Section 13.14 Appendix D-12 Statement of Basis, Wyodak Coal Aquifer Exemption

WDEQ R&D License Application
Linc Energy Wyoming
UCG Demonstration, Gasifier 6 Project

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13.14 GROUNDWATER RECLASSIFICATION JUSTIFICATION

The Linc Energy Wyoming (Linc) has submitted a research and development (R&D) application to the Wyoming Department of Environmental Quality (WDEQ) to operate an in-situ Underground Coal Gasification (UCG) project (Gasifier 6) in Campbell County, Wyoming. As part of the process, air is injected into the coal seam via an injection well. The injection well is classified as a **Class III** injection well under Wyoming's Underground Injection Control (UIC) program. A complete copy of the R&D application is included on DVD as Attachment A. The license application is currently under review as TFN 5 5/128.

Linc has continuously operated a UCG demonstration facility near Chinchilla, Queensland, Australia since 1999. Linc has successfully operated UCG operations on the Chinchilla site while maintaining environmental compliance. To date, five gasifiers have been operated at Chinchilla with each gasifier being more technologically advanced than the previous. Currently, Gasifier 4 and Gasifier 5 feed syngas to a gas to liquids (GTL) plant. Linc continues to make synthetic crude from the syngas captured from Gasifiers 4 and 5.

13.14.1 Introduction

This Statement of Basis is intended to support classification of the Wyodak coal aquifer in the vicinity of the R&D facility as Class V (Mineral Commercial) and for provision of an aquifer exemption for that portion of the Wyodak. The Consolidated Permits Regulations (40 CFR §146.04 and §144.7) allow Environmental Protection Agency (EPA), or approved State programs with EPA concurrence, to exempt underground sources of drinking water from protection under certain circumstances. An underground source of drinking water may be exempted if:

> *A. It does not currently serve as a source of drinking water and;*
>
> *B. It cannot now and will not in the future serve as a source of drinking water because it is mineral, hydrocarbon, or geothermal energy producing, or it can be demonstrated by a permit applicant as a part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.*

Pursuant to Wyoming Water Quality Rules and Regulations (WQRR) Chapter VIII, Section 4(d)(viii): Groundwater of the State found closely associated with commercial deposits of minerals is classified as Class V (Mineral Commercial) Groundwater of the State. WQRR, Chapter VIII, Section 4(d) (viii) (B) further states:

> *"A discharge into a Class V (Mineral Commercial) Groundwater of the State shall be for the purpose of mineral production and shall not result in the degradation or pollution of the associated or other groundwater and, at a minimum, be returned to a condition and quality consistent with the pre-discharge use suitability of the water."*

13.14.2 Geographic Extent of Aquifer

The coal lease associated with the project covers the entire 640 acres within Section 36, Township 44 North, Range 74 West (the Project Area). The UCG Demonstration Gasifier 6 Project (the project) is located within the NW ¼ of Section 36, Township 44 North, Range 74 West of the 6th Principal Meridian, Campbell County, Wyoming.

The horizontal boundary of the Wyodak Coal aquifer proposed to be classified as Class V (Mineral Commercial) is depicted on Figure 13.14-1. The aquifer exemption is only requested for approximately 80 acres immediately surrounding the gasifier. A legal description of the geographic location of the Wyodak aquifer proposed for classification as Class V (Mineral Commercial) is:

The area located within of the NW ¼ of Section 36, Township 44 North, Range 74 West as shown in Figure 13.14-1.

The horizontal boundary for the Wyodak aquifer exemption area was determined based on the location of the Wyodak excursion wells and a science-based calculation to establish a reasonable distance beyond the excursion well perimeter. The calculation consists of three components:

- the distance a potential excursion could extend between adjacent excursion wells (assuming radial flow) prior to detection at an excursion well,
- the distance an excursion can travel from time of initial detection until recovery operations are initiated, and
- dispersivity that may result from movement of an excursion beyond calculated distances due to heterogeneity.

13.14.3 Commercial Production Potential of the Ore Deposits

A detailed description of the proposed UCG mineral extraction is included in Section 14: Mineral Extraction Plan of the R&D License Application (Attachment A).

Coal gasification is the process of converting solid coal into a synthesis gas (syngas) through a series of chemical reactions. UCG is an in-situ gasification process carried out in deep coal seams. Injection well(s) supply oxidants in the form of ambient air and/or

oxygen to the gasifying coal and production well(s) recover the product gas. The technique can be applied to coal resources that are otherwise unprofitable or technically complicated to extract.

Linc has proven the commercial viability of UCG. Linc is the current majority owner of Yerostigaz, a commercial UCG facility in Uzbekistan, which has been in operation for over 50 years. Linc has continuously operated a UCG demonstration facility near Chinchilla, Queensland, Australia since 1999.

The UCG process produces synthesis gas, or syngas. The produced syngas is comprised primarily of carbon monoxide (CO), hydrogen (H2), carbon dioxide (CO2), methane (CH4), and water (H2O) as steam). Nitrogen (from injected air) will also react to produce ammonia (NH3).

In a commercial application, the produced syngas can be separated into individual products to be sold as commodities. Alternatively, the various components can be recombined to produce a range of high-purity, clean, fuel products using a Fischer-Tropsch reactor or similar technology. Syngas can be used to produce numerous other products or serve as feed-stocks in substitution for other than fuels. Furthermore, the heat and pressure created during the gasification processes can also be used for power generation or radiant heat.

At the request of the WDEQ, Linc has agreed to conduct a demonstration project prior to full-scale operations to document the feasibility and viability of UCG in the Powder River Basin (PRB). The total amount of coal to be consumed during the demonstration project is projected to range from 1,008 to 2,020 tons of coal. The objectives of the Gasifier 6 UCG Demonstration Project are to prove the technical soundness of Linc's UCG design, operation and restoration procedures and that UCG can be accomplished in the PRB without adverse environmental impacts.

Linc proposes to commission Gasifier 6 to gasify the Wyodak coal located approximately 1,100 feet below land surface (bls). Approximately 11 to 16.8 tons of coal per day will be consumed to produce approximately one million standard cubic feet per day (MMscfd) of synthesis gas or "syngas" during the demonstration period.

13.14.4 Geologic Properties

13.14.4.1 Regional Geology

A detailed description of the regional geology is included in Section 13.7.4.1: Regional Geology of the R&D License Application (Attachment A).

The proposed facility will be located in the PRB of Northeastern Wyoming. The PRB is a north-northwest trending asymmetric syncline. The basin is bounded by the Bighorn Mountains to the west, the Black Hills to the east, and the Hartville Uplift and Laramie Mountains to the south.

The Wyodak coal is located about 1,100 ft below land surface at the proposed demonstration site. It is one of the coals within the Tongue River Member of the Fort Union Formation. The Fort Union Formation of Tertiary age consists of interbedded sandstone, siltstone, mudstone, and shale with numerous coal seams. These sedimentary rocks were deposited in a braided stream environment and are characterized a high degree of lateral and vertical heterogeneity. The Fort Union formation contains numerous coal beds that are mined extensively throughout the PRB.

13.14.4.2 Site Geology

A detailed description of the regional geology is included Section 13.7.4.2: Site Geology of the R&D plication (Attachment A). Figures 13.7-7, 13.7-8, and 13.7-9 of Attachment A present geologic cross sections of the permit area illustrating the site-specific stratigraphy. Addendum 13.7-B of Attachment A contains geophysical logs of wells installed by Linc Energy and lithologic logs from these wells are included as Addendum 13.7-G of Attachment A. Addendum 13.7-C of Attachment A presents core photographs and core description logs. Addendum 13.7-E of Attachment A contains geophysical logs of CBM Wells within permit area. A stratigraphic column of the site hydrostratigraphy is presented as Figure 13.14-2.

13.14.4.3 Wyodak Coal

The Wyodak coal is sub-bituminous C to sub-bituminous B rank. Studies conducted by the U.S Geological Survey report ash content ranging from 4.5 to 5.7 percent and BTU values of 8,500 to 8,300. The Wyodak Coal is 24 to 30 feet thick and laterally continuous within the Project Area. It is throughout most of the permit area. The exception is within the northeast portion the Project Area where it about 12 feet thick. The depth to top of the Wyodak Coal ranges from 1,075 feet in the northeast to 1,230 feet in the southwest. The Wyodak is bounded both above and below by shale and claystone of varying thickness.

13.14.4.4 Interburden, Overburden and Underburden

The interburden consists of the sandstone, siltstone, with shale between the Wyodak coal seam and overlying Big George coal seam. The interburden thickness ranges from 104 feet in the southwest of the Project Area to 332 feet in the northeast of the Project Area.

The overburden directly overlying the Wyodak coal is comprised of the shale. The thickness of the overburden shale above the Wyodak ranges from about 24 to 30 feet in

the in the vicinity of Gasifier 6. The sandstone above the shale overburden is referred to as the Overburden aquifer.

The underburden directly underlying the Wyodak coal is comprised of the shale. The thickness of the underburden shale below the Wyodak is about 10 feet in the vicinity of Gasifier 6. The sandstone below the shale underburden is referred to as the Underburden aquifer.

13.14.5 WDEQ Groundwater Classifications

13.14.5.1 WDEQ Groundwater Classification Based on Current Use

Official classification of water in Wyoming is performed by the WDEQ. A detailed description of **current groundwater use in the area** is included in *Section 13.8.8.1 Groundwater Rights* and *Section 14.4.7 Water Rights* of the R&D License Application (Attachment A). Groundwater quality baseline data from the Overburden, Wyodak, and Underburden aquifers for the parameters listed in Table 1 of Wyoming Water Quality Rules & Regulations, Chapter 8 are presented as **Appendix 13.14-E**.

The only water wells located within the Project Area are either industrial wells or coalbed methane (CBM) production wells. Several of the CBM wells are designated CBM/Stock but are not used for stock watering. These wells are not currently used for any purpose; the wells are currently not known sources of supply and they are shut in according to the SEO.

Groundwater rights within three (3) miles of the Project Area extracted from the Wyoming State Engineers Office (SEO) well database are listed in Table 13.14-1. No potable-use wells are located within the Project Area (consisting of Section 36, T44N, R74W). There are two (2) industrial wells within the Project Area, both are used to support oil and gas production; neither produces water from the Wyodak coal aquifer. There are a number of CBM wells within the Project Area that have produced water from the Wyodak and Big George coals **but are currently shut-in**. Groundwater withdrawals from the Wyodak in support of CBM production have been discontinued.

No potable-use wells are located within a three-mile radius of the Project Area. There are 18 wells outside the Project Area but within three (3) miles (plus one listed as cancelled). These wells are listed as CBM wells, CBM/Stock wells, monitor wells or "miscellaneous". Except for some of the CBM and CBM/Stock wells, none produce from the Wyodak aquifer.

Wells listed in the SEO database within ¼ mile of the proposed aquifer exemption area are shown on Figure 13.14-3 and listed in Table 13.14-2. All of the wells are listed as either CBM wells or CBM/Stock wells.

13.14.5.2 WDEQ Groundwater Classification Based on Ambient Quality

A detailed description of the ambient groundwater quality is included in Section 13.8.7.5: Groundwater Classification of the R&D License Application (Attachment A). Official classification of water in Wyoming is performed by the WDEQ. However, comparing groundwater chemistry of Wyodak groundwater at the Project Area to the criteria presented in Wyoming Water Quality Rules and Regulations, Chapter 8, Table 1- Underground Water Class; groundwater in the Wyodak aquifer would be considered Class III (stock). **WDEQ can classify the water as Class I based on the technical practicability and economic reasonableness of treating ambient water quality to meet use suitability standards. In this case, Wyodak groundwater is found closely associated with commercial deposits of minerals and is Class V (Mineral Commercial).**

Table 13.14-3 presents representative analytical results for the constituents listed on Table 1 of DEQ Water Quality Division, Rules and Regulations, Chapter 8 for the Overburden (364474-04OW31-WDOB), Wyodak (364474-13MW19-WD) and Underburden (364474-04MW10-WDUB) aquifers. Tables 13.14E-1 through 13.14E-3 of Appendix E list complete baseline groundwater analytical results for these aquifers and provide statistical analysis. Table 13.14-4 **compares the groundwater baseline analytical results** for the Overburden, Wyodak and Underburden aquifers to **water quality standards presented in DEQ Rules Chapter 8, Table 1**. Ambient concentrations of iron (Fe), manganese (Mn) and Total Dissolved Solids (TDS) in the Wyodak aquifer samples exceeded the maximum concentrations for Class I groundwater. The Sodium Adsorption Ratio (SAR) in the samples exceeded the maximum concentration for Class II groundwater as does, in some samples, Residual Sodium Carbonate and iron.

13.14.6 Aquifer Properties

A detailed description of the aquifer properties is included in *Section 13.7 Geology* and *Section 13.8 Hydrology* of the R&D License Application (Attachment A).

13.14.6.1 Name of Formation

The Wyodak coal will be extracted during the demonstration project. The Wyodak is one of the coals of the Ft. Union formation. The Wyodak has been designated an aquifer in the sense that it is an underground source of drinking water as defined by UIC regulations.

13.14.6.2 Aquifer Elevations

The elevation of the top of the Wyodak is approximately 3,910 feet NGVD (National Geodetic Vertical Datum) and the elevation of the base approximately 3,880 feet NGVD.

13.14.6.3 Aquifer Thickness

The thickness of the Wyodak aquifer is approximately 30 feet.

13.14.6.4 Confining Formations

The Wyodak aquifer is approximately 30 feet thick in the vicinity of Gasifier 6. It consists entirely of coal and is present from about 3,910 to 3,880 feet NVGD. The Wyodak is a confined aquifer and overlain and underlain by low permeability claystone and shale. In the vicinity of Gasifier 6, the confining unit above the Wyodak is approximately 30-feet thick and the confining unit beneath the Wyodak is about 10-feet thick.

