20 = 17.58 avg

O.B. 135'
waste 67'
202'

Ratio 5/1

[illegible]
135
167

SOHIO PETROLEUM COMPANY

ASPHALT RIDGE PROJECT

CORE HOLE DATA

GROUND ELEV 5017'

TOTAL DEPTH 378.0'

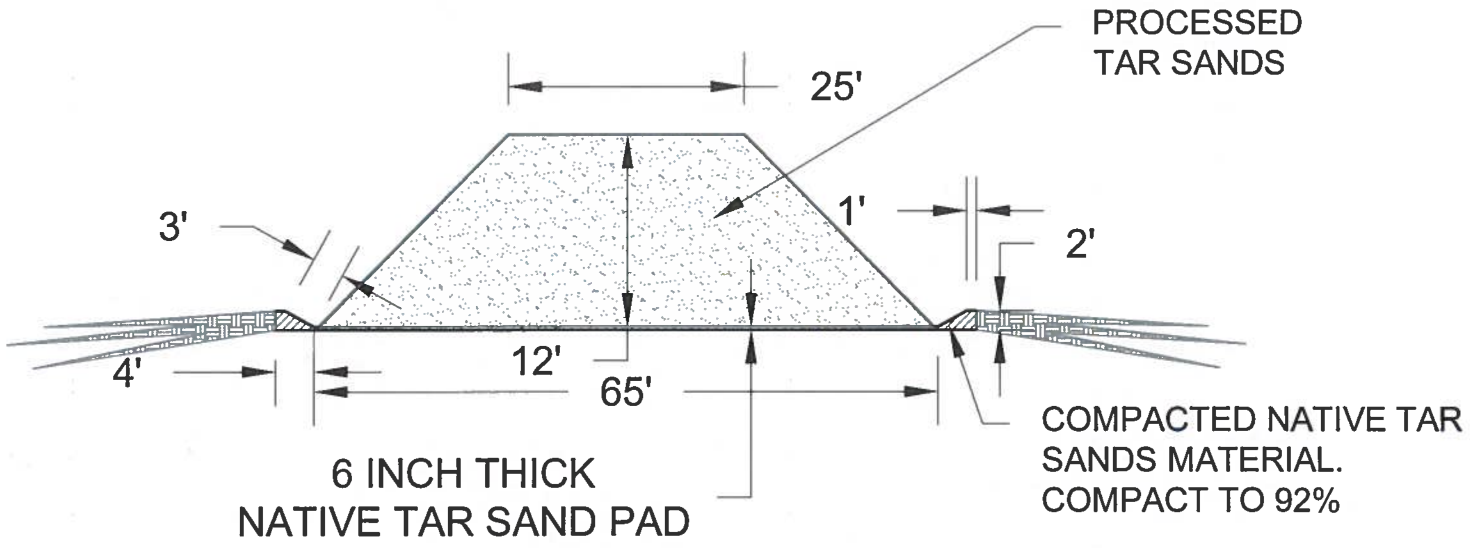
INTERVAL CORED 10.0'-378.0 DATE 11-12-57

CLAIM Contested F

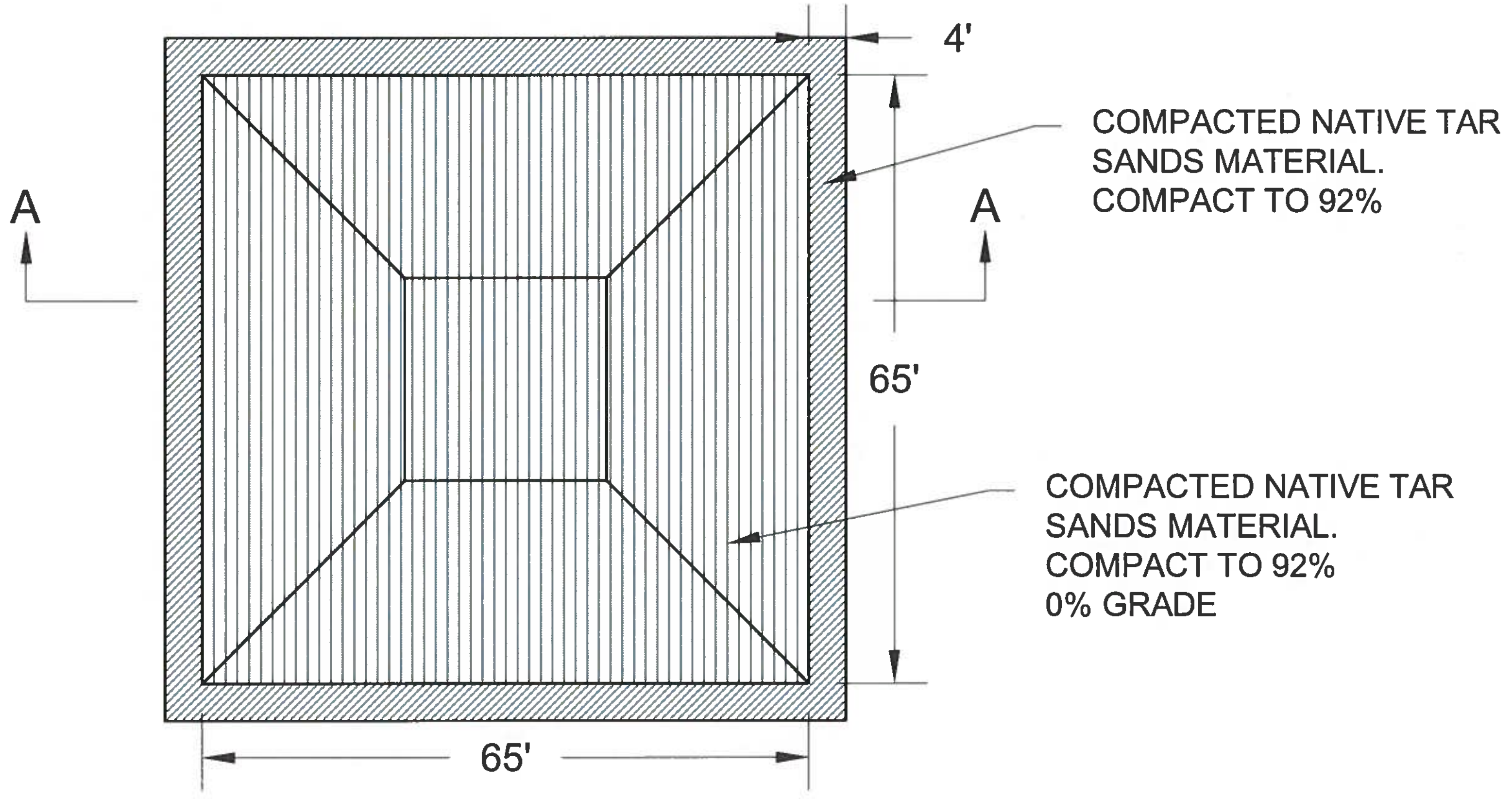
HOLE NO. CF-1

LOCATION 550' South and 550' West of NE Corner, SW/4, SW/4, Section 31, T5S, R22E.

CORE NO.	INTERVAL	FEET RECOVERY	FORMATION	GEOLOGIC DESCRIPTION OF CORE	SAMPLE NO.	SAMPLE DEPTH	POROSITY	PERME-ABILITY	RESID. LIQ. SAT. % PORE SPACE		RESID. LIQ. SAT. % BULK VOLUME		RESIDUAL OIL SATURATION GALS./CU.YD	RESIDUAL OIL SATURATION GALS./TON
									OIL	WATER	OIL	WATER		
			Duchesne River	263.9-265.3 Conglomerate, gray, pebbles to 1" in diameter, sub-rounded, gray limestone, matrix fine sand and calcareous clay, matrix has light oil saturation. 265.3-266.4 Shale, light gray, hard, calcareous.										
28	270-280	8.9		266.4-271.4 Sandstone, gray, medium fine, grains sub-angular, mainly quartz, fair sorting, friable, light oil saturation, water wet.	25	267							4.56	2.70
29	280-290	4.8		271.4-272.9 Shale, light gray, hard, calcareous. 272.9-286.8 Sandstone, gray, fine, grains sub-angular, mainly quartz, well sorted, porous, light oil saturation, water wet.	26	276							8.54	5.02
30	290-300	10.0		286.8-293.6 Shale, light gray, silty, calcareous.										
31	300-310	.9.8												
32	310-320	9.6												
33	320-330	9.3												
34	330-340	8.1		293.6-339.5 Conglomerate, dark gray, pebbles to 3" in diameter, sub-rounded, gray chert and gray limestone, matrix clay and fine sand, light oil saturation in matrix.	27	301							2.36	0.97
					28	306							5.05	2.32
					29	310							4.02	1.86
					30	314							5.22	2.87
					31	323							6.13	3.13
					32	325							7.69	4.71
					33	328							1.95	0.90
				339.5-340.1 Shale, light gray, hard, calcareous.										
35	340-350	4.8												
36	350-360	8.3												
37	360-370	8.4												
38	370-378	6.2	"	340.1-378.0 Conglomerate, gray, pebbles to 3" in diameter, sub-rounded, gray limestone and gray chert, matrix clay and fine sand, non porous.										



A - A



STOCK PILE
RETENTION AREA

REGISTERED STRUCTURAL ENGINEER
167895
TROY D.
OSTLER
STATE OF UTAH
6-9-15

No.	DATE	BY	REMARKS

REVISIONS

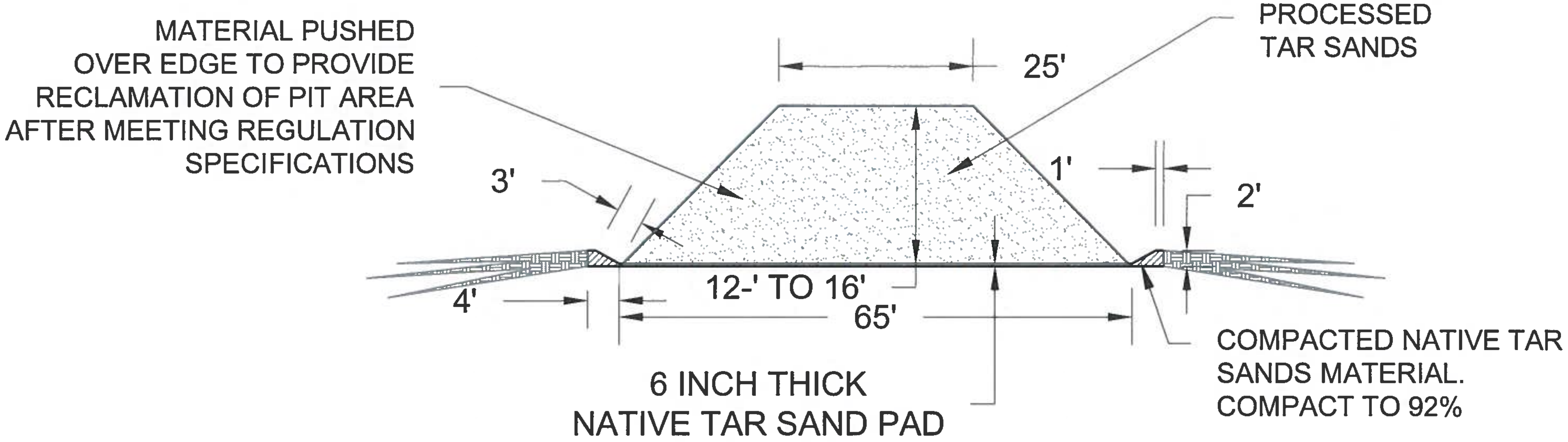
UTAH DEPARTMENT OF TRANSPORTATION
ROADWAY DESIGN

DRAWN BY ####
QC CHECKED BY ####
DATE
APPROVED
PROFESSIONAL ENGINEER

PROJECT
MCW Energy Group
Maeser Facility

PROJECT NUMBER
PIN
Processed Tar Sands
Temp Storage Area

SHEET No DT-5



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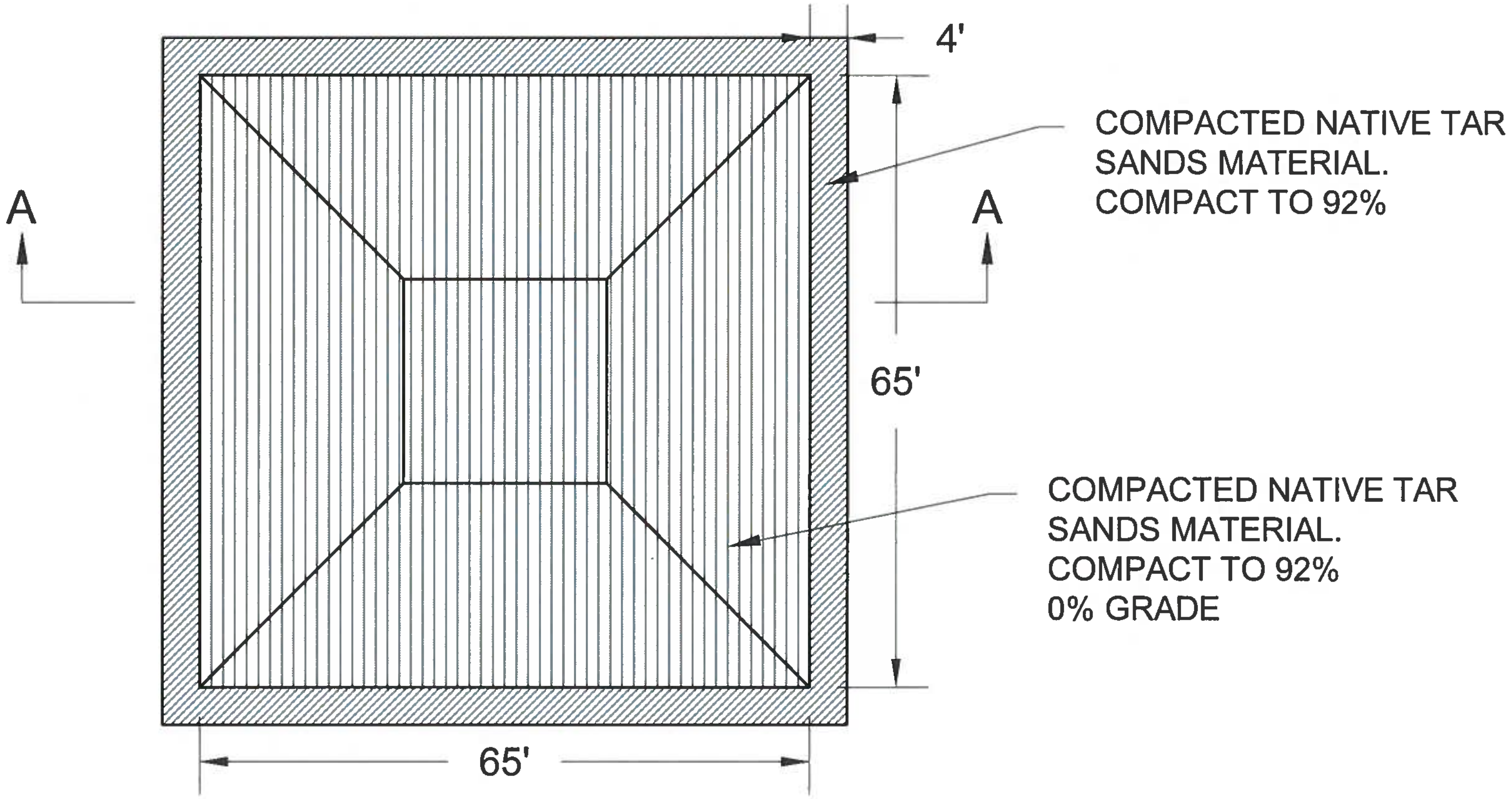


MINE SITE
STOCK PILE RETENTION AREA

167895
TROY D.
OSTLER
6-9-15

UTAH DEPARTMENT OF TRANSPORTATION
ROADWAY DESIGN

No.	DATE	BY	REMARKS	REVISIONS

DRAWN BY ####
QC CHECKED BY ####
APPROVED
PROFESSIONAL ENGINEER
DATE

PROJECT
Temple Mountain Energy
Mine Site
PROJECT NUMBER
PIN
Processed Tar Sands
Retention Area

SHEET No DT-6

New temporary pad dimensions and storm water catchment solution

At full production the plant will process 7 to 10 cubic yards an hour.

9 yd^3 x 24 hours x 27 ft^3/yd^3 = 5,832 ft^3 per day x 7 days = **40,824 ft^3 per week**

The current temporary tailing pad was designed for **17,460 ft^3**, just over 2 days of tailings at full production. If we take the tailings back to the mine site after each load of ore is delivered, this should not be a problem, but since we are resubmitting the application, we should enlarge the pad to accommodate some additional material so that we are not on such a tight schedule taking tailings back to the mine site.

If we increase the dimensions of the temporary tailings pile to the following…

Perimeter Length (**b1**) - 65 ft (assume a square base)

Height - **h1** - 32.5 ft

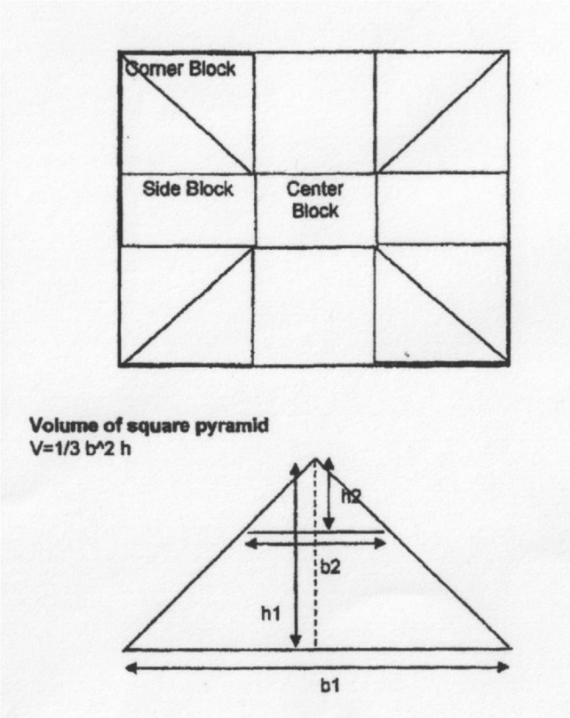
Volume V1 = b1^2 (h1/3) = 65^2 (32.5/3) = **45,771 ft^3**

Width of flat top (**b2**) - 25 ft

Height - **h2** - 12.5 ft.

Volume V2 = b2^2 (h2/3) = 25^2 (12.5/3) = **2,604 ft^3**

Volume of stockpile = V1 – V2 = 45,771 ft^3 - 2,604 ft^3 **= 43,167 ft^3,** which is a full week's storage at 9 cubic yards per hour.



Source: Permit presently on file with DWQ

Bulk Density - 125 lbs/ft3

Tailings in Stockpile - 43,167 ft^3 x 125 lbs/ft^3 = 5,395,875 lbs = **2,698 tons**

Stockpile Height - 20 ft

Ideally, two trips per week would prevent the tailings pile from reaching maximum capacity, but if one trip per week was done, there would be enough storage capacity.

