Rough Draw Unit

Form 2920-1 Land Use Permit

Plan of Development

Addendum

November 30, 2011

Submitted by

Patriot Energy Resources LLC

Rough Draw Unit
Form 2920 Land Use Permit
Plan of Development
Patriot Energy Resources LLC

1.0 Project Description

1.1. Introduction

Patriot Energy Resources LLC (Patriot), a subsidiary of Luca Technologies Inc., (Luca) is applying to the Bureau of Land Management (BLM) for a land use permit to allow the implementation of Luca's patented process to enhance biogenic gas production within the Project Area and determine the effect of the process on these publicly owned coal seams. The technology to be employed invigorates native gas-producing microbes through the circulation of coal bed methane (CBM) water enhanced with benign nutrients within the source coal seams (See **Table 3-1**). The proposed term of this permit is three years with an option to renew.

The proposed action is located within Patriot's Rough Draw Unit Project Area (Project Area). The surface of the Project Area is leased and developed for CBM production and is occupied by related infrastructure. Minimal additional facilities will be needed as most infrastructure is in place. The coal seams which Patriot seeks permission to use through this application are not currently leased for coal development nor used for any other purpose.

Patriot will produce gas and water during the normal course of the project's CBM production of the Anderson, Canyon, Lower Canyon, and Wall coal seams. The water will be conserved and used within the field. Water conservation is key to the production plan and enhanced gas recovery, as water provides a medium for nutrient delivery to the coal seams. In some cases the produced CBM water may be enhanced with nutrients prior to injection into a production coal seam to stimulate existing biogenic gas production in the coal zone. All wells in the Project Area may be treated with this enhancement process. See **Exhibit 1, Project Well List** for a list of those wells.

The injection action itself is regulated by the Wyoming Department of Environmental Quality (DEQ) as a Class 5F2 individual area underground injection control (UIC) permit. Patriot is subject to extensive testing and monitoring of the water quality under the standard permit conditions. The Wyoming DEQ UIC permit

application is currently under review by the agency. See **Exhibit 2 Rough Draw Unit DEQ UIC Class 5F2 Permit Application**

Concurrent with the application to the DEQ, a request for the formation of an enhanced gas recovery unit in the Project Area will be filed with the Wyoming Oil and Gas Conservation Commission (WOGCC). The unitization is related to the area, utilizing nutrient injections. Patriot plans to begin injection work when all applicable permits are in place. The tentative start date for this activity is January 2012.

1.2 Purpose and Need

The purpose of the proposed project is to determine the effects of Luca's patented biogenic gas generation process on the coal resource in a mature CBM field drawing production from multiple publicly owned coals.

The need for BLM action is to respond to an application seeking permission to implement a new technology which stimulates sustained gas production, and; grant access to publicly owned coal to determine whether the process results in any substantial effects on the mineral and consequently the mineral's value as an energy resource.

1.3 General Project Description and Basis of Unit Formation

The Project Area is located in Campbell County, north of Gillette, Wyoming (**Map 1**). **Table 1 Project Legal Description** provides details on the location of the proposed project activity.

The historic CBM production targets in the Project Area have been the Smith, Anderson, Canyon, Lower Canyon, and Wall coal seams for wells on forty- and eighty-acre spacing. This 15-year old production field comprises producing and shut-in wells with supporting infrastructure as well as undeveloped well spots. Produced water has been managed through surface discharge and impoundment.

Map 2 (see larger version attached with Exhibits) illustrates the existing CBM infrastructure in the Rough Draw Unit area. The proposed Rough Draw Unit comprises 17818.53acres in leasehold and 283 Wyodak wells, all held and operated by Patriot. The proposed unit activity will focus on the Anderson, Canyon and Wall coal seams.

This project will require Patriot to combine its leases together into a "unit" under the WOGCC rules and regulations. This Unit allows implementation of Luca's nutrient enhancement technology and insures that all the owners of the various interests

equitably share in production. In order for this Project to move forward, 80% of the royalty owners and working interest owners must agree to the unit. In addition, any party objecting to the unit has the opportunity to appear before the WOGCC and have those objections heard in that forum. In order for Patriot to receive approval from the WOGCC and put a unit in place, it must demonstrate that "the value of the estimated additional recovery of oil or gas will exceed the estimated additional costs incident to conducting unit operations." Wyo. Stat. Ann. § 30-5-110.

Consequently, any requirements that would make the Project uneconomic not only prevent the project from being a profitable endeavor, but actually prevent the Project from receiving regulatory approval. In addition, the unit area must be large enough to insure that the gas produced from the unit is captured within the unit boundary. This block of coal, land and wells is appropriately sized for the emplacement of the Luca enhanced-gas recovery process and for efficient capture of the new methane to be produced.

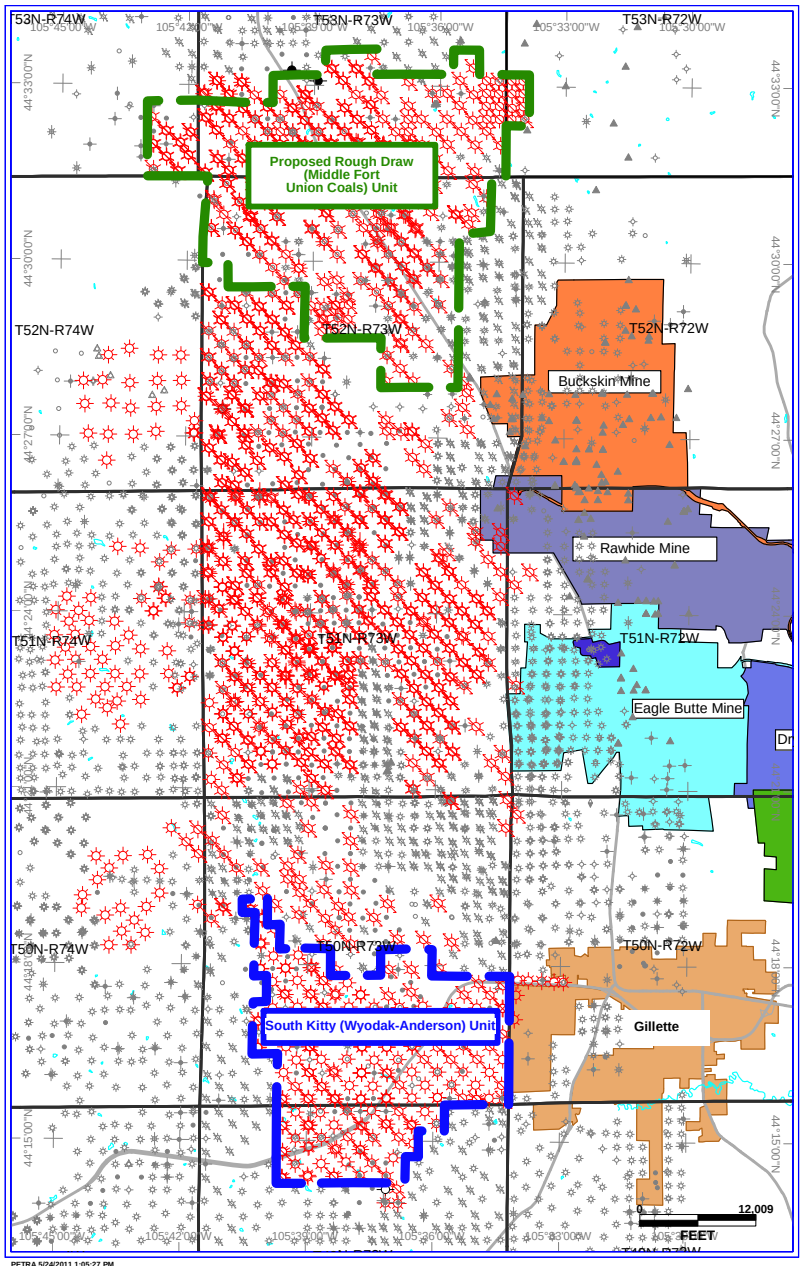
The proposed project is designed to create new methane at commercial rates utilizing Luca's proprietary technology. This project will incorporate lessons learned by Patriot and Luca since 2006, when the technology was first deployed on a pilot basis into PRB coals:

- On a per-well basis, rates of production of new methane are significant, however operating profit margins will be thin, compared to those of new wells producing at stronger rates. Control of operating costs will be critical to ongoing profitability. An essential aspect of cost control will be operating on a large scale. Even conventional PRB CBM projects, earning higher profit margins, are typically several hundreds of wells in size, or more.
- Luca has observed that new gas sometimes travels significant distances within the coal seams. Economics will suffer if a project creates new microbial enhanced-recovery gas, but the gas migrates outside the project, to be harvested by a third party. A successful commercial project must provide some wells for the capture of this gas.
- A successful enhanced-gas recovery project must both *create* new gas, and *harvest* it. The geology of the Rough Draw area may be characterized as having an up dip area to the east, close to outcrop, to which new gas will tend to migrate, and a down dip area to the west, with greater water resources, more suited for the generation of gas. While a significant portion of the new enhanced-recovery gas will be recovered within the down dip area, in general the movement of new gas is expected to have a west-to-east (down dip to up dip) vector. Both the down dip (generation) and the up

dip (harvest) areas will be crucial to project economic success. The project must be large enough to incorporate both areas.

During the proposed new phase of the well-field development, Patriot will continue to produce gas and water as for a normal course of CBM production. The new aspects of the well-field design include nutrient enhancement of and injection to conserve water levels in the target coals. Sections 2 and 3 of this POD provide more information regarding the planned implementation and operations.

Map 1: Project Area Location Map



Mine boundaries indicate leasehold.

Map 2: Rough Draw Area Existing Infrastructure – also see Map 2 in Exhibits.

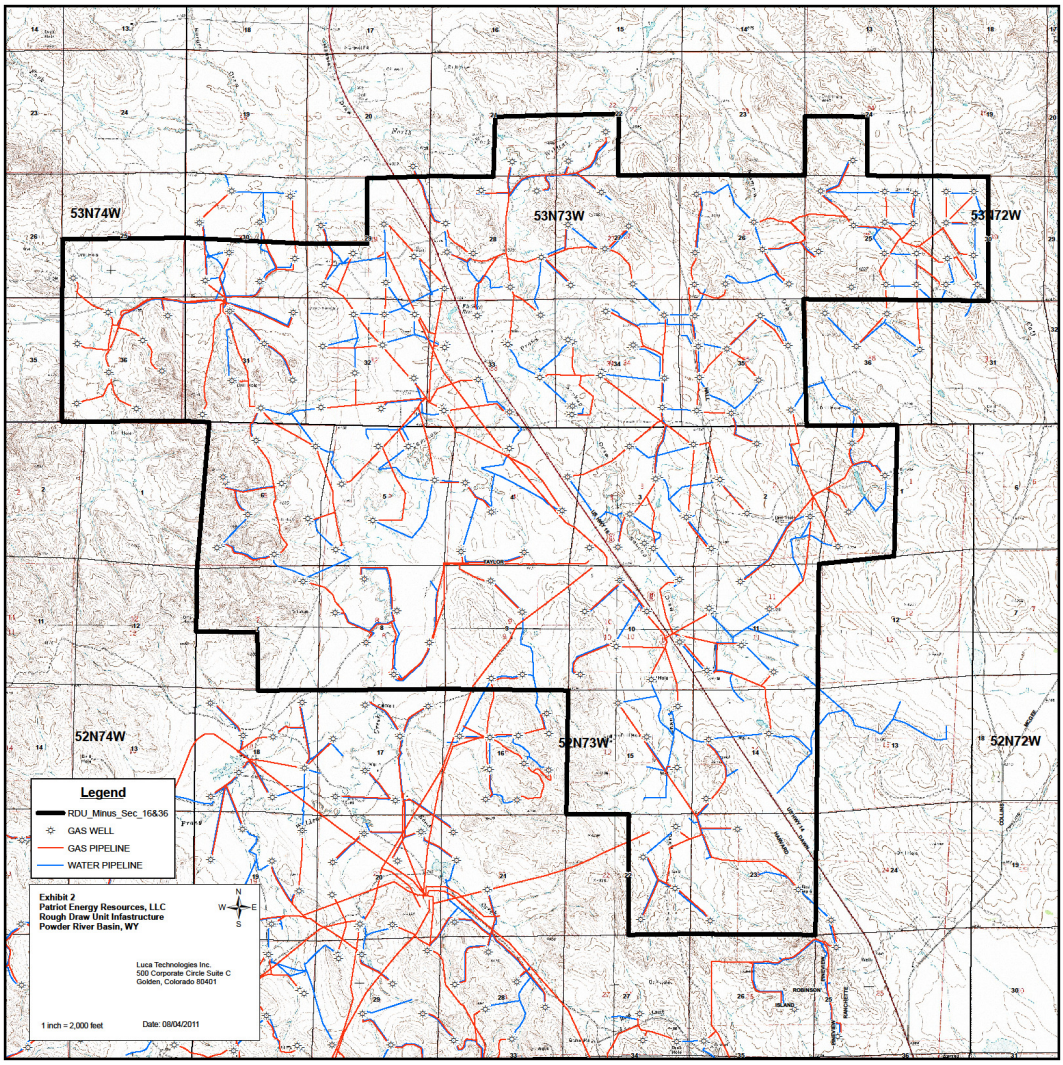


Table 1: Project Legal Description

All legal descriptions are from the 6th Principal Meridian and are in Campbell County, Wyoming.

<u>T52N / R73W</u>

- Section 1: W/2
- Section 2: all
- Section 3: all
- Section 4: all
- Section 5: all
- Section 6: all
- Section 7: NW/4, E/2
- Section 8: all
- Section 9: all

- Section 10: all
- Section 11: all
- Section 14: all
- Section 15: all
- Section 22: E/2
- Section 23: all

T53N/R72W

- Section 30: W/2

T53N / R73W

- Section 21: SE/4
- Section 22: SW/4
- Section 24: SW/4
- Section 25: all
- Section 26: all
- Section 27: all
- Section 28: all
- Section 29: E/2, SW/4
- Section 30: S/2
- Section 31: all
- Section 32: all
- Section 33: all
- Section 34: all
- Section 35: all

T53N / R74W

- Section 25: S/2
- Section 36: all

The surface is entirely owned by the State of Wyoming or private landowners.

State of Wyoming	1,135.95 acres	6.38%
Private Surface	16,682.58 acres	93.62%
Federal Surface	None	00.00 %

Oil and gas ownership within the Project Area is:

State of Wyoming	1,135.95 acres	6.38 %
Fee Oil and Gas	12,706.80 acres	71.31%
Federal Oil and Gas	3,975.90 acres	22.31 %

Coal Ownership within the Project Area is:

State of Wyoming	640	acres	3.59 %
Fee Coal	80	acres	00.45 %
Federal Coal	17,098.53	acres	95.96 %

The coal lease held by Buckskin Mine includes Section 25 of T53N R73W. Although that lease boundary is within 0.5 mile o f the proposed Rough Draw Unit boundary, the mine face and activity is approximately five miles from the Project Area. A description of plans to avoid impacts to coal mining activity is found in Section 5 of this document.