The potentiometric surface of the Wyodak has been lowered substantially from CBM development and it currently ranges from about 4,320 to 4,330 feet NVGD within the permit area. CBM production from the Wyodak at the site has been discontinued and groundwater levels in the Wyodak are slowly recovering. Potentiometric levels within the Wyodak in the vicinity of the gasifier cavities are about 320 feet lower than the underlying Underburden aquifer and about 80 feet lower than the overlying Overburden aquifer. These steep vertical hydraulic gradients support the effectiveness of the confining units above and below the Wyodak aquifer.

13.14.6.5 Hydraulic Properties

A detailed description of the hydraulic properties is included in Section 13.8.2.5: Aquifer Parameters of the R&D License Application (Attachment A).

The matrix hydraulic conductivity of coal is low. Groundwater flow is primarily through fractures within the coal. Fractures occur along bedding planes, as a result of structural deformation, and along cleats. Cleats are fractures in coal that usually occur in two mutually perpendicular sets that are in turn perpendicular to bedding. Through-going cleats form first and are referred to as face cleats; cleats that end at intersections with through-going cleats form later and are called butt cleats. The nature of cleat geometry, with face cleats continuous and butt cleats terminating at face cleats, often results in an anisotropic aquifer system. The direction of the maximum fracture hydraulic conductivity is considered parallel to the face cleats. The minimum fracture hydraulic conductivity is generally considered parallel to the butt cleat. The matrix hydraulic conductivity is the lowest of all.

Two, variable rate, multiple well, Wyodak aquifer tests were performed. Results of the aquifer test analysis are shown in Table 13.14-5 and graphical curve matching solutions included as Addendum 13.8-D of Attachment A.

The first Wyodak test was performed in June 2011. A water-sampling event occurred on June 26, 2011, two days prior to the start of the Wyodak pumping test on June 28, 2011. Groundwater levels were rising in several Wyodak observation wells as a result of the sampling event and trend corrections were made to the water level measurements collected during the test.

Wyodak well 364474-04MW09-WD was the pumping well and wells 364474-04OW27-WD, 364474-04OW33-WD, 364474-04OW34-WD, and 364474-04OW35-WD were used as observation wells. Well 364474-04MW09-WD was pumped at an average rate of 4.5 gpm for 8.5 hours. Total drawdown in the pumping well was 636 feet. Drawdown in the Wyodak observation wells ranged from 1.3 to 4.4 feet. Water level recovery was monitored for 480 hours.

During the Wyodak test, drawdown in underlying Wyodak Underburden (WDUB) ranged between 0.8 to 9.6 feet and drawdown in a well screened in the aquitard separating the Wyodak and the Overburden aquifer was 1.1 ft. It was subsequently determined that flaws in construction of Wyodak well 364474-04MW09-WD created an artificial connection between the Wyodak and Underburden aquifers within the well. Groundwater levels in Wyodak well 364474-04MW09-WD were about 300 feet higher than nearby Wyodak observation wells and groundwater chemistry was indicative of the Underburden aquifer. The original borehole for well 364474-04MW09-WD was drilled through the Wyodak and underlying confining unit, and into the Underburden aquifer for purposes of geophysical logging. The attempted seal was not effective and groundwater from the Underburden aquifer seeped up through the annulus and into the Wyodak. The well was subsequently plugged and abandoned by drilling out the grout and bentonite through the confining layer and grouting the well from total depth to surface.

A second Wyodak aquifer test was performed January 27 to February 6, 2012 to determine Wyodak aquifer properties in the immediate vicinity of Gasifier 6. Well 364474-04TR44-WD was pumped at an average discharge rate of 1.2 gpm for approximately 248 hours. Water-level response was monitored in five observation wells during the test. Total drawdown was 217 feet in the pumping well at the end of the test. Drawdown was recorded at all five observation wells during the test. A maximum drawdown of 27.6 feet occurred at 364474-04OW27-WD, 686.02 feet from the pumped well. A minimum drawdown of 1.5 feet was observed at 364474-03MW36-WD, 630.62 feet from the pumping well. Transmissivity values calculated from the observation well data ranged from 0.57 to 2.0 ft^2/day. Storativity values from the observation well data ranged from $3.7x10^{-5}$ to $2.0x10^{-4}$.

Leakage analysis was evaluated using the Neuman-Witherspoon solution. The transmissivity and storage parameters from the Theis analysis were set as constants and curving matching was obtained by adjusting the leakage factors r/B and β (Neuman-Witherspoon, 1969). Parameters from the un-pumped aquifer were estimated to be 10 ft^2/day for transmissivity and 1 X 10^{-5} for storativity. Results of the leakage analysis are summarized in Table 13.14-5 and graphical curve matching solutions included as Addendum 13.8-D of Attachment A.

Review of the distance-drawdown data from all observation wells indicated anisotropic characteristics of the aquifer. Analysis of the areal anisotropy (Mutch, 2005) resulted in a major axis of transmissivity of 1.72 ft^2/day at N12°E, and a minor axis of transmissivity of 1.14 ft^2/day at N78°W.

13.14.7 Mine Plan Considerations

13.14.7.1 Description of Mineral Zone

A detailed description of the mineral zone is included in Addendum 14-D: Cavity Growth Model and Addendum 14-E: Subsidence Analysis of the R&D License Application (Attachment A).

The mineral zone is the Wyodak coal. It is about 30-feet thick and consists of C to B-rank, sub-bituminous coal. The geomechanical properties of the coal are described in Addendum 14-D: Cavity Growth Model and Addendum 14-E: Subsidence Analysis of the license application (Attachment A).

13.14.7.2 Process Description

The gasification of coal is a function of coal properties, water ingress, oxidant injection rate, reaction rates, pressure and temperature. Coal quality may vary slightly locally, but is assumed to have a consistent average quality. Water ingress is a function of the hydrogeology, gasifier pressure, and operating conditions. Air injection and gasifier pressure are carefully monitored to provide accurate control over the temperature and water ingress.

The main production zone comprises the total gasifier cavity, which will increase as coal is consumed. Gasifier 6 will maintain gasification operations for 90 to 120 days. The demonstration is anticipated to extract an estimated 11 to 16.8 tons of coal daily and produce approximately 1.5 MMscfd (1,655 Nm^3/hr) wet syngas or 1.1MMscfd (1,264 Nm^3/hr) dry syngas.

Based upon the lithology and confining conditions surrounding Gasifier 6, the design included sufficient room to provide a total of five cavities (four primary cavities, with a

fifth contingency location) connected via a horizontal injection well to the production well. The final dimension of each cavity for the demonstration will be approximately 11.5 feet high, 24 feet wide, and 66 feet long at maturity. A 52-ft long pillar separates cavities. Total distance between the northwest end of one cavity to the northwest end of the adjacent cavity is approximately 118 feet. Figure 14-5 of the license application (Attachment A) shows the production zone, predicted cavity sizes, and pillars between cavities.

13.14.7.2.1 Well Construction and Completion

A detailed description of well construction and completion is included in Section 14.3.3 Well Construction and Linkage of the R&D License Application (Attachment A).

Gasifier 6 process wells and additional trend and excursion wells will be installed after approval of the R&D License application and prior to construction. The vertical service wells and production well will be installed to approximately the base of the target coal seam. The injection well will be horizontally drilled through the lower portion of the Wyodak coal seam using directional drilling techniques, sequentially intersecting the three vertical process wells.

Detailed well designs for the injection, production and service wells will be completed by a third party provider that has extensive experience in high temperature casing design. The designs will be similar to those that have been tested and successfully used for the latest gasifiers operating at the Linc Energy Chinchilla demonstration site. Specifically, a Confidential Project Memorandum regarding Preliminary Casing Design Review for Gasifiers 4 and 5is included in the license application (Attachment A).

The annular cement to be used is a proprietary blend (designated as such by the supplier) designed for Linc that has been successfully tested up to 1,000°C (1,832°F). Subsurface temperatures having direct contact with the high temperature cement will not exceed 1,000°C. A professional paper presented at the IADC/SPE Asia Pacific Drilling Technology Conference in 2010 describes the cement design, characteristics and feasibility of use in high temperature environs. The paper titled “Pushing Portland Cement beyond the Norm of Extreme High Temperature” is included in the license application as Addendum 14-I, Business Confidential. A cross sectional view schematic of the injection, production and service wells has also been provided in the license application as Addendum 14-I, Business Confidential.

Injection Well

The primary functions of the injection well are to deliver the oxidant feed (air) to the gasifier and allow the sequential ignition of the individual gasifier cavities. The injection

well design includes a vertical segment and a horizontal directionally-drilled segment to create linkage within the gasifier process wells.

From the injection wellhead, a section of 13⅜" surface casing will be installed. A 5 ½" carbon steel casing will be installed through the surface casing. The horizontal section of the injection well will be drilled through the bottom portion of the Wyodak coal and will be cased with 5 ½" carbon steel casing whereby linking the injection well, service wells, and production well.

Service Wells

Service Well #1 will be located within the second cavity, and Service Well #2 will be located within the fourth cavity. The service wells will be constructed with a 5½ inch casing with appropriate casing and cement design parameters to accommodate high temperatures and pressure. These wells provide contingency functionality for use as ignition wells and releasing over-pressure to reverse groundwater excursion. The service wells may also be used to:

- Monitor gasifier conditions,
- Evacuate groundwater during decommissioning and restoration, and
- Inject steam to quench the gasifier during decommissioning.

Production Well

The primary function of the production well is to recover syngas and production water from the gasifier during operation. Nominal 13⅜-inch diameter steel surface casing well be installed to a depth of approximately 120 feet bls and grouted in place with cement. A nominal 9⅝-inch diameter intermediate casing will be installed through the Big George coal and grouted in place with cement. High temperature, nominal 5½-inch diameter steel casing will be installed to the bottom of the Wyodak and cemented to surface with high temperature cement.

Subsidence Wells

Three subsidence monitoring wells are to be located on the centerline of Gasifier 6 above the first, third and fifth cavities as depicted in Figure 14-3 of the license application (Attachment A). Subsurface yielding or deformation due to relaxation of the overburden will be monitored above the gasifier with the installation of Time Domain Reflectometry (TDR) cables (or similar device). TDR cables will be installed to monitor yielding or movement in the roof rock above the gasifier. The TDR's are designed to minimize potential conduits for syngas transport to the overlying strata. Proper grouting of the TDR wellbores will mitigate the risk of such a conduit. Subsidence wells are described in Sections 14.3.3.5 and 14.6.2.1 of the license application and a subsidence monitoring

plan is included in Addendum 14-E of the license application (Attachment A) which includes completion diagram a typical TDR (Addendum 14-E, Figure 6).

Trend and Excursion Wells

The trend and excursion monitor well locations were selected to detect possible excursions from the gasifier and will serve as the primary monitor well network during UCG operations. The wells are completed in the Wyodak aquifer, the Overburden aquifer and Underburden aquifer.

A total of 20 trend wells and 17 excursion wells will be used to monitor groundwater in the vicinity of the Gasifier. Monitor well installation and completion will be in accordance with protocols previously approved by LQD. Typical well construction details for trend and excursion wells are shown in Figure 13.8-6 of the license application (Attachment A).

Temperature, specific conductivity, and water levels around the cavities will be monitored during gasifier operation using transducers installed in trend wells. The transducers may be connected to a Supervisory Control and Data Acquisition (SCADA) system, or hard-wired to the control room, to provide operators with real-time information. The monitoring system will be telemetry based and supplied by Insitu, Inc. or hard-wired directly to the control room.

13.14.7.2.2 Mechanical Integrity Testing

A detailed description of Mechanical Integrity Testing is included in Section 14.3.3.7.1 of the R&D License Application (Attachment A).

UCG injection wells are classified by the WDEQ as UIC Class III wells for fluid injection associated with the extraction of minerals. Mechanical Integrity Tests (MITs) of the process wells (injection, production and service) will be performed to document casing integrity. An MIT will be conducted on all UCG process wells prior to start-up and after any repair where a down-hole drill bit or under-reaming tool is used. A new MIT will be performed on any process well with suspected subsurface damage prior to being returned to service. Normally, MITs of process wells are required at least once every five (5) years. Due to the short duration of this demonstration project, MITs of process wells will be completed prior to startup.

MITs will be completed in accordance with approved testing procedures to demonstrate the mechanical integrity of the well casings. The MITs will be documented to include the well designation, date of the test, test duration, beginning and ending pressures, and the signature of the individual responsible for conducting the test. Results of tests will be submitted to WDEQ-LQD prior to the ignition of the gasifier. Results of the MITs will

also be maintained on site and available for inspection. Post-commissioning MIT testing results will also be provided to WDEQ-LQD in annual reports if required.

The MITs will be pressure tests. The bottom of the casing will be sealed with a plug, down-hole packer, or other suitable device. The top of the casing will be sealed in a similar manner or with a threaded cap, and a calibrated pressure gauge installed to monitor the pressure inside the casing. The casing will be tested at the greater of a minimum pressure of 300 psi or a pressure equivalent to the maximum injection pressure, up to a maximum of 1,000 psi. If the pressure drop is less than ten percent, the well casing is considered to have acceptable mechanical integrity. Once a well has been repaired and passes the MIT, it will be placed in its intended service.

If there are obvious leaks, or the pressure drop rate is greater than ten percent during the ten-minute period, the seals and fittings on the packer system will be reset and/or checked, and another test conducted. If a well casing does not pass the MIT, the well casing will be repaired, if possible. After being repaired, the well will be re-tested. If it is determined that the well cannot be repaired it will be plugged and abandoned. The WDEQ-LQD will be notified in the event a well fails the MIT, and the well will only be placed in service upon approval from the LQD Administrator, once the well successfully passes the MIT.