Concerning storm water capacity - the original temporary tailings holding pad had the capacity to hold 480 ft^3 of water in the base 10 inches of clean sand with 25% porosity.

48 ft x 48 ft x (10/12) x 0.25 = **480 ft^3 of pore space**.

A 100-year 24-hour rain event in eastern Utah will yield 2.3 inches of rain.

48 x 48 x (2.3/12) = **441.6 ft^3 of storm water**.

The new dimensions will also accommodate a 100-year 24-hour rain event…

65 ft x 65 ft x (10/12) x 0.25 = **880 ft^3 of pore space**.

A 100-year 24-hour rain event in eastern Utah will yield 2.3 inches of rain.

65 x 65 x (2.3/12) = **809 ft^3 of storm water**.

We can cheaply and easily modify the design of the base of the pad to accommodate even more water. If the berm surrounding the pad is 2 feet high, we get a total of **2,112 ft^3** of storm water storage capacity with a flat bottom. With an asphalt base, this should be more than adequate to prevent any storm water from contaminating the ground water with leachate.

Total volume = 65 x 65 x 2 x 0.25 = **2,112 ft^3** of total storm water storage space.

http://www.wrcc.dri.edu/pcpnfreq/ut100y24.gif

We can have two 100-year 24-hour rain events in the same week and still have the capacity to store all the storm water within the temporary tailings holding pad without any storm water runoff.

It should be noted that the tailings themselves have the capacity to hold even more water since they will be coming out of the dryer virtually free of any moisture. The capillary forces within the tailings after a rain storm will be quite strong and hold a significant amount of water. This was not considered in the original application since the saturated storage was adequate to hold a

100-year 24-hour rain event. It may be beneficial for us to include this information in the new application.

If we use a water holding capacity chart as a measure of the storage capacity of the tailings and use fine sand as the category of soil that the tailings are equivalent to, then each vertical foot of tailings should be able to hold 1.8 inches of rainwater via capillary forces (Table 1). Two feet of tailings will hold 3.6 inches of rain, this is more than the 100-year 24-hour rain event without taking into consideration the saturated storage capacity of the sand.

Table 1. Water holding capacity measured in inches of water per foot of soil.

Soil Type	Total Available Water, in/ft
coarse sand	0.6
fine sand	1.8
loamy sand	2.0
sandy loam	2.4
sandy clay loam	1.9
loam	3.8
silt loam	4.2
silty clay loam	2.4
clay loam	2.2
silty clay	2.6
clay	2.4
peat	6.0

Source: http://nrcca.cals.cornell.edu/soil/CA2/CA0212.1-3.php

Lastly, we should also include the fact that the temporary storage pad will also be temporary since we will be going to a system of having the dry tailings loaded directly onto trailers right from the conveyor belt in the short term future.

June 1, 2015

SPECIAL PROVISION

SECTION 02744S

OIL SAND ASPHALT (OSA)

Add Section 02744:

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Products and procedures for mixing, laying, and compacting a surface course of one or more layers of oil sand asphalt comprised of raw oil sands.

1.2 REFERENCES

A. ASTM D 2950: Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods

B. ASTM E 178: Practice for Dealing with Outlying Observations

1.3 DEFINITIONS

A. Oil Sands
    1. A mined material comprised of natural asphalt and sand.

1.4 ACCEPTANCE

A. A lot equals the number of tons of OSA placed during each production day. The Engineer may:
    1. Conduct the following tests on the placed OSA for acceptance:
        a. Obtain samples for density and thickness.
            1. Obtain one core per 250 tons, randomly as instructed, and in the presence of the Engineer within two days after the pavement is placed.(UDOT Materials Manual of Instruction Part 8-981: Random Sampling, UDOT Materials Manual of Instruction Part 8-984: Sampling Methods)
            2. Move transversely to a point one foot from the edge of the pavement if the random location for cores falls within one foot of the edge of the overall pavement section (outer part of shoulders).

3. Fill core holes with OSA or high AC content cold mix and compact.
4. Obtain one nuclear density test for each 2500 Sq. Ft. of placed OSA.

PART 2 PRODUCTS

2.1 OIL SAND

A. Use Oil Sand supplied by the owner. Load and haul oil sands from source identified by owner.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

A. Locate, reference, and protect all utility covers, monuments, and other components affected by the paving operations.

B. Remove all moisture, dirt, sand, leaves, and other objectionable material from the prepared surface before placing the OSA.

3.2 COMPACTION

A. Use a small compactor or vibratory roller in addition to normal rolling at structures.

B. Operate in a transverse direction next to the back wall and approach slab.

C. Use aggressive rolling techniques to minimize risk of under-compacted OSA courses.

D. Roll surface immediately after placement.

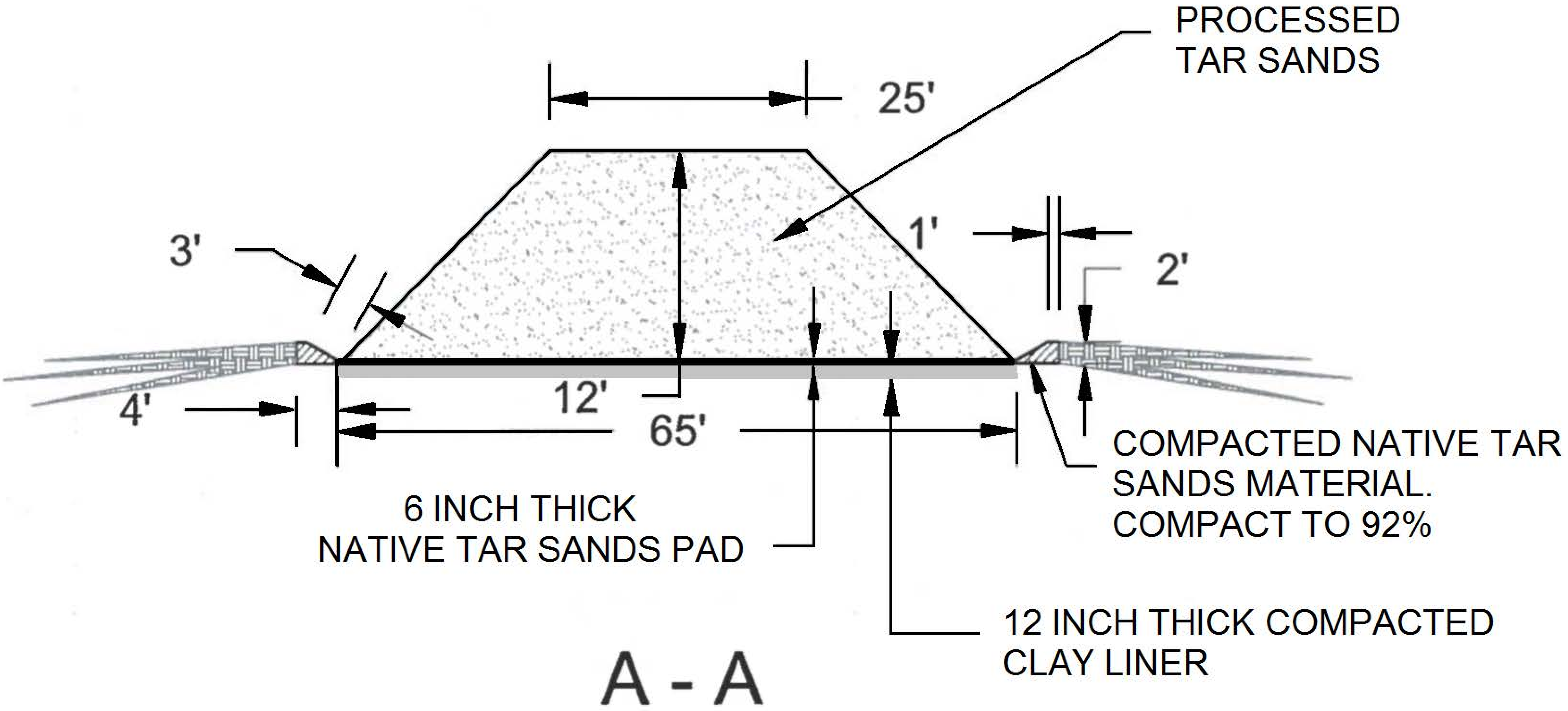
3.3 LIMITATIONS

A. Do not place OSA on frozen base or subbase.

B. Do not place OSA during adverse climatic conditions, such as precipitation, or when surface is icy or wet.

C. Place OSA from when the air temperature in the shade and the surface temperature are above 70 degrees F.
   1. The Engineer determines if it is feasible to place OSA outside the above limits. Obtain written approval from the Engineer prior to paving.

END OF SECTION


PROCESSED
TAR SANDS
25'
3'
1'
2'
12'
4'
65'
COMPACTED NATIVE TAR
SANDS MATERIAL.
COMPACT TO 92%
6 INCH THICK
NATIVE TAR SANDS PAD
12 INCH THICK COMPACTED
CLAY LINER
A - A

GeoEng2000, Melbourne Australia, 19-24, November 2000

ASPHALT BARRIERS FOR WASTE ISOLATION

John J. Bowders[1], J. Erik Loehr[2], D. Todd Mooney[3] and Abdelmalek Bouazza[4]

ABSTRACT

Prior to the mid 1980s, asphalt barriers were primarily used to control water seepage from facilities such as ponds, impoundments and earth dams. Asphalt was applied as hot-sprayed buried asphalt membranes and as asphalt concrete for the barrier layers. The establishment of rules for hazardous and solid waste landfill designs focused the industry toward composite liners consisting of geomembranes and compacted soil. However, in the mid-1980s, resurgence into the use of asphalt concrete for waste isolation was initiated by the US Department of Energy in their quest for very-long-term (1000+ years) hydraulic barriers for radioactive and mixed waste sites. Existing data demonstrate that asphalt concrete barriers and fluid-applied asphalt layers can provide extremely low hydraulic conductivities ($<1x10^{-11}$ cm/s). On-going research results show that asphalt may have the robust properties for a service life approaching 1000 years. Field demonstration of the attributes of asphalt concrete barriers through test pads and monitored prototypes can answer the question of equivalency or superiority of asphalt concrete barriers for waste isolation.

INTRODUCTION

Asphalt containing materials have been used for hydraulic barriers for ages, possibly more than 5000 years (Freeman et al. 1994, Kays 1977, Asphalt Institute 1976). Hot-sprayed buried asphalt membranes have been used for lining water containment structures and controlling seepage through dams for about the last 60 years (Creegan and Monismith 1996, Hickey and Jones 1968, Smith 1962). Over the last 30 years, asphalt concrete has been used for hydraulic barriers and in some cases for liners for waste containment facilities (Asphalt Institute 1976). However, with the initiation of landfill composite (geomembrane + compacted soil) liner systems for waste disposal have dominated new and expanded facilities.

Most regulations allow for site-specific or alternative liner designs provided they meet environmental performance criteria set forth in the rules. Typical regulations provide performance criteria that alternative liners must meet such as the concentrations of specific constituents not be exceeded in the uppermost aquifer at a specific point of compliance. Given these possibilities for alternative liner (and cover) designs, it is worthwhile to examine the state of knowledge regarding asphalt barriers.

Asphalt concrete consists of asphalt and aggregate that are heated, mixed and typically placed in a hot condition, e.g., paving highways. It can also be used for hydraulic barriers. Typical mix ratios for pavements and hydraulic barrier applications are shown in Table 1. The main difference between the paving and hydraulic barrier applications is the percentage of asphalt in the mix; however, mixes for hydraulic applications also include dense graded aggregates and higher fines contents. For the barrier applications, the asphalt content is increased from about 5 percent (total weight basis) to 6 to 9 percent. The increased asphalt content decreases the volume of air voids in the asphalt concrete and thereby reduces the hydraulic conductivity.

Motivations for using asphalt concrete in hydraulic barrier applications include: asphalt tends to have an extremely low hydraulic conductivity, it resists desiccation and cracking, and displays some ability for “cold flow” or creep which may lead to “self-healing” of cracks or construction-formed voids (Kim et. al 1994). Asphalt also has been documented to provide a very long service life especially when buried.

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Table 1 – Comparison of Typical Mixes for Asphalt Concrete in Hydraulic Barrier (Asphalt Institute 1991) and Pavement Applications (Asphalt Institute 1996).

Constituent	Hydraulic Barrier		Pavements	
	Weight (%)	Volume (%)	Weight(%)	Volume (%)
Asphalt	6.5 to 9.5	14	5	13
Coarse Aggregate (>No. 4)	20 to 30	33	50	44
Fine Aggregate (<No. 4)	70-80	44	39	34
Mineral Dust (<No. 200)	8 to 15	5	6	5
Air	**	<4	**	>4

CASES FROM THE LITERATURE

There are numerous citations for the use of asphalt in hydraulic containment structures (Creegan and Monismith 1996). Most of the citations, beginning around the 1940s, refer to the use of hot-sprayed buried asphalt membranes (HSBAM) for controlling seepage of water. In many instances the HSBAM were used for potable water supplies. Asphalt concrete has also been used for hydraulic barriers and in at least one case was used for the low hydraulic conductivity liner for a municipal waste landfill (Asphalt Institute 1976). The literature cases with specific application to waste isolation are summarized in Table 2 and briefly discussed in the following.

Liner Systems

In 1972, the Winnebago County Land Reclamation Site an abandoned gravel pit located in Rockford, Illinois was lined with 5 cm (2 in.) of asphalt concrete. The asphalt was covered with a tar emulsion to isolate the asphalt from naptha and other potentially disruptive solvents that might possibly leach from the waste. A 15-cm (6 in.) sand leachate collection layer was placed on top of the tar emulsion. This is the only municipal solid waste bottom liner of asphalt concrete documented in the surveyed literature. At the time, 1976, the liner apparently was working satisfactorily.

The US EPA's *Lining of Waste Impoundment and Disposal Facilities* (US EPA 1980) discusses asphalt concrete liners in section 3. Haxo and White (1976) measured laboratory conductivity of $3x10^{-9}$ cm/s on asphalt concrete with 9% asphalt cement. A test liner, exposed for 4.6 years was in good condition. The properties had not changed from those recorded initially. Haxo and White (1976) recommended the liner thickness be greater than 10 cm (4 in.).

Styron and Fry (1977) investigated the compatibility of an asphalt concrete liner and leachate from flue gas cleaning sludge (a high pH solution). They found that an 11%-asphalt content in a 5-cm (2-in.) liner met the conductivity requirement.

Cover Systems

The largest use of asphalt concrete barriers in waste containment applications has been for cover or capping systems. In these applications, the principal agent being contained is water from precipitation events. Typically, chemical compatibility with the water is not a primary issue since data show that water does not have any appreciable negative impact on the hydraulic conductivity of asphalt. There are however, lessons to be learned from this application that are directly applicable to asphalt concrete bottom liners.

In 1985, University of Texas at Austin (UT) labs tested asphalt concrete specimens prepared by a designer (Bowders 1999). Specimens prepared at 7.5% asphalt had conductivities averaging $2x10^{-6}$ cm/s while those containing 8% asphalt had conductivities less than $1x10^{-7}$ cm/s. The designer then proceeded with the project, a cover system for a superfund site in Montana and recovered cores from the completed asphalt concrete cover. The cores were tested in the UT labs. The conductivity ranged from $1x10^{-6}$ cm/s to $9x10^{-8}$ cm/s.

An asphalt concrete cap was placed over the Western Processing Co. superfund site in Kent, Washington in the mid-1980's (Repa et al. 1987). Eighteen asphalt concrete core samples were exhumed from the cap and tested in the laboratory. The resulting conductivities ranged from $3x10^{-1}$ cm/s to $1x10^{-2}$ cm/s. The conductivities exceeded the desired $1x10^{-7}$ cm/s by 5 to 6 orders of magnitude. The percentage of air voids in the cores ranged from 12 to 17 percent. This is 3 to 4 times greater than that recommended air voids for hydraulic barrier asphalt concrete (Asphalt Institute 1976, Creegan and Monismith 1996). Factors

Table 2 - Asphalt Concrete Hydraulic Barriers for Waste Isolation

Project/Location	Application	Hydraulic Conductivity	Status	Reference
Winnebago County Landfill, Rockford Illinois, 1972	-MSW liner -5 cm asphalt concrete -Tar emulsion surface -15 cm sand layer LCS	None reported	-1972 receiving 500 metric tons of waste/day -Current status unknown.	The Asphalt Institute (1976)
Liner Exposed to Simulated Landfill Leachate, 1976	-9% asphalt cement -6 cm asphalt concrete	-Water – 3x10^{-9} cm/s -Use >10 cm thick. For leachates	-Liner in good condition after 4.6 years of exposure	US EPA (1980)
Flue Gas Sludge Leachate/Liner Compatibility, 1977	-11% wt basis asphalt cement -5-cm asphalt concrete liner	None reported	-Met hydr. cond. requirements	US EPA (1980)
Superfund site, Montana, 1985	-Cover for former surface impoundment	-Lab: 7.5% asphalt – 2x10^{-6} cm/s -Lab: 8% asphalt cement- <10^{-10} cm/s -Field cores: 1x10^{-6} to 9x10^{-8} cm/s	-Poor construction quality control	Bowders (1999)
Western Processing Company, Kent Washington, 1987	-Cover for waste site -6% asphalt cement -Hi-way paving mix	-3x10^{-1} to 1x10^{-2} cm/s cores from cover	-12 to 17% air voids -Insufficient compaction	Repa et al (1987)
Landfill Cover, Oregon, 1990	-Cover and roadway	-Field test: <1x10^{-7} cm/s (SDRI)	-Sealed double ring infiltr. field test	Bowders (1999)
Hanford Permanent Isolation Barrier Program, Hanford, Washington, 1994	-Prototype cap -7.5% asphalt cement -Two 15-cm layers of asphalt concrete -FAA on surface	Asphalt concrete: -Field cores: 1.3x10^{-9} to 1.2x10^{-10} cm/s -Field SRIs: 1.1x10^{-7} to1.9x10^{-9} FAA: 1.8x10^{-11} cm/s	-Variation in single ring k values likely due to measurement technique (SRI)	Freeman at al (1994) Mancini at al (1995)
Rocky Flats, Denver, Colorado, 1997	-Fluid applied asphalt above the asphalt concrete	-FAA: 1.0x10^{-11} cm/s or lower	-Lower limit of k test device. -No effect on k of gravel embedment.	Glade and Nixon (1997)
Industrial waste, pulp & paper ash landfill, British Columbia, Canada 1998	-Cover for landfill -Asphalt cement included petroleum contaminated soils -15-cm of AC	None reported	-1999, cover performing well.	Kilback and Barrett (1998) Kilback (1999)
Port of Tacoma, Washington, 1999	-Cover for a slag dump	<1x10^{-7} cm/s	-Cover serves as a parking lot	Richardson (1999)

believed contributing to the high conductivities include: a standard highway paving mix was used with the specification for at least 6 percent asphalt but no other specification regarding hydraulic conductivity. Also, field compaction may have been insufficient due to light weight equipment and inclement weather.

The evaluators of the Western Processing cap made the following recommendations for achieving low conductivity asphalt concrete caps in the field:

- Asphalt content at 6 to 9.5%,
- Mineral filler content from 8 to 13%,
- Aggregate should be sized so as not to bridge coarse aggregate,
- Test under lab and field conditions,
- Subgrade must be adequately drained and be stable,

- Slope joint edges to ensure good compaction,
- Apply tack coat to joint edges to ensure bonding,
- Compact asphalt concrete to <4% air voids, and
- Apply an asphalt sealer to the surface.