1.4 Alternatives Considered

No Action

The No Action alternative would be to not permit the proposed action. This would lead to the immediate cessation of coal bed methane production in the Project Area. Plugging of wells, removal of production related equipment and reclamation of disturbed areas would be required under the permits that originally approved the development. The following arguments illustrate why the No Action is not a viable Alternative.

Patriot currently has many oil and gas leases within the Project Area that involve privately held oil and gas rights on privately owned surface. These gas owners that have leased to Patriot are asking that Patriot move forward with implementation of this technology on these leases. The private property owners claim that Patriot has the right to implement this technology under their privately held oil and gas leases. Part of the private gas owner's argument is that they read *Amoco Prod. Co. v. S. Ute Indian Tribe*, 525 U.S. 1118 (1999) as establishing that this technology can be implemented as part of the gas estate; that as owners of the gas, they have the right to develop their gas; and that as the leaseholder, Patriot has a legal obligation to move forward with development.

This reasoning, in part, is based on the following quotation from *Amoco*, part 879 (emphasis added):

> It may be true, nonetheless, that the right to mine the coal implies the right to release gas incident to coal mining where it is necessary and reasonable to do so. The right to dissipate the CBM gas where reasonable and necessary to mine the coal does not, however, imply the ownership of the gas in the first instance. **Rather, it simply reflects the established common-law right of the owner of one**

> **mineral estate to use, and even damage, a neighboring estate as necessary and reasonable to the extraction of his own minerals.** See, e. g., Williams v. Gibson, 84 Ala. 228, 4 So. 350 (1888); Rocky Mountain Mineral Law Foundation, 6 American Law of Mining § 200.04 (2d ed. 1997). Given that split estates were already common at the time the 1909 and 1910 Acts were passed, see, e. g., Chartiers Block Coal Co. v. Mellon, 152 Pa. 286, 25 A. 597 (1893), and that the common law has proved adequate to the task of resolving the resulting conflicts between estates, there is no reason to think that the prospect of a split estate would have deterred Congress from reserving only the coal.

Patriot is faced with potential liability from these mineral owners for failure to develop the leases if Patriot does not move forward with all diligence. At the same time, Patriot has many leases that are nearing the end of their term. Patriot cannot maintain these leases if it is not allowed to move forward with this technology in the near future.

In addition, all of the parties are aware that without additional technology like Luca's, CBM development in the Project Area will cease. Every day additional wells are being plugged and abandoned throughout the Powder River Basin. A No Action alternative would mean wells in the Project Area would follow this same path. Once those wells are plugged and abandoned and the infrastructure is dismantled, opportunity for further development of this resource will be lost. This enhancement process will stimulate sustained gas production in a mature CBM field that is no longer capable of commercial production. Abandonment of the field will cause the loss of revenues, economic activity, and taxes available to the mineral owners and beneficiaries of this homegrown resource. Fee mineral owners in the Project Area understand that this technology has to be implemented quickly or they will lose the opportunity as wells are plugged and abandoned.

As stated earlier, the purpose of this permit is to put in place this enhancement process that will stimulate sustained gas production in a mature CBM field that is no longer capable of commercial production and allow assessment of the process on each of the target coal seams. A No Action alternative does not meet the purpose of this project and would additionally lead to abandonment of the field resulting in the loss of revenues, economic activity, and taxes available to the mineral owners and beneficiaries of this homegrown resource.

1.5 Other Federal, State and Local Agency Permit Requirements

The Wyoming Department of Environmental Quality (DEQ) will require a UIC Class 5F2 Individual Area Permit to inject produced waters with added nutrients. The EPA has been heavily involved with the DEQ in the Project's permitting process. The DEQ Permit conditions will require extensive monitoring of the water quality. The application for this Permit has been submitted and is in the review and approval process. The regulatory timeline for the general process suggests that the Permit could be noticed for public comment by mid-October and finally approved by late November. Patriot will supplement this Plan of Development with a final DEQ permit at that time.

Patriot will soon submit an application to the WOGCC for the formation of an enhanced gas recovery unit in the Project Area. This unitization is being driven by the proposed gas formation enhancement in the Project Area. The application is in progress, and will be submitted to the WOGCC in October. Assuming WOGCC meets their schedule for decision, the unit should be approved at the December 13, 2011 WOGCC hearing.

In addition to the WOGCC approval of the unit, the BLM Wyoming State Office Reservoir Management Group (RMG) will also have to put the unit formation through their review and approval process, as it will be a federal unit. RMG has been involved in the permit application process and is working with the WOCGG in the formation and approval of the unit. RMG approval is contingent on WOGCC approval.

The BLM Buffalo Field Office is requiring a new water management plan to replace the existing plan currently approved for operation of the federal wells. This plan must be approved prior to the proposed change in water management. The preparation of this submittal is in process.

Any required monitoring wells will be subject to permitting by the various agencies and subject to their respective regulations.

2.0 Proposed Action

2.1 Study Program - Coal Quality and Methanogenesis

Trillions of cubic feet of gas have been produced from the methanogenesis process and the coal remaining in the basin still has a high BTU value. In fact, an interesting observation is that the coal seams that have produced the most CBM are the coal seams with the highest BTU values. This would indicate the natural process does not destroy the coal. See **Table 2-1 Calorific value of coals**.

Table 2-1 Calorific value of coals

Calorific value of coals in Gillette Coal Field, Btu/lb (USGS OFR 2008-1202)					
		Thickness-weighted average calorific values			
	Individual seams	all coals in Area	CBM coals	non-CBM coals	CBM minus non-CBM
North Mining Area	8,110	8,200	8,268	7,978	290
Middle Mining Area	8,250	8,388	8,500	8,317	183
South Mining Area	8,442	8,718	8,875	8,597	278

Again, Patriot and Luca are simply restoring and enhancing this natural process. Patriot and Luca, through the research they have performed to date, have found the microbial enhancement has minimal, if any, effects on the coal quantity and quality (**Exhibit 6 Comments and Calculations**). Field testing will confirm or deny the findings of this research. This project proposes to implement the nutrient enhancement process on a field wide basis. Monitoring and site study information will reveal whether and to what extent coal quality and quantity are affected by the process. To gather the needed information, the following study program will be implemented.

Plan of Technical Investigation and Analysis:
Assessment of Coal Degradation Resulting from Methanogenesis

Objective: to determine the extent (if any) to which the operation of Luca's process for creation of microbial enhanced-recovery gas reduces the calorific value of target PRB coals.

Initial Positions

- Luca: no apparent degradation takes place, certainly not on a scale to threaten the values of PRB coals which could be mined. See **Exhibit 4 Analysis of Impacts of Methane Farming**.
- BLM: the valuation of the coal resource, and protection of a billion dollar per year coal mining industry in the PRB, should be done to provide quantitative data to provide indications of any changes to the calorific value of the coals.