In addition to the initial testing completed during installation, an MIT will be conducted on the well after any work that involves use of a down-hole drill bit or under-reaming tool in the well. Any well with evidence of suspected subsurface damage would require an MIT prior to the well returning to service. In accordance with WDEQ requirements, MITs will be repeated once every five years for all injection and production wells. The well integrity information will be documented and filed on site and provided to WDEQ-LQD on a quarterly basis.

13.14.7.2.3 Hydraulic Containment

A detailed description of hydrodynamic control system is included in Section 15.1.1 of the R&D License Application (Attachment A).

The project trend wells will be utilized to control hydrostatic pressures within the Overburden, Underburden and Wyodak aquifer surrounding the gasifier. The hydrodynamic control system and procedures are described in Section 15 of the license application (Attachment A).

One of the research and development objectives of the project is to refine techniques and procedures to establish hydraulic control of not only the Gasifier 6 cavity but also of the pressures within the surrounding groundwater system. Objectives of the hydrodynamic control system are to:

- Maintain vertical and horizontal groundwater flow potential toward the gasifier throughout operations and restoration, and
- Control the pressure differential between the Wyodak and adjacent aquifers, and
- Control groundwater impingement rates to the gasifier.

The hydrodynamic control system will only be operated as necessary to maintain groundwater flow toward the gasifier cavities or to limit the quantity of groundwater inflow to the cavities during operation. Control of the pressures surrounding the gasifier will consist of three primary processes:

1. Pumping groundwater from the Underburden to reduce the pressure differential between the Underburden aquifer and the Wyodak while maintaining Underburden pressure slightly higher than that of the Wyodak. This will maintain groundwater flow potential from the Underburden to the gasifier but limit the rate of groundwater inflow to the cavity.
2. Pumping groundwater from the Overburden aquifer to reduce the pressure differential between the Overburden aquifer and the Wyodak while maintaining Overburden pressure slightly higher than that of the Wyodak. This will maintain groundwater flow potential from the Overburden to the gasifier but limit the rate of groundwater inflow to the cavity.
3. Injecting groundwater into the Wyodak surrounding the gasifier to maintain lateral groundwater flow within the Wyodak toward the cavity. It is anticipated that the injection will only occur during the restoration phase; and only if pressures within the gasifier cavity increase as the result of inflow from the Underburden or Overburden and restoration of groundwater quality within the gasifier has not yet been completed; and
4. Injecting groundwater into the Overburden aquifer during decommissioning to compensate for increased pressures in the Wyodak either due to infiltration from the Underburden or water level recovery from prior CBM development.

In each case, the proposed trend wells will be used for hydrodynamic control of the pressures within the Overburden, Wyodak, and Underburden aquifers. Hydrodynamic control processes and procedures are detailed further in Section 15.1.1 of the license application.

13.14.7.2.4 Groundwater Monitoring Plan

The groundwater-monitoring plan for excursion and trend wells during the 90 to 120-day demonstration project was developed based on the hydrogeology at the site, the operational plan, and WYDEQ guidance documents. The primary focus of the plan is to monitor potentiometric levels, temperature, and specific conductivity in the Wyodak,

Overburden and Underburden trend wells immediately surrounding the cavities to ensure horizontal and vertical groundwater flow potential is consistently toward the gasifier and to quickly identify excursions should they occur. As per WYDEQ Guideline 8, "… water quality need only be monitored annually if water levels define a hydraulic gradient towards the pit." This approach will provide for protection of groundwater quality while minimizing the risk of gas migration that is associated with physically sampling wells in the vicinity of the gasifier.

Trend and Excursion Monitor Well Network

A total of 20 trend wells and 17 excursion wells will be used to monitor groundwater in the vicinity of Gasifier 6. Well locations are shown on Figure 13.14-1. Monitor well installation and completion will be in accordance with protocols previously approved by LQD. Typical well construction details are shown in Figures 13.8-6 of the license application (Attachment A) for trend and excursion wells, respectively. Each trend and excursion well will be equipped with a dedicated submersible pump for sampling.

The trend and excursion monitor well locations were selected to detect possible excursions from the gasifier and will serve as the primary monitor well network during UCG operations. The wells are completed in the Wyodak, Overburden and Underburden aquifers.

Design of trend and excursion well spacing and arrangement has taken into consideration site-specific aquifer characteristics, gasifier operational requirements, and lessons learned from Linc's operational experience, as well as lessons learned from UCG projects performed by other groups. Linc's analysis and rationale supporting the placement of trend and excursion wells consists of five elements:

- UCG monitoring experience at Rocky Mountain 1 UCG test and Linc's own experience,
- Evaluation of preferential groundwater flow paths at the Gasifier 6,
- Contaminant fate and transport analytical modeling, and
- Excursion control and capture analysis.

Linc's UCG experience and the results of the Rocky Mountain 1 UCG test indicate that during UCG operations, a gasifier operations zone of elevated product gas concentration and pressure commonly extends into the coal surrounding the gasifier cavity. Following the Rocky Mountain 1 UCG test, WDEQ-LQD recognized that a flare zone in proximity to the gasifier cavity is associated with UCG operations, and recommended that monitoring wells be placed at least 600 feet from any gasifier cavity. Therefore, the actual gasifier operation consists of the gasifier cavity and an area that extends at least 600 ft beyond the cavity within the target coal.

The evidence for preferential groundwater flow paths supports the conclusion that the most likely direction of maximum principal transmissivity in the Wyodak aquifer coal aquifer is along a north-northeast to south-southwest oriented axis. Therefore, in order to maximize the likelihood of detecting a process excursion, Wyodak trend and excursion monitoring wells will be located to the north-northeast and to the south-southwest of the gasifier cavities (see Figure 13.14-5).

Linc conducted contaminant fate and transport analysis of chloride and benzene to aid in understanding how dissolved-phase chemical species are likely to behave and travel through the Overburden aquifer, Wyodak aquifer and Underburden aquifers. A concentration of 25 mg/l chloride (emanating from a continuous 500 mg/l source) is estimated to travel 200 feet from its source in the Wyodak aquifer in 5.8 to 10.8 years. In comparison, an identical release of chloride in the Overburden aquifer is estimated to travel 200 feet in approximately 31.8 to 187 years, and the same release in the Underburden aquifer is expected to travel 200 feet in about 9.4 to 26.2 years. The benzene model results highlight the substantial retardation of dissolved organic contaminants in high-carbon content aquifers such as the Wyodak coal. The estimated first arrival of 0.0005 mg/l of benzene at a distance of 200 feet in the Wyodak is greater than 100,000 years. In contrast, the low organic carbon content of the Overburden and Underburden sandstone aquifers gives a range of benzene arrival times at 200 feet of 38.1 to 262 years, and 10.9 to 31.2 years, respectively.

The time to control an excursion (reverse the gradient) in the Wyodak aquifer at distances of 600-feet from the gasifier cavities was estimated to be about one day, regardless of aquifer porosity. Thus, excursion control in the Wyodak aquifer, as defined by WDEQ Guideline No. 4, can be demonstrated well within the recommended 60-day limit. Excursion capture, as defined by WDEQ Guideline No. 4, is expected to occur in approximately 129 days with an assumed Wyodak porosity of 0.01 and 252 days with a an assumed porosity of 0.02.

The time to control an excursion (reverse the gradient) in the Overburden aquifer at distances of 1,100-feet from the gasifier was estimated to be about 1 day, regardless of aquifer porosity. Thus, excursion control as defined by WDEQ Guideline No. 4 can be demonstrated well within the recommended 60-day limit. Excursion capture, as defined by WDEQ Guideline No. 4, is expected to occur in approximately 2.9 years with an Overburden porosity of 0.15 and 5.8 years with an assumed porosity of 0.3.

It should be emphasized that these results represent the anticipated maximum excursion capture times due to conservative estimates of transmissivity, and the sole use of trend wells for excursion control and capture. In the unlikely event of an actual excursion, additional wells in the affected aquifer would be utilized, and new wells could be installed if deemed necessary in order to expedite excursion capture.

The consistent and steep hydraulic gradients directed towards the Wyodak aquifer from both the Overburden aquifer and Underburden aquifer, caused by residual drawdown within the Wyodak aquifer from coal bed methane development, will prevent any gasifier-related byproducts or contaminants from migrating advectively from the Wyodak to these units. If operational gas flares create transient excursions that transfer gasifier-related contaminants to the Overburden or Underburden aquifers, these same gradients will exert hydraulic control and cause migration towards the Wyodak aquifer.

The excursion well siting and monitoring plans were developed for the specific hydrogeologic and operational considerations of the Wyodak, Overburden and Underburden aquifers. The details of number of wells, locations and spacing are supported by analyses of previous UCG monitoring experience, the available evidence of preferential groundwater flow pathways, contaminant fate and transport calculations, and demonstration of excursion control and capture in accordance with WDEQ Guideline No. 4. These plans, in conjunction with the operation and decommissioning plan described in Section 14 of the license application (Attachment A) and the proposed restoration plan described in Section 17 of the license application (Attachment A), will result in the timely detection, control and restoration of any potential groundwater quality impacts associated with Gasifier 6.

Frequency of Monitoring and Parameters Monitored

WDEQ Guideline No. 8 addresses frequency of monitoring during mining operations. If water level measurements indicate no possibility for groundwater flow off-site (closed cone of depression), then annual monitoring is suggested. If monitoring data suggest that a closed cone of depression is not maintained, then more frequent monitoring is required, with the frequency dependent on site-specific factors. The gasifier operation as well as the "Clean Cavern Concept" for gasifier decommissioning that will be utilized by Linc requires that a closed cone of depression be maintained around the gasifier throughout operation and decommissioning.

Down-Hole Groundwater Monitoring

Continuous monitoring will be conducted during the demonstration in trend and excursion wells using a network of electronic transducers and data loggers. Potentiometric level, temperature and specific conductivity will be measured in trend wells and potentiometric level measured in excursion wells. Based on the experiences of the Rocky Mountain 1 UCG test, conductivity and groundwater head elevation are expected to act as highly sensitive and effective indicators of a groundwater excursion or gas migration from the operational area (Lindblom and Smith, 1993 p. 52–56). In-situ monitoring will reduce the risk of UCG gas migration induced by lowering hydrostatic pressure from pumping wells for sample collection.

Potentiometric level, temperature and specific conductivity at trend wells and potentiometric level at excursion wells will be measured at frequent (10-30 minute) intervals throughout the demonstration period. The data will be telemetered and continually monitored within the onsite control room. Alarm functions will be employed to alert operators of pressure, temperature or specific conductivity anomalies that could indicate a gas excursion or groundwater flow potential away from the gasifier.

Data from these instruments will be downloaded periodically and reviewed by Linc personnel, and made available to the WDEQ. Data collected will be stored on Linc's internal computer network, which will make the data available for access from both the site operations office and Linc's Casper office.

The stream of nearly real-time groundwater monitoring data provided by the down-hole instrumentation will be used for two purposes:

- The primary purpose of these data will be to monitor the groundwater flow regime and groundwater quality in the operational area, as required for in-situ mining operations by WDEQ-LQD. The data collected will be used to confirm that a gasifier-directed hydraulic gradient is maintained in the Wyodak and that impacted groundwater is not migrating from the operational area into the Overburden or Underburden aquifers.
- A secondary use of these data will be to provide rapid feedback on groundwater conditions to gasifier operators (in addition to data provided by process-specific instrumentation), thus assisting in the proactive management of gasifier operational parameters in order to further minimize the chance of a groundwater excursion occurring.
- In the unlikely event that a gasifier-directed hydraulic gradient is not maintained during operations or decommissioning, or that degradation in groundwater quality is detected through down-hole monitoring, then the physical-chemical/sampling program will be implemented.

Collection of groundwater samples will be minimized during operations to minimize the potential for gas excursions from the operating UCG gasifier. Well evacuation procedures associated with well sampling will reduce hydrostatic pressure at the sampling point, which may increase the potential for gas excursions.

Water Quality Sampling: Annual and Contingency Plans

Groundwater samples will be collected from the excursion wells and trend wells immediately prior to and after gasifier operations and the samples analyzed for the parameters listed in WDEQ Guideline 8 Appendix I VI, VB, and VE. In the case that potentiometric data or conductivity measurements indicate the possibility of an excursion

during the operational or decommissioning phases of the project, a groundwater sampling program will be initiated.

Groundwater sampling will be conducted in accordance with Linc's Sampling and Analysis Plan, previously submitted for approval to the WDEQ-LQD. Groundwater analytical results will be maintained in digital format on Linc's internal computer network, with maintenance and oversight of these records being the responsibility of the Wyoming UCG Project Manager and/or the Senior Hydrogeologist in Linc's Casper office.

The possibility of an excursion will be determined on the basis of one or more of the following conditions:

1. If a cavity-directed hydraulic gradient is not maintained in the Wyodak aquifer or anomalous heads are observed in Overburden or Underburden aquifers during gasifier operation;
2. If down-hole conductivity instrumentation in a trend well detects a change in conductivity greater than 80 µmhos/cm over a 24-hour period; and
3. If water temperature increases by more than 1 ºC over a 24-hour period.

If any of these conditions is met in one or more trend or excursion wells, groundwater samples will be collected from the closest two excursion wells in the same aquifer of the suspected excursion within two days following receipt of the in-situ detection. The samples will be analyzed for the four upper control limit (UCL) parameters: phenol, ammonia, conductivity and benzene. Samples will be collected and analyzed every two weeks until the gasifier-directed hydraulic gradient is re-established in the Wyodak, and/or the head differential between the Overburden/Underburden and the Wyodak is restored, and/or the in-situ conductivity measurements return to their previous levels. If two or more UCL parameters are detected in a sample in excess of UCL values, determination of the well's excursion status will be made in accordance with the following procedure, as outlined in WDEQ Guideline No. 4:

- If two or more UCL parameters are exceeded in a sampled well, then a confirmation sample will be collected from that well within 24 hours of receiving the initial analytical data.

