Analysis of Potential Use and Destruction of Methane Emissions at West Elk Mine

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RAVEN RIDGE RESOURCES
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Executive Summary

Raven Ridge Resources, Incorporated was engaged by Earthjustice to analyze methane emissions data from the West Elk coal mine reported by Mountain Coal Company for adherence to EPA regulations subpart FF. The goal of this analysis was to understand the character of the emissions from the coal mine and develop a conceptual design for abatement of methane emissions to the atmosphere. Emissions data for the years 2011 through 2016 was collated, sorted and analyzed to determine the pattern of emissions, the concentration of methane in the ventilation air and from gas produced from boreholes drilled into mined out areas of the coal mine. These mined-out areas are gob and the boreholes are thus termed gob vent boreholes. Management of the West Elk coal mine utilize the mine's ventilation system and drainage boreholes to remove gas from the mine that may endanger miners. From 2011 through 2016 3.2 billion cubic feet of methane has been admitted to the atmosphere. This is enough methane to have generated 8.5 MW of electricity, which is equivalent to the amount of electricity typically used by 5500 homes on annual basis.

Due to commercial and institutional issues that restrict sale of electricity generated by the mine to the electrical grid and overall low energy prices, a conceptual design was developed that envisions gathering and destroying gas that is emitted from gob vent boreholes; flaring was determined to be the most cost-effective and economic option. During the period from 2011 through 2016, the amount of gas emitted from gob vent boreholes amounted to 1.13 billion cubic feet cubic feet of methane gas. Presently the conceptual design envisions capturing the gas for newly drilled gob vent boreholes, but could be expanded to include gas that could be drained from existing boreholes. Gas captured and transported by the gathering system would be destroyed by an enclosed flare. Such flares are presently being used to destroy gas being drained from the Oxbow mine which is located nearby.

A detailed economic model was constructed based on the conceptual project design using inputs supplied by consulting engineers and vendors. Our analysis used a project life of 10 years and demonstrates that it is technically and economically feasible to safely gather and destroy the drained gas by using an industry standard enclosed flare. Revenue from the project is derived solely from the creation and sale of carbon credits. A carbon market was created by the California Air Resources Board and allows carbon emission reduction projects to generate verifiable credits that can be used by industries included in the program. The predicted economic performance of the proposed project is favorable.

Economic performance of the project was gaged by standard financial industry metrics such as, net present value, internal rate of return, return on investment and time to achieve investment pay back. The project will require a total of 12.54 million dollars of capital expenditures and 3.5 million dollars of operating expense over the project life. With a forecast of 6.7 billion cubic feet of gas produced through GVBs over a 10-year period, net total emissions of 2.64 million tonnes of CO_2e would be destroyed over that period, or about 720 thousand tonnes of carbon. The net present value of the project is $6.51 million USD, the internal rate of return is 121.5%, return on investment is 80.6%, with the project paying out before the end of the first year, meaning that revenue generated from the sale of carbon credits is greater than the sum of the initial investment and operating expenses in the initial year, and every year thereafter during the project life.

Introduction and Previous Studies and Findings from Work Conducted at West Elk Mine

Introduction

Raven Ridge was contracted by Earthjustice to perform an independent evaluation of publicly available methane emissions data submitted for the West Elk Mine, by Mountain Coal Company. Data reported to EPA and available to the public includes volumes and concentrations of methane liberated from the West Elk Mine for the years 2011 through 2016. This data was used to generate forecasts of methane emissions that could be liberated from the proposed lease expansion areas if Mountain Coal Company is allowed to mine the coal contained within the lease areas. These forecasts comprise gas that could be emitted from the drainage and ventilation systems. Raven Ridge used this data to develop a conceptual design for abating the emissions.

Prior EPA Work

Beginning in December 2003, Raven Ridge Resources, Incorporated (Raven Ridge), as a contractor to the United States Environmental Protection Agency's (USEPA) Coalbed Methane Outreach Program (CMOP), organized meetings with West Elk Mine management and various stakeholders, including project developers, electricity providers, US Forest Service (USFS) and US Bureau of Land Management (USBLM), to discuss the feasibility of siting a power generation facility at the mine, utilizing excess CMM drained from the mine workings. At the time, the mine was using a portion of the drained CMM to heat the intake air, while the remaining majority of the drained gas was vented to the atmosphere. Over the course of these meetings, discussions evolved around the amount of gas available for use, types of equipment best suited for the mine's application, ownership of the power distribution system, wheeling the power to market, the potential to generate greenhouse gas emission reduction credits, and other obstacles and challenges of power generation in the North Fork Valley. At the same time, West Elk Mine management evaluated proposals to generate liquefied natural gas (LNG) using the excess drained CMM, and to develop the ventilation air methane (VAM) resources.

Discussions continued at the beginning of April 2004, regarding power generation at the mine and its distribution through Tri-State Generation & Transmission, via the local cooperative power distributor, Delta-Montrose Electric Association (DMEA). A representative of Aspen Ski Company also participated in the discussions, as did representatives of Holy Cross Energy, the electricity provider to the Aspen region. However, West Elk Mine management decided not to move forward with developing a power project at that time.

In 2007, Raven Ridge, representing an industry client, resumed discussions with MCC, a subsidiary of Arch Coal and owner of the West Elk Mine, in their offices in Grand Junction, and with Arch's corporate management in St. Louis. Arch again expressed interest in pursuing a methane recovery and use project at the mine, but ultimately decided against project implementation.

Techno-Economic Study Commissioned by MCC

Arista Midstream Services was commissioned by MCC in 2009 to evaluate an earlier study to determine the viability of operating a methane recovery and use project at the West Elk lease site, utilizing the methane liberated from the mine via gob vent boreholes and ventilation air, as VAM. While many of Arista's assumptions seem reasonable and applicable, many of the costs used in the economic analysis seem excessive and unnecessary. Further, the study did not recognize that some of the costs included in the analysis should be considered as a "cost of mining". These costs would be accrued as activities which are a routine part of normal mining procedures at West Elk and should not be chargeable to a methane use project. The end uses considered for the gas in the Arista study were:

- flaring (destruction),
- generating electricity for use at the mine, and
- conversion of the methane into LNG for sale into wholesale or retail markets.

No consideration was given to selling the electricity into the regional grid, and subsequently, none of the options proved viable under the conditions considered. In addition, a study by the Verdeo Group commissioned by the USFS and the USBLM was carried out to look at the viability of siting VAM destruction technology at one of the exhaust shafts to destroy the methane and sell the carbon emission reduction credits on the markets in operation at the time. Verdeo Group also evaluated the options for selling any emission reduction credits generated from other end-use options under the compliance cap-and-trade programs that were emerging in 2009.

In 2010, Power Consulting, an independent group, was contracted to review and comment on the inputs, assumptions and conclusions made by these organizations. They concluded that the costs offered by Arista/MCC were extremely high and unreasonable, and by lowering the costs and incorporating revenue from the sale of environmental attributes, all of the end-use options evaluated could meet MCC's economic thresholds.