In the early 1990's a portion of a cover system around a municipal solid waste landfill in Oregon was also required to serve as a roadway. An asphalt concrete was used for the roadway and doubled as the cover for that section of the landfill cover. The in situ conductivity was less than $1x10^{-7}$ cm/s as measured using a sealed double-ring infiltrometer. The final conductivity was likely to be lower but the test was discontinued since the liner met the required conductivity (Bowders 1999).

The US Department of Energy (US DOE) initiated the Hanford Site Permanent Isolation Barrier Development Program (HPIB) in 1985 to develop engineered barriers to isolate waste for long terms (Wing and Gee 1994). The objective of the design is to use natural materials to develop maintenance-free surface barriers that isolate the waste for 1,000 years. The barriers must limit the infiltration of water through the barrier and into the waste to 0.05 mm of water per year (infiltration rate) which corresponds to a hydraulic conductivity of $1.6x10^{-9}$ cm/s. A composite asphalt barrier has been identified and field-tested. The barrier consists of a fluid-applied asphalt and an asphalt concrete layer (Figure 1). The asphalt composite is being presented as the alternative to compacted clay/geomembrane barrier.

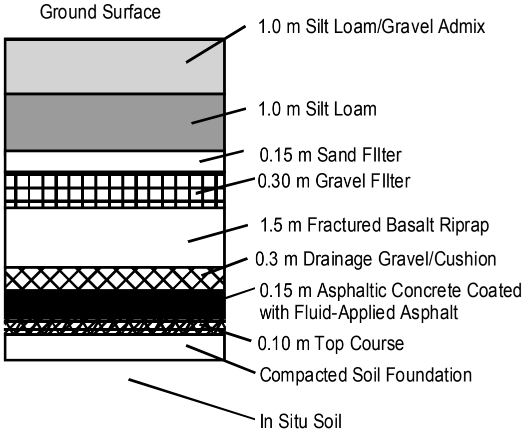

Figure 1 – Cross-Section of Hanford Prototype Permanent Isolation Surface Barrier (Freeman et al. 1994)

The asphalt concrete (AC) and fluid-applied asphalt (FAA) coating make up the hydraulic barrier. The overlying layers constitute drainage and protection layers. A prototype barrier 0.65 hectares (1.6 acres) was constructed in 1994. The asphalt barrier was placed on a 2-degree slope with the joints staggered and layers terraced down slope. The asphalt barrier consists of two 7.5-cm (3-in.) courses of compacted hot mix asphalt concrete containing 7.5 wt% asphalt. Core samples were taken and laboratory hydraulic conductivity tests were performed on them. In addition, a field falling-head permeability test was developed and used on the prototype to measure in situ hydraulic conductivity of the asphalt barrier.

Field measurements of the hydraulic conductivity of the prototype barrier showed hydraulic conductivity decreased with time over a period of 5 days. Eighteen measurements were made over the five days in five locations on the prototype barrier. Two of the measurements exceeded the $1x10^{-7}$ cm/s criterion but these were attributed to leakage of the test apparatus. The remaining conductivities were in the range from $1x10^{-8}$ to $1x10^{-9}$ cm/s. These conductivities are assumed to be conservative (higher than actual) since the bentonite used for sealing the test apparatus to the asphalt was still absorbing water and the test rings only penetrated 5 cm into the asphalt thus allowing lateral flow in addition to vertical flow of water.

Laboratory measured hydraulic conductivity on five asphalt concrete cores averaged $4.7x10^{-10}$ cm/s. This is well below the goal of $1.6x10^{-9}$ cm/s. Conductivity tests on the FAA yielded an average hydraulic conductivity of $1.9x10^{-11}$ cm/s. This was the lower limit of measurement for the testing procedure used.

The DOE is also considering an AC + FAA cover system the Rocky Flats facility near Denver Colorado. In tests on the FAA, Glade and Nixon (1997) found the conductivity to be less than $1x10^{-11}$ cm/s. In related work, Glade et al (1997), found no detrimental effect on the conductivity due to aggregate embedment into the FAA layer. They also found that thickness of the FAA should be greater than 1.5 mm for conductivity requirements and less than 3 mm for long term creep considerations. Creep rate of the FAA tends to increase with increasing thickness of FAA.

Kilback and Barrett (1998) reported on the use of an asphalt concrete in the cover for a industrial waste, pulp and paper ash landfill located in British Columbia. The asphalt concrete was designed to have a low hydraulic conductivity and to incorporate hydrocarbon contaminated soil into the mix as a method of stabilizing the contaminated soils. The site was preloaded for 12 months prior to asphalt placement to reduce settlements once the asphalt cover was in place. Although 7.5 cm (3 in.) of asphalt concrete was sufficient to meet the hydraulic conductivity requirement, a 15-cm (6-in.) thickness was placed. The asphalt concrete barrier is performing well to date (Kilback 1999). No information is available on how the issue of asphalt solubility in hydrocarbons in the contaminated soil was addressed or on settlement tolerance limits for the asphalt concrete cover.

A 0.4 m (16-in.) thick asphalt concrete cap was used to cover a slag dump at the Port of Tacoma, Washington (Richardson 1999). The cap serves as a parking area. The low hydraulic conductivity layer was an asphalt-coated geotextile placed in the asphalt concrete section. The hydraulic conductivity was less than $1x10^{-7}$ cm/s.

OTHER CONSIDERATIONS FOR USING ASPHALT BARRIERS

Asphalt liners are generally not resistant to organic solvents and chemicals, in particular hydrocarbons, so they may not be acceptable liners for petroleum derived wastes or oils, fats, aromatic solvents or hydrogen halide vapors (Kays 1977). Asphalt has shown good resistance to inorganic chemicals and corrosive gases such as hydrogen sulfide and sulfur dioxide. Test results indicated a low permeability of the asphalt materials to radon (Nixon et al 1994). Carbonate-containing aggregates should be avoided if the waste stream or resulting leachates might be acidic (Kays 1977).

In regard to performance lifetimes, if the aggregate in the asphalt concrete mixture is inert, then our attention is focused on the asphalt itself. What is the effective lifetime of asphalt? In their quest for a 1000+ year barrier, the US DOE has performed several evaluations of the effective lifetime for asphalt (Freeman and Romine 1994). Accelerated aging tests on asphalts were performed and the resulting aged specimens evaluated. In addition, testing was performed on asphalt artifacts. Buried asphalt artifacts are analogous to the buried asphalt concrete barrier. Artifacts provide information on the long-term aging behavior of asphalt, which can be used to assess the effect on asphalt concrete barriers.

Mullen (1967) reported on the results of hydraulic conductivity and beam flexure tests for asphaltic concrete samples from pavements in Maryland. The pavements ranged from new to 17 years old. Asphalt cement content ranged from 5 to 6 percent. Samples with less than 6% voids had hydraulic conductivities of less than $1x10^{-7}$ cm/s and limited aging of the asphalt cement. The low-void samples tended to retain ductile load-deflection behavior after years of service. High void samples tended to be dried out and exhibit brittle load-deflection behavior. High asphalt cement content coupled with low void compaction yields low hydraulic conductivity, high ductility, extended life asphalt concrete.

Kays (1977) discusses asphalt concrete liners in general and more specifically as seepage and erosion barriers for earth dams. He stresses analysis of the total design including the nature of the subsurface below the intended liner and the risks associated with leakage from the facility. Kays was ahead of the regulatory agencies in suggesting that performance standards might be more appropriate for design of a liner than simply requiring a prescribed design. Kays (1977) and Creegan and Monismith (1996) provide general design guidance for asphalt concrete hydraulic barriers.

LESSONS LEARNED

Results of laboratory and field efforts with asphalt concrete and fluid applied asphalt illustrate low hydraulic conductivities can be achieved with these barriers given proper design and high level construction quality control. Several lessons to be learned from the existing data include:

- The percentage of air voids must be below 4% (vol. basis) to achieve low hydraulic conductivity,
- Asphalt cement content must be above 6% (wt basis) to achieve low hydraulic conductivity,
- Increase fines content (fraction less than 0.02 mm) to 8% - 15% to insure a dense graded mixture,
- Use at least two layers of asphalt concrete, minimum thickness of 5 cm/layer,
- Apply an asphalt cement tack coat between layers, stagger the joints, and slope them for good compaction,
- The fluid asphalt applied layer should be between 1 and 3 mm thick, and
- The subgrade must be stable and adequately drained.

AREAS REQUIRING FURTHER RESEARCH AND DEVELOPMENT

Results of past laboratory and field efforts indicate several areas in need of further research and development prior to wide acceptance of asphalt barriers for waste isolation. Most of the issues below can be solved through the introduction of instrumented test pads and prototypes. These issues include:

1. Compatibility
   - Liquids (or gases) that might chemically interact with the asphalt or aggregate.
   - Strain possibly causing cracking or distress in the barrier.
2. Construction
   - Procedures for attaining desired compaction and air voids content.
   - Procedures for placing and compacting asphalt on slopes.
   - Standard procedures for Construction Quality Control and Quality Assurance.
3. Performance Monitoring
   - In situ hydraulic conductivity measurements.
   - In situ deformation measurements.
   - Long-term monitoring to assess effective design lifetimes.

CONCLUSIONS

Asphalt materials are being chosen over conventional compacted soil/geomembrane barriers for high level waste isolation because of their low conductivity and promise for long term performance. Similar consideration should be given for all waste isolation applications. Asphalt barriers may be a better long-term solution than currently accepted designs for many situations, in particular, covers for all types of facilities and liners for non-hazardous and inert waste facilities. The challenge to our community is to take on the development of asphalt barriers – a long-term solution for many waste isolation situations.

ACKNOWLEDGEMENTS

The authors greatly appreciate the initial efforts of Paul Axtell, undergraduate research assistant and the enthusiasm of Dan Weiskirch, Hands, Farrow and Weiskirch Engineers, Independence, Missouri. The support by John and Matt Bowen, Bowen Construction Company, Kansas City, Missouri is acknowledged.

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October 21, 2015

MCW Energy Group Mitigation Plan

MCW Energy Group (MCW) has leased a Utah School and Institutional Trust Land Administration tract of land west of Vernal, Utah in Maeser for their processing facility. MCW plans to extract bitumen from tar sands acquired from the Temple Mountain mine site South of Vernal, using a process that produces enhanced bitumen as its primary product and clean, dry sand suitable for construction material as a second product. Tar sand will be hauled by truck from the extraction site south of vernal, to the MCW processing site in Maeser. The tar sand will then be crushed and sent thru the processing plant. The processed tar sand produces Bitumen and sand, the sand that is not sold as a construction product, will be transported by truck to the extraction site and placed on a 65 foot x 65 foot temporary storage area (as shown in the drawing), before being placed in the permanent storage area(as shown in the drawing). The engineering plans for the 65' x 65' temporary storage area are attached as a separate document.

The permanent storage area will have an impermeable base layer ($<= 10^{-7}$ cm/sec) consisting of either clay or native tar sand asphalt. The processed sands will be placed directly on this impermeable base, see attached diagram. When the sands are placed on the storage area, they will be capped with a non-permeable layer of clay or tar sands to prevent precipitation from running on or being allowed to leach thru the sands. As per the recommendations of the DWQ, a plan to monitor the processed sand quality throughout the life of the project will be adhered to. This plan shall include conducting semiannual to annual dry analyses on the sand material (reported in mg/kg) for Total Organic Carbon and the petroleum parameters which were detected in the SPLP analysis, the sands will then be used for remediation of the mine site.

A silt fence will be installed along the southern boundary of the area generating the over burden, to control the silts migration from the regrading of the surfaces. The area to the east of the current mine pit will be graded to create a -2% slope to the west, the over burden will be used to create a barrier to make sure the precipitation flows to the west and south. There is a non-perennial stream on the east side of the storage area and test base lines have been taken and are on file to show the lack of quality water in the stream. The over burden that is not used for a berm will be stock piled to help in the remediation of the mine site.

The area noted on the drawing has a shelf of tar sand material to be mined; when the tar sand material has been mined, it will provide an area to place the produced sand so as to not handle the sands twice. As the mine progresses to the northwest the processed sands will be used to reclaim the area of the mine just mined and the remaining over burden will be placed back on top to produce the rolling hills matching the surrounding area. MCW will use best management practices in the operation of the mining facility, extraction process, and the processing plant. The area around the mine, when the mining is completed, will be contoured and regraded to match the surrounding rolling hills and revegetated with the natural vegetation type of the area.

If you have any questions concerning this matter, please feel free to contact me. I look forward to working with you in the future.

Sincerely,

Troy D Ostler

Troy D. Ostler, SE
CIVCO Engineering, Inc.

cc: Project File

STATE OF UTAH
TROY D. OSTLER
167895
PROFESSIONAL STRUCTURAL ENGINEER
Troy D Ostler
11-5-15

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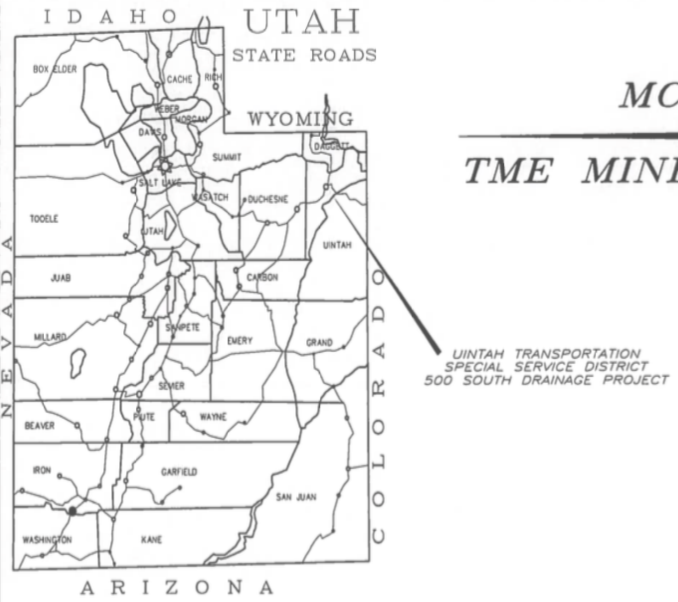
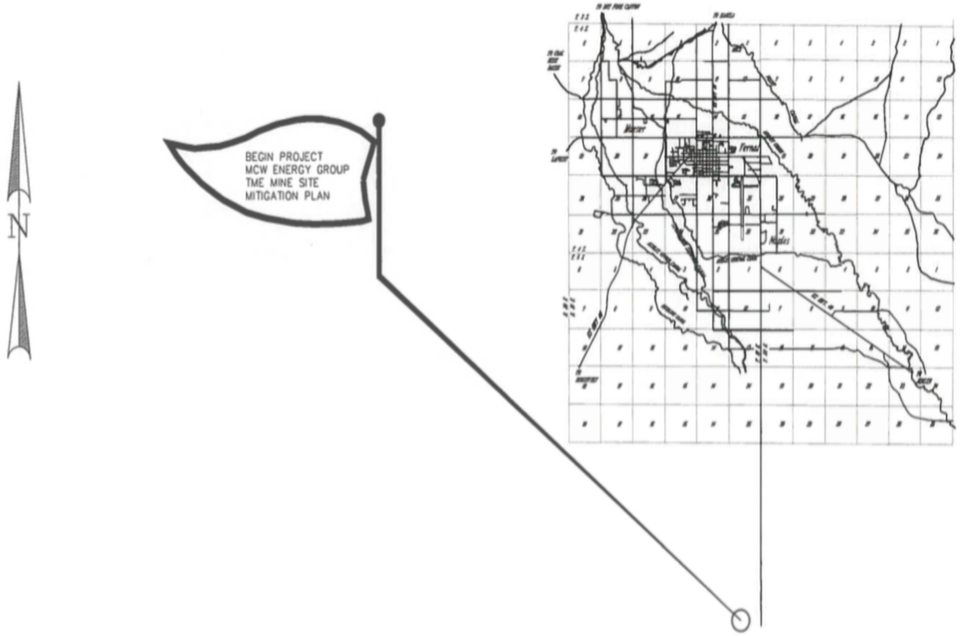


MCW ENERGY GROUP

TME MINE SITE MITIGATION PLAN

UINTAH COUNTY



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167895
TROY D.
OSTLER
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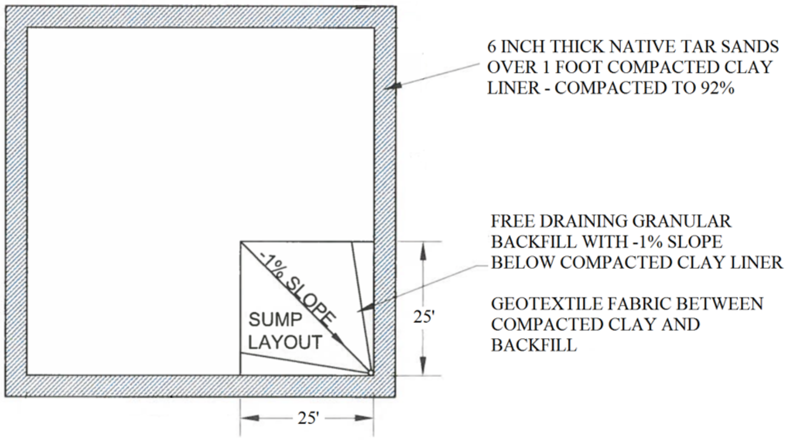
RECOMMENDED FOR APPROVAL: Troy D. Ostler
TROY D. OSTLER, P.E.
CIVCO Engineering, Inc.