Baseline Conditions and Assumptions

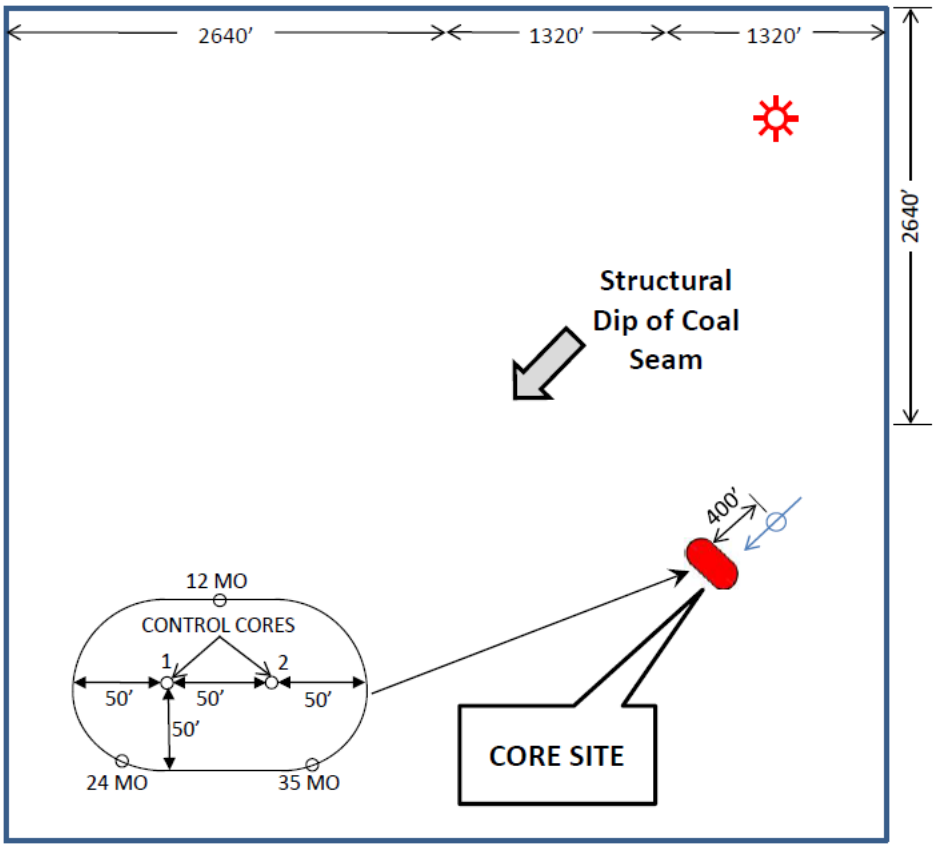
- Coals of interest to Luca and to the mining industry are broadly present around the rim of the PRB.
- Luca can deploy its process into existing infrastructure where CBM has been produced and has agreed to plug and abandon infrastructure if a conflict with an active coal mine occurs.
- Calorific value of coal samples recovered from a given coal seam show significant variability, both areally between different corehole locations, and foot to foot at a given location (USGS OFR 2007-1116).
- To make a valid assessment of coal degradation due to deployment of the Luca process, what is needed is a detailed review using high data concentration at a single location, where the effects of areal variability can be closely measured and considered. A number of less-intensive measurements over numerous sites will serve only to document areal variability of calorific value, which is not questioned by Luca or by BLM.
- Measurement of calorific value per pound of coal is repeatable only to 50 to 100 Btu/lb accuracy (ASTM D5865), which is greater than the pro forma degradation predicted by Luca's material balance calculations (**Exhibit 6 Comments and Calculations**).
- In the lab, measurements of degradation changes to a given mass of coal sample are not possible, due to the coal's susceptibility to alteration by oxidation and desiccation as samples are processed for measurement.
- In the field, a sampling location must be selected that is close enough to an injection site to insure sustained contact by process fluids, but distant enough to represent typical in situ conditions.
- From USGS OFR 2008-1202, thickness-weighted average calorific values for primary CBM-productive coal seams in the "North Mining Area", where application is located, are 8,268 Btu/lb (**Table 2-1 Calorific value of coals**). If coal-quality issues are assumed to arise at levels of calorific value of 7,500 Btu/lb, then average coal degradation (i.e. loss of calorific value) of 9.3% must occur before the resource quality is threatened by deployment of the Luca process. By similar analysis, for average coal quality to reach a 7,500 Btu/lb floor, average coal degradation for the "Middle Mining Area" and "South Mining Area" would be 11.8% and 15.5%, respectively, since these areas host higher-Btu coals.
- For this study, a conservative "degradation exceedance standard" is set at 4% loss of original calorific value.
- This study will focus on coal degradation in the field. Although much of the coal, prospective for deployment of the Luca process, is now technically and/or economically unrecoverable for current surface mining methods, activities herein will not be sited under consideration of coal valuation parameters.

Methodologies to be Used

- The Anderson, Canyon, and Wall coal seams have been responsible for the vast majority of the gas production in the Project Area to date and will be the area of focus for deployment of the technology. Patriot and the BLM will jointly select a test site in each of those three seams near a dedicated injection well, as generically shown by **Figure 2-1 Proposed Study Site Schematic.** The locations for the 3 test sites will be

dispersed throughout the Project Area upon consultation with the BLM. The overall plan described herein is based on thorough, repeated sampling of the target coal at one site per coal seam, in order that statistical analysis can properly overcome background data variability. The technical components of this monitoring program are included in **Exhibit 7 Rough Draw BLM Core Collection & Analyses Project.** This monitoring plan will entail the drilling of 25 core holes over the 3 year period of the permit and the taking and analysis of a minimum of 750 coal samples. Once again, the focus of this study is analysis of the impact of the Luca process on calorific value of coal. Areal variability in calorific value is not in dispute, and in fact will serve to create background noise for the analysis.

Figure 2-1 Proposed Study Site Schematic



- Assess degradation by taking a time course of coal samples from expendable core holes from a Patriot Project Area where the technology is being deployed into target coal seams. At each time stage, collect numerous samples, so that the statistical challenges of measuring small parametric changes are minimized through use of a large data set. Collect samples at the following times:
    - baseline, before the start of process deployment
    - one year after the start of process deployment
    - two years after the start of process deployment
    - three years after the start of process deployment

- possible project extension further into the future, via the taking of additional samples at yearly intervals greater than three years

- Control the anticipated areal variability of calorific value in two ways:
  - by taking this time course of samples within a small area, designed to be only large enough to avoid mechanical influence of results by drilling fluid contamination between core holes; and
  - by utilizing two baseline core hole locations, in order to recognize areal variability of calorific value, if present within the small test area
- Assess true change in calorific value using statistics:
  - for baseline and subsequent core holes, recover one sample per foot of recovered core, and a minimum of 30 samples per core hole
  - calculate average calorific value per hole, at each time interval, using calorific value measurements from samples recovered
- Relevance:
  - use sample recovery and handling techniques (ASTM D5192) Once recovered to surface, cores will be handled following the standard coal industry practices outlined in ASTM D5192 and lab measurement methods (ASTM 5865) consistent with those utilized by the coal industry.
- Consistency:
  - utilize a single third-party laboratory to make all calorific value measurements

<u>Data to be collected</u>

- Sampling location:
  - Select a site of approximately one acre in size, approximately 400' in a down dip direction from a well receiving continuous injection of restoration fluids, as the site for all coring to be performed during this study
  - baseline and subsequent core holes will be laid out in a pattern as shown in **Figure 2-1 Proposed Study Site Schematic**
- Cores recovered:
  - for each core hole drilled on a sampling pad, core will be taken through the full thickness of the target coal seam. All mechanical care (weight on bit; rotary speed; drilling fluid circulation rate) to maximize core recovery will be employed
  - once recovered to surface, cores will be handled consistent with ASTM D5192, as utilized by the coal mining industry in assessing coal quality
  - if more than 30' of core is recovered, a sample will be recovered and processed for each foot of core. If less than 30' of core is recovered, then samples will be taken at consistent shorter intervals, so that a minimum of 30 samples are recovered and processed.
- Laboratory measurements:
  - for each processed coal sample, a measurement of calorific value will be made under ASTM D5865 at Wyoming Analytical, Laramie, WY