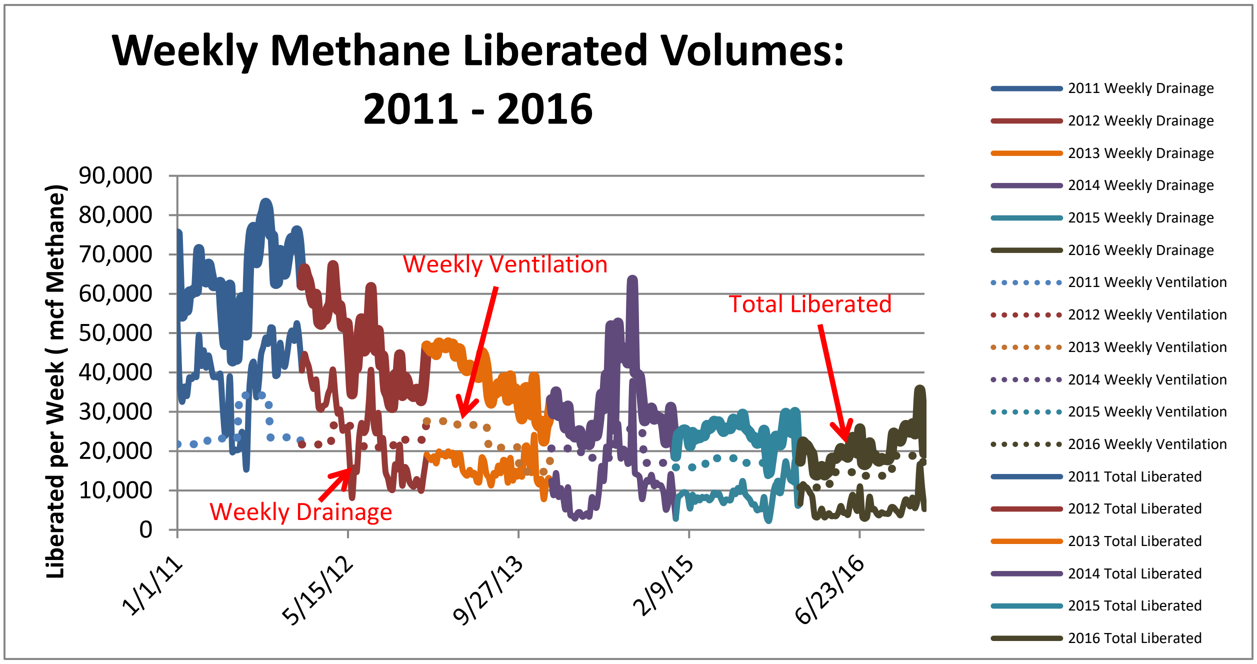
MWCC Methane Emissions Data Reported under Subpart FF

All greenhouse gas (GHG) data reported by U.S. coal mines under the Subpart FF reporting rule is available on the U.S. Environmental Protection Agency's EnviroFacts site for the years 2011 through 2016; recorded first by mine, and then by source (individual borehole or vent shaft). Ventilation data is reported quarterly, including total air flow, and in a different table, methane concentration. Drainage data is reported weekly, with volume and concentration data also in different tables. All data is reported in units of standard cubic feet per minute (scfm), a common unit used in the mining industry to describe flow of air and other gases. This data is collected from GVBs that were drilled above longwall panels active during each of the years 2011 through 2016, and from the Deer Creek ESM shaft and the Sylvester Gulch exhaust vent shaft. The locations of the GVBs and vent shafts can be seen on **Map 1**. Other data is also available such as temperature, pressure, and type of monitoring device used to record the data, but was not included in this study.

MCC uses the term "methane drainage well", or MDW, when referring to gob drainage wells, wells drilled from the surface to intersect sections of the mine where coal has been extracted. The industry standard term is "gob vent borehole", or GVB, which is the term used in this study to distinguish from pre-mine drainage wells that could be drilled in advance of mining.

Results of our initial evaluation of methane liberation from the West Elk Mine for the years 2011 through 2016 is expressed graphically in **Figure 1** below.

Figure 1: Graphic Representation of Publicly Available Methane Liberation Data for West Elk Mine



Methane liberated from the West Elk Mine was noticeably higher in 2011 and 2012 but rapidly decreased to levels seen in 2013 - 2016. For this reason, only data from 2013 – 2016 was used in our analysis, as the higher methane emissions may be related to mining conditions and production rates unique to those years.

The total methane liberated during the period 2011 through 2016 was 3.25 billion cubic feet, 2.12 billion cubic feet, or 65 percent of total methane liberated was emitted to the atmosphere via the two ventilation exhaust shafts, and 1.13 billion cubic feet, or 35 percent of methane liberated, was drained via the GVBs. By employing a more aggressive drainage program, by more closely monitoring the GVBs and allowing the boreholes to produce for a longer period of time, it may be possible to capture a larger portion of the liberated methane which would otherwise be emitted by the ventilation system, thereby reducing the overall ratio of methane liberated via the exhaust shafts. Any acts to manage methane in the mine by increasing GVB production must be evaluated by management and make the safety of the miner paramount. In that regard, it is important to monitor the boreholes to ensure that there is no increased oxygen levels detected in the gob caused by increasing suction at the mine.

Total methane liberated by the mine is equivalent to the carbon dioxide (CO_2) emissions that would be generated from the consumption of 3.55 million barrels of oil. The volume of drained gas alone is sufficient to power an 8.5 MW power station, which would service approximately 5,525 homes. It would take 1.8 million acres of U.S. Forest lands one year to sequester the equivalent volume of greenhouse gases liberated as methane from the West Elk Mine between 2011 and 2016.

Probabilistic Analysis of Emissions Data

To capture the range of uncertainty associated with the data reported by MCC, such as GVB production, the number of GVBs in operation at any one time, and VAM emissions, probability distribution functions were developed by using curve-fitting routines, using Crystal Ball™ to model these variables. Crystal Ball™ is an Excel spreadsheet add-in application used for predictive modeling, simulation, optimization and reporting. The probability distribution functions resulting from the curve fitting are mathematical descriptions of these variables that incorporate the full range of historical values and uncertainty related to the available data sets.

The probability distribution functions generated in this fashion were then used to forecast probabilistic outcomes by using the probability distribution functions to calculate parameters that indicate the economic performance of the capture and use scenarios explored in this analysis. Forecasts presented in this report are outputs of a Monte Carlo simulation conducted using Crystal Ball™. A Monte Carlo simulation is a re-iterative process that randomly samples the probability distributions so that every possible value in the data set is used in combination with the other variables for calculating potential outcomes. The resultant is also a mathematical model, or probability distribution that forecasts the range of possible outcomes.

This re-iterative process allows for the full range of input values to be used in order to determine the most likely outcome, or p_{50} value. The p_{50} value is the median value of the distribution, meaning that there is a 50 percent probability that the value will be greater than the value presented, and a 50 percent probability that the value will be less than the value presented.

Other probabilistic outcomes are calculated indicating the probability of that value occurring:

- The p_{10} value is used to mean that there is a 10 percent probability that the value will be greater than the value presented, and a 90 percent probability that the value will be less than the value presented.
- The p_{90} value is used to mean that there is a 90 percent probability that the value will be greater than the value presented, and a 10 percent probability that the value will be less than the value presented.

Ventilation Air Methane Analysis

Presently, West Elk mine management reduces the amount of methane emitted into the mine's workings using a combination of dilution and evacuation of the methane via the ventilation system by using boreholes to drain areas of the mine where coal has been extracted. These areas are known as the gob and they are largely closed off to the active portions of the mine. The low concentrations of methane in the ventilation air indicate that the system is working to effectively keep the miners safe from potential methane related accidents. This is the primary goal of methane management, but a secondary goal should be to reduce the overall emissions of methane to the atmosphere and there is potential to lower the amount of methane that is exhausted by the ventilation system. About two-thirds of the methane liberated by mining is vented, therefore, it is important to understand the volume and concentrations of the methane in the VAM. Our analysis shows that while it may not be possible to achieve a positive economic outcome by using one of several commercially available options for destruction of methane by oxidation, it is technically feasible to do so without endangering miners or adding criteria pollutants to the environment. Moreover, there is a potential to reduce the amount that is vented by working to increase gob drainage and investigating other potential in-mine drainage schemes.