- The confirmation sample will be analyzed for the same four UCL parameters. If the confirmation sample does not exceed a UCL, another confirmation sample will be collected from the well in question within 48 hours of receiving analytical data from the first confirmation sample. The second confirmation sample will also be analyzed for the four UCL parameters.

- If neither of the two confirmation sample results affirms the initial UCL exceedances, then the well in question will not be placed on excursion status.

- If results of either the first or second confirmation samples affirm UCL exceedances for the same two parameters, then the well will be placed on excursion status.

Once a monitor well placed on excursion status it will be verbally reported to the WDEQ within 24 hours of confirmation and reported in writing within seven (7) days. Groundwater samples will be collected from the well on excursion, and the two nearest excursion wells in the same aquifer, on a weekly basis until the excursion is controlled. These samples will be analyzed for the four (4) UCL parameters. When UCL parameters indicate that a well is no longer on excursion status, a sample will be collected and analyzed for the full suite of WDEQ Guideline No. 8 Appendix 1 VI, VB and VE parameters. Furthermore, if any well remains on excursion for longer than 30 consecutive days, a groundwater sample will be collected and analyzed for the WDEQ Guideline No. 8 Appendix 1 VI, VB and VE parameters.

The possibility of an excursion is unlikely. However, if an excursion were to occur, delineation of the extent and magnitude of the excursion will immediately begin and corrective actions would be implemented within seven days. The approach to excursion-related corrective action is described below; however, these principles may be modified on an as-needed based for the particular circumstances of an excursion.

In the event an excursion is detected, appropriate actions will be implemented to arrest any further contaminant migration. Excursions are further defined in Section 14.5.4 of the license application (Attachment A). Any excursion detected will be reported to WDEQ-LQD within 24 hours of the discovery of the excursion. Reporting is discussed further in Section 15 of the license application (Attachment A).

Excursions

An excursion is defined to occur when any two UCL parameters exceed their UCL values and is confirmed by a follow-up sample. If an excursion, as defined above, is confirmed at an excursion well, appropriate remedial action will be determined and a remedial action plan submitted to WDEQ-LQD within 7 days of confirmation.

Progress of remedial measures at that time shall also be submitted to the WDEQ-LQD. Samples will be collected and analyzed on a weekly basis for the suite of UCL parameters until the excursion is controlled. If the excursion lasts longer than 30 days, a sample shall be analyzed for the full suite of parameters listed in WDEQ-LQD Guideline 8, Appendix 1 IV, VB and VE. WDEQ-LQD regulations define excursion control as the time at which “the movement of recovery fluid out of the production zone and into unauthorized areas has ceased”, and require that an excursion shall be controlled within 60 days of confirmation of the excursion. At the time when UCLs are no longer exceeded

at the well on excursion, a sample will again be collected and analyzed for the full suite of Guideline 8 parameters (WDEQ-LQD Rules and Regulations Ch. 18). The following are proposed methods that Linc may use to address an excursion:

- Lower the operating pressure in the UCG cavity in order to increase the hydraulic gradient directed towards the gasifier, and to further decrease pressure in the gasifier compared to the pressure in the Overburden and Underburden aquifers,
- Pumping of one or more trend or excursion wells could be performed to locally exert hydraulic control of the groundwater and capture the contaminant excursion. This procedure would generally follow the excursion capture process outlined in WDEQ's Guideline No. 4. Trend wells have been specifically designed and located to control excursions detected at the excursion wells within the 60-day period suggested in this guideline. See Addendum 14-F of the license application (Attachment A) for this evaluation, and
- Other additional excursion control measures (with the prior approval of the WDEQ) include installation of additional groundwater recovery wells, increased pumping from the UCG cavity, use of injection wells to establish hydraulic barriers to migration, and in-situ alterations of the groundwater chemistry and/or oxidation-reduction state.

The trend or excursion wells will only be engaged as groundwater remediation wells if the need arises to control an excursion. Such an action is expected to mitigate further impairment to groundwater quality by removing contaminated groundwater from the aquifer system. The goal for implementing this corrective action is to intercept the plume prior to it extending beyond the excursion wells. It is anticipated that a hydraulic or pumping response should be effective in containing and remediating an excursion because of the radius of influence generated by pumping a trend or excursion well. Therefore, it is expected that hydraulic control measures may be appropriate in most cases.

In the event that an excursion is detected and the primary corrective actions described above are determined to be ineffective, then a more aggressive strategy will be developed and subsequently implemented that best complements the situation. In such an event, Linc will seek guidance from the WDEQ-LQD/WQD before implementing any corrective action.

Corrective measures and monitoring will continue until UCL exceedances are no longer detected for three consecutive months, at which time another suite of samples would be collected and analyzed for WDEQ Guideline No. 8 and additional required parameters. Once this occurs, it will be concluded that the excursion has been arrested, WDEQ will be notified and Linc will submit a formal request to declare the well or wells be taken off excursion status.

Reporting

Monitoring reports will be prepared by Linc and submitted to the WDEQ-LQD every two (2) weeks. The monitoring reports will include operational and monitoring data related to overall operations of the gasifier and subsurface conditions.

Progress reports submitted to the WDEQ-LQD six (6) months after completion of the demonstration period and every six (6) months thereafter until groundwater restoration and surface reclamation is complete. In-situ monitoring data from trend and excursion wells will be available to DEQ at the Linc operations office at Gasifier 6. A summary of the monitoring data will be provided to DEQ following the demonstration period. Groundwater analytical results will be maintained in digital format on Linc's internal computer network with maintenance and oversight of these records being the responsibility of the Wyoming UCG Project Manager and/or the Senior Hydrogeologist in Linc's Wyoming office.

Excursion reporting is summarized as follows:

- A monitor well placed on excursion status will be verbally reported to the WDEQ within 24 hours of confirmation, and reported in writing within seven (7) days,
- If an excursion, as defined above, is confirmed at an excursion well, appropriate remedial action will be determined and a remedial action plan submitted to WDEQ-LQD within seven (7) days of confirmation,
- Progress of remedial measures will be submitted to the WDEQ-LQD at times specified in the remedial action plan until such time as the excursion is controlled;
- In the event that the primary corrective actions described above are determined to be ineffective, then a more aggressive strategy will be developed and Linc will seek guidance from the WDEQ before implementing any additional corrective action; and
- Once UCL exceedances are no longer detected for three consecutive months, and following confirmation sampling, it will be concluded that the excursion has been arrested. WDEQ will be notified and Linc will submit a formal request to declare the well or wells be taken off excursion status.

13.14.8 Notification for Public Participation (Public Notice)

The notice of the intent to issue the mining permit and aquifer reclassification will be published once a week for four consecutive weeks in a newspaper of general circulation in the locality of the proposed operation. The Administrator of the Land Quality Division, Wyoming Department of Environmental Quality will accept objections to the proposed operation for 30 days following the day of last publication. If required, a hearing before the Wyoming Environmental Quality Council will be held within twenty (20) days following the last day of public comment (if requested), unless the applicant and objector both agree to a later date.

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FIGURES

Figure 13.14-1: Requested Aquifer Exemption Area

Figure 13.14-2: Hydrostratigraphic Column

Figure 13.14-3: Water Wells within 1/4 Mile of Proposed Aquifer Exemption Area

TABLES

Table 13.14-1: Groundwater Rights Within 3 Miles of Project Boundary

WR Number	Priority Date	Water Right Status	Applicant	Facility Name	Uses	Township	Range	Section	Qtr Qtr	Longitude	Latitude	Total Flow	Total depth (Ft)	Static Water Level (Ft)	Well Log	Buffer Proximity
P124377.0W	3/20/2000		Wyo State Board of Land Commissioners	ENL K-BAR CS STATE #3	CBM	044N	074W	36	NW1/4NE1/4	-105.69301	43.74947	50	850	474	N	In Permit Boundary
P124376.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #2	CBM	044N	074W	36	SE1/4NW1/4	-105.69811	43.74579	35	898	527	N	In Permit Boundary
P124378.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #4	CBM	044N	074W	36	SW1/4NE1/4	-105.69313	43.74583	50	855	566	N	In Permit Boundary
P124379.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #5	CBM	044N	074W	36	NW1/4SE1/4	-105.69325	43.74219	50	890	525	N	In Permit Boundary
P124380.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #6	CBM	044N	074W	36	NW1/4SW1/4	-105.70322	43.74213	50	1037	369	N	In Permit Boundary
P124381.0W	3/20/2000		Yates Petroleum Corp.	ENLK-BAR CS STATE #7	CBM	044N	074W	36	NE1/4NW1/4	-105.69799	43.74941	50	863	264	N	In Permit Boundary
P124382.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #8	CBM	044N	074W	36	SW1/4SE1/4	-105.69337	43.73855	50	957	409	N	In Permit Boundary
P124383.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #9	CBM	044N	074W	36	NE1/4SW1/4	-105.69824	43.74216	50	952	323	N	In Permit Boundary
P124384.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #10	CBM	044N	074W	36	NW1/4NW1/4	-105.70296	43.74935	50	947	199	N	In Permit Boundary
P124385.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #11	CBM	044N	074W	36	SW1/4NW1/4	-105.70309	43.74574	50	991	310	N	In Permit Boundary
P124386.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #12	CBM	044N	074W	36	SE1/4SW1/4	-105.69837	43.73854	50	1045	456	N	In Permit Boundary
P124387.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #13	CBM	044N	074W	36	SW1/4SW1/4	-105.70336	43.73853	50	1085	464	N	In Permit Boundary
P124388.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #14	CBM	044N	074W	36	NE1/4NE1/4	-105.68804	43.74953	50	804	460	N	In Permit Boundary
P124389.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #15	CBM	044N	074W	36	NE1/4SE1/4	-105.68827	43.74222	50	838	444	N	In Permit Boundary
P124390.0W	3/20/2000		Yates Petroleum Corp.	ENL K-BAR CS STATE #16	CBM	044N	074W	36	SE1/4SE1/4	-105.68838	43.73856	50	885	480	N	In Permit Boundary
P177369.0W	9/21/2006		Yates Petroleum Corp.	K-BAR CS STATE #1	CBM	044N	074W	36	SE1/4NE1/4	-105.68815	43.74587	200	0	0	N	In Permit Boundary
P138055.0W	8/16/2001		Yates Petroleum Corp.	K-BAR CS STATE # 26	CBM; STK	044N	074W	36	SW1/4SE1/4	-105.69337	43.73855	200	0	0	N	In Permit Boundary
P124375.0W	3/20/2000	Cancelled	Yates Petroleum Corp.	ENL K-BAR CS STATE #1	CBM	044N	074W	36	SE1/4NE1/4	-105.68815	43.74587	35	802	483	N	In Permit Boundary
P110604.0W	6/15/1998	Cancelled		K-BAR CS STATE #1	CBM; STK	044N	074W	36	SE1/4NE1/4	-105.68815	43.74587	25	802	483	N	In Permit Boundary
P111825.0W	9/15/1998	Cancelled		ENL K-BAR CS STATE #1	CBM; STK	044N	074W	36	SE1/4NE1/4	-105.68815	43.74587	70	802	483	N	In Permit Boundary
P116200.0W	6/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #14	CBM	044N	074W	36	NE1/4NE1/4	-105.68804	43.74953	100	804	460	N	In Permit Boundary
P116201.0W	6/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #15	CBM	044N	074W	36	NE1/4SE1/4	-105.68827	43.74222	100	838	444	N	In Permit Boundary
P116202.0W	6/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #16	CBM	044N	074W	36	SE1/4SE1/4	-105.68838	43.73856	100	885	480	N	In Permit Boundary
P111630.0W	8/28/1998	Complete		K-Bar CS State #3	CBM; STK	044N	074W	36	NW1/4NE1/4	-105.69301	43.74947	20	850	474	N	In Permit Boundary
P111631.0W	8/28/1998	Complete		K-Bar CS State #4	CBM; STK	044N	074W	36	SW1/4NE1/4	-105.69313	43.74583	25	855	566	N	In Permit Boundary
P111632.0W	8/28/1998	Complete		K-Bar CS State #5	CBM; STK	044N	074W	36	NW1/4SE1/4	-105.69325	43.74219	25	890	525	N	In Permit Boundary
P112353.0W	10/5/1998	Complete		Enl K-Bar CS State #2	CBM; STK	044N	074W	36	SE1/4NW1/4	-105.69811	43.74579	30	898	527	N	In Permit Boundary
P112354.0W	10/5/1998	Complete		Enl K-Bar CS State #3	CBM; STK	044N	074W	36	NW1/4NE1/4	-105.69301	43.74947	20	850	474	N	In Permit Boundary
P112355.0W	10/5/1998	Complete		Enl K-Bar CS State #4	CBM; STK	044N	074W	36	SW1/4NE1/4	-105.69313	43.74583	30	855	566	N	In Permit Boundary
P112356.0W	10/5/1998	Complete		Enl K-Bar CS State #5	CBM; STK	044N	074W	36	NW1/4SE1/4	-105.69325	43.74219	40	890	525	N	In Permit Boundary
P135591.0W	6/4/2001	Complete	Wyo State Board of Land Commissioners	K-BAR CS STATE #20	CBM; STK	044N	074W	36	NW1/4NW1/4	-105.70296	43.74935	200	1108	291	N	In Permit Boundary
P113646.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #13	CBM; STK	044N	074W	36	SW1/4NW1/4	-105.70309	43.74574	25	1085	464	N	In Permit Boundary
P113647.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #12	CBM; STK	044N	074W	36	SE1/4SW1/4	-105.69837	43.73854	50	1045	456	N	In Permit Boundary
P113648.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #11	CBM; STK	044N	074W	36	SW1/4NW1/4	-105.70309	43.74574	100	991	310	N	In Permit Boundary
P113649.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #10	CBM; STK	044N	074W	36	NW1/4NW1/4	-105.70296	43.74935	100	947	199	N	In Permit Boundary
P113650.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #9	CBM; STK	044N	074W	36	NE1/4SW1/4	-105.69824	43.74216	100	952	323	N	In Permit Boundary
P113651.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #8	CBM; STK	044N	074W	36	SW1/4SE1/4	-105.69337	43.73855	100	957	409	N	In Permit Boundary
P113652.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #6	CBM; STK	044N	074W	36	NW1/4SW1/4	-105.70322	43.74213	100	1037	369	N	In Permit Boundary
P113653.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #7	CBM; STK	044N	074W	36	NE1/4NW1/4	-105.69799	43.74941	100	863	264	N	In Permit Boundary
P138052.0W	8/16/2001	Complete	Yates Petroleum Corp.	K-BAR CS STATE # 22	CBM; STK	044N	074W	36	SW1/4NE1/4	-105.69313	43.74583	200	1093	280	N	In Permit Boundary
P138053.0W	8/16/2001	Complete	Yates Petroleum Corp.	K-BAR CS STATE # 23	CBM; STK	044N	074W	36	NE1/4SE1/4	-105.68827	43.74222	200	1130	1035	N	In Permit Boundary
P195107.0W	1/13/2011	Incomplete	YATES PETROLEUM CORP	K-BAR WATER WELL #13	MIS	044N	074W	36	SW1/4SW1/4	-105.70349	43.73926	100	0	0	N	In Permit Boundary
P195108.0W	1/13/2011	Incomplete	YATES PETROLEUM CORP	K-BAR WATER WELL #25	MIS	044N	074W	36	SW1/4SW1/4	-105.70351	43.73854	100	0	0	N	In Permit Boundary
P194827.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS INC	11-MW57-WY	MON	044N	074W	36	NE1/4SW1/4	-105.69667	43.74306	0	0	0	N	In Permit Boundary
P194824.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS INC.	11-MW56-OB	MON	044N	074W	36	NE1/4SW1/4	-105.69667	43.74306	0	0	0	N	In Permit Boundary
P193469.0W	8/11/2010	Incomplete	LINC ENERGY OPERATIONS, INC	MW-41	MON	044N	074W	36	SW1/4NE1/4	-105.6931	43.74583	50	0	0	N	In Permit Boundary
P193470.0W	8/11/2010	Incomplete	LINC ENERGY OPERATIONS, INC	MW-42	MON	044N	074W	36	SW1/4NE1/4	-105.69329	43.74546	50	0	0	N	In Permit Boundary
P193058.0W	5/30/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	CPMW02	MON	044N	074W	36	SW1/4SW1/4	-105.70271	43.73926	0	0	0	N	In Permit Boundary
P193059.0W	5/30/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	CPMW03	MON	044N	074W	36	SW1/4SW1/4	-105.7022	43.73968	0	0	0	N	In Permit Boundary
P193060.0W	5/30/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	CPMW04	MON	044N	074W	36	NW1/4SW1/4	-105.70124	43.74071	0	0	0	N	In Permit Boundary
P193061.0W	5/30/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	CPMW05	MON	044N	074W	36	SW1/4SW1/4	-105.70362	43.73756	0	0	0	N	In Permit Boundary
P193062.0W	5/30/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	CPMW06	MON	044N	074W	36	SW1/4SW1/4	-105.7024	43.73861	0	0	0	N	In Permit Boundary
P193063.0W	5/30/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	CPMW07	MON	044N	074W	36	SW1/4SW1/4	-105.70144	43.73915	0	0	0	N	In Permit Boundary