DATE



STOCK PILE
RETENTION AREA

PROJECT MCW ENERGY GROUP
TEMPLE MOUNTAIN SITE
PROJECT NUMBER PROCESSED TARSANDS PAD
MITIGATION LAYOUT
SHEET No. 2

CIVCO Engineering, Inc.
1256 W. 400 S. STE 1, P.O Box 1758, Vernal, Utah 84078
Telephone: (435) 789-5448 Fax: (435) 789-4485

APPROVED
PROFESSIONAL ENGINEER
11-5-15
DATE

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QC CHECKED BY ####

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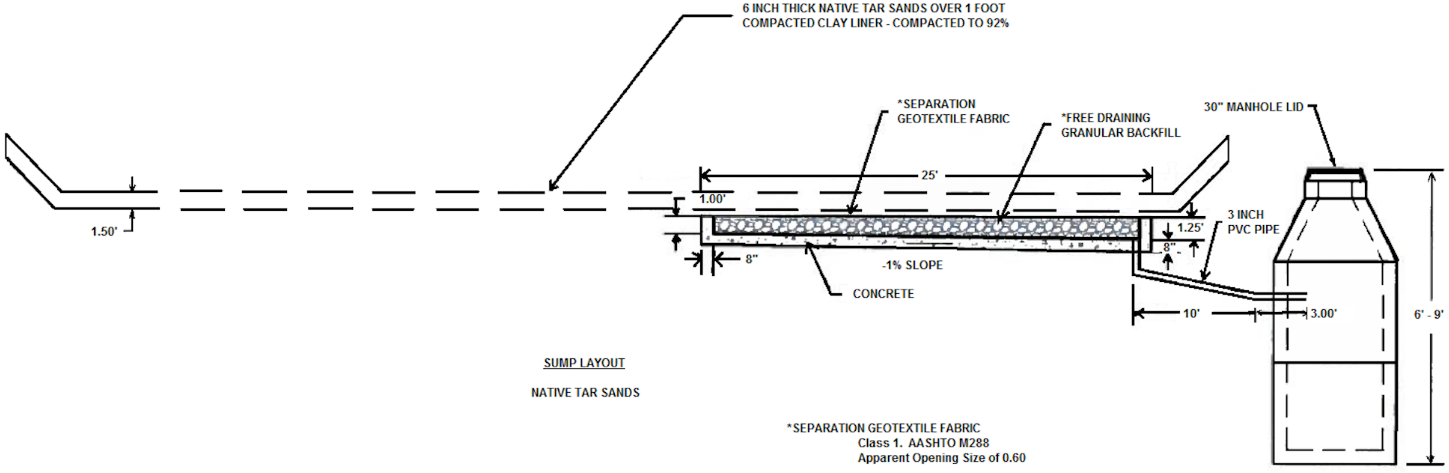
REVISIONS



SUMP LAYOUT

NATIVE TAR SANDS

*SEPARATION GEOTEXTILE FABRIC
Class 1. AASHTO M288
Apparent Opening Size of 0.60

* Free Draining Granular Backfill

Sieve Size	% Passing
1 1/2 inch	100.00
1 inch	95.00
1/2 inch	25.00
No. 4	0 - 10
No. 200	0 - 5

PROJECT MCW ENERGY GROUP
TEMPLE MOUNTAIN SITE
PROJECT NUMBER LYSIMETER LAYOUT
MITIGATION LAYOUT

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Geological Society of America
Special Paper 370
2003

Extreme paleoceanographic conditions in a Paleozoic oceanic upwelling system: Organic productivity and widespread phosphogenesis in the Permian Phosphoria Sea

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ABSTRACT

High-resolution geochemical data from phosphorites and associated lithofacies of the Permian Phosphoria Rock Complex suggest that organic matter deposition and phosphogenesis occurred in fundamentally different oceanographic conditions than those of modern oceanic upwelling systems. Unlike modern phosphorites, those of the Phosphoria accumulated in a shallow marginal sea within a semi-restricted epicontinental embayment that extended landward into proximal environments bordered by evaporative lagoons. The Phosphoria Rock Complex phosphorites formed in outer ramp (<200 m water depth), organically productive mid-ramp, and very shallow and restricted inner-ramp environments. Chemostratigraphic data (total organic carbon, sulfur, phosphate, $\delta^{13}C_{PO_4-CO_3}$, Ni, Cr, and Cd) indicate that this wide range of paleoenvironments was largely dysoxic or anoxic; euxinic conditions developed sporadically. High cadmium and nickel concentrations suggest maximum paleoproductivity (preserved total organic carbon up to 15 wt%) was associated with anoxic and euxinic conditions. Water column oxygen and trophic levels are interpreted to have been the primary controls over macrofaunal distribution in the Phosphoria, not cold-water temperatures as has been previously inferred.

These findings, augmented by recent Permian paleoclimate and ocean circulation models, suggest that an oxygen-poor, nutrient-rich intermediate water mass flowed into the Phosphoria embayment and impinged on the mid-ramp area. Seasonal coastal upwelling brought this water to the surface, where it mixed with warm waters flowing seaward from the restricted shallow lagoons in west-central Wyoming, resulting in high paleoproductivity and organic matter accumulation and oxygen depletion in the water column. Warming of the waters on the broad, shallow ramp, coupled with seasonal attenuation of the coastal upwelling system, is predicted to have led to a positive feedback between productivity and phosphogenesis through a wide range of environments. This new model and our findings illustrate that paleoceanographic setting and paleoenvironment must be taken into account to fully understand the geochemical variation seen in ancient phosphorites.

Keywords: Phosphoria, upwelling, chemostratigraphy, chemofacies, phosphorite, paleoceanography.

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Hiatt, E.E., and Budd, D.A., 2003, Extreme paleoceanographic conditions in a Paleozoic oceanic upwelling system: Organic productivity and widespread phosphogenesis in the permian phosphoria sea, *in* Chan, M.A., and Archer, A.W., eds., Extreme depositional environments: Mega end members in geologic time: Boulder, Colorado, Geological Society of America Special Paper 370, p. X–XX.

INTRODUCTION

The Phosphoria Rock Complex contains one of the largest sedimentary phosphate deposits in the geologic record (e.g., Cook and McElhinny, 1979). This series of phosphorite-siltstone-chert-carbonate-evaporite successions was deposited in the "Phosporia Sea" on the western margin of North America during the Permian (Fig. 1). The Phosphoria Rock Complex contains more than five times the total mass of phosphorus in today's oceans (McKelvey et al., 1953); an estimated 1.7×10^{12} metric tons of P_2O_5 were originally deposited (Cathcart et al., 1984). Organic carbon concentrations can exceed 15 wt% (Maughan, 1994; Hiatt, 1997), and 31×10^9 metric tons of petroleum have been generated (Claypool et al., 1978). The Phosphoria Rock Complex is truly an example of an extreme sedimentary system.

The Phosphoria Rock Complex also spans one of the most extraordinary global climate transitions in earth history (Fig. 2). The Early Permian was marked by widespread glaciation in the southern hemisphere (Pennsylvanian to Early Permian), low CO_2 levels, and probably widespread sea ice at the North Pole (Barron and Fawcett, 1995). In contrast, the Late Permian marks the onset of hot and dry climates over most of the middle and low-latitude continents, rapidly increasing CO_2 levels (two to five times modern values; Berner, 1994), widespread desert environments with vast areas of evaporite deposition (Ziegler, 1990; Zarkov, 1984), and widespread anoxic deep-water conditions in the world's oceans (Wignall and Twitchett, 1996; Knoll et al., 1995). In contrast to Early Permian glaciation, the southern continents in the Late Permian were marked by warm, high-latitude climates that brought boreal forests, coal swamps, and reptiles within 10° of the South Pole (Taylor et al., 1992; Dickins, 1984, 1996; Rees et al., 1999).

The abundance of phosphate, organic matter, and chert in the Phosphoria Rock Complex has long been cited as evidence for a coastal upwelling system in the Phosphoria Sea (e.g., McKelvey et al., 1959; Sheldon, 1989). Upwelling is also predicted by phosphate and elemental mass balance calculations (Piper and Link, 2002), atmospheric circulation models (Parrish, 1982; Kutzbach and Ziegler, 1994), and paleowind directions that suggest a net offshore movement of surface waters by Ekman transport (Sheldon et al., 1967; Parrish and Peterson, 1988). There is no doubt that upwelling-associated biological productivity led to the deposition of organic matter and phosphate in the Phosphoria Rock Complex.

Although the existence of an oceanic upwelling system in the Phosphoria Sea is considered a certainty, many unanswered questions remain concerning the oceanographic conditions that led to these extreme sedimentary deposits. As Boyd (1993, p. 183) pointed out, "A completely satisfying explanation for the origin of the phosphatic members has yet to appear." Key unanswered questions are: What was the nature (oxygen and nutrient levels, primarily) of the upwelled water? Under what oceanographic conditions did sedimentary phosphate form? And, what role did the semi-restricted nature of this embayment play in the oceanography of the Phosphoria Sea?

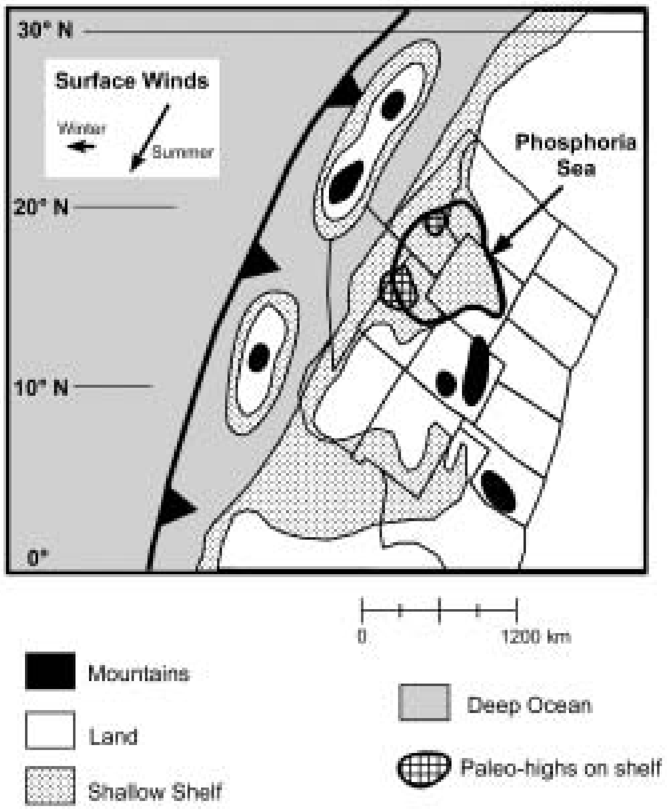

Figure 1. Position of Phosphoria Sea in context of Late Permian plate tectonic reconstruction of western North American continent and eastern Panthalassa Ocean. Position of paleoshoreline represents sea-level highstand. Paleowind vectors are based on Kutzbach and Ziegler (1994); wind strengths (inset box) are 5.0 and 1.8 m/s for summer and winter, respectively. Approximate positions of paleohighs on the Wyoming paleoshelf are from Skipp and Hall (1980) and Wardlaw (1977). Map is modified from Scotese and Langford (1995).

We believe that answers to these questions have been hindered by attempts to make the Phosphoria Rock Complex "fit" a model based on the modern Peru margin—a model that involves upwelling of cold (0–10 °C), nutrient-rich deep water onto a steep and narrow continental shelf (e.g., McKelvey et al., 1953, 1959; Sheldon, 1963, 1984; Parrish, 1982; Wardlaw and Collinson, 1984). The applicability of this interpretation to the Phosphoria Rock Complex has been bolstered by the presence of faunal elements that are interpreted as representing cold-water, "Arctic" conditions in the Phosphoria Sea (Wardlaw, 1980; Wardlaw et al., 1995).

In the last 20 years, research on the modern ocean and the Phosphoria Rock Complex has resulted in a somewhat different view of these enigmatic rocks. It now appears that the Phosphoria Sea was a relatively shallow (<200 m), semi-isolated epicontinental basin (Ketner, 1977; Scotese and Langford, 1995). Paleoclimate models suggest mean summer air temperatures over the shallow, marginal Phosphoria Sea were as high as 30–45 °C

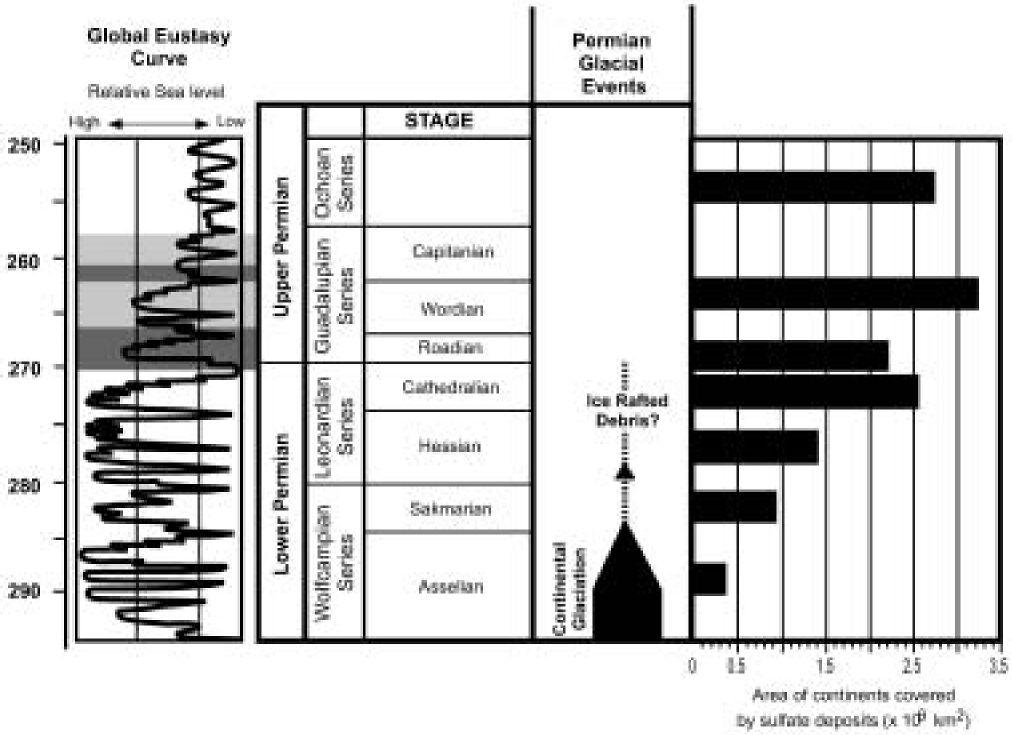

Figure 2. Permian Series and Stage names for southwestern United States and global eustasy curve; eustasy curve records sea-level variations with amplitudes of ~200 m (modified from Ross and Ross, 1994). Shaded zone on eustasy curve represents Phosphoria Rock Complex, and darkly shaded zones represent intervals of phosphate-rich Meade Peak (lower zone) and Retort (upper zone) deposition. Relative extents of Permian glacial events are shown in middle right column (width of black area provides an estimate of possible ice sheet extent; evidence for ice sheets extending to the earliest Sakmarian from González-Bonorino and Eyles (1995) and Dickins (1996); evidence for ice sheets in South Africa in Artinskian from Visser, 1996; evidence for ice-rafted debris from Frakes et al. (1992). Extent of global evaporite deposits as sulfate minerals (anhydrite and gypsum) is shown by bar graph at right (data from Zharkov, 1984).

(Kutzbach and Ziegler, 1994; Barron and Fawcett, 1995). Phosphogenesis, which is the precipitation of phosphate from seawater at or just below the sediment-water interface, occurred not only in the deeper portions of the basin, but also in shallower, inner-shelf settings (Sheldon, 1984; Peterson, 1984; Hiatt, 1997; Trappe, 1998; Stephens and Carroll, 1999; Hendrix and Byers, 2000). Paleotemperatures ranged from temperate (14–26 °C; mean of 21 °C) at sites of maximum phosphogenesis to warm (34–37 °C) across the shallow paleoshelf (Hiatt and Budd, 2001). Elevated salinities and stratification of the water column have also been proposed (Hite, 1978; Dahl et al., 1993; Stephens and Carroll, 1999). Piper and Link (2002), however, argued for temperature rather than salinity stratification. Based on the lower, phosphorite-rich portion of the Meade Peak member and mass balance calculations, Piper and Link (2002) determined that the Phosphoria Sea was "sediment-starved" and that, based on analogies with modern ocean basins, biological productivity was only moderately high. Piper (2001) used concentrations of Cd, Mo, Zn, Cu, and perhaps Ni as further evidence of elevated biological productivity in the Meade Peak member, and he coupled these with other trace elements, such as Cr, V, and U to further suggest that the Phosphoria Sea was marked by anoxic, denitrifying, but not sulfate-reducing bottom waters during deposition of this lower Meade Peak interval. Piper (2001) and Piper and Link (2002), however, did not analyze their data in a stratigraphic and regional framework. This leads to the question: How did oceanographic conditions vary regionally or temporally (stratigraphically) during the life of the upwelling system? In addition, no one has directly studied the relationship between paleoecology and chemostratigraphy of the Meade Peak to test whether the paleontologic data support either the salinity or temperature stratification model.

All of these recent findings and the fundamental unanswered questions that remain suggest it is time to reassess the nature of the original upwelling model of the Phosphoria Sea. Here, the geochemical and macrofaunal data from the Meade Peak member of the Phosphoria Formation are presented in a stratigraphic and regional framework that further clarifies the relationship between paleoproductivity, chemofacies, phosphogenesis, and oceanographic setting.

THE PHOSPHORIA ROCK COMPLEX

Deposition of the Phosphoria Rock Complex occurred in the "Phosphoria Sea" (Fig. 1), which formed in a shallow marginal foreland basin on the western margin of North America at a paleolatitude of about 20°N (Scotese and Langford, 1995). The Phosphoria Sea was partially separated from the Panthalassa Ocean by an island arc system (e.g., Scotese and Langford, 1995). The Phosphoria Rock Complex is composed of three unconformity-bounded stratigraphic sequences (Fig. 3). Phosphate (as francolite; $Ca_{10-a-b-c}Na_a,Mg_b,(PO_4)_{6-x},(CO_3)_{x-y-z}(CO_3,F)_y,(SO_4)_zF_2$, where $x = y + a + 2c$ and c = the number of Ca vacancies; Nathan, 1984) occurs throughout all three sequences, but phosphorites (beds with >10% francolite) are concentrated in the Meade Peak and Retort members of the Phosphoria Formation in the upper two sequences. In subtidal to peritidal deposits, phosphate occurs primarily as phosphatic peloids, with phosphatic ooids, intraclasts, and phosphatized skeletal grains being less common. Phosphorites are often marked by grain-supported textures, grading, and contain mechanically abraded grains, all of which suggest mechanical reworking (McKelvey et al., 1959; Trappe, 1998; Hiatt and Budd, 2001). These attributes also suggest that these beds represent relatively shallow-water deposition.

Herein, our focus is the Meade Peak member, which is the larger of the two high-productivity deposits in the Phosphoria. Meade Peak deposition was initiated in the Late Leonardian and extended through the Roadian stage of the Guadalupian (Fig. 4). Sedimentation and phosphogenesis occurred on a nearly flat ramp with an estimated shelf depositional angle of only 0.04–0.22° between the Meade Peak depocenter and the paleoshoreline (Hiatt, 1997). The Meade Peak is a seaward-thickening wedge of sediments whose depocenter was in southeastern Idaho (Maughan, 1984). Palinspastic reconstructions and regional facies patterns in the entire Phosphoria Rock Complex have been interpreted to suggest a shelf margin just to the east of that depocenter (e.g., McKelvey et al., 1959; Peterson, 1984), but no distinctive shelf-margin facies in the Meade Peak has ever been described, which is further evidence for the ramp profile. Outer- and mid-ramp deposits include thinly bedded, finely laminated fine- to medium-grained sandstone, dolomitic siltstone, and carbonate mudstone that previous workers refer to as “shales.” Petrographic studies reveal, however, that shales are rare (Hiatt, 1997; Carroll et al., 1998). To the east, the Meade Peak pinches out into green siltstones and carbonates, which, in turn, grade into red beds and eventually interbedded red siltstones and evaporites in central Wyoming (Fig. 4; Maughan, 1984; Peterson, 1984).