<u>Analyses to be performed</u>

- Baseline core holes:
  - average calorific value will be determined for each core hole, by calculating the average of the values for all samples for each hole

- Baseline Calorific Value and Degradation Exceedance Standard for each sampling pad:

-if the variability of the average calorific value is within 4%, then Baseline Calorific Value is the average, and Degradation Exceedance Standard is 4%. Example calculation:

- hole #1 average calorific value = 8,750 Btu/lb; #2 = 8,500
- then, variance = (8,750-8,500)/((8,750+8,500)/2)

= 250/8,625
=2.9%

- thus, Baseline Calorific Value = 8,625 Btu/lb, and Degradation Exceedance Standard = 4%

-if the variability of the average calorific value is greater than 4% (probably due to areal variability in coal quality between the two baseline core hole locations), then Baseline Calorific Value is once again the average, but now Degradation Exceedance Standard is the calculated variance. Example calculation:

- hole #1 average calorific value = 8,750 as before; #2 = 8,100
- variance = (8750-8,100)/((8,750+8,100)/2)

=650/8,425
=7.7%

- as a result, in this case Baseline Calorific Value = 8,425 Btu/lb, and Degradation Exceedance Standard = 7.7%

- Each successive core hole, annually after the start of process fluid injection:
  - calculate average calorific value from lab measurements
  - compare to Baseline Calorific Value, and Degradation Exceedance Standard

<u>Patriot reporting to BLM</u>

- for each sampling pad, after baseline core holes are drilled, and all lab measurements are complete, Patriot will calculate Baseline Calorific Value and Baseline Exceedance Standard, and will write a report to BLM, reporting these results and appending all lab measurements of calorific value from the baseline core hole samples
- annually, after each new core hole is drilled and samples are analyzed, Patriot will write a report summarizing these results, appending the lab measurements, and reporting on the comparison of the average calorific value of the new core to the Baseline Calorific Value and the Baseline Exceedance Standard

2.2 Existing Infrastructure

No new construction will be necessary to implement this Plan of Development. All existing CBM production infrastructure will be utilized to produce and gather the methane. This same infrastructure will be used to introduce the nutrient mixture into the subject coal zones. Many existing water discharge points and the attendant reservoir structures will be, and are currently being, removed and the areas reclaimed. Most of the remaining reservoirs will be reclaimed or retained by landowners for their ranching operations.

2.3 Water Injection Facilities

Implementation will require that Nutrient Delivery Skids be set on well locations or that the nutrient delivery components normally housed in a skid be set in existing Central Delivery Point (CDP) buildings (see **Figure 2-2 Nutrient Delivery Skid**). Skids set on well locations will be within 30 feet of the wellhead to share electrical access and to minimize freeze-up of nutrient enhanced water as it flows from the nutrient delivery system to the wellbore. These skid set areas are all within the existing surface disturbance at each well location. No additional surface occupancy will be necessary.

The existing water pipeline system (infrastructure) will be used to transport produced water from CBM wells to the Nutrient Delivery sites. Nutrient amended water will flow through an outlet hose from the nutrient delivery tank to the available valve on the wellhead (**see #2 in Figure 2-2 Nutrient Delivery Skid**) or will be contained in the header systems in the CDP buildings and flow out existing infrastructure to the well bores The inlet hose to the skid (**#1, Figure 2-2 Nutrient Delivery Skid**) is also connected to the water discharge system on location, downstream of the check valve, and the outlet hose.

No supplemental pump pressure is needed to emplace the amended water into the well bore. The injectate will not exceed 15 psi at the wellhead.

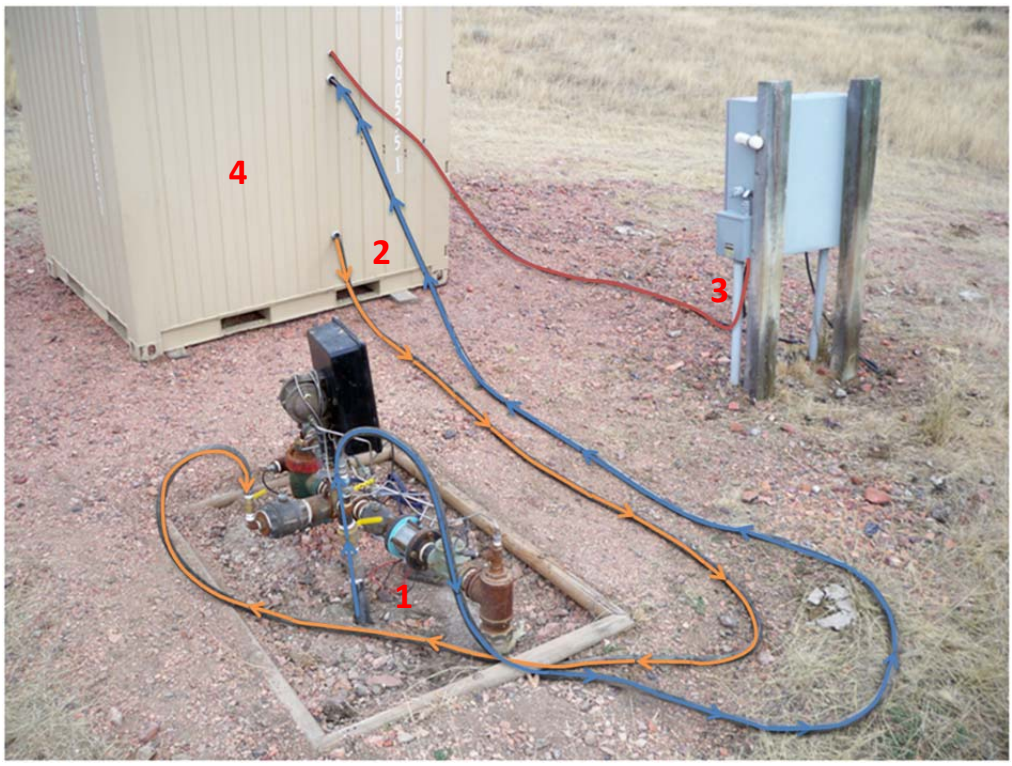


Figure 2-2 – Nutrient Delivery Skid connected to a wellhead.

#1 Inlet line connected to water discharge system, supplies source water to the skid.

#2 Outlet line from skid connected to wellhead casing delivers amended injectate to the formation via the casing.

#3 Skid connected to 480v power on location which is transformed to 120v power for the amendment pump.

#4 The Nutrient Delivery Skid

2.4 Study Site Coring

The purpose of the project is to study the effect of enhanced biogenic gas production on the coal calorific quality. In order to fulfill the purpose, cores will be taken from each target coal seam to determine baseline (current) conditions and follow up coring to obtain samples in order to assess whether changes in this parametric occur over time and to what extent.

Coring is accomplished with a shallow depth water/CBM drilling rig. Drilling and coring activities require the excavation of a mud pit and leveling of set up pads. Coring sites are yet to be determined, however it is expected they will be located within 300 feet of existing wells. Coring activities require one to two days, followed by reclamation activities within two weeks of coring completion. Follow-up coring will require the same procedure at the same location of the original core hole.

3.0 Operations and Maintenance

3.1 Operation of the Project

Initiation of this project is not expected to change the daily activities or workforce that is involved in the operation of a CBM gas field. The implementation of Luca's technology involves injection of produced CBM waters and nutrient amendments. See **Table 3-1 Nutrients used** for a brief explanation of the nutrient amendments.