WR Number	Priority Date	Water Right Status	Applicant	Facility Name	Uses	Township	Range	Section	Qtr Qtr	Longitude	Latitude	Total Flow	Total depth (Ft)	Static Water Level (Ft)	Well Log	Buffer Proximity
P193064.0W	5/30/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	CPMW08	MON	044N	074W	36	SE1/4SW1/4	-105.70017	43.73949	0	0	0	N	In Permit Boundary
P193065.0W	5/30/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	CPMW09	MON	044N	074W	36	SW1/4SW1/4	-105.70194	43.73763	0	0	0	N	In Permit Boundary
P193066.0W	5/30/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	CPMW10	MON	044N	074W	36	SW1/4SW1/4	-105.70214	43.73806	0	0	0	N	In Permit Boundary
P193471.0W	8/11/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	MW-43	MON	044N	074W	36	SW1/4NE1/4	-105.69313	43.74584	50	0	0	N	In Permit Boundary
P193472.0W	8/11/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	MW-44	MON	044N	074W	36	NE1/4SW1/4	-105.69824	43.74226	50	0	0	N	In Permit Boundary
P193473.0W	8/11/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	MW-45	MON	044N	074W	36	NE1/4SW1/4	-105.69824	43.74218	50	0	0	N	In Permit Boundary
P193474.0W	8/11/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	MW-46	MON	044N	074W	36	NE1/4SW1/4	-105.69811	43.74231	50	0	0	N	In Permit Boundary
P194078.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	1-MW03-OB	MON	044N	074W	36	NE1/4NE1/4	-105.68777	43.74945	0	0	0	N	In Permit Boundary
P194079.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	1-MW05-UB	MON	044N	074W	36	NE1/4NE1/4	-105.68798	43.74931	0	0	0	N	In Permit Boundary
P194080.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	4-MW08-OB	MON	044N	074W	36	NW1/4NW1/4	-105.70265	43.74904	0	0	0	N	In Permit Boundary
P194081.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	4-MW09-WY	MON	044N	074W	36	NW1/4NW1/4	-105.70289	43.74931	0	0	0	N	In Permit Boundary
P194082.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	4-MW10-UB	MON	044N	074W	36	NW1/4NW1/4	-105.70288	43.74913	0	0	0	N	In Permit Boundary
P194083.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	7-MW13-OB	MON	044N	074W	36	SW1/4NE1/4	-105.69513	43.74475	0	0	0	N	In Permit Boundary
P194084.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	7-MW14-WY	MON	044N	074W	36	SW1/4NE1/4	-105.69513	43.74475	0	0	0	N	In Permit Boundary
P194085.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	7-MW15-UB	MON	044N	074W	36	SW1/4NE1/4	-105.69513	43.74475	0	0	0	N	In Permit Boundary
P194086.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	13-MW18-OB	MON	044N	074W	36	SW1/4SW1/4	-105.70313	43.73842	0	0	0	N	In Permit Boundary
P194087.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	16-MW23-OB	MON	044N	074W	36	SE1/4SE1/4	-105.68872	43.73814	0	0	0	N	In Permit Boundary
P194088.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	13-MW20-UB	MON	044N	074W	36	SW1/4SW1/4	-105.70294	43.73815	20	0	0	N	In Permit Boundary
P194090.0W	10/21/2010	Incomplete	LINC ENERGY OPERATIONS, INC.	16-MW25-UB	MON	044N	074W	36	SE1/4SE1/4	-105.68848	43.73841	20	0	0	N	In Permit Boundary
P194812.0W	1/8/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	16-MW62-OB	MON	044N	074W	36	SE1/4SE1/4	-105.69	43.73972	0	0	0	N	In Permit Boundary
P194813.0W	1/8/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	16-MW63-WY	MON	044N	074W	36	SE1/4SE1/4	-105.69	43.73972	0	0	0	N	In Permit Boundary
P194814.0W	1/8/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	16-MW64-UB	MON	044N	074W	36	SE1/4SE1/4	-105.69	43.73972	0	0	0	N	In Permit Boundary
P194815.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	1-MW26-OB	MON	044N	074W	36	SW1/4NE1/4	-105.69312	43.74532	0	0	0	N	In Permit Boundary
P194816.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	1-MW27-WY	MON	044N	074W	36	SW1/4NE1/4	-105.69314	43.74532	0	0	0	N	In Permit Boundary
P194817.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	1-MW28-UB	MON	044N	074W	36	SW1/4NE1/4	-105.69312	43.74537	0	0	0	N	In Permit Boundary
P194818.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	1-MW29-OB	MON	044N	074W	36	SW1/4NE1/4	-105.69319	43.74534	0	0	0	N	In Permit Boundary
P194819.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	1-MW30-WY	MON	044N	074W	36	SW1/4NE1/4	-105.69314	43.74534	0	0	0	N	In Permit Boundary
P194820.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	1-MW31-UB	MON	044N	074W	36	SW1/4NE1/4	-105.69319	43.74539	0	0	0	N	In Permit Boundary
P194821.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	2-MW32-OB	MON	044N	074W	36	NW1/4NE1/4	-105.69139	43.74889	0	0	0	N	In Permit Boundary
P194822.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	2-MW33-WY	MON	044N	074W	36	NW1/4NE1/4	-105.69139	43.74889	0	0	0	N	In Permit Boundary
P194823.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	2-MW34-UB	MON	044N	074W	36	NW1/4NE1/4	-105.69139	43.74889	0	0	0	N	In Permit Boundary
P194825.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	6-MW35-OB	MON	044N	074W	36	SE1/4NW1/4	-105.69667	43.74528	0	0	0	N	In Permit Boundary
P194826.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	6-MW36-WY	MON	044N	074W	36	SE1/4NW1/4	-105.69667	43.74528	0	0	0	N	In Permit Boundary
P194828.0W	1/5/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	6-MW37-UB	MON	044N	074W	36	SE1/4NW1/4	-105.69667	43.74528	0	0	0	N	In Permit Boundary
P194829.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	7-MW38-OB	MON	044N	074W	36	SW1/4NE1/4	-105.69139	43.74667	0	0	0	N	In Permit Boundary
P194830.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	7-MW39-WY	MON	044N	074W	36	SW1/4NE1/4	-105.69139	43.74667	0	0	0	N	In Permit Boundary
P194831.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	7-MW40-UB	MON	044N	074W	36	SW1/4NE1/4	-105.69139	43.74667	0	0	0	N	In Permit Boundary
P194832.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	7-MW41-OB	MON	044N	074W	36	SW1/4NE1/4	-105.69333	43.74528	0	0	0	N	In Permit Boundary
P194833.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	7-MW42-WY	MON	044N	074W	36	SW1/4NE1/4	-105.69333	43.74528	0	0	0	N	In Permit Boundary
P194834.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	7-MW43-UB	MON	044N	074W	36	SW1/4NE1/4	-105.69333	43.74528	0	0	0	N	In Permit Boundary
P194835.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	8-MW44-OB	MON	044N	074W	36	SE1/4NE1/4	-105.68806	43.74694	0	0	0	N	In Permit Boundary
P194836.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	8-MW45-WY	MON	044N	074W	36	SW1/4NE1/4	-105.69314	43.74534	0	0	0	N	In Permit Boundary
P194838.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	9-MW47-OB	MON	044N	074W	36	NE1/4SE1/4	-105.68833	43.74083	0	0	0	N	In Permit Boundary
P194839.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	9-MW48-WY	MON	044N	074W	36	NE1/4SE1/4	-105.68833	43.74083	0	0	0	N	In Permit Boundary
P194840.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	9-MW49-UB	MON	044N	074W	36	NE1/4SE1/4	-105.68833	43.74083	0	0	0	N	In Permit Boundary
P194841.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	10-MW50-OB	MON	044N	074W	36	NW1/4SE1/4	-105.69361	43.74306	0	0	0	N	In Permit Boundary
P194842.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	10-MW51-WY	MON	044N	074W	36	NW1/4SE1/4	-105.69361	43.74306	0	0	0	N	In Permit Boundary
P194843.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	10-MW52-UB	MON	044N	074W	36	NW1/4SE1/4	-105.69361	43.74306	0	0	0	N	In Permit Boundary
P194844.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	10-MW53-OB	MON	044N	074W	36	NW1/4SE1/4	-105.69139	43.74083	0	0	0	N	In Permit Boundary
P194845.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	10-MW54-WY	MON	044N	074W	36	NW1/4SE1/4	-105.69139	43.74083	0	0	0	N	In Permit Boundary
P194846.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	10-MW55-UB	MON	044N	074W	36	NW1/4SE1/4	-105.69139	43.74083	0	0	0	N	In Permit Boundary
P194847.0W	1/7/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	11-MW-58-UB	MON	044N	074W	36	NE1/4SW1/4	-105.69667	43.74306	0	0	0	N	In Permit Boundary
P194848.0W	1/8/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	15-MW59-OB	MON	044N	074W	36	SW1/4SE1/4	-105.69139	43.73861	0	0	0	N	In Permit Boundary
P194849.0W	1/8/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	15-MW60-WY	MON	044N	074W	36	SW1/4SE1/4	-105.69139	43.73861	0	0	0	N	In Permit Boundary
P194850.0W	1/8/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	15-MW61-UB	MON	044N	074W	36	SW1/4SE1/4	-105.69139	43.73861	0	0	0	N	In Permit Boundary
P194851.0W	1/8/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	16-MW65-OB	MON	044N	074W	36	SE1/4SE1/4	-105.68833	43.73861	0	0	0	N	In Permit Boundary