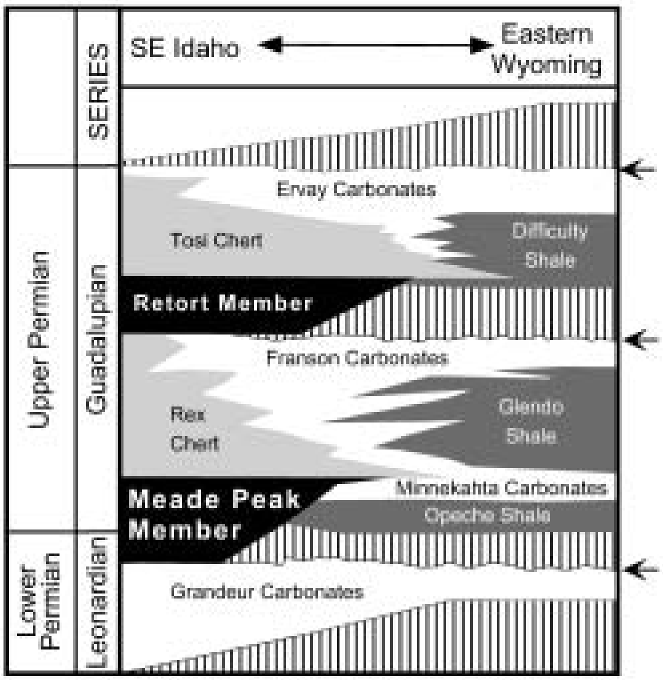

Figure 3. Stratigraphic relationships in Phosphoria Rock Complex. Vertical ruled areas denote hiatuses; arrows denote tops of unconformity-bounded sequences (modified from Maughan, 1984).

METHODS

Proxies for paleoceanographic conditions during Phosphoria Rock Complex deposition were derived from high-resolution

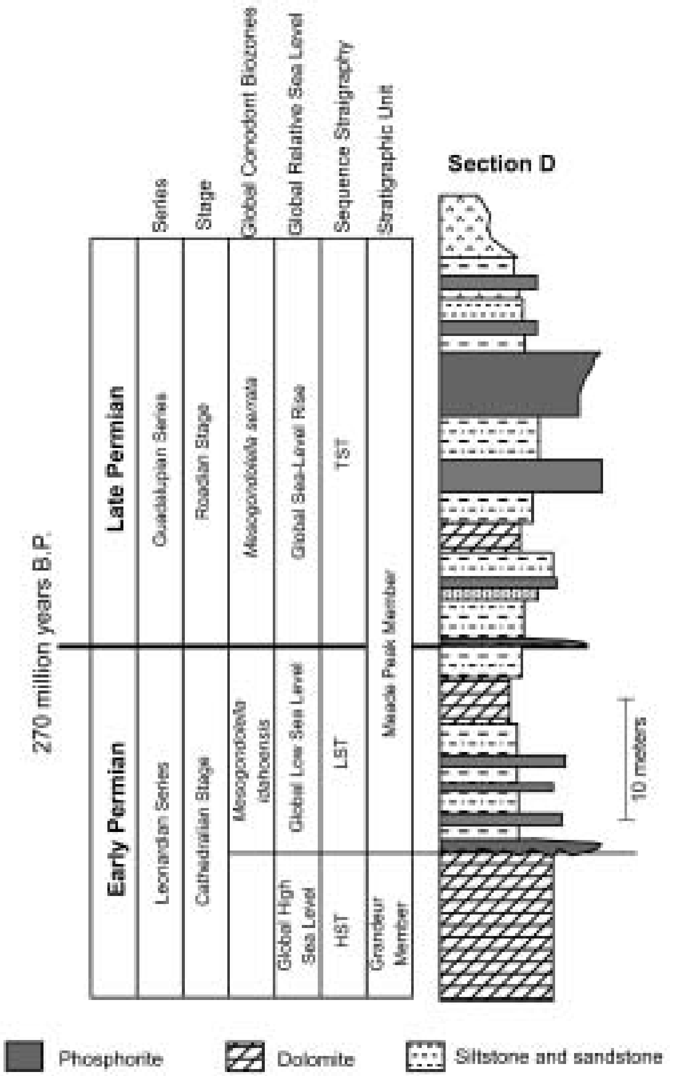

Figure 4. Generalized stratigraphic section of Meade Peak member (section D from southeastern Idaho; Fig. 5) that shows approximate position of important biostratigraphic boundary between conodonts *Mesogondolella idahoensis* and *M. serrata* (Wardlaw and Collinson, 1984), which is the accepted global boundary between Leonardian (Early Permian) and Guadalupian (Late Permian) series (Glenister et al., 1992). Series and stage names from Ross and Ross (1994). Sequence stratigraphic systems tracts from Hiatt (1997; LST—lowstand system tract, TST—transgressive system tract, HST—highstand system tract).

lithostratigraphy and chemostratigraphy. Four stratigraphic sections that form an offshore outer ramp to nearshore inner ramp transect through the Meade Peak member (Fig. 5) were utilized; they were chosen for their stratigraphic completeness and lack of visible chemical or textural alteration. Thin sections from all lithologies were examined to refine lithologic and textural classifications made during hand-sample examination. Bulk mineralogy was done by powder X-ray diffraction on a Scintag PAD-5 diffractometer. Total organic carbon (TOC) and total sulfur (TS) were determined using a Leco combustion-spectrometric device.

Phosphate grains for geochemical analyses were isolated by first disaggregating the granular phosphorite rock, sieving the resultant material into size fractions, and then passing the sand fractions through a magnetic susceptibility separator to remove glauconitic and pyritic grains. A heavy liquid separation (undiluted acetylene tetrabromide, density = 2.96 at 25 °C) was then used to remove carbonate and silicate grains. The remaining sample was washed multiple times with acetone and deionized water and dried in an oven at 80 °C for 12 hours. At this point, each size fraction was approximately 100% phosphate (francolite), as confirmed by X-ray diffraction analysis. Individual phosphatic peloids were handpicked from these concentrated and washed splits and used for the trace-element and isotopic analyses. Cadmium (Cd) concentrations were determined using X-ray fluorescence analysis; Ni and Cr concentrations were determined using instrumental neutron activation analysis. Details are given in Hiatt (1997).

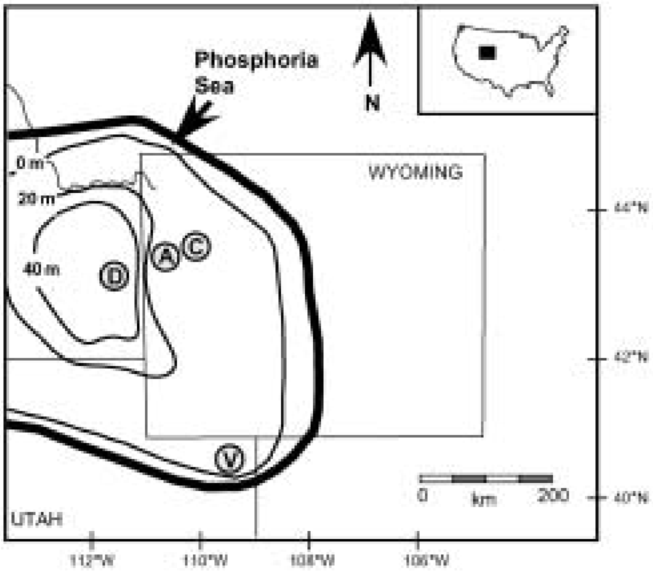

Figure 5. Map of study area showing extent of Phosphoria Sea during deposition of Meade Peak member. Isopach contours of Meade Peak member (in meters, from Maughan, 1994) and position of four stratigraphic sections utilized in this study (D—Dry Ridge; A—Astoria Hot Springs, C—Crystal Creek; V—Vernal-Brush Creek). See Hiatt (1997) for detailed locality information. Paleolatitude and base map orientation are from Scotese and Langford (1995).

Carbon isotopic values of the carbonate in the francolite crystal structure ($\delta^{13}C_{PO_4-CO_3}$) were measured in the stable isotope laboratory of the U.S. Geological Survey (USGS) in Denver. Powdered samples, averaging 100 mg in size, of isolated phosphorite peloids were reacted for 3 hours at 50 °C in individual reaction vessels with 4 ml of 100% anhydrous phosphoric acid. Evolved CO_2 was purified and isolated using two water traps maintained at –75 °C, and its isotopic composition was analyzed on a Finnigan MAT 252 mass spectrometer. Analytical precision on multiple runs (n = 35) of an internal calcite standard (CU-2) was ±0.04 for $\delta^{18}O$ and ±0.02 for $\delta^{13}C$.

All of the mineralogy, total organic carbon, total sulfur, trace element, and isotopic data generated can be found in Hiatt (1997) and is also available in tabular format from the GSA Data Repository[1]. Summary tables and figures are presented herein.

RESULTS

Meade Peak Lithofacies and Biofacies

Four general lithofacies dominate the Meade Peak member in the four stratigraphic sections analyzed. These are peloidal phosphorite packstone/grainstone, peloidal phosphorite wackestone, siltstone/sandstone, and carbonate mudstone (Fig. 6). From most seaward (section D) to most landward (section V), these four sections represent outer ramp, mid ramp, inner ramp, and nearshore paleoenvironmental settings (Fig. 7).

Sediments at the Dry Ridge (52 m thick), Astoria Hot Springs (11.6 m thick) and Crystal Creek (8.1 m thick) locations (sections D, A, and C, respectively) are dark gray to black, with phosphorites comprising about 25% of each section. All the phosphorites in these sections are planar bedded; none show any visible evidence of cross bedding. Medium- to coarse-grained phosphatic peloids predominate. Intercalated with the phosphorites at Crystal Creek and Astoria Hot Springs are thin-bedded, non-fossiliferous, organic carbon–rich silty dolomite mudstones and siltstones. Intercalated facies at the Dry Ridge locality consist of bioturbated siltstone, silty carbonate mudstone, and fine- to medium-grained sandstone with hummocky cross-stratification. In contrast, in the more landward Vernal-Brush Creek section (7 m thick), all rocks are gray to tan with decimeter-thick phosphorite beds comprising 60% of the section. None of the latter phosphorites show any visible evidence of cross bedding or fining-upward textures; all are planar bedded and consist of either well-sorted fine- to medium-grained phosphatic peloids or mixtures of peloids and small intraclasts. Intercalated lithologies are thin to very thin beds of dolomitic phosphatic wackestone and silty dolomite. Further details of the sedimentology at each section are summarized by Hiatt (1997) and Hiatt and Budd (2001).

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[1] GSA Data Repository item 2003097, Meade Peak member samples and interpreted chemofacies, is available on request from Documents Secretary, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA, editing@geosociety.org, or at www.geosociety.org/pubs/ft2003.htm.

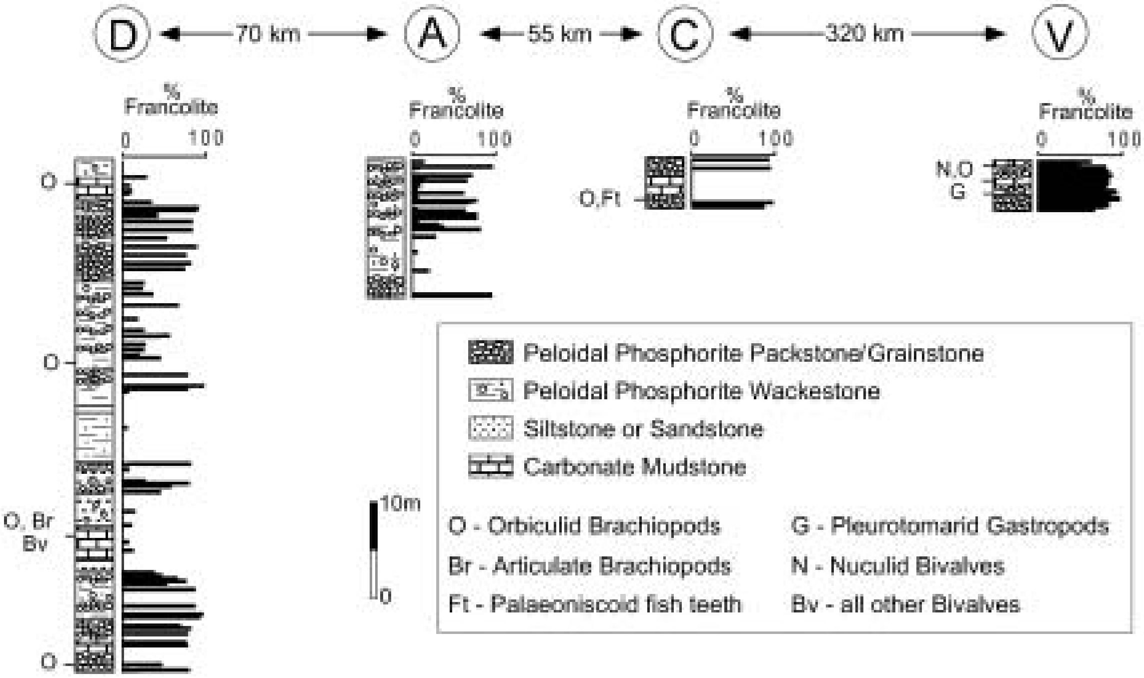

Figure 6. Stratigraphic plots of the Meade Peak member showing fauna, lithofacies, and abundance of sedimentary phosphate (as francolite).

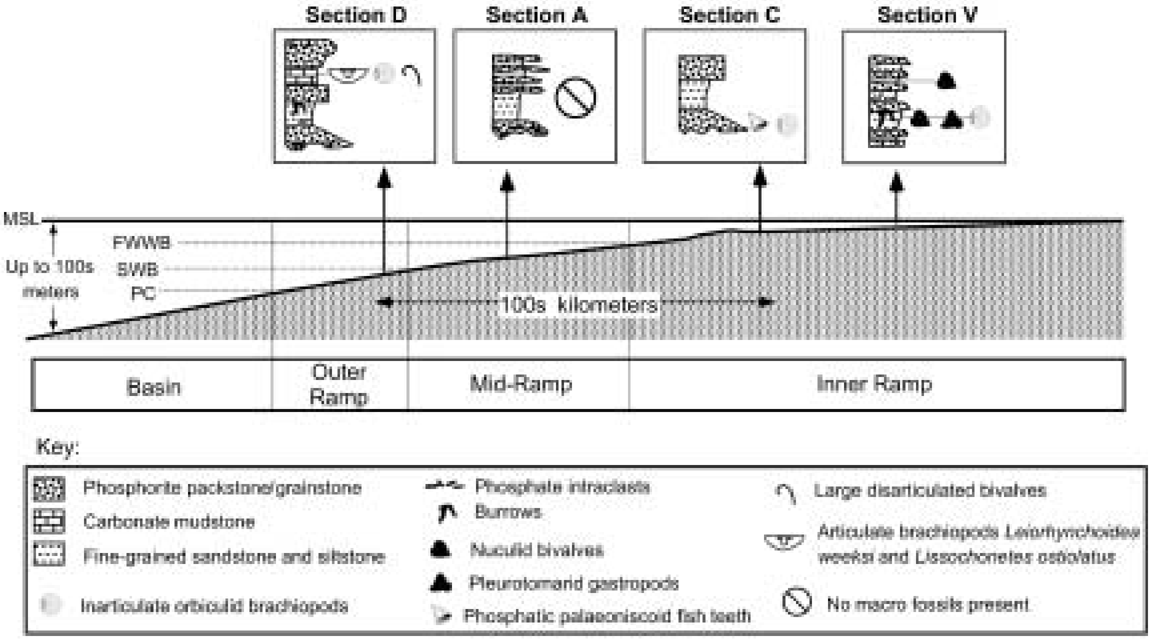

Figure 7. Diagram showing representative lithofacies associated with each Meade Peak depositional setting. See Figure 5 for section locations. Vertical exaggeration is extreme; regional slope on Wyoming paleoshelf was <0.25°. MSL—mean sea level; FWWB—fair-weather wave base; SWB—storm wave base; PC—pycnocline.

Individual phosphorite units are not randomly distributed in the Phosphoria Rock Complex. In all four sections, phosphorite beds form the grain-rich portion of individual depositional cycles (Fig. 8). Each phosphorite usually overlies a sharp basal diastem surface. About one-fifth of those surfaces are clearly erosional as they scour into the underlying bed. Exclusive of the Vernal-Brush Creek section, about half of the phosphorites exhibit a coarse sand or pebble lag (lithoclasts up to 8 cm long) and a poorly defined fining-upward texture, which suggests deposition and winnowing in the waning phase of a high-energy storm event (cf., Föllmi, 1990). The phosphorite beds grade upward into overlying finer-grained lithofacies (siltstone, sandstone, and carbonate mudstone/wackestone) that typically contain small, in situ phosphate peloids. These finer-grained units are separated from the next phosphorite by another diastem surface (Fig. 8). The beds below the upper diastem may be bioturbated, but shelly macrofauna are not common. These relationships are consistent with Föllmi's (1990) model of alternating periods of phosphogenesis, reworking, and condensation. The basic sedimentation unit is consistent across the shelf; only the scale changes, with a general decrease in diastem-to-diastem thickness from centimeters to meters at Dry Ridge to centimeters to decimeters in the other settings.

In the outer ramp Dry Ridge section, located near the depocenter of the Meade Peak (locality D), a few beds of dolomitic mudstone contain phosphatic orbiculid inarticulate brachiopods, and the articulate brachiopods *Leiorhynchoidea weeksi* and *Lissochonetes ostiolatus*, rare benthic foraminifers, and molds of disarticulated bivalves (Figs. 6 and 7). This inarticulate and articulate brachiopod assemblage characterizes dysoxic conditions in Late Paleozoic sections worldwide (Allison et al., 1995). No macrofossils were observed in the mid ramp section (Astoria Hot Springs, section A; Figs. 6 and 7). In the inner ramp section (Crystal Creek, section C; Figs. 6 and 7), the only macrofossils observed were fish teeth (order Palaeoniscoidea) and mechanically reworked orbiculid brachiopod fragments in the lowermost phosphorite packstone/grainstone lag. A faunal assemblage consisting of orbiculid inarticulate brachiopods, phosphatized nuculoid bivalves, and pleurotomarid gastropods was found in bioturbated wackestones and abraded phosphorite lags in the nearshore section (Vernal-Brush Creek, section V; Figs. 6 and 7). These mollusks are typical of nearshore, shallow-water settings in the Late Paleozoic (Stevens, 1966).

Meade Peak Chemostratigraphy

Organic Carbon, Sulfur, and Trace Elements

The stratigraphic and regional variation of phosphate (as francolite), total organic carbon, total sulfur, Cd, and carbon isotope values from phosphate peloids ($\delta^{13}C_{PO_4-CO_3}$) for the outer- to innermost-ramp transect are shown in Figure 9 and summarized in Table 1. Sedimentary phosphate is abundant throughout the Meade Peak member. The outer ramp section (locality D) is characterized by high francolite, high total organic carbon, and some high total sulfur beds. There are also two Cd-rich intervals in the outer-ramp section that also exhibit high total organic carbon and high phosphate concentrations. The concurrence of these phosphate-, TOC-, and Cd-rich intervals suggests paleoproductivity peaks with low water-column oxygen levels. Throughout the mid-ramp section (locality A), there is a similar pattern of high phosphate, high total organic carbon, high total sulfur, and high Cd concentrations. Some of the highest Cd (>300 ppm), the highest total organic carbon concentrations (>10 wt%), the highest total sulfur values, and lowest TOC:TS ratios are observed in this section. The inner ramp and nearshore sections (localities C and V) are also pervasively enriched in phosphate with thin siltstone and mudstone beds separating many of the phosphorite beds in the nearshore section (too thin to be shown in Fig. 9). These two sections, however, exhibit low total organic carbon (<1 wt%) and low total sulfur (<0.4 wt%) values, and low Cd concentrations in francolite (<5 ppm).