Water is a precious resource that is vital to Luca's process for sustained gas production. Water conservation through continuous withdrawal, re-injection, and circulation is a key component of Patriot's gas reservoir management strategy. Consequently, unnecessary surface discharge of water is an undesirable water management strategy in this field development. Every well operated by Patriot in the Project Area will become a dual-purpose well, at times producing and at times injecting, consistent with WOGCC and BLM requirements for unitized operations.

Waters produced from the Anderson, Canyon, Lower Canyon, and Wall coal seams will be re-injected using gravity pressures without added surface injection pressure. Based on the coal zone biologic character, the injectate will sometimes include nutrients and at other times will simply be produced water.

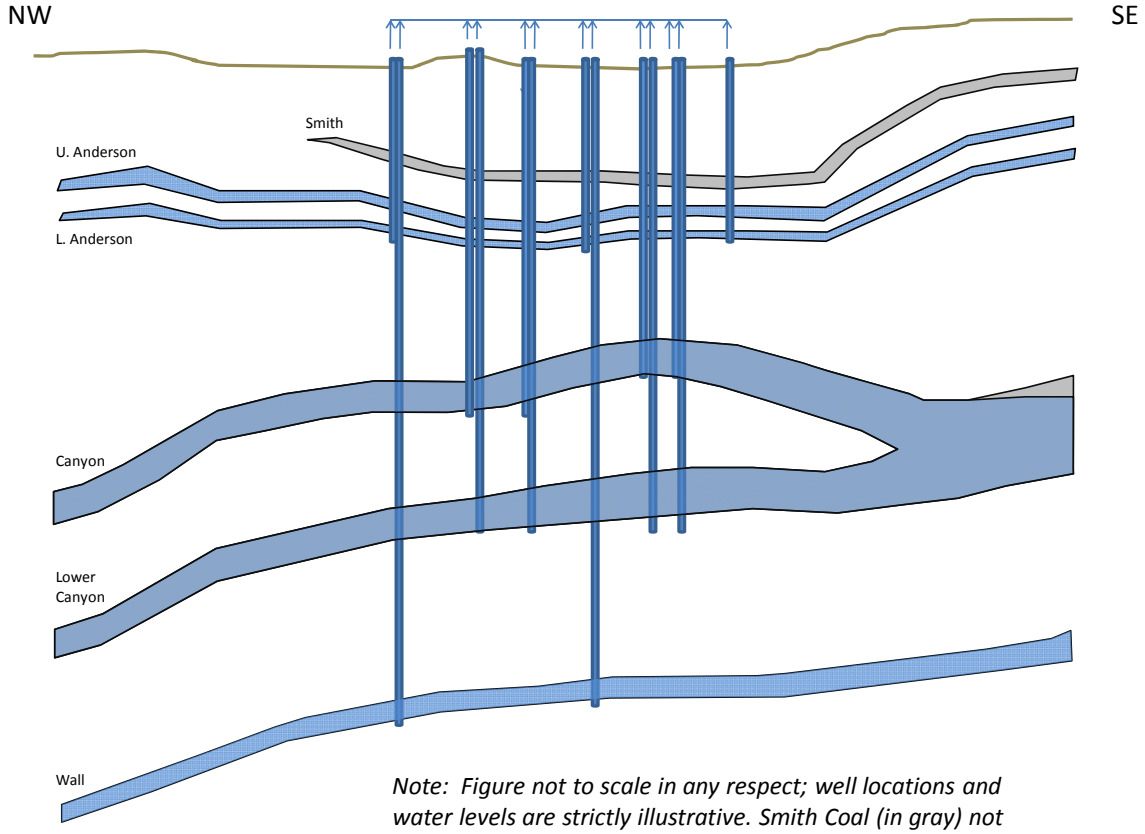
The four coal seams involved in the project have all produced methane gas via traditional CBM production operations (**Figure 3-1 Cross-section diagram**), and are currently in an advanced state of gas depletion. In the Project Area, the wells have generally been shut in since November, 2010, and in most wells, water levels are above the top of coal. The Canyon and Lower Canyon are more highly developed for CBM production, with relatively uniform well coverage over the area. The Anderson and Wall are less-developed, with wells placed more sporadically.

The maximum sustainable total water production rate for the Project Area is expected to be 1575 gallons per minute, or approximately 54,000 barrels/day (bpd) or 2540 acre-feet (ac-ft) per year. Over the three year operational period requested by this permit, it is the intent to use produced water beneficially by re-injecting it with or without nutrients back into the various receiver coals. The cumulative estimated injection volume for the five year DEQ permit application is 12,700 ac-ft. The difference in the 3-year BLM 2920 permit versus the 5 year DEQ Class 5F2 permit is due to the regulatory constraints within the agencies.

Table 3-1: Nutrients used

Nutrient	Common usage analogy
Vitamins and minerals	
Calcium (added as calcium chloride)	Milk
Magnesium (added as magnesium chloride)	Vegetables, cereal
Phosphate (added as magnesium phosphate, phosphoric acid, calcium phosphate, sodium phosphate, potassium phosphate, or sodium tripolyphosphate)	Milk, cheese, meats
Potassium (added as potassium chloride)	Milk, fruits, vegetables
Vitamin B-12, niacin, thiamin, riboflavin, biotin, pantothenic acid, folate	Many foods, human vitamin supplements
Multi-nutrients	
Casein hydrolyzates	Special dietary foods as a protein source
Yeast extract, brewer's yeast, soy protein, peptones	Food flavorings
Cell vitality enhancers	
Glycerol	Many prepared foods
Weak organic acids (and sodium, potassium, calcium and magnesium forms)	Formic: fruits, honey; Acetic: vinegar; Propionic: butter, cheese; Butyric: butter, cheese; Lactic: yogurt, cottage cheese; Decanoic: added to coat fruits and vegetables
Glyceryl triacetate	Food additive
Ethyl lactate	Wine, fruits, chicken
Polyoxyethylene	Sweeteners

Figure 3-1 Cross-section _ current CBM well field design in Project Area



Note: Figure not to scale in any respect; well locations and water levels are strictly illustrative. Smith Coal (in gray) not affected by proposed project.

Table 3-2 Historical CBM water production provides a summary of water volumes withdrawn annually by CBM wells within the Rough Draw Unit since 1996. An estimated water injection schedule is also presented and is based on the assumption of permit approval in late 2011. These volumes represent production from all four coal seams. The proposed injection will be managed to result in a water gain in some coals and water loss in others. The intent of this design is to maintain the Project Area water balance at zero.

Table 3-2 - Historical CBM water production and projected net water injection

Produced water volumes for Middle Fort Union Coals within the proposed Rough Draw Unit boundary. Historical production data source: IHS Rocky Mountain Production Data - accessed via Enerdeq on 15 May 2011.

Year	Water produced from all CBM wells (in barrels) production shown as negative numbers	Water Injected into the coals (in barrels)	Net Water Production / Injection (in barrels)	Equivalent Net Volume in Gallons	Equivalent Net Volume in Acre-feet
1996	15,709	0	15,709	659,778	2
1997	23,458	0	23,458	985,236	3
1998	2,743,544	0	2,743,544	115,228,848	354
1999	10,861,857	0	10,861,857	456,197,994	1,400
2000	20,603,240	0	20,603,240	865,336,080	2,656
2001	10,960,294	0	10,960,294	460,332,348	1,413
2002	17,113,270	0	17,113,270	718,757,340	2,206
2003	11,538,340	0	11,538,340	484,610,280	1,487
2004	8,387,011	0	8,387,011	352,254,462	1,081
2005	10,849,239	0	10,849,239	455,668,038	1,398
2006	10,016,944	0	10,016,944	420,711,648	1,291
2007	8,085,749	0	8,085,749	339,601,458	1,042
2008	9,747,382	0	9,747,382	409,390,044	1,256
2009	4,135,941	0	4,135,941	173,709,522	533
2010	4,004,881	0	4,004,881	168,205,002	516
2011	88,305	0	88,305	3,708,810	11
2012	*19,710,000*	*19,710,000*	0	0	0
2013	*19,710,000*	*19,710,000*	0	0	0
2014	*19,710,000*	*19,710,000*	0	0	0
2015	*19,710,000*	*19,710,000*	0	0	0
2016	*19,710,000*	*19,710,000*	0	0	0

Luca's process involves movement of water and nutrients through the coal seams in order to optimize sustained gas production through the microbial process. Wells not utilized for enhancement injections will be operated to produce water and gas, just as in typical CBM operations. However, while in traditional CBM, the produced waters are commonly disposed of on the surface, in the proposed process, these waters are captured and usually remain in a closed pipeline system to be re-injected into other wells within the Project Area.