WR Number	Priority Date	Water Right Status	Applicant	Facility Name	Uses	Township	Range	Section	Qtr Qtr	Longitude	Latitude	Total Flow	Total depth (Ft)	Static Water Level (Ft)	Well Log	Buffer Proximity
P194852.0W	1/8/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	16-MW66-WY	MON	044N	074W	36	SE1/4SE1/4	-105.68833	43.73861	0	0	0	N	In Permit Boundary
P194853.0W	1/8/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	16-MW67-UB	MON	044N	074W	36	SW1/4SE1/4	-105.69338	43.73804	0	0	0	N	In Permit Boundary
P195289.0W	3/21/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	LINC 03-MW26-44-74-36	MON	044N	074W	36	NE1/4NW1/4	-105.70014	43.74759	0	0	0	N	In Permit Boundary
P195296.0W	3/28/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	LINC 364474-01-MW04-WY	MON	044N	074W	36	NE1/4NE1/4	-105.70511	43.73844	0	0	0	N	In Permit Boundary
P195297.0W	3/28/2011	Incomplete	LINC ENERGY OPERATIONS, INC.	LINC 364474-13-MW19-WY	MON	044N	074W	36	SW1/4SW1/4	-105.70329	43.73902	0	0	0	N	In Permit Boundary
P135592.0W	6/4/2001	Suspended	Wyo State Board of Land Commissioners	K-BAR CS STATE #21	CBM; STK	044N	074W	36	SW1/4NW1/4	-105.70309	43.74574	200	1133	320	N	In Permit Boundary
P138051.0W	8/16/2001	Suspended	Yates Petroleum Corp.	K-BAR CS STATE # 19	CBM; STK	044N	074W	36	NE1/4NE1/4	-105.68804	43.74953	200	1168	1073	N	In Permit Boundary
P138054.0W	8/16/2001	Suspended	Yates Petroleum Corp.	K-BAR CS STATE # 24	CBM; STK	044N	074W	36	NE1/4SW1/4	-105.69824	43.74216	200	1150	164	N	In Permit Boundary
P138061.0W	8/16/2001	Suspended	Yates Petroleum Corp.	K-BAR CS STATE # 25	CBM; STK	044N	074W	36	SW1/4SW1/4	-105.70336	43.73853	200	1221	437	N	In Permit Boundary
P171424.0W	10/27/2005		YATES PETROLEUM CORP.	FOURMILE CS FEDERAL #9	CBM	044N	074W	25	NE1/4SE1/4	-105.6875	43.75666	200	0	0	N	0.5 mi
P75448.0W	8/24/1987		Union Pacific Resources, Inc.	MI 2	MIS	044N	074W	35	NW1/4NE1/4	-105.71305	43.74927	0	330	76.44	N	0.5 mi
P75449.0W	8/24/1987		Union Pacific Resources, Inc.	MI 3	MIS	044N	074W	35	NW1/4NE1/4	-105.71305	43.74927	0	332	78.88	N	0.5 mi
P75450.0W	8/24/1987		Union Pacific Resources, Inc.	MI 4	MIS	044N	074W	35	NW1/4NE1/4	-105.71305	43.74927	0	225	76.34	N	0.5 mi
P75451.0W	8/24/1987		Union Pacific Resources, Inc.	MI 5	MIS	044N	074W	35	NW1/4NE1/4	-105.71305	43.74927	0	160	62.63	N	0.5 mi
P115594.0W	5/4/1999	Cancelled	FULLER, DOUGLAS P & SUZANNE M/PAT D	D FULLER FEDERAL 31W-12	CBM; STK	044N	073W	31	NW1/4SW1/4	-105.68311	43.74222	60	0	0	N	0.5 mi
P66353.0W	2/1/1984	Cancelled	Davis Oil Co.	#1 MARQUIS WATER WELL	MIS	044N	073W	30	NW1/4SW1/4	-105.6827	43.75686	100	0	0	N	0.5 mi
P75447.0W	8/24/1987	Cancelled	Union Pacific Resources, Inc.	MI 1	MON	044N	074W	35	NW1/4NE1/4	-105.71305	43.74927	0	330	76.75	N	0.5 mi
P78542.0W	11/10/1988	Cancelled	Union Pacific Resources, Inc.	MI 6U	MON	044N	074W	35	NW1/4NE1/4	-105.71305	43.74927	0	145	61.4	N	0.5 mi
P124391.0W	3/20/2000	Complete	Yates Petroleum Corp.	ENL LUDINGTON CS FEE #1	CBM	044N	074W	25	SW1/4SW1/4	-105.70284	43.75299	50	940	515	N	0.5 mi
P124392.0W	3/20/2000	Complete	Yates Petroleum Corp.	ENL LUDINGTON CS FEE #2	CBM	044N	074W	25	SE1/4SW1/4	-105.69786	43.75306	50	855	492	N	0.5 mi
P127939.0W	8/7/2000	Complete	Yates Petroleum Corp.	GROVES CS FEE #30	CBM	043N	073W	6	SW1/4NW1/4	-105.68317	43.73122	200	907	550	N	0.5 mi
P129527.0W	8/21/2000	Complete	Yates Petroleum Corp.	MOORE CS FEE #5	CBM	043N	074W	1	SW1/4NW1/4	-105.70299	43.73117	200	1042	597	N	0.5 mi
P129528.0W	8/21/2000	Complete	Yates Petroleum Corp.	MOORE CS FEE #7	CBM	043N	074W	1	SW1/4NE1/4	-105.69313	43.73119	200	1010	615	N	0.5 mi
P129531.0W	8/21/2000	Complete	Yates Petroleum Corp.	MOORE CS FEE #26	CBM	044N	074W	35	SW1/4NE1/4	-105.71316	43.74568	200	962	788	N	0.5 mi
P129532.0W	8/21/2000	Complete	Yates Petroleum Corp.	MOORE CS FEE #30	CBM	044N	074W	35	SW1/4SE1/4	-105.71338	43.73848	200	975	768	N	0.5 mi
P129538.0W	8/21/2000	Complete	Yates Petroleum Corp.	GROVES CS FEE #28	CBM	043N	073W	6	NE1/4NW1/4	-105.67797	43.7349	200	805	554	N	0.5 mi
P129540.0W	8/21/2000	Complete	Yates Petroleum Corp.	LUDINGTON CS FEE #5	CBM	044N	074W	25	NE1/4SW1/4	-105.69775	43.75673	200	852	452	N	0.5 mi
P129564.0W	8/21/2000	Complete	Yates Petroleum Corp.	MCCULLOUGH CS FEE #4	CBM	044N	074W	26	NE1/4SE1/4	-105.70776	43.75662	200	983	758	N	0.5 mi
P129567.0W	8/21/2000	Complete	Yates Petroleum Corp.	MCCULLOUGH CS FEE #9	CBM	044N	074W	26	SW1/4SE1/4	-105.71294	43.75291	200	960	815	N	0.5 mi
P117670.0W	8/11/1999	Complete	Yates Petroleum Corp.	Groves CS FEE #29	CBM; STK	043N	073W	6	NW1/4NW1/4	-105.68319	43.73489	100	882	480	N	0.5 mi
P117671.0W	8/11/1999	Complete	Yates Petroleum Corp.	LUDINGTON CS FEE #1	CBM; STK	044N	074W	25	SW1/4SW1/4	-105.70284	43.75299	100	940	515	N	0.5 mi
P117672.0W	8/11/1999	Complete	Yates Petroleum Corp.	LUDINGTON CS FEE #2	CBM; STK	044N	074W	25	SE1/4SW1/4	-105.69786	43.75306	100	855	492	N	0.5 mi
P117673.0W	8/11/1999	Complete	Yates Petroleum Corp.	McCULLOUGH CS FEE #1	CBM; STK	044N	074W	35	NE1/4NE1/4	-105.70798	43.7493	100	985	658	N	0.5 mi
P117674.0W	8/11/1999	Complete	Yates Petroleum Corp.	McCULLOUGH CS FEE #2	CBM; STK	044N	074W	26	SE1/4SE1/4	-105.70787	43.75294	100	990	449	N	0.5 mi
P117675.0W	8/11/1999	Complete	Yates Petroleum Corp.	Moore CS FEE #2	CBM; STK	043N	074W	1	NW1/4NE1/4	-105.69335	43.73489	100	992	654	N	0.5 mi

Note: Latitude/Longitude determined from SEO Database, datum is NAD83 according to SEO.

Table 13.14-2: Water Wells within 1/4 Mile of Aquifer Exemption Area

WR Number	Priority Date	Water Right Status	Applicant	Facility Name	Uses	Township	Range	Section	Qtr Qtr	Longitude	Latitude	Total Flow	Total depth (Ft)	Static Water Level (Ft)	Well Log	Buffer Proximity
P110629.0W	8/28/1998	Complete	Yates Petroleum Corp.	K-Bar CS State #2	CBM; STK	044N	074W	36	SE1/4NW1/4	-105.69811	43.74579	25	836	527	N	In Permit Boundary
P111630.0W	8/28/1998	Complete	Yates Petroleum Corp.	K-Bar CS State #3	CBM; STK	044N	074W	36	NW1/4NE1/4	-105.69301	43.74947	20	850	474	N	In Permit Boundary
P111631.0W	8/28/1998	Complete	Yates Petroleum Corp.	K-Bar CS State #4	CBM; STK	044N	074W	36	SW1/4NE1/4	-105.69313	43.74583	25	855	566	N	In Permit Boundary
P111632.0W	8/28/1998	Complete	Yates Petroleum Corp.	K-Bar CS State #5	CBM; STK	044N	074W	36	NW1/4SE1/4	-105.69325	43.74219	25	890	525	N	In Permit Boundary
P112353.0W	10/5/1998	Complete	Yates Petroleum Corp.	Enl K-Bar CS State #2	CBM; STK	044N	074W	36	SE1/4NW1/4	-105.69811	43.74579	30	898	527	N	In Permit Boundary
P112354.0W	10/5/1998	Complete	Yates Petroleum Corp.	Enl K-Bar CS State #3	CBM; STK	044N	074W	36	NW1/4NE1/4	-105.69301	43.74947	20	850	474	N	In Permit Boundary
P112355.0W	10/5/1998	Complete	Yates Petroleum Corp.	Enl K-Bar CS State #4	CBM; STK	044N	074W	36	SW1/4NE1/4	-105.69313	43.74583	30	855	566	N	In Permit Boundary
P112356.0W	10/5/1998	Complete	Yates Petroleum Corp.	Enl K-Bar CS State #5	CBM; STK	044N	074W	36	NW1/4SE1/4	-105.69325	43.74219	40	890	525	N	In Permit Boundary
P113646.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #13	CBM; STK	044N	074W	36	SW1/4NW1/4	-105.70309	43.74574	25	1085	464	N	In Permit Boundary
P113647.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #12	CBM; STK	044N	074W	36	SE1/4SW1/4	-105.69837	43.73854	50	1045	456	N	In Permit Boundary
P113648.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #11	CBM; STK	044N	074W	36	SW1/4NW1/4	-105.70309	43.74574	100	991	310	N	In Permit Boundary
P113649.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #10	CBM; STK	044N	074W	36	NW1/4NW1/4	-105.70296	43.74935	100	947	199	N	In Permit Boundary
P113650.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #9	CBM; STK	044N	074W	36	NE1/4SW1/4	-105.69824	43.74216	100	952	323	N	In Permit Boundary
P113652.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #6	CBM; STK	044N	074W	36	NW1/4SW1/4	-105.70322	43.74213	100	1037	369	N	In Permit Boundary
P113653.0W	1/21/1999	Complete	Yates Petroleum Corp.	K-BAR CS STATE #7	CBM; STK	044N	074W	36	NE1/4NW1/4	-105.69799	43.74941	100	863	264	N	In Permit Boundary
P117671.0W	8/11/1999	Complete	Yates Petroleum Corp.	LUDINGTON CS FEE #1	CBM; STK	044N	074W	25	SW1/4SW1/4	-105.70284	43.75299	100	940	515	N	0.25 mi
P117672.0W	8/11/1999	Complete	Yates Petroleum Corp.	LUDINGTON CS FEE #2	CBM; STK	044N	074W	25	SE1/4SW1/4	-105.69786	43.75306	100	855	492	N	0.25 mi
P117673.0W	8/11/1999	Complete	Yates Petroleum Corp.	McCULLOUGH CS FEE #1	CBM; STK	044N	074W	35	NE1/4NE1/4	-105.70798	43.7493	100	985	658	N	0.25 mi
P124378.0W	3/20/2000	Complete	Yates Petroleum Corp.	ENL K-BAR CS STATE #4	CBM	044N	074W	36	SW1/4NE1/4	-105.69313	43.74583	50	855	566	N	In Permit Boundary
P124391.0W	3/20/2000	Complete	Yates Petroleum Corp.	ENL LUDINGTON CS FEE #1	CBM	044N	074W	25	SW1/4SW1/4	-105.70284	43.75299	50	940	515	N	0.25 mi
P124392.0W	3/20/2000	Complete	Yates Petroleum Corp.	ENL LUDINGTON CS FEE #2	CBM	044N	074W	25	SE1/4SW1/4	-105.69786	43.75306	50	855	492	N	0.25 mi
P129540.0W	8/21/2000	Complete	Yates Petroleum Corp.	LUDINGTON CS FEE #5	CBM	044N	074W	25	NE1/4SW1/4	-105.69775	43.75673	200	852	452	N	0.25 mi
P135591.0W	6/4/2001	Complete	Wyo State Board of Land Commissioners	K-BAR CS STATE #20	CBM; STK	044N	074W	36	NW1/4NW1/4	-105.70296	43.74935	200	1108	291	N	In Permit Boundary
P135592.0W	6/4/2001	Suspended	Wyo State Board of Land Commissioners	K-BAR CS STATE #21	CBM; STK	044N	074W	36	SW1/4NW1/4	-105.70309	43.74574	200	1133	320	N	In Permit Boundary
P138052.0W	8/16/2001	Complete	Yates Petroleum Corp.	K-BAR CS STATE # 22	CBM; STK	044N	074W	36	SW1/4NE1/4	-105.69313	43.74583	200	1093	280	N	In Permit Boundary
P138054.0W	8/16/2001	Suspended	Yates Petroleum Corp.	K-BAR CS STATE # 24	CBM; STK	044N	074W	36	NE1/4SW1/4	-105.69824	43.74216	200	1150	164	N	In Permit Boundary