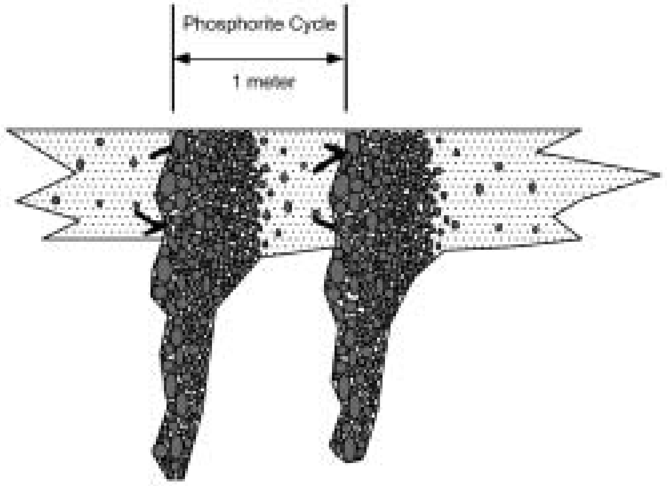

Figure 8. Generalized diagram of complete phosphorite depositional cycle in Meade Peak member of Phosphoria Rock Complex. Cycle starts with a diastem that is often erosional and bioturbated. Coarse, poorly sorted peloidal to intraclastic phosphorite is found just above diastem surface and grades into finer-grained peloidal phosphorite, followed by gradational contact with overlying organic carbon- and sulfide-rich sandstone to mudstone facies. Small, in situ phosphatic peloids are found in latter facies.

The number of analyses of Ni and Cr is not as large as that for Cd; thus, the distribution of these elements is not shown on Figure 9, but it is summarized in Table 1. The regional trends for Ni are the same as those affecting Cd, with highest values occurring in the outer and mid-ramp sections (D and A), which are rich in organic matter. Lower values of Ni occur in the landward sections (C and V), although Ni concentrations do not decrease to the same degree abruptly as those of Cd. In contrast, Cr values are relatively high in all sections.

Carbon Isotope Data

Table 1 and Figure 9E show the stratigraphic and regional patterns of francolite $\delta^{13}C_{PO_4-CO_3}$ values in each of the four Meade Peak sections. Francolite $\delta^{13}C_{PO_4-CO_3}$ values average

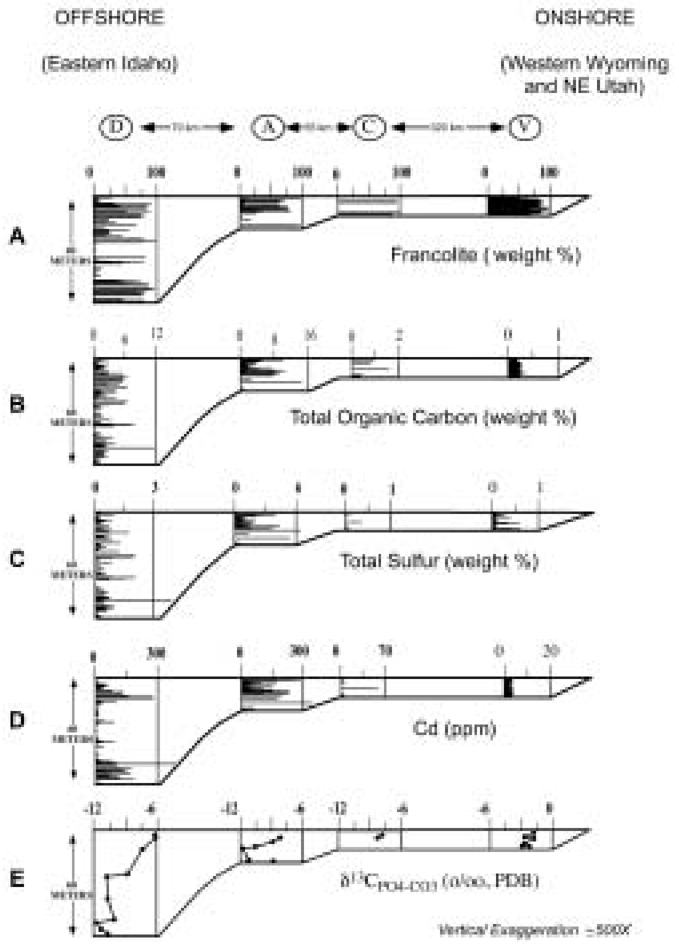

Figure 9. Regional and stratigraphic plots showing trends in (A) sedimentary phosphate (as francolite), (B) total organic carbon, (C) total sulfur, (D) Cd, and (E) $\delta^{13}C_{PO_4\text{–}CO_3}$ for Meade Peak sections in a seaward to landward transect. Francolite values are in counts per second (CPS) and are from X-ray diffraction analysis and are interpreted as semi-quantitative concentrations of francolite in rock.

<–8.0‰ Peedee belemnite in all but the nearshore section (locality V), where the mean is –2.7. The most negative individual values occur in the outer and mid ramp sections (localities D and A). There is a great deal of stratigraphic variability in these two sections as well, with more negative values (nearly –12‰) near the base and a trend toward less negative values (–8 to –6‰) stratigraphically upward (Fig. 9E).

Chemofacies

A chemofacies classification was developed based on the total organic carbon content of the rocks and their total organic carbon to total sulfur ratio. These parameters have been used to estimate paleoceanographic conditions under which fine-grained siliciclastic rocks were deposited (Berner and Raiswell, 1983; Raiswell and Berner, 1986; Allison et al., 1995) and are a result of the interplay of organic paleoproductivity, oxygen levels both in the water column and in the sediments, and in some cases, the availability of reduced iron species. This approach can present problems when used to interpret analyses of typical organic matter-bearing siliciclastics, but those shortcomings are insufficient to prevent discrimination of major geochemical facies in the Meade Peak. For example, TOC:TS ratios alone are not always able to discriminate differences in paleo-oxygen levels in organic-rich “normal marine shales” formed by typical surface productivity that have undergone significant organic burial diagenesis (Jones and Manning, 1994). However, factors such as these are not likely to generate the large, systematic, bed-by-bed differences in total organic carbon (0.1–15.7 wt%) and TOC:TS ratios (0.3–36.4) that occur in the Meade Peak (e.g., location D; Fig. 9); these are not the subtle shifts seen in “normal marine shales.” Therefore, although other methods of discriminating paleoenvironmental oxygen levels are sometimes more appropriate (e.g., degree of pyritization, Raiswell et al., 1988; indicator of anoxicity, Raiswell et al., 2001), total organic carbon values and TOC:TS ratios are sufficient to discriminate between major paleo-oceanographic differences in the Meade Peak.

Based on published total organic carbon and total sulfur values for modern and ancient environments (Berner, 1981, 1984; Berner and Raiswell, 1983; Raiswell and Berner, 1986), and allowing for diagenesis to have lowered total organic carbon values, we used these two proxies to define three broad chemofacies (Fig. 10): dysoxic, anoxic, and euxinic. The dysoxic chemofacies was simply defined as stratigraphic units with less than 1.5 wt% total organic carbon. The anoxic chemofacies occurs in beds with greater than 1.5 wt% total organic carbon and TOC:TS ratios greater than 2.0. The euxinic chemofacies is defined by total organic carbon values greater than 1.5 wt% and TOC:TS ratios less than 2.0. Figure 10A shows the range of total organic carbon and total sulfur data for all lithologies in the phosphate- and organic carbon-rich members of the Phosphoria Formation (Meade Peak data of this study plus data from the Retort member of the Phosphoria Formation; Hiatt, 1997), as well as how these values relate to published values from modern environments and to interpreted paleoenvironments. Figure 10B shows total organic carbon and total sulfur data for just the phosphorites of the Meade Peak member and the resultant chemofacies defined herein.

The average values and ranges of bulk rock total organic carbon and total sulfur values, TOC:TS ratios; Cd, Ni, and Cr concentrations; and the $\delta^{13}C_{PO_4\text{–}CO_3}$ of phosphatic peloids in each of the three chemofacies is summarized in Table 2. Combined, these data show that the dysoxic facies is characterized by low total organic carbon (by definition), low total sulfur, high TOC:TS, the least negative $\delta^{13}C_{PO_4\text{–}CO_3}$ values, and the minimum and lowest average Cd, Ni, and Cr concentrations. Of the three, only Cr has a mean concentration above 40 ppm (mean = 395 ppm) in the phosphate peloids of the dysoxic facies.

The anoxic chemofacies (Table 2) is characterized by high total organic carbon (by definition), moderate total sulfur, high TOC:TS (by definition), very negative $\delta^{13}C_{PO_4\text{–}CO_3}$, and high

TABLE 1. SUMMARY OF MEADE PEAK GEOCHEMICAL DATA BY STRATIGRAPHIC SECTION

	Section D (Dry Ridge)	Section A (Astoria Hot Springs)	Section C (Crystal Creek)	Section V (Vernal–Brush Creek)
Total organic carbon				
Range	0.27 to 8.50 wt	0.56 to 15.7 wt%	0.27 to 1.56 wt%	0.08 to 0.30 wt%
Average	2.63 ± 2.35	4.41 ± 3.51	0.73 ± 0.44	0.17 ± 0.05
n	79	45	6	49
Total sulfur				
Range	0.01 to 3.88 wt%	0.21 to 6.41 wt%	0.11 to 0.34 wt%	0.02 to 0.57 wt%
Average	0.48 ± 0.44	1.43 ± 1.39	0.21 ± 0.09	0.10 ± 0.13
n	79	45	6	49
Total organic carbon:total sulfur				
Range	1.8 to 36.4	0.9 to 5.6	2.0 to 7.3	0.3 to 7.3
Average	7.0 ± 5.4	3.6 ± 1.4	3.6 ± 1.9	3.4 ± 1.9
n	79	45	6	49
Cd				
Range	2 to 385 ppm	2 to 326 ppm	3 to 62 ppm	1 to 4 ppm
Average	51 ± 70 ppm	95 ± 78 ppm	13 ± 22 ppm	2.6 ± 0.7 ppm
n	79	45	6	49
Ni				
Range	40 to 540 ppm	86 to 166 ppm	40 to 115 ppm	13 to 37 ppm
Average	141 ± 169 ppm	110 ± 33 ppm	81 ± 31 ppm	21 ± 8 ppm
n	7	4	3	10
Cr				
Range	143 to 1540 ppm	177 to 1372 ppm	147 to 426 ppm	140 to 709 ppm
Average	430 ± 467 ppm	770 ± 460 ppm	282 ± 114 ppm	451 ± 191 ppm
n	7	4	3	10
$\delta^{13}C_{PO4-CO3}$				
Range	–11.4 to –6.0 ‰	–11.7 to –7.9 ‰	–8.1 ‰ to –7.9 ‰	–3.3 ‰ to –2.2 ‰
Average	–9.3 ± 1.9 ‰	–9.9 ± 1.3 ‰	–8.0 ± 0.1 ‰	–2.7 ± 0.3 ‰
N	11	7	2	6

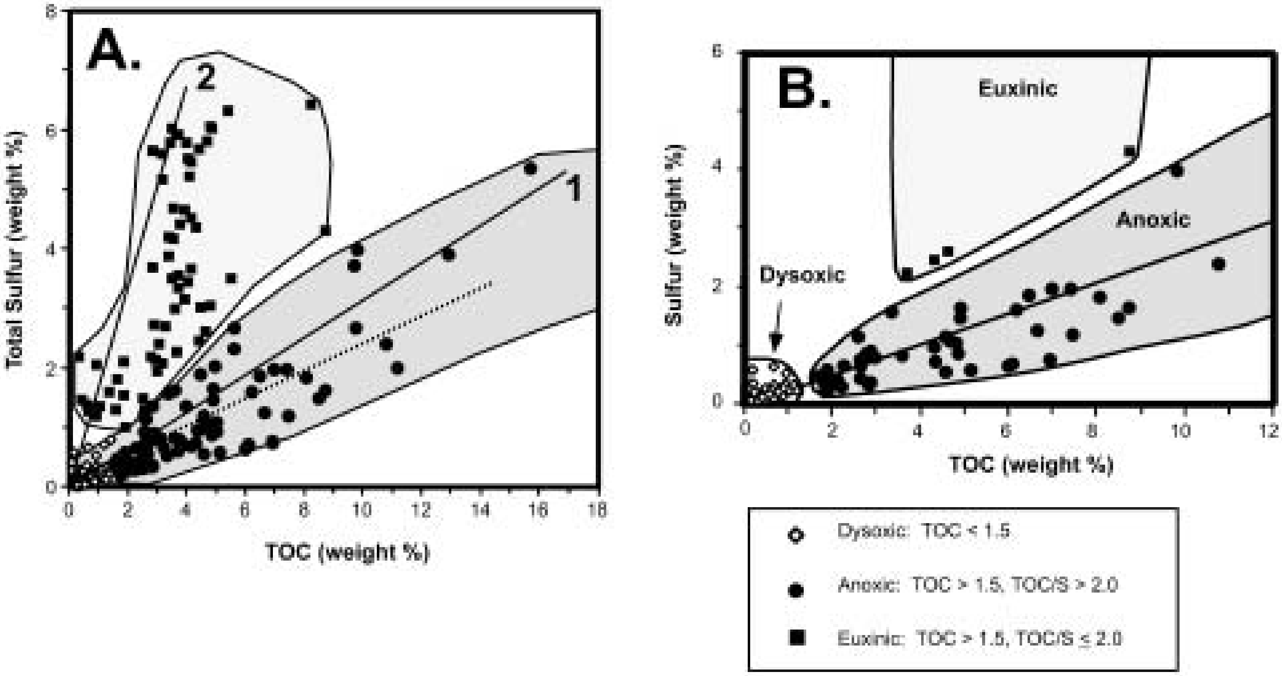

Figure 10. A: Phosphoria Rock Complex total organic carbon (TOC) and total sulfur data from all lithofacies, including non-Meade Peak rocks (additional data from Hiatt, 1997). Line 1 is trend defined by modern "normal" marine shales, and line 2 is trend for marine shales believed to have been deposited in euxinic environments (based on Berner and Raiswell, 1983). B: Total organic carbon and total sulfur data for all Meade Peak phosphorites with dysoxic, anoxic, and euxinic facies field interpretations added.

TABLE 2. SUMMARY OF MEADE PEAK GEOCHEMICAL DATA BY CHEMOFACIES

	Dysoxic chemofacies	Anoxic chemofacies	Euxinic chemofacies
Total organic carbon			
Range	0.08 to 1.46 wt%	1.56 to 15.7 wt%	1.66 to 8.75 wt%
Average	0.47 ± 0.40	4.82 ± 2.91	4.71 ± 3.12
n	93	81	5
Total Sulfur			
Range	0.01 to 0.78 wt%	0.19 to 5.35 wt%	0.99 to 6.41 wt%
Average	0.14 ± 0.05	1.03 ± 0.89	3.09 ± 1.99
n	93	81	5
Total organic carbon:total sulfur			
Range	0.3 to 36.4	2.1 to 9.6	0.9 to 1.9
Average	5.1 ± 5.4	5.2 ± 2.0	1.5 ±0.4
n	93	81	5
Cd			
Range	1 to 181 ppm	3 to 385 ppm	16 to 218 ppm
Average	13 ± 27 ppm	85 ± 82 ppm	104 ± 84 ppm
n	93	81	5
Ni			
Range	13 to 115 ppm	40 to 540 ppm	86 to 98 ppm
Rverage	39 ± 32 ppm	144 ±156 ppm	92 ± 6 ppm
n	14	8	2
Cr			
Range	140 to 709 ppm	143 to 1540 ppm	506 to 1372 ppm
Average	395 ± 192 ppm	505 ± 479 ppm	939 ± 433 ppm
n	14	8	2
$\delta^{13}C_{PO4-CO3}$			
Range	–10.1 to –2.2 ‰	–11.4 to –6.0 ‰	–11.7 ‰ to –7.9 ‰
Average	–6.6 ± 2.9 ‰	–9.8 ± 1.7 ‰	–9.8 ± 2.7 ‰
n	12	12	2

average Cd and Ni values. The euxinic chemofacies, which is the least common (n = 5), is characterized by high total organic carbon, very high total sulfur, low TOC:TS ratios (by definition), the most negative e $\delta^{13}C_{PO_4-CO_3}$ values, and the highest average Cr and Cd concentrations.

Figure 11 depicts the lateral arrangement of these chemofacies and their relationship to lithofacies and macrofauna in the Meade Peak member. The sections show varying degrees of chemofacies intercalation. The one exception is the inner ramp section (locality V), which is marked exclusively by the dysoxic chemofacies. In general, the dysoxic facies dominates the nearshore Meade Peak section (locality V), whereas the anoxic chemofacies dominates both the outer ramp section and the mid ramp sections (localities D and A). The euxinic facies is found only in a few beds of the mid ramp section (Fig. 11).