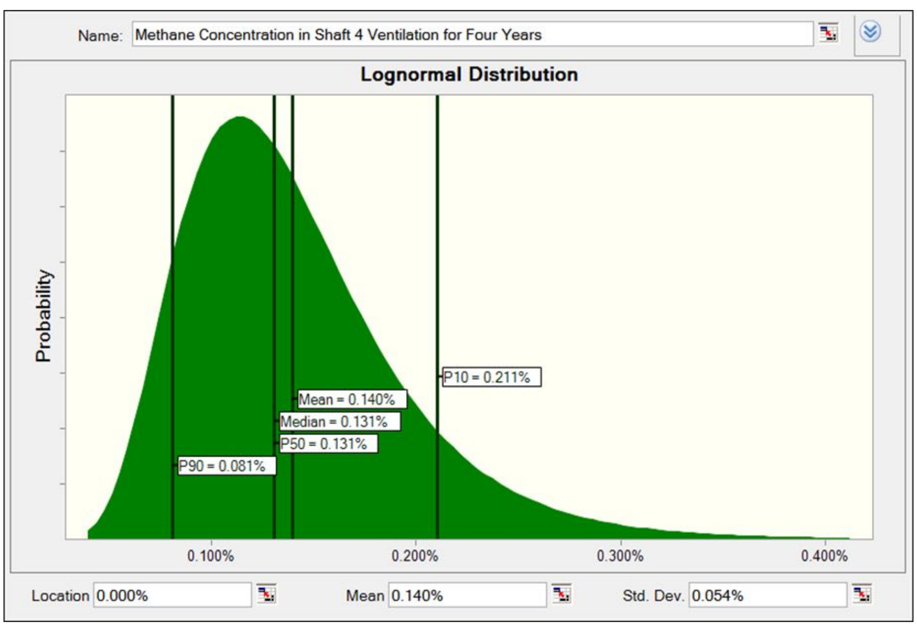
West Elk ventilation air data is reported quarterly, with total volumes and methane concentration data reported separately. The reported data is acquired from four unique locations at mine:

- flow from three sites within the mine, all of which exits the Deer Creek, or East South Mains (ESM) Shaft;
- the remaining ventilation air volume exits the Sylvester Gulch Shaft.

This analysis uses the data collected from the Deer Creek (ESM) shaft, as this shaft recorded the largest volume of VAM with the highest methane concentration. Concentration of methane ventilation air is key to safe effective operation of VAM destruction units. Methane concentration in ventilation air ranges from 0.059 percent to 0.321 percent in air, and the total volume ranges from 777,220 scfm to 1,030,234 scfm. The probabilistic analysis was carried out to determine:

- p_{50} methane concentration in the ventilation stream for ESM shaft for years 2013-2016, as shown in **Figure 2**, and
- p_{50} methane volumes in the ventilation stream for ESM shaft for years 2013-2016, shown in **Figure 3**.

Figure 2: Probability Distribution for Methane Concentration in ESM Shaft

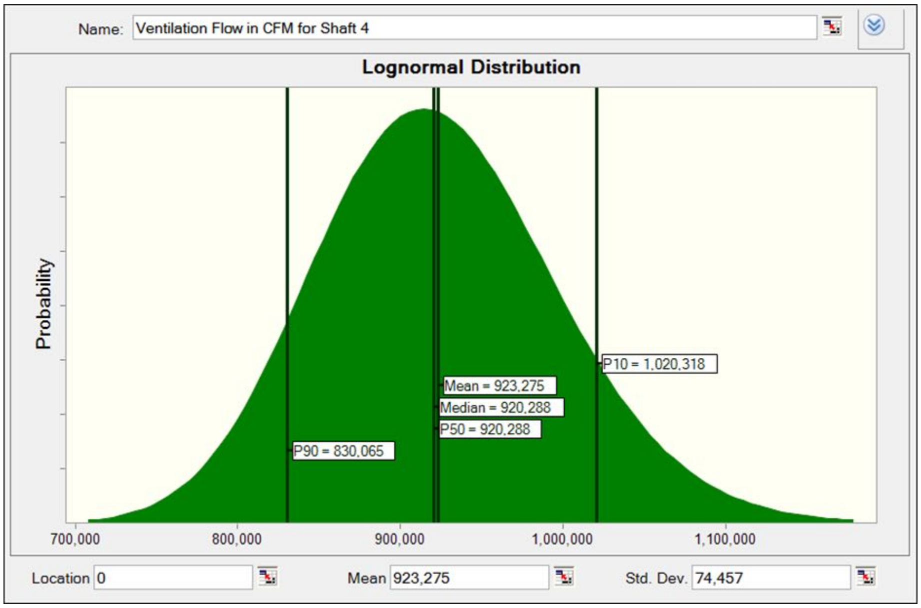


p_{50} = Median, there is a 50 percent probability that the methane concentration in the shaft will be 0.131 percent.

p_{10} = There is a 10 percent probability that the methane concentration in the shaft will be 0.211 percent or greater.

p_{90} = There is a 90 percent probability that the methane concentration in the shaft will be 0.081 percent or greater.

Figure 3: Probability Distribution of Total Ventilation Flow for ESM Shaft



p_{50} = Median, there is a 50 percent probability that the ventilation flow in the Deer Creek ESM shaft will be 920,288 scfm.

p_{10} = There is a 10 percent probability that the ventilation flow in the Deer Creek ESM shaft will be 1,020,318 scfm or greater.

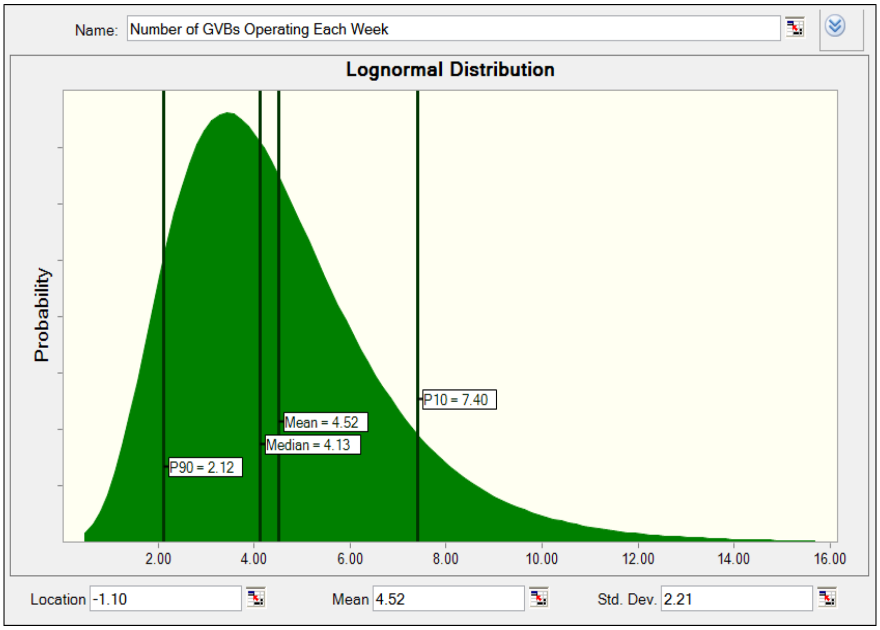
p_{90} = There is a 90 percent probability that the ventilation flow in the Deer Creek ESM shaft will be 830,065 scfm or greater.

GVB Production Analysis

The GVB data is reported on a weekly basis for each operating GVB, with methane concentration and volumes reported separately. Methane concentration in the GVBs ranges from 26.06 percent to 91.89 percent. Curve fitting and probabilistic analysis was carried out to determine the following:

- Number of GVBs operating at each week, shown as **Figure 4**;
- Weekly production of all operating GVBs, shown in **Figure 5;**
- Methane concentration in gob gas, shown in **Figure 6**;
- Number of Weeks each GVB is operating, **Figure 7**;
- p_{50} production volumes for the years 2013 through 2016; and
- p_{50} duration that each GVB is operating for the years 2013 through 2016 in weeks.