Table 13.14-3: Representative Background Groundwater Quality

Parameter	Units	Wyodak Groundwater (13MW19-WD)	Overburden Groundwater (04OW31-WDOB)	Underburden Groundwater (04MW10-WDUB)
Aluminum	mg/L	<0.20	3.7	<0.10
Ammonia	mg/L	0.39	0.72	0.43
Arsenic	mg/L	<0.0010	0.0012	0.0083
Barium	mg/L	<0.10	0.51	0.27
Beryllium	mg/L	<0.010	<0.010	<0.010
Boron	mg/L	<0.10	<0.10	<0.10
Cadmium	mg/L	<0.010	<0.010	<0.010
Chloride	mg/L	15.7	7.3	8.9
Chromium	mg/L	<0.050	<0.050	<0.050
Cobalt	mg/L	<0.010	<0.010	0.012
Copper	mg/L	<0.010	<0.010	0.046
Cyanide	mg/L	<0.010	<0.010	<0.010
Fluoride	mg/L	0.44	0.58	0.70
Hydrogen Sulfide	mg/L	<0.10	<0.10	<0.10
Iron	mg/L	0.23	8.7	16.8
Lead	mg/L	<0.050	<0.050	<0.050
Lithium	mg/L	<0.10	<0.10	<0.10
Manganese	mg/L	0.086	0.29	0.19
Mercury	mg/L	<0.0010	<0.00020	<0.00020
Nickel	mg/L	<0.050	<0.050	<0.050
Nitrate	mg/L	<0.20	<0.20	<0.20
Nitrite	mg/L	<0.10	<0.10	<0.10
(NO3+NO2)-N	mg/L	<0.20	<0.20	<0.20
Oil & Grease	mg/L	<5.2	<5.2	<5.2
Phenol	ug/L	<10.0	<0.050	<0.050
Selenium	mg/L	<0.0010	<0.0010	0.0017
Silver	mg/L	<0.010	<0.010	<0.010
Sulfate	mg/L	34.8	<1.0	6.7
Total Dissolved Solids	mg/L	568	730	284
Vanadium	mg/L	<0.20	<0.10	<0.10
Zinc	mg/L	<0.020	0.041	0.14
pH	Std. Units	8.3	7.8	8.4
SAR		13.2	10.7	9.8
RSC	meq/L	6.2	8.0	3.1
Radium-226	pCi/L	0.0493 ± 0.168 (0.363)	3.29 ± 1.17 (0.678)	1.15 ± 0.786 (0.953)
Radium-228	pCi/L	0.429 ± 0.352 (0.692)	3.07 ± 1.05 (1.43)	0.876 ± 0.590 (1.07)
Combined Total Radium 226 and 228(8)	pCi/L	0.4783	6.36	2.026
Total Strontium 90	pCi/L	2.14 ± 0.805 (1.18)	-0.155 ± 0.353 (0.926)	0.356 ± 0.378 (0.791)
Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium8	pCi/L	-0.119 ± 1.11 (1.78)	40.3 ± 8.67 (3.90)	12.1 ± 3.44 (1.69)

Table 13.14-4: Baseline Analytical Results Compared to Use Suitability Water Quality Standards (Water Quality Rules and Regulations, Chapter 8, Table 1)

Strata	Well ID	Parameters in Exceedence of:				
		U.S. EPA Primary MCL	U.S. EPA Secondary MCL	WDEQ Class I	WDEQ Class II	WDEQ Class III
OB	364474-01MW03-WDOB	--	Fe, Mn	Fe, Mn	RSC, SAR	--
	364474-07MW13-WDOB	Ra-226+Ra-228	Fe, Mn, TDS	Fe, Ra-226+Ra-228, TDS	Ra-226+Ra-228, RSC, SAR,	Ra-226+Ra-228
	364474-13MW18-WDOB	Ra-226+Ra-228	Al, Fe, Mn, TDS	Fe, Mn, Ra-226+Ra-228, TDS	Fe, Ra-226+Ra-228, RSC, SAR	Ra-226+Ra-228
	364474-16MW23-WDOB	--	Fe, Mn	Fe	RSC, SAR	--
	364474-04-OW31-WDOB	α, Ra-226+Ra-228	Al, Fe, Mn, TDS	α, Ra-226+Ra-228, NH_3, Fe, Mn, TDS	α, Ra-226+Ra-228, Al, Fe, Mn, SAR, RSC	α, Ra-226+Ra-228, Al
WY	364474-04OW30-WD	$C_{24}H_{38}O_4$	Fe, Mn, TDS	Fe, Mn, TDS	SAR	--
	364474-04OW33-WD	--	Fe, Mn, TDS	Fe, Mn, TDS	Fe, SAR	--
	364474-13MW19-WD	--	Fe, Mn, TDS	Fe, Mn, TDS	RSC, SAR	--
UB	364474-01MW05-WDUB	--	Fe, pH	Fe	RSC, SAR	--
	364474-04MW10-WDUB	--	Al, Fe, Mn	Fe, Mn	Al[1], Fe, RSC, SAR	Al[1]
	364474-07MW15-WDUB	--	Al, Fe, Mn	Fe	RSC, SAR	--
	364474-13MW20-WDUB	α[2]	Al, Fe, Mn	α[2], Fe	α[2], RSC, SAR	α[2]
	364474-16MW25-WDUB	--	Al, Fe, Mn	Fe	RSC, SAR	--

α	Gross Alpha, Adjusted
Al	Aluminum
$C_{24}H_{38}O_4$	bis(2-ethylhexyl)Phthalate
Fe	Iron
Mn	Manganese
RSC	Residual Sodium Carbonate
Ra-226+Ra-228	Radium-226 + Radium-228
SAR	Sodium Adsorption Ratio
SO_4^{2-}	Sulfate
TDS	Total Dissolved Solids

Table 13.14-5: Summary of Hydraulic Parameters Wyodak Aquifer

Aquifer	Test No.	Well ID	Pumping (P) or Observation (O) Well	Distance from Pumping Well to Observation Well (FT)	Transmissivity (ft^2/d)				Storativity				Leakage Analysis - Neuman-Witherspoon	
					Theis	Cooper-Jacob	Hantush	Papadopolus-Cooper	Theis	Cooper-Jacob	Hantush	Papadopolus-Cooper	r/B	β
Wyodak	1	364474-04MW09-WD	P		0.59				N/A					
		364474-04OW27-WD	O	176.72	3.19		16.1		3.31E-04		1.00E-04			
		364474-04OW33-WD	O	185.29	1.87		12		2.15E-04		1.03E-04			
		364474-04OW34-WD	O	244.92	23.9		52.8		1.75E-03		4.24E-05			
		364474-04OW35-WD	O	630.62	2.4		16.4		2.27E-04		9.44E-05			
Wyodak	2	364474-04TR44-WD	P		0.34			0.24	N/A			N/A		
		364474-04OW35-WD	O	625.44	1.82			1.82	3.70E-05			3.60E-05	0.0537	0.00676
		364474-04OW27-WD	O	686.02	1.1			1.6	4.10E-05			4.10E-05	0.09333	0.00316
		364474-04OW30-WD	O	875.13	0.57			0.54	4.60E-05			3.90E-05	8.7E-05	0.0004
		364474-03MW36-WD	O	630.62	2			1.95	2.00E-04			1.90E-04	0.00537	0.0871
		364474-03TR53-WD	O	751.79	1.26			1.37	4.80E-05			4.70E-05	0.06607	0.00955

Appendix A: Calculation of Aquifer Exemption Boundary Distance Beyond the Excursion Wells

Aquifer Exemption Boundary Calculations

Aquifer Exemption Boundary calculations were prepared by Petrotek Engineering Corporation as described in the technical memorandum included herein. The calculations included three components to determine the distance of the boundary beyond the excursion wells;

- the distance a potential excursion could extend between adjacent excursion wells (assuming radial flow) prior to detection at an excursion well,
- the distance an excursion can travel from time of initial detection until recovery operations are initiated, and
- dispersivity that may result from movement of an excursion beyond calculated distances due to heterogeneity.

The distance a potential excursion could extend between adjacent excursion wells (assuming radial flow) prior to detection at an excursion well is based on the leading edge of a concentric plume moving between two adjacent wells and extending beyond the imaginary line connecting the two wells prior to reaching either well. This distance was calculated by Petrotek at 71 ft based on a distance from the source of 600 ft and a distance between excursion wells of 600 ft. Since the distance between excursion-well pairs ranges from 204 ft downgradient of the gasifier cavities to 912 ft upgradient of the gasifier cavities and the distance from the excursion wells to the cavities ranges from 531 to 688 ft; values of ΔT were calculated for each excursion well pair (Table 13.14-A1). These values were added to the distances for response time and dispersivity calculated by Petrotek to determine the distance the exemption boundary extends beyond the excursion wells at the midpoint between well pairs. ΔT is assumed to decrease logarithmically from the maximum at the midpoint between excursion well pairs to zero at each excursion well.

Table 13.14-A1: Calculated values of ΔT for excursion well pairs

Well Pair (see Figure 13.14-1)	Distance Between Excursion Wells (ft)	Distance of Midpoint Between Excursion Wells to Cavities (ft)	ΔT** (ft)
B1	816	531	139
B4	391	688	27
B5	681	563	95
B6	913	531	169
B7	560	563	66
B8	460	563	45
B9	788	531	130
B10	519	688	47

* Well pairs B2 and B3 are exterior of pair B10 and were not used

** See Petrotek Technical Memorandum for definition of ΔT

Appendix B: EPA Guidance

A. Submittal Requirements

1. A map showing the boundaries of the area to be exempted.

See Figure 14.13-1.

2. The name of the formation or aquifer to be exempted.

The aquifer to be exempted is the Wyodak coal aquifer.

3. Subsurface depth or evaluation of the formation to be exempted.

The Wyodak coal is approximately 1,100 feet below land surface.

4. Vertical confinement from other Underground Sources of Drinking Water (USDWs).

The Wyodak is overlain and underlain by shale confining units. The head in the Wyodak is approximately 80 feet lower than the overlying Overburden aquifer and 340 feet lower than the underlying Underburden aquifer, reflecting the effectiveness of the bounding confining units.

5. The thickness of the formation or aquifer to be exempted.

The Wyodak is approximately 30 feet thick within the proposed exemption area.

6. A water-quality analysis of the formation or aquifer to be exempted.

Groundwater quality analyses for samples from the Wyodak coal aquifer are described in Sections 13.8.2.6 Baseline Groundwater Quality and Section 16.1.3 Statistical Analysis and UCL Calculations of the license application (Attachment A).

B. "It does not currently serve as a source of drinking water"

The Wyodak within the permit area and within at least three miles of the permit area does not serve as a source of drinking water based on a well and groundwater rights survey. Table 13.14-1 lists the groundwater rights and associated wells identified within three miles of the permit area. None are used for drinking water. Figure 13.8-22 of the license application (Attachment A) shows all wells within three miles of the proposed exempted aquifer.

No residences or commercial buildings (except for Linc's field trailer which does not have a water source) are located on site or within a ¼ mile radius of the site. No drinking water wells are located within the Project Area or within ¼ mile (Figure 13.14-3).

C. "It cannot now and will not in the future serve as a source of drinking water because it is mineral, hydrocarbon, or geothermal energy producing, or it can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible."

The Wyodak aquifer proposed for exemption is a 30-ft thick coal with properties suitable for UCG. The site met with the commercial site selection guidelines:

- Coal thickness greater than 15 ft with no partings,
- Depth in excess of 1,000 ft to reduce the chances of surface impacts,
- Impervious over and underburden (coal horizon being a confined aquifer),
- Suitable hydrostatic pressures,
- No geological faulting intersecting the proposed gasifier, and
- Coal quality.

D. It cannot now and will not in the future serve as a source of drinking water because it is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical:

The Wyodak coal aquifer is not now and will not likely in the future serve as a source of public drinking water supply due to its depth, location and low yield (about 1 gpm) which makes recovery of water for drinking water purposes economically impractical.

a. Availability and quality of alternative water supply sources.

There is availability of multiple alternate groundwater supply sources in the area that provide higher quality water from aquifers that are more productive and less expensive to develop. According to Harza (1982), "Groundwater in the Powder River Basin is available from several geologic formations: Wasatch sandstone, alluvial sands and gravels, Tensleep sandstone, and Madison Limestone".

Three separate aquifers were identified within the Wasatch Formation for a three dimensional groundwater flow model of the PRB (Applied Hydrology Associates, Inc. and Greystone Environmental Consultants, Inc., 2002). The Wasatch Formation at the site is much shallower than the Wyodak coal, essentially present from land surface to a depth of about 500 ft. According to Harza (1982), "The broad expanse of Wasatch sandstone is tapped by many low-yield livestock wells and rural domestic wells". Well yields from the Wasatch in the southern part of the Powder River Basin reported to be as high as 500 gpm (Uranerz Energy, 2007). Within the Project Area, Yates Petroleum converted a Wyodak CBM well to Wasatch-aquifers wells to use as industrial water supply oil drilling because of the low yield of the Wyodak.

Most of the large groundwater public supplies users, such as Gillette, produce groundwater from the lower Ft. Union, below the Wyodak and/or the even deeper Madison limestone. A smaller public supply system in the area likely would utilize the shallower Wasatch formation. If producing from the Ft. Union within the permit area, the target would be the Underburden aquifer, below the Wyodak, which yields greater than 30 GPM with lower dynamic head.

b. Adequacy of alternative supplies to meet present and future needs.