Patriot intends to apply an initial treatment of each well in the Project Area by injection of water with added nutrients. Once this initial treatment is done, wells would in some cases be returned to production, or in other cases, would receive additional injection of water, commonly without added nutrients. In order to best manage and optimize the process, over the life of the permit, a given well could sometimes be producing gas and water, sometimes be receiving nutrient-amended water, and sometimes be receiving water without added nutrients.

Patriot is requesting from Wyoming DEQ various maximum injection rates and volumes for individual wells, as well as for the project in total. For interior wells, a maximum injection rate of 2,000 bpd, and a maximum total injection volume of 3,650,000 barrels ("BBL") of water is requested over the life of the 5 year DEQ permit. For wells on the perimeter of the Project Area, a maximum injection rate of 400 bpd and a maximum total injection volume of 730,000 BBL water is requested. **Exhibit 2 Rough Draw Unit DEQ UIC Class 5F2 Permit Application** specifically lists the wells and the requested rate and volume limits.

Note that while very large rates and volumes are specified above, they are very conservative maximums. For example, many wells will likely not accept 2,000 bpd under gravity alone, and project wide, the total injection rate and volume is limited by water production. As such, at any given time, only a fraction of the permitted wells would actually be receiving injection waters, and even then, likely at rates well below the maximum.

Water will be injected under gravity, meaning that no additional pressure will be supplied at the injection wellhead. Water will be provided via the low-pressure flow line system that gathers produced waters. Precise water flow line pressures (and hence the wellhead pressures at injection wells) are low, but will vary somewhat due to topography, and the water pumping rates of production wells on the system. Patriot has requested from Wyoming DEQ a wellhead injection pressure limit of 15 PSIG for each injection well.

Field wide, in their DEQ Class 5F2 Application, Patriot has proposed a maximum injection rate (sum of injection) of 54,000 bpd, and a field wide maximum injection volume of 98,600,000 BBL. These numbers are based on historical and recent water production rates (which limit overall injection rates). Note that these field wide limits, averaged across 300 wells, would be an average rate of 180 bpd, and an average injection volume of 328,667 BBL, much lower than the per-well maximums listed above. This reinforces the expectation, that at any given time, only a subset of the wells would be acting as injectors, and that few if any would inject at maximum rate, or for the full duration of the permit.

4.0 Environmental Considerations

4.1 Site Characteristics

The Rough Draw Unit Project Area consists of mostly flat plains with a few rolling hills and interspersed drainages. The primary use of the Project Area is grazing for livestock, mainly cattle. Coal bed methane production has been present on the Project Area since at least 1996. Previous environmental analyses in the area (Federal Oil and Gas Estate only) by the BLM, found potential impacts to water resources, cultural or historic values, wetland/riparian zones and invasive non-native weed species. These issues were addressed with a Water Management Plan and the application of Conditions of Approval by the BLM. On the private and State mineral estate, similar issues would have been addressed by the landowner in the surface use agreement with Patriot or their predecessor for drilling the wells.

Current production activities related to CBM production are ongoing and will continue under this proposal and past approvals. Human activity in the Project Area will not change appreciably.

What will change is the decrease and eventual elimination of surface discharge of produced water. Because the aquifers are currently relatively full, Patriot may need limited surface discharge to initiate this process. However, as the process moves forward, Patriot will conserve water by recirculating it within the coal seems and will initiate the process of abandoning and reclaiming their water discharge points. Where produced waters were going to reservoirs, these containment structures will be reclaimed or released to the landowner if they wish to maintain the structure.

4.2 Possible Environmental Concerns

Patriot has performed extensive lab and field testing over the past eight years, including the deployment of over 500 field level applications of the enhancement technology, which have:

- proved the effectiveness of the technology to economically and sustainably create new methane gas from wells treated with the technology;
- demonstrated that additional value can be created from using existing natural gas wells and pipeline infrastructure, potentially extending the economic lives of thousands of wells;
- confirmed that water should be conserved and re-used whenever feasible, as it is integral to the biogenic creation of new methane gas; and
- demonstrated through extensive testing that the technology is safe to the public and the environment.

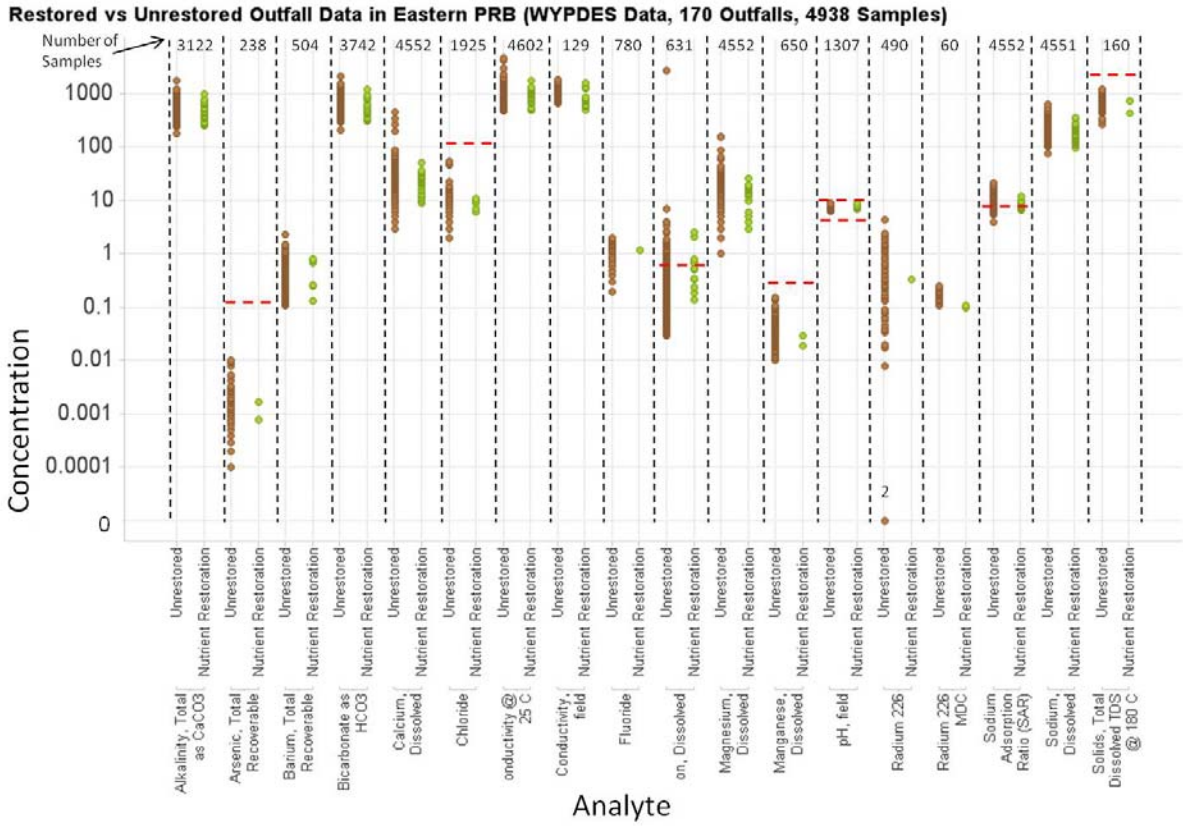
There is extensive evidence that this process will have a minimal impact on the affected environment. First, this process has naturally occurred in the coal for millions of years. Patriot's only activity that will occur under this project is to place benign nutrients into the coal seams to reactivate this methanogenic process. See **Table 3-1 Nutrients used** for a listing of nutrients that are used in the process.