DISCUSSION

Meade Peak Chemofacies and Paleoproductivity

Phosphorites are formed through chemical processes that occur independently of lithofacies. Therefore, a chemofacies approach is more indicative of the environments of phosphogenesis and a more informative paleoceanographic and paleoproductivity tool. We defined the three broad chemofacies largely on both total organic carbon values and TOC:TS ratios. The cause of high levels of organic carbon and sulfide mineral concentration and preservation has been vigorously debated. Although high concentrations of organic matter have been interpreted as simply an indicator of water column anoxia (e.g., Demaison and Moore, 1980), they are likely a complex function of biological produc-

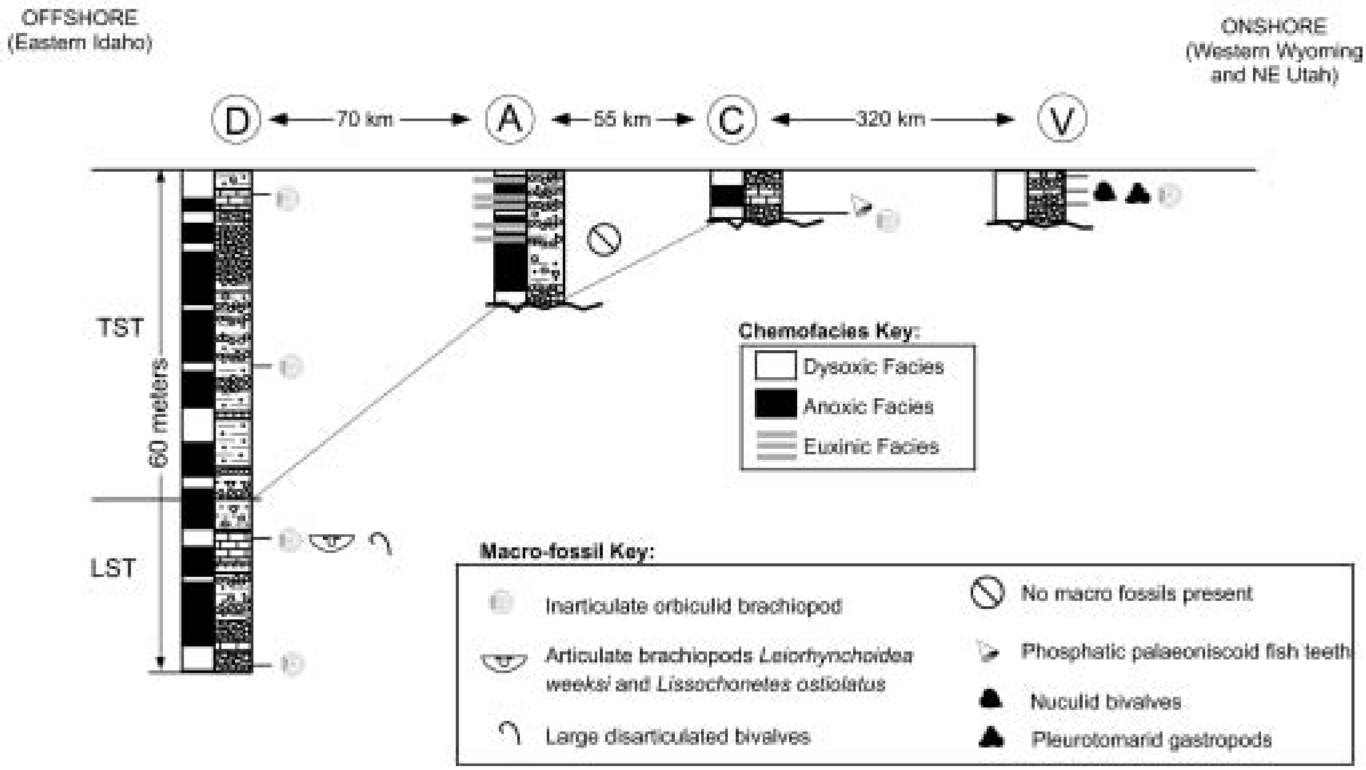

Figure 11. Meade Peak member chemofacies (left columns), lithofacies (right columns), and macrofauna (See Fig. 6 for lithofacies symbols and Fig. 5 for location information). Note that macrofossils only occur in dysoxic chemofacies. LST—lowstand systems tract; TST—transgressive systems tract.

tivity in the water column as well as sedimentation rate (e.g., Pedersen and Calvert, 1990; Canfield, 1994). Preservation of organic matter, however, is certainly enhanced under anoxic conditions (e.g., Demaison and Moore, 1980; Canfield, 1994; Ingall and Jahnke, 1997).

The important interrelationships between these factors are often lost in the debate regarding whether anoxia (e.g., Demaison and Moore, 1980) or organic productivity (e.g., Pedersen and Calvert, 1990) cause enhanced organic carbon preservation. As it falls through the water column, organic matter produced near the sea surface is broken down due to bacterial respiration (e.g., Froelich, et al., 1979; Schlesinger, 1997). Nutrients, such as phosphorus and nitrogen, are released to the water column, and oxygen is consumed in the process; if productivity is sufficient, then all water column oxygen can be consumed (e.g., Canfield, 1994). Continued breakdown of organic matter occurs after deposition leading to the release of additional phosphorus, nitrogen, and bioreactive trace elements (Froelich et al., 1979). Ingall and Jahnke (1997) pointed out that these processes are particularly important where upwelling-induced marine productivity occurs, because once nutrients are added (P, N, and sometimes Fe), increased biological productivity can quickly result in consumption of all oxygen in the water column below. Ingall and Jahnke showed that a positive feedback can develop, in which breakdown of organic matter leads to anoxic conditions that, in turn, increase phosphorus regeneration and enhance organic matter preservation. The regenerated phosphorus is released to the intrasediment porewater, where it can be fixed as sedimentary phosphate (francolite), and to the water column, where it contributes to further enhancement of productivity (Ingall and Jahnke, 1997).

Concentrations of Cd, Ni, and Cr in the phosphatic peloids augment the chemofacies approach because these elements are known to exhibit nutrient-like distributions in the modern oceans (e.g., Broecker and Peng, 1982; Calvert and Pedersen, 1993; Nathan et al., 1997; Schlesinger, 1997) and are concentrated in sediments under low-oxygen conditions (e.g., Calvert and Pedersen, 1993). Furthermore, Cd, and possibly Ni, is fixed as sulfides in sediments under sulfate reducing conditions, but Cr becomes concentrated in sediments under the less-reducing conditions of denitrification (Piper, 2001). In sediments and sedimentary rocks, these elements can be used to track past nutrient levels and paleoceanographic conditions because they are incorporated into the preserved sediments, whereas the actual nutrients (e.g., P and N) are largely recycled and remobilized in the depositional environment. These elements have been linked to biological processes and are characteristic of sediments deposited in highly productive oceanic areas today (e.g., Broecker and Peng, 1982; Schlesinger, 1997). In particular, phytoplankton concentrate Cd, and although concentrations are high, Piper et al. (2000) showed that Cd/Zn ratios in the Meade Peak member are similar to those found in modern plankton. With subsequent bacterial breakdown of organic matter, Cd can become highly concentrated in the organic residue (Gauthier et al., 1986). Ni, a micro-nutrient to many organisms, is associated with high marine productivity, and it promotes the growth of anaerobic bacteria (Cox, 1995).

The low total organic carbon and total sulfur values and low Cd, Ni, and Cr concentrations of the dysoxic Meade Peak chemofacies are all compatible with the presence of O_2 in the depositional environment and, thus, compatible with the recycling rather than burial of organic-carbon and nutrients. The low concentrations of the nutrient proxies (Cd, Ni, and Cr) suggest either low nutrient levels and/or aerobic conditions. We believe the latter to be the appropriate interpretation, because Cr exhibits a relatively high mean concentration (395 ppm). Unlike the other trace-element proxies for nutrients, Cr has multiple oxidation states and can be concentrated in sediments associated with high productivity under dysoxic conditions (Murray et al., 1983; Calvert and Pedersen, 1993). The fact that Cr concentrations in the phosphatic peloids of the dysoxic facies are not as low as the concentrations of the other trace elements suggests that nutrients were not limited, just effectively recycled by bacterial respiration of organic matter under denitrifying conditions (Piper, 2001). The oxygen present in the water, however, prevented sulfate reduction either in the water column or in the sediment that would have formed sulfide and trapped Cd and Ni, making their concentrations generally low.

In contrast, the high total organic carbon, high TOC:TS, and high average Cd and Ni values of the Meade Peak anoxic facies is compatible with an absence of O_2 in the water column and sediments. Free hydrogen sulfide in the water column must also have been absent; otherwise, total sulfur values would be higher and TOC:TS values would not be as great.

The very high concentrations of Cd in the anoxic chemofacies are probably indicative of high nutrient levels and a greater flux of organic matter to the seafloor. In the modern ocean, Cd concentrations are highest where sulfide is present in the sediment because it is incorporated into iron sulfide phases (Van Geen et al., 1994). The lack of covariance, however, between Cd and total sulfur (Fig. 9) indicates that Cd concentrations are not linked directly to pyrite content, but Cd is instead high because of extreme surface productivity and was incorporated into the francolite crystal structure under low oxygen conditions (cf., Nathan et al., 1997). The absence of O_2 suggested by this chemofacies points to ineffective recycling of organic matter and nutrients, thus the high total organic carbon values in the sediments and high trace-element concentrations in the francolite. However, the fact that such conditions persisted and dominated the outer and mid ramp settings (Fig. 11) means that the nutrient influx to these settings must have been maintained; otherwise, nutrients would have become limited, and paleoproductivity would have slowed or ceased. This, in turn, suggests that the anoxic chemofacies marks the sites of intense and persistent upwelling.

Finally, the high total organic carbon, very high total sulfur, and low TOC:TS values, and high Cd and Cr concentrations of the euxinic Meade Peak chemofacies are all compatible with an absence of O_2 and the presence of free hydrogen sulfide in the water column and sediments. Total organic carbon levels are similar to those of anoxic facies (Table 1), indicating that high productivity prevailed in the water column, coupled with effective preservation. Extremely high pyrite concentrations suggest that iron was readily available and was probably sourced from terrigenous clastic sediments supplied by wind (cf. Carroll et al., 1998) or as shown for euxinic conditions in the Black Sea (Canfield et al., 1996), from breakdown of particulate organic matter in the water column. Hypereutrophic, sulfate-reducing conditions probably existed, and productivity was restricted to phytoplankton. Indeed, biomarker studies (Dahl et al., 1993; and Stephens and Carroll, 1999) indicate that phytoplankton and bacteria were abundant in the water column over the mid-ramp euxinic chemofacies. The average trace element concentrations are much higher than the dysoxic facies, and thus are compatible with high nutrient levels and reducing conditions. As with the anoxic facies, the euxinic chemofacies must also mark the site of intense and persistent upwelling.

The intercalation of anoxic and dysoxic chemofacies in the outer and inner ramp settings (Fig. 11) does suggest either temporal and/or spatial shifts in upwelling intensity away from the mid-ramp locus of upwelling and paleoproductivity. Movement in time and space of upwelling farther onto the paleoramp would generate changes in the location of maximum surface productivity and thus cause a switch from anoxic to dysoxic in the outer ramp and a concurrent switch from dysoxic to anoxic in the inner ramp. The converse, movement off the paleoramp, would generate the opposite effects in both settings. Assuming depositional rates measured in millimeters per 1000 yr or less, the thickness of the intercalated chemofacies (centimeters to meters) indicates a forcing factor with a frequency measured in 10^5 or more years. What such factors might have been is unclear to us, although fluctuations in global ocean circulation patterns are certainly feasible. A link between extreme paleoproductivity and southern-hemisphere glaciation has been suggested by prior workers (e.g., Pardee, 1917; Sheldon, 1984; Piper and Kolodny, 1987), and glacio-eustacy has also been implied in the interpretation of cyclicity in other Phosphoria Rock Complex units (e.g., Hendrix and Byers, 2000; Trappe, 2000). However, a glacio-eustatic climate and/or sea-level driver must be considered unlikely, given that recent biostratigraphic constraints establish that widespread glaciation in Gondwanaland ended millions of years before deposition of the Meade Peak phosphate and organic, carbon-rich units (Fig. 2).

Carbon Isotopic Variation

In general, the primary $\delta^{13}C_{PO_4-CO_3}$ values of phosphorites represent a largely benthic signal derived as francolite forms and recrystallizes due to microbial-mediated reactions within centimeters of the sediment-water interface (e.g., Jarvis, 1992; Jarvis et al., 1994). Burial diagenesis can lower $\delta^{13}C_{PO_4-CO_3}$

values; the Phosphoria phosphorites are widely perceived to represent an advanced diagenetic end member (McArthur et al., 1986; Jarvis et al., 1994). Interpretation of the Meade Peak $\delta^{13}C_{PO_4-CO_3}$ data thus requires that we first evaluate the possibility of burial alteration.

The burial alteration hypothesis, as articulated by McArthur et al. (1986) and Jarvis et al. (1994) assumes that Miocene and younger phosphorites define the primary isotopic composition of francolites regardless of geologic age. Implicit in this assumption is the idea that all sedimentary francolites have formed under similar environmental conditions, which ignores secular changes in ocean-water chemistry and the diverse paleoenvironmental settings in which ancient phosphorites are known to have formed (e.g., Cook et al., 1990; Glenn et al., 1994). In fact, it is becoming clear that the Meade Peak phosphorites did not form under environmental conditions like any Neogene or Quaternary phosphogenetic environment (Dahl et al., 1993; Hiatt, 1997; Stephens and Carroll, 1999; Hiatt and Budd, 2001; Piper and Link, 2002). Thus, the diagenetically unaltered young phosphorites are not reasonable analogs for the initial $\delta^{13}C_{PO_4-CO_3}$ of the Meade Peak phosphorites.

The burial alteration hypothesis also ignores the fact that some geochemical proxies are much less likely to alter than others. Shemesh et al. (1988) concluded that $\delta^{18}O_{PO_4-CO_3}$ (isotopic value isolated from the structural carbonate site within the francolite crystal lattice) values were altered in many phosphorites, but that $\delta^{13}C_{PO_4-CO_3}$ and $\delta^{18}O_{PO_4}$ (isotopic value isolated from the structural phosphate site within the francolite crystal lattice) values were extremely resistant to diagenetic alteration. Because modern and ancient phosphorites show ranges of similar magnitude in their carbon isotopic values, the $\delta^{13}C_{PO_4-CO_3}$ values in francolite may be better preserved over geologic time than the simple burial alteration hypothesis presumes (Shemesh et al., 1988; Kolodny and Luz, 1992).

The Meade Peak $\delta^{13}C_{PO_4-CO_3}$ values reported herein do show some covariance with burial depth. The most negative values occur in the outer ramp section (Fig. 9E), which experienced the greatest burial depths (5.5 km, Hiatt and Budd, 2001). The least negative values occur in the nearshore section (Fig. 9E), which experienced the least burial depths (3 km, Hiatt and Budd, 2001). A least-square linear regression between $\delta^{13}C_{PO_4-CO_3}$ values and the maximum burial depth of the four localities yields an *R*-value of 0.69. However, this apparent covariance may just be a coincidence, as the deepest buried sections (D and A) are also the most organic-rich sections. A linear regression between $\delta^{13}C_{PO_4-CO_3}$ and total organic carbon in the same rock samples yields an R-value of 0.66, which is statistically indistinguishable from the value derived from the regression against maximum burial depth. The $\delta^{13}C_{PO_4-CO_3}$ of the Meade Peak phosphorites is thus just as likely to be a function of the total organic carbon of the rock as it is to be one of burial alteration. Of course, total organic carbon values have probably also been reduced by organic diagenesis; however, the analysis of chemofacies suggests that the main control on total organic carbon variation is changes in paleoproductivity. By analogy, we thus conclude that the primary depositional conditions across the ramp are also recorded in the $\delta^{13}C_{PO_4-CO_3}$ signal, although some diagenetic alteration cannot be completely ruled out.

As a proxy of primary depositional conditions across the Meade Peak ramp, the interpretation of the $\delta^{13}C_{PO_4-CO_3}$ values must include consideration of the chemofacies. The least negative $\delta^{13}C_{PO_4-CO_3}$ values reflect the least influence of organic ^{12}C. Such values occur in the dysoxic facies (Table 2), which is compatible with the more complete recycling of organic matter before burial below the sediment-water interface. As the francolite formed below that interface, it thus did not incorporate as much organic ^{12}C as francolite formed in the other chemofacies. The anoxic and euxinic facies would represent the opposite situation. High burial rates of organic matter due to inefficient recycling in the water column would have meant pore waters enriched in organic ^{12}C, and thus the more negative $\delta^{13}C_{PO_4-CO_3}$ values for the francolites formed in those chemofacies (Table 2). Indeed, McArthur et al. (1986) predicted that the carbon isotopic signature of francolite precipitated in dysoxic porewater should have a $\delta^{13}C_{PO_4-CO_3}$ value of –2‰ to –6‰, and those precipitated in anoxic porewater should have $\delta^{13}C_{PO_4-CO_3}$ values of –6‰ to –15‰ (PDB). These ranges are similar to those observed in the Meade Peak phosphorites (Tables 1 and 2). The lateral and vertical variations in $\delta^{13}C_{PO_4-CO_3}$ values (Fig. 9E) are thus further evidence that the process of phosphogenesis in the Meade Peak occurred across a broad spatial and temporal range of paleoceanographic conditions.

Phosphogenesis in the Phosphoria Sea

In mid and outer ramp settings where total organic carbon and total sulfur values, nutrient trace-element proxies, and phosphorite percentages are all high, phosphogenesis likely occurred much as it does in the modern ocean, albeit in much shallower waters. That is, large amounts of organic matter accumulated on the seafloor where primary productivity was extreme. Anoxic conditions within the sediments and bacterial breakdown of the organic matter (Froelich et al., 1979) released organic-bound phosphorous into the sediments (Filippelli and Delaney, 1996; Ingall and Jahnke, 1997). This process lead to phosphogenesis, while attendant anoxic conditions led to high amounts of sulfide and organic matter, and the efficient “trapping” of the nutrient-like cations in the sediments (Westerlund et al., 1986; Nathan et al., 1997). Continued influx of upwelled waters provided a source of new nutrients; thus, high productivity, high burial rates of organic carbon, and phosphogenetic processes can be long lasting.

Conditions on the inner ramp appear to have been much different. Abundant phosphorite yet low total organic carbon and total sulfur values and low nutrient-like trace-element concentrations indicate that phosphogenesis in the shallow nearshore environments must have either differed in some way from that described above, or all nearshore phosphorites were derived by long distance transport from mid-ramp settings. Although some of those nearshore phosphorites may be allochthonous, others clearly are not. In particular, the presence of small, phosphatized peloids in the intercalated carbonate muds is suggestive of in situ phosphogenesis in this setting. The phosphatization of the infaunal bivalves, many of which are still articulated and in their original burrows (Hiatt and Budd, 2001), also argues for autochthonous phosphogenesis on the inner ramp. A variation on the standard phosphogenesis model is thus needed to account for the phosphorites of the inner ramp setting.

The abundance of nearshore phosphorite formation indicates that there must have been a significant influx of phosphorous, which in turn means an influx of nutrient-rich waters to the innermost part of the ramp. Although riverine inputs have been documented for some nearshore phosphorites (e.g., Föllmi, 1996), we do not consider that a likely source for the Meade Peak phosphorites. The adjacent coastal landmass was characterized by evaporite deposits (Maughan, 1984; Peterson, 1984), and there is no published evidence for fluvial inputs to the Phosphoria Sea during Meade Peak deposition. A major source of detrital material to the sediments that make up the Meade Peak was derived by eolian influx (Carroll et al., 1998). Thus, the only viable source of nutrients was the water that upwelled farther seaward in the area of maximum upwelling (mid-ramp position) and eventually flowed into the inner ramp.

Ingall and Jahnke (1997) showed that phosphorus is more efficiently regenerated to the water column relative to organic matter under anoxic conditions. The corollary to this scenario is that where organic matter breaks down in dysoxic settings, such as the inner ramp, phosphorus is more likely to be fixed as francolite at the same time organic matter is consumed (Van Cappellen and Ingall, 1994). Therefore, phosphorus released to waters flowing from the anoxic environments in the mid-ramp could have fed productivity in the inner ramp. Oxygen supplied by air-sea exchange in these shallow-water settings, however, seems to have prevented the seawater, seafloor, and sediments from becoming anoxic, which in turn suppressed sulfide formation. Organic matter must have been efficiently recycled at and just below the sediment-water interface, resulting in low preserved total organic carbon. Over time, a net flux of phosphorous into phosphorites would occur, but because of the winnowing effect of storm-generated waves and the addition of oxygen through exchange with the atmosphere, there would be little preservation of organic carbon. Reasonably high productivity, coupled with high water temperatures on the inner ramp (Hiatt and Budd, 2001), may have resulted in a stable, possibly thermally (Piper and Link, 2002) or salinity (Dahl et al., 1993; Stephens and Carroll, 1999) stratified dysoxic water column that limited benthic dissolved oxygen levels and was supplied with enough nutrients to maintain phosphogenesis. Phosphogenesis in such a setting is distinctly different than any modern environment of phosphogenesis.