Figure 4: Probability Distribution of Number of GVBs Operating each Week

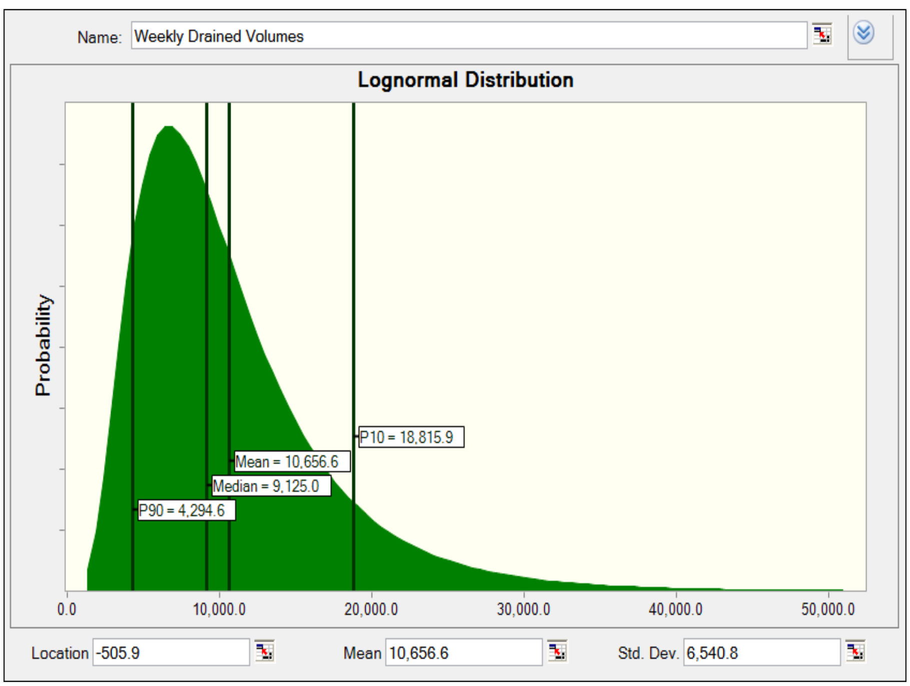


p_{50} = Median, there is a 50 percent probability that 4.13 wells are in service during any given week.

p_{10} = There is a 10 percent probability that there are at least 7.4 wells operating during any given week.

p_{90} = There is a 90 percent probability that there are at least 2.12 wells operating during any given week.

Figure 5: Probability Distribution of Weekly Production for all Operating GVBs

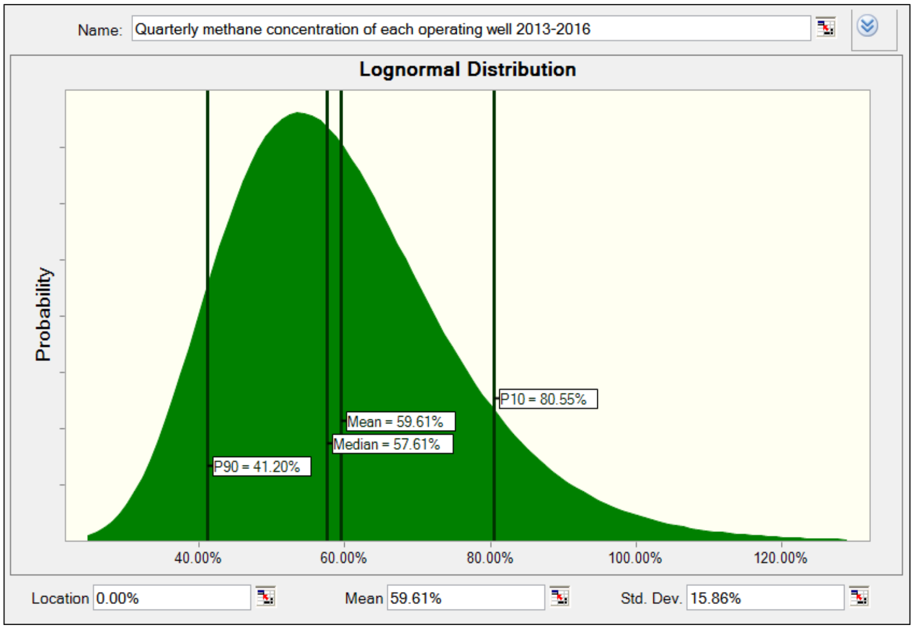


p_{50} = Median, there is a 50 percent probability that weekly methane production will be 9,125 scfm.

p_{10} = There is a 10 percent probability that weekly methane production will be 18,816 scfm or greater.

p_{90} = There is a 90 percent probability that the weekly methane production will be 4,295 scfm or greater.

Figure 6: Probability Distribution of Methane Concentration in Gob Gas

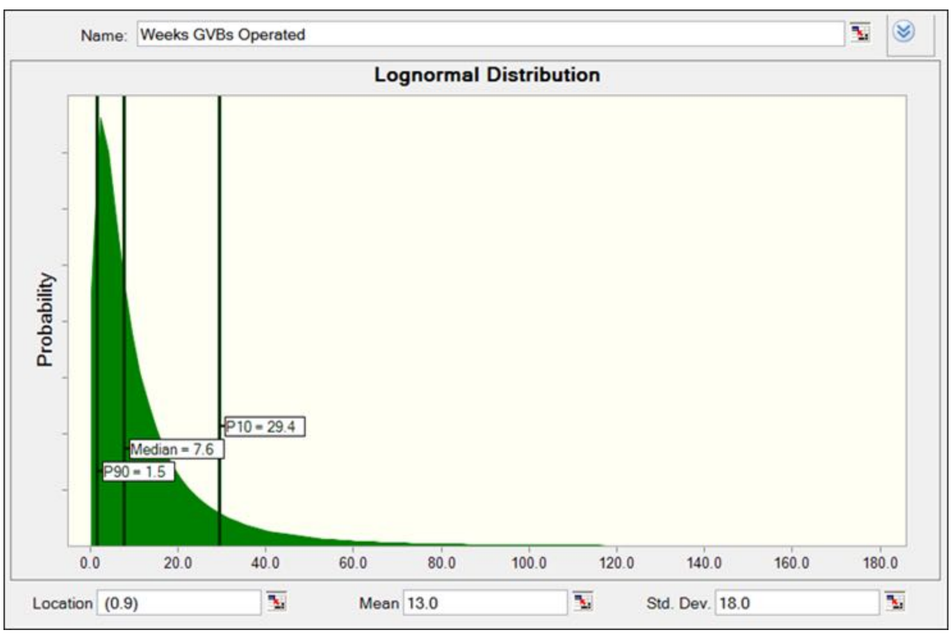


p_{50} = Median, there is a 50 percent probability that weekly methane concentration in all the GVBs will be 57.61 percent.

p_{10} = There is a 10 percent probability that weekly methane concentration in all the GVBs will be 80.55 percent or greater.

p_{90} = There is a 90 percent probability that the weekly methane production will be 41.20 percent or greater.

Figure 7: Probability Distribution of the Number of Weeks each GVB Operates



p_{50} = Median, there is a 50 percent probability that GVBs will operate for 7.6 weeks.

p_{10} = There is a 10 percent probability that GVBs will operate for at least 29.4 weeks

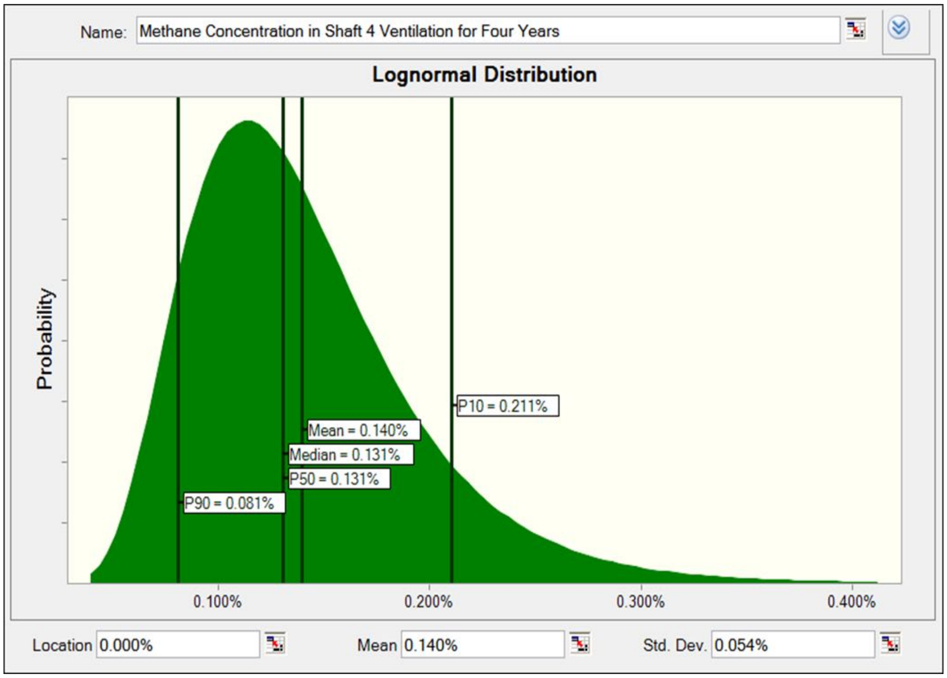
p_{90} = There is a 90 percent probability that GVBs will operated for at least 1.5 weeks.