The exact formula and ingredients are key to Luca's success and it is critical that this recipe remain confidential. Patriot will submit that formulation to the BLM under a separate cover with the requirement that it be kept confidential.

With produced waters being reinjected, affects to ground water quality will have to be addressed. The State of Wyoming DEQ has primacy for surface and ground water quality issues. Patriot, through their application process with the Wyoming DEQ for a Class 5F2 reinjection permit, will be required to extensively test and monitor the water quality of the receiving zones. There are several domestic use wells within the immediate vicinity permitted to use water from the Fort Union intervals containing the Anderson, Canyon, Lower Canyon and Wall coal seams and sands. Therefore, the ground water in the Canyon, Lower Canyon, Anderson and Wall coal seams of the Fort Union Formation are classified as Class I (Domestic) by use. Since the ground water is classified as Class I, the water quality in CBM wells and domestic wells will be monitored to ensure that water quality is not degraded from baseline levels. Please see **Exhibit 2 Rough Draw Unit DEQ UIC Class 5F2 Permit Application,** Patriot's application for the DEQ's Class 5F2 permit.

Trace minerals solubility and mobility may be an issue as injected waters and nutrient solution pass through the coal seams. Luca Technologies has researched this issue and found that the nutrient enhancement process does not cause the trace minerals to become soluble or mobile. **Exhibit 3 Assessment of Trace Metal Solubility and Mobility** in Powder River Basin Coal Seams Upon Enhancing Methanogenesis, Luca, December 2009, provides their findings on this issue. At a minimum, these trace minerals would be part of the monitoring program put in place by the DEQ permit. Any change in the water quality would be monitored and regulated under that permit. **Figure 4.1 Water Quality in Restored vs Unrestored Coal Seams** summarizes the results of extensive testing of aquifers before and after treatment of coal seams and further illustrates the basis of Luca's conclusion.

Figure 4.1 - Water Quality in Restored vs Unrestored Coal Seams



Sage grouse were not an issue when the original development of the Project Area was done. No new activities are planned other than drilling to obtain coal cores for analysis of the calorific values of the subject coals prior to and during nutrient enhancement. The Rough Draw Unit is not located in Core Sage Grouse Habitat. Accordingly, any stipulations regarding timing of drilling or construction activities for non-core areas set forth by the Wyoming Governor's Executive Order 2011-5, *Greater Sage Grouse Core Area Protection*, would be followed.

5.0 Mitigation Measures

5.1 Mitigation of Conflict with Coal Mining Activities

As part of its WOGCC unit and as part as this permitting process, Patriot will agree to plug and abandon all wells and associated infrastructure at least 60 days prior to the intersection of an active surface coal mine. Under these provisions Patriot will have a legally binding commitment to move out of the way of coal mining activity. Should any coal mine move into the Project Area, Patriot will be legally required to remove the wells and infrastructure, as required by the WOGCC Rules and Regulations governing plugging and abandonment, at least 60 days prior to the intersection of the active coal mine with the infrastructure. Patriot has submitted this limitation as a condition of this permit. In addition, this limitation will be a condition of the WOGCC unit process.

5.2 Mitigation for Potential Loss of Coal Quality

As the minerals manager of the publicly held coal resource and custodian of the public interest, the BLM has a responsibility to ensure that the nation's citizens are properly compensated for any economically related impact to its coal resource, and that appropriate rules are followed for development. These concerns are coupled with the issue of royalties. An uncertainty lies between the alternatives of: a) a determination that this gas belongs to the gas estate and royalties belong to the gas estate owner, and; b) this gas is created from the coal estate and royalties belong to coal estate owner. The answer might well be somewhere in-between. For example, royalties could be paid to the gas estate owner and some sort of access fee could be paid to the coal estate owner.

On the one hand, Patriot and the BLM face the threat of litigation and liability, coupled with the loss of a tremendous amount of infrastructure and resources if the gas resources aren't developed according to owners' rights and lease terms. On the other hand, the BLM is justifiably concerned about adequate compensation for use of the public coal resource. Patriot has developed the following proposals to address the royalty issues for the most likely ownership combinations.

Proposal 1: Coal and gas estate are both publicly held

Where the federal government administers both the coal estate and the gas estate, royalties for gas production from Luca's technology would be due to the BLM. This is in line with the Analysis of the Impacts of Methane Farming on Federal Coal in the Powder River Basin, Wyoming dated March 11, 2010 (see **Exhibit 4 Analysis of Impacts of Methane Farming on Federal Coal in the Powder River Basin, Wyoming**), Mr. Fred Crockett and Mr. Steven Wright of the BLM determined that

the federal government would recover nearly triple the royalties under a gas lease that it would under a coal royalty.

Proposal 2: Coal is publicly held and gas is privately owned
Compensation becomes an issue where the federal government administers the coal and someone else owns the gas. Patriot, therefore, proposes that wherever there is federal coal and private gas, Patriot would emplace a bond that would cover all royalties that could be reasonably recoverable by the coal estate. The initial amount of the bond covers royalties for Year One. At the close of Year One, the bond can be adjusted to match what the actual royalties would have been and an additional bond put in place for Year Two and Year Three.

Under this logic, the "coal estate" or the BLM as the administrator of the coal would get a royalty for this activity if there were ever a determination that this process is akin to coal gasification and royalties would be paid under the coal gasification regulations and BLM guidance documents. This is the calculation that Crockett and Wright completed in their Analysis based on federal coal estate royalties under a coal lease. Under a "best case scenario" the coal estate would be entitled to $0.08/mcf.

Patriot has also reviewed the Instructional Memoranda Mr. Crockett relied on in that analysis and believe that he has followed the most recent BLM instructions for how to calculate a coal gasification royalty. Mr. Crockett's analysis assumes 100% of the gas is new gas created by this process. While it's unknown how much new gas will be generated, Patriot knows that a portion of the gas that will be produced already exists in the coal or is being created over time without Luca's technology. Patriot believes that it is appropriate to reduce the $0.08/mcf in order to take into account the existing gas. Patriot's proposed analysis for bond computation, therefore, is based on $0.06/mcf of estimated production for Year One. **Exhibit 5 Bond Amount** provides more information and detail on the bond amount and bond payments.

Patriot, obviously, disputes that the coal estate would be entitled to this money. However, Patriot is willing to place a reasonable royalty amount into a bond account until such time as a) the legal issues regarding the coal vs. gas estate are resolved and b) the technical issues set out in Mr. Crockett's analysis are verified. This approach protects both parties from the most difficult issue regarding this development. Coal gasification royalties will be held as a bond and could be recoverable by the BLM as the parties reach an agreement on the proper payment or the payment issue is otherwise resolved. The private property rights are respected and both the BLM and Patriot avoid potential liability.