There currently are no present or future anticipated needs for public water supply in the area. Water supplies for stock watering or for an industrial supply in support of oil and gas drilling would be developed from the Wasatch Formation aquifers, just as is currently done.

i. Distance from the proposed exempted aquifer to public water supplies.

The closest public water supply is in Wright, Wyoming, approximately eight miles east of the site.

ii. Analysis of future water supply needs within the general area.

There currently are no present or future anticipated needs for public water supply in the area. The only potential water supply needs in the vicinity are for stock water, CBM extraction, and oil and gas development.

c. Current sources of water supply for potential users of the proposed exempted aquifer.

The only use of the proposed exempted aquifer in the area is for Coal Bed Methane production. All Wyodak CBM wells within the permit area are shut-in due to poor gas production. Other potential users of groundwater supply in the area utilize the Wasatch Formation aquifers as a source.

d. Depth of proposed exempted aquifer.

The Wyodak aquifer is located approximately 1,100 ft deep in the area and yields slightly more than 1 gpm, the EPA threshold for potential public water supply. The potentiometric surface is approximately 800 ft below land surface. Wyodak wells exhibit very low specific capacities, less than 0.005 gpm/ft of drawdown, and quickly develop a high total dynamic head in response to pumping. The potentiometric surface when pumping at 1 gpm is rapidly drops to more than 1,000 ft below land surface. This pumping level requires a submersible pump with a rated capacity sufficient to maintain production against this head. Use of a commercially-available submersible pump suitable for this application would require a well at least 7-in diameter to a depth of about 1,100 ft.

e. Cost associated with the development and treatment of the aquifer to be exempted.

The cost for a Wyodak water-supply well yielding 1 GPM with treatment is estimated at $155,000.

i. Quality of the water in the proposed exempted aquifer.

The quality of groundwater within the Wyodak coal would likely be classified as Class III Stock Water based on groundwater chemistry and WDEQ water quality standards. Table 13.14-A1 provides a summary of the baseline groundwater quality analytical results. Table 13.14-A2 summarizes the groundwater classification based on water quality.

ii. Well construction costs.

The cost for a Wyodak water-supply well yielding 1 GPM, not including treatment, is estimated at $150,000

iii. Transportation costs.

No transportation costs would be anticipated for a small local water supply system.

iv. Treatment costs.

The cost for a Wyodak groundwater treatment for a public water supply is estimated at $5,000.

E. It cannot now and will not in the future serve source of drinking water because it is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption.

The Wyodak coal aquifer is not contaminated such that it would be economically or technologically impractical to render that water fit for human consumption.

F. It cannot now and will not in the future serve as a source of drinking water because it is located over a Class III mining area subject to subsidence or catastrophic collapse.

The Wyodak coal aquifer is not located over a Class III mining area subject to subsidence or catastrophic collapse.

G. The Total Dissolved Solids content of the ground water is more than 3,000 and less than 10,000 mg/L and it is not reasonably expected to supply a public water system.

The TDS of groundwater in the Wyodak is less than 3,000 mg/L.

TABLES

Table 13.14-B1: Background Groundwater Quality (all results mg/L)

Aquifer	Location	Date Sampled	Anions (meq/l)	Bicarbonate as HCO3	Calcium	Carbonate as CO3	Cation-Anion Balance (unitless) % difference meq/l	Cations (meq/l)	Magnesium	Potassium	Sodium	Solids, Total Dissolved Calculated	Solids, Total Dissolved TDS @ 180 C	Sulfate	TDS @ 180 vs. TDS Calc
Wyodak Overburden	364474-01MW03-WDOB	9/22/2011	6.4	289	10	13	4.5	7	ND	2.3	138	352	373	1.6	1.1
		10/4/2011	6.7	305	10.8	9.5	2.2	7.1	2	2.3	153	367	374	7.7	1
		10/21/2011	6.6	284	10.5	29.4	0.73	6.5	2.1	2.1	147	345	388	ND	1.1
		11/1/2011	6.4	296	10.2	8.9	4.8	7	1	2.1	141	354	389	ND	1.1
	364474-07MW13-WDOB	9/20/2011	11.7	570	29.4	ND	1.2	12	19.4	5.4	225	608	666	2	1.1
		10/4/2011	11.9	581	33.4	ND	0.57	12.1	20.4	5.5	236	625	644	ND	1
		10/17/2011	11.7	571	34.2	ND	3	12.5	21.1	5.6	252	628	664	ND	1.1
		11/2/2011	11.7	568	28.3	ND	4.6	12.8	19.9	5.3	233	635	653	ND	1
	364474-13MW18-WDOB	9/19/2011	11.3	548	34.8	ND	1.2	11	13.2	4.8	415	584	631	ND	1.1
		10/6/2011	11.3	549	30.2	ND	1.6	11.6	13.9	5.2	256	599	635	ND	1.1
		10/19/2011	11.2	545	24.1	ND	1.4	11.5	13.4	5.2	242	594	639	ND	1.1
		11/1/2011	11.3	548	25.8	ND	4.2	12.2	13.5	4.8	228	612	652	ND	1.1
	364474-16MW23-WDOB	9/20/2011	6.3	294	13	ND	14.3	8.4	5.3	2.7	130	379	354	1.7	0.93
		10/6/2011	6.2	293	13.5	ND	1.8	6.4	5.3	2.8	132	330	344	ND	1
		10/18/2011	6.1	290	13.7	ND	1.2	6.2	5.4	2.6	134	324	360	ND	1.1
		11/3/2011	6.1	285	12.6	ND	3.7	6.5	5.4	2.6	135	331	381	ND	1.2
Wyodak	364474-04OW30-WD	03/21/2012 14:00	9.2	NA	24.5	NA	1.8	9.6	4.4	4	178	504	542	10.5	1.1
		03/21/2012 14:30	9.2	NA	24.2	NA	3.4	9.8	4.4	3.9	185	508	506	12.4	1
		03/21/2012 14:50	9.3	NA	23.9	NA	2.3	9.7	4.4	4	180	507	543	15	1.1
		03/21/2012 15:10	9.1	NA	23.3	NA	2.8	9.6	4.5	3.8	182	503	518	16.5	1
	364474-04OW33-WD	03/21/2012 14:15	9.4	NA	24.3	NA	0.09	9.4	4.1	3.8	181	515	534	6.8	1
		03/21/2012 14:25	9.3	NA	23.6	NA	1.7	9.6	4.2	3.8	185	507	540	6.5	1.1
		03/21/2012 14:35	9.3	NA	23.6	NA	1.6	9.6	4.2	3.9	186	511	558	7.3	1.1
		03/21/2012 14:45	9.3	NA	23.5	NA	0.25	9.3	4.1	3.8	179	501	544	8.5	1.1
	364474-13MW19-WD	03/21/2012 12:20	9.7	NA	24.4	NA	1.1	9.9	3	3.7	192	531	573	9.9	1.1
		03/21/2012 12:30	9.4	NA	24.5	NA	2.7	10	3	3.7	194	525	551	9.8	1
		03/21/2012 12:40	9.6	NA	23.8	NA	0.89	9.8	2.8	3.7	192	525	579	9.9	1.1
		03/21/2012 12:50	9.6	NA	24.2	NA	2.5	10.1	3.1	3.8	197	532	556	9.9	1
		9/20/2011	10	401	21.4	26.9	1.5	9.7	2.5	4.8	203	539	599	44.9	1.1
		10/6/2011	10	405	21.4	24	3	10.7	ND	5	219	562	585	44.8	1
		10/20/2011	9.8	392	21.7	28.3	5.2	10.8	2.4	5.2	204	557	577	40.5	1
		11/2/2011	10	428	21.9	10.7	7.8	11.7	2.5	4.6	210	579	568	34.8	0.98
Wyodak Underburden	364474-01MW05-WDUB	9/21/2011	5.1	87.6	7.8	11.6	5.5	4.6	ND	1.6	112	312	337	139	1.1
		10/3/2011	5.3	88.6	8.4	13.7	13.8	7	ND	1.6	111	377	349	146	0.93
		10/20/2011	5.3	89.8	8.5	10.1	0.56	5.3	ND	1.7	112	337	342	146	1
		10/31/2011	5.1	89.8	8	8.3	2.4	5.3	ND	1.6	103	328	334	138	1
	364474-04MW10-WDUB	9/22/2011	4.2	174	19.6	16	1.2	4.1	5.3	4.6	91.6	225	284	6.7	1.3
		10/3/2011	4.3	190	8	8.1	0.71	4.2	1.7	2.2	95.3	226	253	1.9	1.1
		10/21/2011	4.2	180	6.5	10.3	0.78	4.1	ND	1.5	93.4	221	239	4.6	1.1
		10/31/2011	4.2	187	5.6	6.2	2.2	4.4	ND	1.6	97.5	227	240	2.7	1.1
	364474-07MW15-WDUB	9/20/2011	4.6	206	7.8	10	1.3	4.7	ND	1.8	105	247	245	2	0.99
		10/4/2011	4.8	215	7.9	9.8	11.1	6	ND	1.8	110	284	290	4	1
		10/17/2011	4.6	219	8.7	ND	1	4.7	ND	1.7	109	247	272	ND	1.1
		11/2/2011	4.6	212	7.6	5.3	3.6	4.9	ND	1.7	101	251	285	ND	1.1
	364474-13MW20-WDUB	9/19/2011	3.8	147	4	17.6	2.7	4	ND	1.8	105	208	258	7.1	1.2
		10/5/2011	3.9	149	3.5	17.7	2.1	4	ND	1.9	94.4	212	255	8.5	1.2
		10/19/2011	3.9	151	3.8	20.5	0.77	3.9	1.1	2.2	94.4	208	238	6.8	1.1
		11/1/2011	3.8	131	3.8	38.6	2.3	4	1.1	1.9	92	210	238	6.2	1.1
	364474-16MW25-WDUB	9/20/2011	4.7	146	8.8	10	0.06	4.7	ND	1.8	107	273	319	64.6	1.2
		10/6/2011	5.2	94.9	9.5	11.8	3.1	5.5	ND	1.8	116	332	344	134	1
		10/18/2011	5.6	90.9	11.9	14.6	5.2	5.1	ND	1.9	120	346	342	158	0.99
		11/3/2011	5.3	74	9.4	29.1	0.32	5.4	ND	ND	110	336	308	143	0.92

Table 13.14-B2 Baseline Analytical Results Compared to Use Suitability Standards (Water Quality Rules and Regulation, Chapter 8, Table 1)

Strata	Well ID	Parameters in Exceedance of:				
		U.S. EPA Primary MCL	U.S. EPA Secondary MCL	WDEQ Class I	WDEQ Class II	WDEQ Class III
OB	364474-01MW03-WDOB	--	Fe, Mn	Fe, Mn	RSC, SAR	--
	364474-07MW13-WDOB	Ra-226+Ra-228	Fe, Mn, TDS	Fe, Ra-226+Ra-228, TDS	Ra-226+Ra-228, RSC, SAR,	Ra-226+Ra-228
	364474-13MW18-WDOB	Ra-226+Ra-228	Al, Fe, Mn, TDS	Fe, Mn, Ra-226+Ra-228, TDS	Fe, Ra-226+Ra-228, RSC, SAR	Ra-226+Ra-228
	364474-16MW23-WDOB	--	Fe, Mn	Fe	RSC, SAR	--
	364474-04-OW31-WDOB	α, Ra-226+Ra-228	Al, Fe, Mn, TDS	α, Ra-226+Ra-228, NH_3, Fe, Mn, TDS	α, Ra-226+Ra-228, Al, Fe, Mn, SAR, RSC	α, Ra-226+Ra-228, Al
WY	364474-04OW30-WD	$C_{24}H_{38}O_4$	Fe, Mn, TDS	Fe, Mn, TDS	SAR	--
	364474-04OW33-WD	--	Fe, Mn, TDS	Fe, Mn, TDS	Fe, SAR	--
	364474-13MW19-WD	--	Fe, Mn, TDS	Fe, Mn, TDS	RSC, SAR	--
UB	364474-01MW05-WDUB	--	Fe, pH	Fe	RSC, SAR	--
	364474-04MW10-WDUB	--	Al, Fe, Mn	Fe, Mn	Al[1], Fe, RSC, SAR	Al[1]
	364474-07MW15-WDUB	--	Al, Fe, Mn	Fe	RSC, SAR	--
	364474-13MW20-WDUB	α^2	Al, Fe, Mn	α^2, Fe	α^2, RSC, SAR	α^2
	364474-16MW25-WDUB	--	Al, Fe, Mn	Fe	RSC, SAR	--

α	Gross Alpha, Adjusted
Al	Aluminum
$C_{24}H_{38}O_4$	bis(2-ethylhexyl)Phthalate
Fe	Iron
Mn	Manganese
RSC	Residual Sodium Carbonate
Ra-226+Ra-228	Radium-226 + Radium-228
SAR	Sodium Adsorption Ratio
SO_4^{2-}	Sulfate
TDS	Total Dissolved Solids

Appendix C: DEQ/WQD EPA Memorandum of Agreement

I. Introduction

A. Appendix A of the Memorandum of Agreement between the State of Wyoming DEQ/WQD and the EPA lists the following information requirements:

1. Application Appendix D-5

A copy of this Statement of Basis for the Aquifer Exemption is included as Section 13.14, Appendix D-12 of the license application.

2. Mine Operations Plan

A copy of the Mine Operations Plan is included in the license application provided on DVD as Attachment A.

3. Public Notice Documentation

As soon as available, affidavits of notice to the public and copies of comments related to the groundwater classification will be provided.

Appendix D: Aquifer Exemption Boundary Shapefiles (CD)

Appendix E: Groundwater quality baseline data from the Overburden, Wyodak, and Underburden aquifers for the parameters listed in Table 1 of Wyoming Water Quality Rules & Regulations, Chapter 8

CONTENTS

Attachment A: DVD of License Application