Considerations for Capture and Use of CMM at the West Elk Mine

Presently, methane is liberated from the West Elk Mine in two forms; via GVBs where the gas concentration ranges from 30 percent to as high as 90 percent by volume in air, with a p_{50} value of 56.87

percent, and via ventilation exhaust shafts as VAM, in concentrations ranging from negligible to greater than 0.3 percent in air, with a p_{50} methane concentration of 0.131 percent for the Deer Creek shaft (**Figure 8**).

Figure 8: Probability Distribution of Methane Concentration in the Deer Creek ESM Shaft



p_{50} = Median, there is a 50 percent probability that the methane concentration in the Deer Creek ESM shaft will be 0.131 percent.

p_{10} = There is a 10 percent probability that the methane concentration in the Deer Creek ESM shaft will be 0.211 percent or greater.

p_{90} = There is a 90 percent probability that the methane concentration in the Deer Creek ESM shaft will be 0.081 percent or greater.

CMM Capture

The West Elk Mine regularly employs GVBs as a component of its methane ventilation program, with the production from GVBs ranging between 12 and 71 percent of total methane liberated, and an average contribution of 41 percent since the mine began reporting this information in 2011.

The general practice for the mine is to vent this gas to the atmosphere, occasionally transporting gas to burners located in Sylvester Gulch to heat the air that is pumped into the mine. This is only done during the winter months and utilizes only a very small percentage of drained gob gas. The method that the mine uses to gather and transport the gas for this task is the same concept that is envisioned for the capture and use projects evaluated in this study, with the exception that in this study we assume that all available gas produced from active GVBs will be utilized or destroyed, rather than vented. Given that methane has a global warming potential (GWP) of greater than 36 times that of CO_2 when measured over a 100-year period and 87 times that of CO_2 when measured over a 20-year period, destruction of this gas, as opposed to venting it, will have a positive impact on the local and regional environment. For the purposes of this study, a GWP of 25 is used to calculate project emission reductions and the amount of carbon emissions credits generated, as 25 is the value that is currently used by the carbon markets.

The Grand Mesa, Uncompaghre and Gunnison National Forests (GMUG) overlie the mine. The GMUG has been negatively impacted by climate change in recent years, and therefore, GMUG management is actively practicing what the Department of Agriculture (DoA) terms, "climate smartness". This involves managing the forest's natural resources to be resilient to disturbances like wildfires, insect and disease infestations and frequent, extreme weather events. These are events that can be attributed to climate change, and reducing methane emissions supports the DoA program and USFS's efforts in practicing climate smartness.

Post-mine drainage from the surface

Design and installation of the GVBs used in this analysis incorporate best practices and the safety features that West Elk currently employs, including flame arresters and safety controls and monitoring, as well as all safety practices normally utilized in the oil and gas industry. It is also envisioned that all access roads and gas gathering lines will utilize existing roads and right-of-ways, not requiring any additional surface disturbance. Placement and timing of the drilling of GVBs will still be supervised by the mine and the length of time that the GVBs produce must be managed by mine personnel, as they are now, so as not to allow the gas concentration of any well to approach explosives levels. Our analysis has shown that MCC typically operates GVBs as long as mining continues on a longwall panel, but if desired, mine management could operate many of the GVBs for longer periods. With a methane mitigation system in place, this would allow for the destruction of more gas rather than eventually allowing it to escape through the ventilation system.

Abatement of drained CMM from GVBs

Several end-uses for the gob gas were considered in this study, but after a preliminary evaluation, flaring was determined to be the most cost-effective and economic at this time. Our conceptual design envisions that available GVB production from the new leasehold will be gathered and transported to a central location along existing roads and right-of-ways within the new leasehold boundary where an enclosed flare will be sited; no additional roads or right-of-ways will be required for gas gathering operations. Drained gas will be treated at the wellhead so that the moisture in the gas will not freeze, and then transported via 6-inch SDR 11[1] plastic pipe to the flare site.

The proposed flare, which will be an enclosed flare designed to destroy drained gas at 99.9 percent efficiency, would be mounted onto a concrete pad with an additional four feet of buffer, and surrounded by an enclosed fence. It will be designed to avoid over firing of the unit which could lead to air starvation and incomplete combustion. The unit is designed to shut off in cases of over firing or any type of instability in the operation. Immediately prior to shutdown, the system is equipped with a purge blower which creates a safe atmosphere within the flare, ensuring that no flames escape out the top. The system is also equipped with a UV scanner; if the pilot flame is lost, the main flame automatically shuts down. During all shutdown cases, the system immediately goes into safe mode, whereas gas is prohibited from contact with the flare unit. Also, the flare chamber is internally lined with refractory material, minimizing the impact of the flare on the outside shell temperature which further reduces any

[1] SDR 11 means that the outside diameter of the pipe is eleven times the thickness of the pipe wall.

chance of heat radiation.[2] . All personnel operating on the flare unit will be trained by the original equipment manufacturer (OEM) to handle combustion devices, and will be required to wear fire-proof clothing and personal methane gas detectors while working on the unit. Maintenance on the unit is nominal, requiring a scheduled preventive review only every six months, which can be performed by trained mine personnel. Also, because the flare is enclosed, it will not give off light, whereas any artificial light at this location can potentially have a negative impact on the local ecosystems. It has been proven that artificial light disrupts animal's nocturnal activity, interfering with their reproduction and thus reducing natural wildlife populations. Given the intrinsic safety of the flare, with proper installation, operation and maintenance performed by properly trained personnel, the flare should not endanger the surrounding forest, the mine or its workers.

Economic Evaluation of CMM Abatement

Raven Ridge analyzed the option of reducing methane emissions at the mine as an investment opportunity. Our analysis was performed by calculating a string of annual free cash flow values, which are calculated by subtracting outflows of investment capital, operating capital, loan repayment, and other costs from the revenues or inflows from sales of verified carbon emission reductions. To allow comparison of the economic performance of the proposed investment opportunity at the coal mine against other investment opportunities which may be available to MCC, Raven Ridge performed a discounted cash flow analysis.

Discounted Cash Flow Analysis

Discounted cash flow analysis uses the string of annual cash flows to calculate the profit that will be realized over the life of the project. To make the future invested capital and profits relevant in today's monetary terms, a discount factor is used. This factor is used to discount future cashflows because we recognize cash flows in the future are worth less than cash flows realized in the present. This is to say, that even if the values occur in year six of a project that lasts 10 years, the values are brought forward to the present by discounting the future cash flows by an annual discount factor. We used a range of discount factors to analyze the investment, but we report the results using a discount rate of 10 percent, as it is a factor commonly used by analysts. As an example, the results of our analysis could be compared against an investment where the investment paid out in ten years and had a compound interest rate of ten percent per year.

Net present value (NPV) is the value that is calculated and commonly used to evaluate investment opportunities. It is a measurement of profit calculated from the present value of a string of annual free cashflows (positive or negative) over time using a discount rate. Again, in our analysis we use a ten percent discount rate, and based on our analysis, as explained later in the report the most likely NPV of the project is $6.51 million USD.

Internal rate of return (IRR) is used to evaluate an investment by comparing the annual rate at which the value of the project increases. The IRR is the discount rate at which the NPV of a string of annual cash

[2] P. Kondagari (2017), personal conversation with P. Kondagari, manager of enclosed combustion for Aereon, October 20, 2017.

flows is zero. As an example, in our analysis we calculate that the most likely outcome from analysis is that the project will achieve an IRR of 121.5 percent. This implies that it would require a discount rate of 121.5 percent to cause the NPV to be zero.