The low Cd and Ni concentrations of the inner ramp phosphorites also imply efficient recycling of these nutrient-like cations, and/or their depletion in the nearshore organic matter and the presence of oxygen in the water. Depletion is plausible if a significant percentage of the mass of these cations that was brought onto the Phosphoria ramp with upwelling waters was "trapped" in the anoxic outer- and mid-ramp sediment as sulfides. Anoxic marine basins are known to efficiently trap Cd and other metals in their sediments (Westerlund et al., 1986). Because of the superb textural preservation of all Meade Peak phosphorites, and the fact that the highest cation concentrations are found in the most deeply buried sections (localities D and A), we do not believe the low Cd, Ni, and Cr concentrations of the inner-ramp phosphorites are due to diagenetic mobilization.

Reassessment of the Paleoecology of the Phosphoria Rock Complex Biota

It has long been noted that the faunas of the Phosphoria and equivalent rocks exhibit low faunal diversity and abundance relative to age-equivalent lower-latitude sections (Yochelson, 1968; Wardlaw and Collinson, 1984; Boyd, 1993). Yochelson (1968), in the most comprehensive study of Phosphoria Rock Complex paleontology, interpreted this low diversity to be the result of low water temperatures. Wardlaw (1980) and Wardlaw et al. (1995) furthered the general acceptance of a cold-water "Arctic" fauna. The only dissenting voice to date has been that of Peterson (1980, 1984), who noted that maximum faunal diversity in the Phosphoria Rock Complex occurred in the carbonate bioherms of the Rex Chert member (Fig. 3) near the western border of Wyoming, where upwelling is predicted to have been most intense. As a result, Peterson reasoned that cool water was unlikely to have caused the low faunal diversity in the Phosphoria Rock Complex because diversity was apparently greatest where the water would have been the coldest.

We concur with Peterson (1980, 1984) that cool water was not the major biolimiting agent in the Meade Peak member and probably in the entire Phosphoria Rock Complex. Instead, the data described herein shows that macrofossils in the Meade Peak member occur almost exclusively in beds of the dysoxic chemofacies (Fig. 11). Bioturbation, described in detail by Hendrix and Byers (2000), is probably also limited to beds that would fall into our dysoxic chemofacies category. The anoxic chemofacies rarely contains macrofossils, and when present, the macrofossils always show signs of mechanical reworking. The euxinic chemofacies never contains any macrofauna or bioturbation. Where the latter two chemofacies prevailed, seafloor oxygen levels must have been so low as to exclude even the low diversity dysaerobic communities that characterize portions of the dysoxic facies.

Elevated salinity levels and possible salinity stratification caused by brines flowing westward from evaporative basins to the east of the Phosphoria Sea (Hite, 1978, Dahl et al., 1993; Stephens and Carroll, 1999) could also be a factor in explaining the faunal distribution, but Piper and Link (2002) determined that the Phosphoria Sea was probably temperature-stratified, not salinity-stratified. The absence of macrofauna in the highly productive mid-ramp section (Fig. 7A), where upwelling and influx of normal salinity ocean water from the west would have been greatest, further suggests that salinity was not the major biolimiting agent. Our data clearly suggest that the low faunal diversity and abundance of the Meade Peak member is related first and foremost to low oxygen levels.

Although we believe oxygen levels to be the foremost biolimiting factor in the Meade Peak, temperature probably did play a role. However, that role was primarily related to warm temperatures, not cold. This is evidenced by a comparison of the macrofauna in the dysoxic outer ramp facies (section D) with the macrofauna in the most landward sections (section V). Hiatt and Budd (2001) showed the outer ramp section was the site of cool, but not cold, paleotemperatures. As noted previously, the macrofauna in that section is composed of small chonetid and leiorhynchid articulate brachiopods, a few small bivalves, and orbiculid inarticulate brachiopods. This is the only Meade Peak member assemblage that closely approximates a "normal," albeit dysoxic Late Paleozoic marine fauna (Allison et al., 1995). In contrast, the faunal assemblage of the inner ramp and nearshore sections consists only of orbiculid inarticulate brachiopods, nuculoid bivalves, and pleurotomarid gastropods (Figs. 6 and 13), which is indicative of restricted shallow water, dysaerobic conditions of variable salinity (Stevens, 1966; Kammer et al., 1986). Restriction, shallow water, and the broad nature of the ramp setting all resulted in mean paleotemperatures in excess of 30 °C (Hiatt and Budd, 2001), which may have raised salinities due to evaporation and limited the biota. In this setting, oxygen levels are the primary control on the fauna, but warm temperature is a secondary factor due to the lower solubility of oxygen at higher water temperatures and the greater consumption of oxygen by bacterial respiration.

The argument for oxygen as the dominant biolimiting factor in the paleoecology of the Meade Peak is also strengthened by a critical reanalysis of the arguments for an "Arctic" fauna. In particular, the cold water "Arctic" fauna interpretation, which is based on ammonites and one species each of conodont and brachipod (Wardlaw, 1980; Wardlaw et al., 1995), is weakened when the distribution of all Phosphoria Rock Complex fauna is considered in the context of recent plate tectonic reconstructions.

The conodont *Mesogondolella phosphoriensis* (= *Mesogondolella rosenkrantzi*; Wardlaw et al., 1995) is cited as one line of evidence for an "Arctic" fauna (Wardlaw, 1980). However, other reported occurrences of *M. phosphoriensis* are at paleolatitude less than or equal to 40° when plotted on the modern plate reconstruction of Scotese and Langford (1995). Specifically, the data of Bender and Stoppel (1965), Toula (1875), Sweet (1976), and Szaniawski and Malkowski (1979) indicate that this conodont is found at Permian paleolatitudes of 27°N (Greenland), 3°S (Sicily), and 40°N (Spitsbergen). This suggests that *M. phosphoriensis* may not be indicative of an "Arctic" fauna after all. Further, it has been reported only in the upper meter or so of the Meade Peak member (Wardlaw and Collinson, 1984), yet four other conodont species are found throughout the Meade Peak that are also widespread in low-latitude, Paleotethys and equatorial sections of western North American (e.g., *Mesogondolella serrata* , *M. gracilis*, *M. idahoensis*, and *Neostreptognathodus sulcoplicatus*; Yugan et al., 1994; Behnken et al., 1986; Igo, 1981; Szaniawski and Malkowski, 1979). The presence of these widespread "warm"-water conodonts in the Meade Peak member is not easily explained in the context of an "Arctic" fauna.

The case for a "cool water brachiopod fauna" in the Phosphoria Rock Complex (Wardlaw, 1980) is based on the presence of *Neospirifer striato-paradoxus*, which was originally described by Toula (1875) from Spitzbergen (Permian paleolatitude of 40°N). Specimens of *N. striato-paradoxus* were identified in the Phosphoria Rock Complex in rocks of Middle Wordian age (Wardlaw, 1980), which constrains the stratigraphic unit to either the Franson or the Rex Chert member of the Park City Formation (Fig. 4). Thus, this "Arctic" form is not found in the stratigraphic units associated with maximum paleoproductivity (the Meade Peak and Retort members) as has often been assumed (Parrish, 1982; Parrish and Peterson, 1988; Whelan, 1993; Inden and Coalson, 1996).

There are also several Phosphoria Rock Complex brachiopods that are characteristic of low-latitude North American and Paleotethys locations. These include *Kuvelousia leptosa*, which is common in the equatorial Paleotethys region and is found in the Rex Chert and Franson members of the Phosphoria Rock Complex in southwestern Montana (Wardlaw, 1977). There is also extensive overlap between the Phosphoria Rock Complex brachiopod fauna and sections near the paleo-equator of west Texas (Yochelson, 1968; Brittenham, 1973), Mexico (Wardlaw et al., 1979), and south China (Xu and Grant, 1994). As with the conodonts, the entire brachipod fauna does not present a convincing argument for cold water.

Lastly, support for the "cool-water" model was also deduced from ammonoids. Wardlaw et al. (1995; p. 36) pointed out that specimens of the ammonoid genus *Daubichites* found in the Meade Peak member have "....been reported (Spinosa and Nassichuk, 1985) as having a 'boreal' or cool-water, high-latitude distribution." However, Spinosa and Nassichuk (1985) also pointed out that *Daubichites* is a geographically widespread ammonoid and, in addition to its occurrence in the Meade Peak member, it is also found in the equatorial Paleothethys (Siberia, Australia, China) and northern Canada. More recently, an equatorial Permian ammonoid (*Demarezites furnishi*) was reported from the Meade Peak of southeastern Idaho (Spinosa and Nassichuk, 1994); the only other reported occurrences of this ammonoid are from west Texas and central Mexico (Spinosa and Nassichuk, 1994), areas that were situated within 10° of the Permian equator.

In summary, Phosphoria Rock Complex conodont, ammonite, and brachiopod faunas have some affinities to high-latitude Permian settings but do not provide a convincing and overwhelming argument for widespread and persistent "cool-water" conditions in the Phosphoria Sea. There are, in fact, just as many similarities in the fauna assemblage to warm, tropical settings. This suggests that other environmental factors served as the primary biolimiting agent. The chemofacies distributions defined herein clearly indicate that oxygen availability was more likely the cause of a sparse Phosphoria Rock Complex fauna in general and Meade Peak fauna in particular.

NEW PALEOCEANOGRAPHIC MODEL FOR THE PHOSPHORIA UPWELLING SYSTEM

Information from Recent Climate Models

Findings from climate models for the Permian are relevant to any reinterpretation of phosphogenesis and paleoceanography in the Phosphoria Rock Complex. Kutzbach and Ziegler (1994) produced a high-resolution model that included inland seas, large lakes, and marine embayments like the Phosphoria Sea. Their model indicates that the atmosphere over the Phosphoria Sea would have had a mean annual surface air temperature of 30–35 °C with summer surface air temperatures rising as high as 45 °C. These temperatures are in agreement with paleotemperatures of phosphogenesis in the inner ramp setting determined by Hiatt and Budd (2001). East-to-west eolian transport is also predicted from modeled wind directions, which is compatible with an eolian source for the Meade Peak siltstones and sandstones (Carroll et al., 1998). The modeled temperature and rainfall results also agree with geological evidence that indicates an extremely hot desert surrounding the Phosphoria Sea (Sheldon et al., 1967; Ziegler, 1990). Kutzbach and Ziegler's (1994) model thus seems to be geologically reasonable.

Kutzbach and Ziegler's (1994) climate model also shows a drastic wintertime weakening of the atmospheric circulation system and thus attendant reduction in coastal upwelling in the Phosphoria Sea (Fig. 1). The possibility that upwelling was seasonal is particularly important. Surface waters during summer upwelling and phosphogenesis would have been subject to hot (35–45 °C) air temperatures and would have become very warm in the shallow inner ramp. In the winter, the cessation of coastal upwelling would have meant that the waters in the Phosphoria Sea became restricted, possibly stratified, and extreme warming could have occurred in nearshore settings.

The New Paleoceanographic Model

New research and our improved understanding of the modern ocean indicate that the modern Peru-margin analog traditionally used to explain the Phosphoria upwelling system needs to be reassessed. That model cannot account for the variety of paleoenvironments that led to phosphogenesis or the relationship between paleoproductivity and macrofauna distribution. A new paleoceanographic model for the Phosphoria upwelling system is necessary.

The new paleoceanographic model that we propose (Fig. 12) takes into account the shallow and broad ramp setting, warm paleotemperatures (Hiatt and Budd, 2001), seasonal upwelling predicted by climate models (Kutzbach and Ziegler, 1994), severe oxygen depletion, high nutrient levels, and the new geochemical data presented herein. In this interpretation, oxygen-depleted, nutrient-rich water impinged on the Wyoming paleoramp at the mid-ramp position, where anoxia and euxinic conditions prevailed (present-day western Wyoming). Given the semi-restricted, shallow, marginal nature of the Phosphoria Sea, it is unlikely that an open-ocean deep-water mass could have been accessed by the wind-driven upwelling system. The more probable source of this nutrient-rich, oxygen-depleted water was a northward-flowing intermediate water mass (Jewell, 1995). Indeed, nutrient-rich, oxygen-poor water is near the surface over large areas between 20° N and 20° S today (Levitus, 1982), and a much more extreme oxygen-depleted, warm, nutrient-rich intermediate water mass is predicted for the west coast of equatorial Pangea during the Permian (Jewell, 1995; Hotinski et al., 2001). This intermediate layer probably extended into the Phosphoria Sea and was brought to the surface during the summertime, when wind patterns produced coastal upwelling by Ekman transport (Fig. 12). Upwelling may have ceased in winter, which allowed the waters, especially in the inner-ramp setting, to warm and approximate the overlying air temperatures.

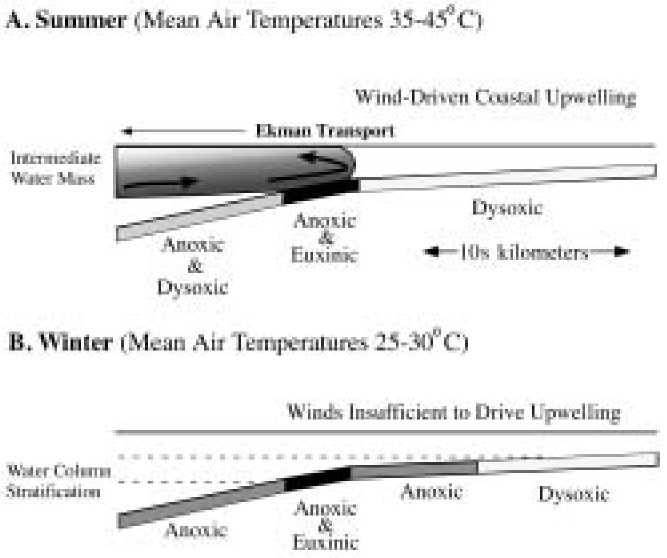

Figure 12. Conceptual model showing distribution of chemofacies, upwelling, and seasonal variation within Phosphoria Sea during Meade Peak deposition. A: Summertime case in which an oxygen-depleted, nutrient-rich water mass enters Phosphoria Sea and is driven to surface and seaward by coastal upwelling. High biological productivity in mid-ramp caused high organic particulate flux to seafloor, where bacterial respiration consumed all dissolved oxygen. Regeneration of phosphorus provided a supply of nutrients to inner ramp setting, where phosphogenesis occurred under dysoxic conditions. B: Wintertime case in which wind strength decreased and direction changed (Kutzbach and Ziegler, 1994) such that it was not able to maintain significant upwelling. Possible thermal stagnation may have occurred, water temperature of inner to mid-ramp settings would have risen, and continued bacterial respiration of organic matter in water column and below sediment-water interface would have consumed oxygen and resulted in expansion of anoxic and euxinic conditions.

The water flowing into the Phosphoria embayment probably had little or no dissolved oxygen to begin with, but as it warmed, its oxygen-carrying capacity remained extremely low, which prevented significant oxygen uptake from the atmosphere. This, combined with bacterial respiration of organic matter in the water column, favored development of widespread anoxia and even euxinic conditions. Even in nearshore environments, oxygen uptake would have been limited, and the water never became more than dysaerobic. As a result, macrofauna were suppressed due to low oxygen stress while phosphogenesis occurred in environments that ranged from dysoxic shallow inner-ramp settings to predominately anoxic mid- and outer-ramp settings. Salinity variation between the inner ramp and outer ramp probably influenced which organisms lived in which of those two settings, but the complete absence of macrofossils in the mid ramp suggests that elevated salinity did not play a major role in controlling the presence/absence of macro organisms in any setting. Paleoproductivity indicators suggest that maximum upwelling occurred in the mid-ramp position, and thus there was an ample influx of ocean water that would have prevented the elevation of salinity at this location.

This new model and our findings have great significance for the interpretation of other ancient phosphorites and suggest that paleoceanographic setting and paleoenvironment must be taken into account to fully understand the geochemical variation seen in ancient phosphorites.

CONCLUSIONS

The late Early to Late Permian is an important transitional time in earth history; the Phosphoria Rock Complex spans this change in global oceanographic, climatic, and biotic regimes. The widespread continental glaciation that marked the southern continents during the Early Permian had ended long before the phosphorites of the Phosphoria Rock Complex began forming. Extreme oceanographic conditions marked the Phosphoria Sea, and sedimentary phosphate and organic carbon were deposited across a broad range of paleoceanographic and paleoenvironmental settings, a range of phosphogenetic environments not seen today. Specifically:

1. Phosphogenesis in the Phosphoria Rock Complex occurred in depositional environments ranging from “basinal” outer ramp settings in <200 m water depth to very shallow, restricted inner ramp environments.

2. The organic carbon, sulfur, trace element, and $\delta^{13}C_{PO_4\text{–}CO_3}$ signatures vary systematically with position on the shelf, reflecting diverse paleoceanographic conditions across the paleoshelf and phosphogenesis in dysoxic to euxinic conditions.

3. Phosphogenesis in anoxic settings is strongly related to paleoproductivity indicators and occurred much as it does in the modern ocean, albeit in much shallower waters. Large amounts of organic matter accumulated on the seafloor due to the anoxic conditions and breakdown of the organic-matter-released, organic-bound phosphorous that in turn led to phosphogenesis.

4. Abundant phosphorite, yet low total organic carbon and total sulfur values and low, nutrient-like, trace-element concentrations indicate that phosphogenesis in nearshore, shallow-water, dysoxic settings was dramatically different. Oxygen supplied by air-sea exchange in these shallow-water settings maintained low oxygen levels and promoted the recycling of organic matter from the sediments. Yet, some of the liberated phosphorous produced phosphorites. Reasonably high productivity coupled with high water temperatures resulted in a stable dysoxic water column that was supplied with just enough nutrients to maintain phosphogenesis.

5. Cations that serve as paleoproductivity indicators are in low concentrations in the nearshore dysoxic settings due to either their efficient recycling or their “trapping” in the anoxic outer- and mid-ramp sediment.

6. Based on integration of lithofacies, biofacies, and chemofacies it is clear that the traditional cold- and deep-water upwelling model for the Meade Peak is not tenable. A more realistic paleoceanographic model is one in which a northward-flowing, oxygen-depleted, nutrient-rich intermediate water mass impinged on the seafloor at the mid-ramp position where anoxic and euxinic conditions prevailed. This shallow intermediate layer extended into the Phosphoria Sea and was brought to the surface during the summertime, when wind patterns produced coastal upwelling by Ekman transport. The water probably had very little dissolved oxygen to begin with, and as it warmed in the shallow waters of the Phosphoria Sea, its oxygen-carrying capacity remained extremely low. As a result, the upwelled water mass never became more than dysaerobic in nearshore environments, yet it was still capable of driving phosphogenesis in shallow-water settings.

7. Macrofauna in the Meade Peak member are only found in dysoxic facies, and their absence elsewhere (anoxic and euxinic chemofacies) is related first and foremost to low oxygen levels. Macrofauna also exhibit lateral variations that can be related to warm temperatures on the paleo ramp, but these variations are secondary to the control exerted by oxygen levels. All prior workers who use the occurrence, distribution, and nature of the Phosphoria Rock Complex fauna to argue for a simple cold-water upwelling model failed to recognize this point.

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