Return on investment (ROI) is used to indicate the efficiency at which invested capital generates profit. This indicator is simply calculated by subtracting the cost of investment from the gain in investment divided by cost of investment; or, in other words, divide the profit by the cost of the investment. Positive ROI indicates that the investment plus a profit is returned. Discounted cash flow is not used for this calculation so the ROI does allow an easy comparison of two investments that differ by the length of time before profit is returned. Using this analysis of this investment opportunity, the ROI for this project is most likely to be 80.6 percent, meaning that if implemented MCC could enjoy the return of their investment plus an additional 80 percent of the total cost of the project.

Flaring as an methane abatement option at West Elk

Through evaluation of the available gob gas and consultations with a representative of the local USBLM office as well as Holy Cross Energy and the DMEA, the utility that provides electricity to the West Elk Mine, the Raven Ridge team has determined that flaring is the best option for methane destruction at the mine.

An Excel-based model was constructed to evaluate the economic performance of siting a flare within West Elk's lease boundary. Aereon provided a quote for an Abutec HTC 18 Combustor flare a newer model of the same flare which has been installed and is operating at the North Fork LLC project at the Elk Creek mine just north of West Elk. This high temperature flare offers up to 99.9 percent destruction efficiency along with a completely enclosed flame. Flare design conditions are listed below in **Table 1**.

Table 1: Abutec Flare Process Data

Gas composition	**56.9% CH_4 & 43.1% AIR**
Maximum flow rate	2.86 MMSCFD
Rated heat release/HTF UNIT:	62 MMBTU/HR
Inlet Temperature:	100°F max
Inlet pressure:	30 psig
Retention time:	Minimum 0.3 SEC
Destruction rate efficiency:	99.9% DRE
Operating temperature:	Up to 1,800 °F
NO_x emissions requirement:	0.15 LBS/MMBTU
CO emissions requirement:	0.2755 LBS/MMBTU

All criteria pollutants are negligible at the stated destruction efficiency. The proposed flare could consume an increased 20 percent volume of gas without design modifications.

For modeling purposes, 2.86 million cubic feet of gas will be available daily, at a concentration of 56.9 percent methane (p_{50} value of GVB production). These parameters were submitted to Aereon to ensure that the recommended flare is compatible with the conditions present at West Elk. The cost of the flare and other materials, equipment and labor incorporated into the model is described in **Table 2**.

Table 2: Model inputs: Flaring Scenario

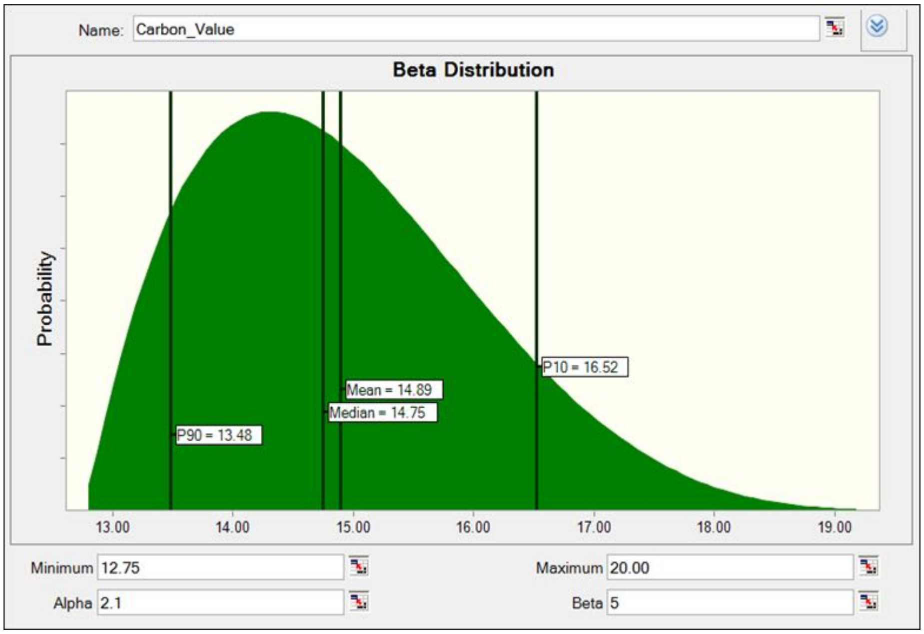
Item	Input Value	Comments
Project evaluation period	10 years	
GVBs	N/A	Cost of drilling and completion is a "cost of mining" and not charged to the project
GVB production	Lognormal distribution, median value is 11,403 scfm, p_{10} is 19,241, p_{90} is 5,589.	Results of data analysis (see figure below)
6 inch gathering line	16,969 ft.[3] annually at $16.96 per ft.	Price quote from Andrew Bates, drilling and completion Engineer with Protocom Consulting - Farmington, NM (Exhibit 2)
Wellheads	14 new GVBs installed annually, 5 GVBs operating at any one time, seven new wellheads installed annually, reusing when possible.	Number of GVBs employed based on forecasts discussed earlier in study. Wellhead cost quote from Andrew Bates.
Monitoring/control system	$405,000 installed at start-up	Quote from Arista report, Bates confirmed as reasonable
Annual operating and maintenance costs	Max extreme distribution, with likeliest value of $362,000.	Quote from Andrew Bates.
Flare system	$328,000 for system with $2,800 for installation	Quote from Aereon (Exhibit 3).
Carbon price	Beta distribution, with likeliest value of $14.75 per ton, max value is $20.00, min value is $12.75.	California Cap-And-Trade Program latest Joint Auction Settlement prices, with forecast for future prices through 2020.
Registration with California Climate Action Reserve.	$20,000 to validate project, $10,000 to verify annually	Verbal quote from verifier.
Federal Royalty	12.5 percent	BLM web-site
Project financing	80 percent debt financed at 8 percent interest	
Taxes	Pre-tax analysis	

The capital expenditures discussed in this study include the cost of the flare, the wellheads installed on each GVB, the gathering lines and the monitoring and control system. The cost of the flare and monitoring and control system is incurred in the first year; the cost of the wellheads and gathering lines are allocated annually for the life of the project.

[3] The length of gathering line is determined by taking the historical length of roads that are visible from satellite imagery (**Map 1**), and service the existing GVBs placed in the e-seam, and by dividing this length by the number of GVBs that were in place (**Exhibit 1**); the resultant value of 1,212 feet per GVB was used to determine the total length of gathering line that would be installed each year. It was forecasted that 14 GVBs will be placed into service each year for a total of 16,968 ft. of gathering line.

Probability distribution functions were generated for carbon price (**Figure 9**) and GVB weekly production (**Figure 10**) to capture the full range of possible values and their impact on uncertainty. The probability distribution for carbon price was constructed using historical California (CARB) and Quebec joint auction settlement prices and forecasts of future prices from published trading analytics (http://californiacarbon.info/).

Figure 9: Probability Distribution for Carbon Sales Price

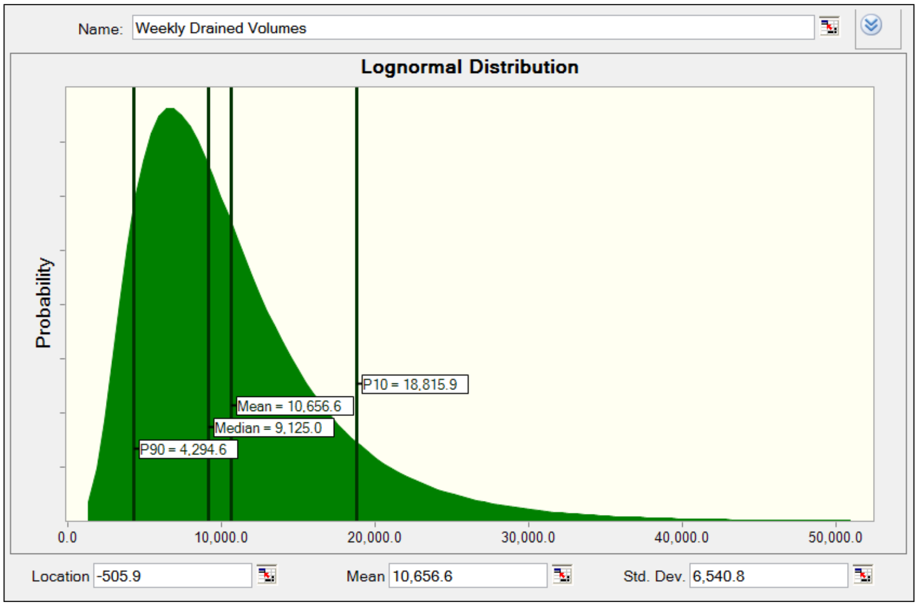


p_{50} = Median, there is a 50 percent probability that the carbon sales price will be $14.75

p_{10} = There is a 10 percent probability that carbon sales price will be $16.52 or greater.

p_{90} = There is a 90 percent probability that the carbon sales price will be $13.48 or greater.

Figure 10: Probability Distribution of Weekly Total GVB Production Rate (scfm)



p50 = Median, there is a 50 percent probability that the weekly total GVB production rate will be 9,125.0 scfm.

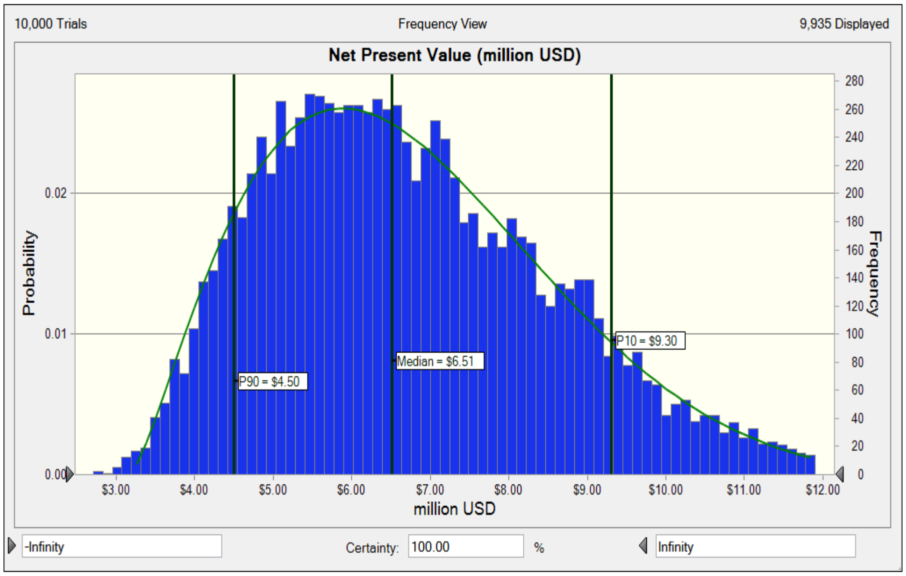
p10 = There is a 10 percent probability that the weekly total GVB production rate will be greater than 18,815.9 scfm.

p90 = There is a 90 percent probability that the weekly total GVB production rate will be greater than 4,294.6 scfm.

Results of CMM Destruction Economic Analysis

Once the economic model was set up, Monte Carlo simulations were run which incorporated the probability distributions of carbon price and GVB weekly production. The outputs of a Monte Carlo simulation are forecasts of Net Present Value (NPV) (**Figure 11**), Internal Rate of Return (IRR) (**Figure 12**) and Return on Investment (ROI) (**Figure 13**), which also are probability distributions. These forecasts are presented below and in **Table 3**.

Figure 11: Net Present Value Forecast (million USD)

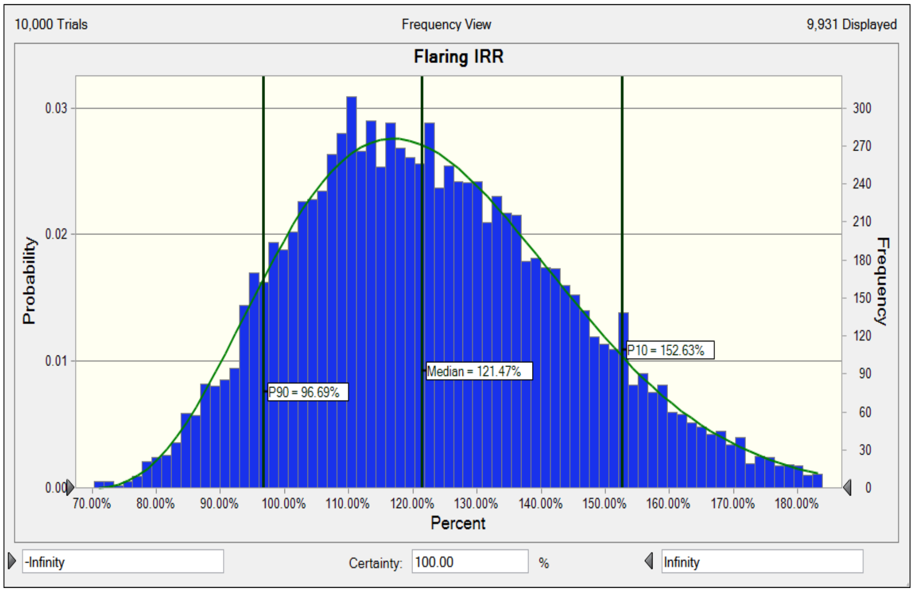


p_{50} = Median, there is a 50 percent probability that the project will result in an NPV of 6.51 million USD over a 10-year project life.

p_{10} = There is a 10 percent probability that the project will result in an NPV of 9.30 million USD or greater over a 10-year project life.

p_{90} = There is a 90 percent probability that the project will result in an NPV of 4.50 million USD or greater over a 10-year project life.

Figure 12: Internal Rate of Return Forecast (percent)

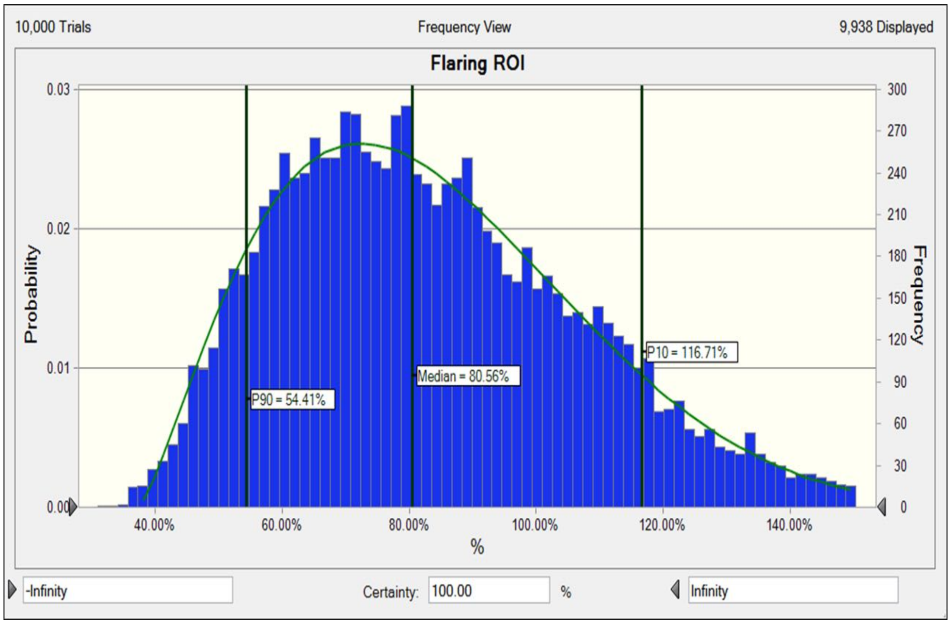


p_{50} = Median, there is a 50 percent probability that the project will result in an IRR of 121.47 percent over a 10-year project life.

p_{10} = There is a 10 percent probability that the project will result in an IRR of 152.63 percent or greater over a 10-year project life.

p_{90} = There is a 90 percent probability that the project will result in an IRR of 96.69 percent or greater over a 10-year project life.

Figure 13: Return on Investment (ROI)



p_{50} = Median, there is a 50 percent probability that the project will result in an ROI of 80.56 percent over a 10-year project life.

p_{10} = There is a 10 percent probability that the project will result in an ROI of 116.71 percent or greater over a 10-year project life.

p_{90} = There is a 90 percent probability that the project will result in an ROI of 54.41 percent or greater over a 10-year project life.

Summary of Findings:

Raven Ridge determined that a gob gas flaring project would be technically and economically viable at the West Elk mine. A similar project located at Oxbow's now shuttered Elk Creek mine began while the mine was active and continues at present as an idled mine methane emission abatement project. The proposed West Elk project would be capable of destroying 634.9 million cubic feet of gas per year amounting to 281.8 thousand tonnes of CO_2e or 76.9 thousand tonnes of carbon. The total capital needs for the project would be $12.54 million USD over a ten-year project life. Assuming a p_{50} forecast of 6.7 billion cubic feet of gas produced through GVBs over a 10-year period, net total emissions of 2.64 million tonnes of CO_2e would be destroyed over that period, or about 720 thousand tonnes of carbon.

The Flaring Project economic indicators are presented in **Table 3**.

Table 3: Economic Indicators - 10 Year Flaring Project

Economic Indicators - 10-yr Project	
Evaluation Scenario	***Flaring***
Gas Forecast - p_{50} (billion cubic feet)	6.7
Total Capital Expenditures (CAPEX in million USD)	$12.54
Total Operational & Maintenance Costs (OPEX in million USD	$3.50
Project Emission Reductions with GWP of 25 (million tCO_2e)	2.64
Project Emission Reductions (thousand tonnes Carbon)	720.32
CAPEX/Tonnes CO_2e	$6.07
CAPEX/Tonnes of C	$1.66
Total Cost of Carbon Reductions ($/tonne of CO_2e)	$20.90
Total Cost of Carbon Reductions ($/tonne of C)	$5.70
Carbon Price (USD/tCO_2e)	$14.75
Net Present Value (p_{50} NPV value in million USD)	$6.51
Internal Rate of Return (p_{50} IRR value in %)	121.5%
Return On Investment (p_{50} ROI value in %)	80.6%

The project shows a very positive economic outcome under the current scenario, paying out before the end of the first year, meaning that revenue generated from the sale of carbon credits is greater than the sum of the initial investment and operating expenses in the initial year, and every year thereafter during the project life. With a carbon price of $14.75, the project returns p_{50} values of $6.51 million USD for the NPV, 121.5 percent for the IRR, and 80.6 percent for the ROI. Even considering the very conservative p_{90} values, the project returns a favorable NPV of $4.5 million USD, an IRR of 96.7 percent and an ROI of 54.4 percent.

Recommendations for Improving Economic Performance of a Flaring Project

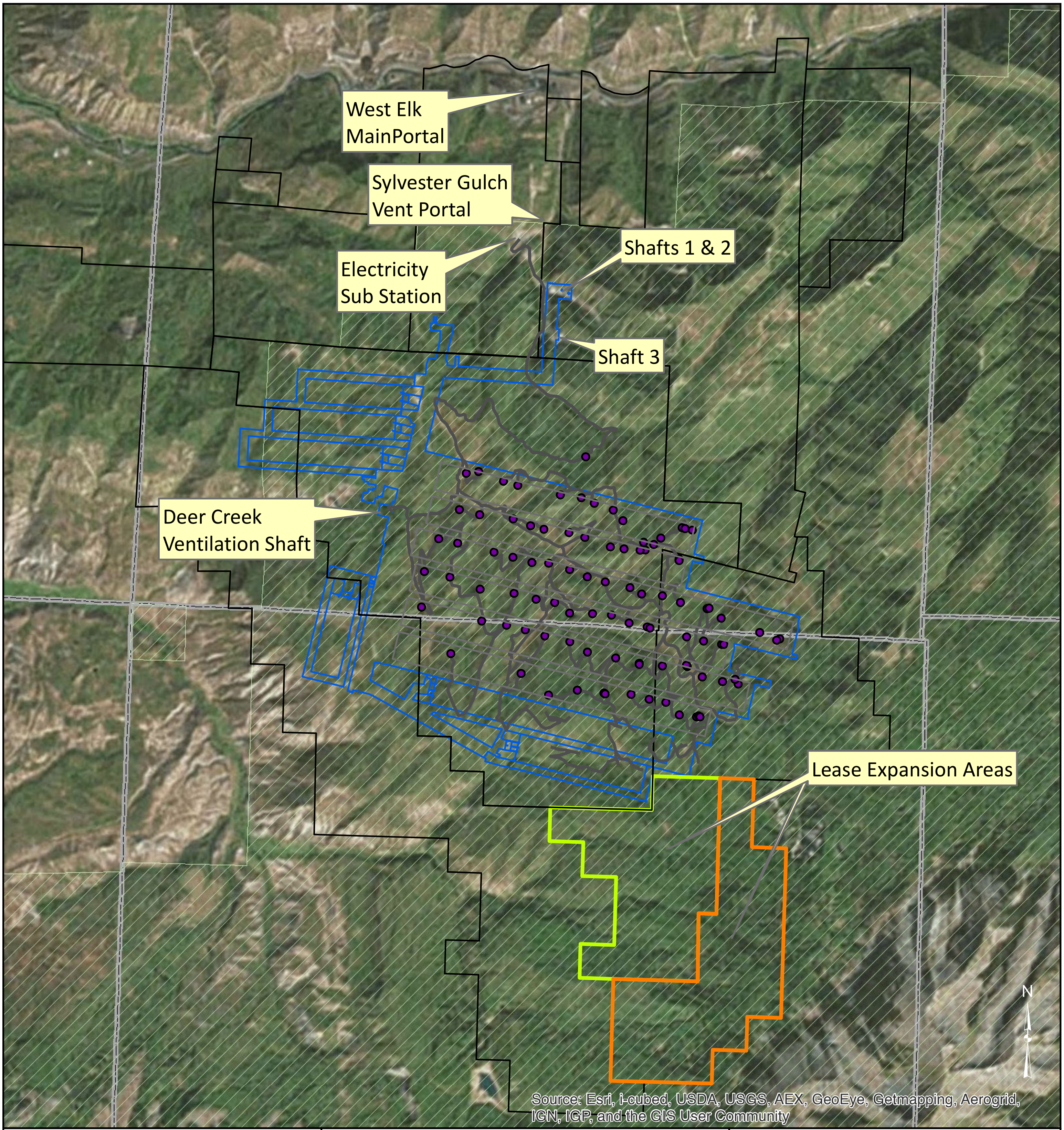
The available GVB production does not include any contribution from production from existing GVBs put into operation prior to project start-up. The current design of the flare can handle a 20 percent increase in gas without reconfiguring, thus transporting additional gob gas from these existing GVBs to the flare site to be destroyed would increase the economic outcome of the project.

The largest single capital expenditure is the flare system; however, it only represents three percent of total capital costs. Other remaining costs include the wellheads, gas gathering, monitoring equipment and controls. The operating and maintenance costs used in our analysis were just 17 percent of the operating and maintenance costs used by the firm hired by MCC in their analysis, which is the primary reason that our results are much more favorable; the reasons for this difference are our cost estimate calls for a significant reduction in all labor categories, the lack of need for the larger 10 inch SDR pipe and the cost associated with moving it, and a significant reduction by renting rather than purchasing compressors (**Table 4**)

Table 4: Gas Gathering System Cost Comparison Table

Cost Categories	MCC Estimate	Raven Ridge Estimate
Labor	888,000	98,000
Methanol	150,000	150,000
Compression	320,000	24,000
Winter Operations/labor	420,000	Included
Miscellaneous	100,000	90,000
Office	240,000	N/A
Total	**2,118,000**	**362,000**

Even with this, all cost assumptions should be refined once a final engineering design is developed. If a dialog is started with mine management, it is quite possible that the mine already has much of the equipment, such as wellheads and 6-inch plastic pipe, as well as trained personnel, possibly reducing the gas gathering capital and operating expenditures significantly. Any reduction in gas treatment and gathering could have a significant positive impact on project economics.



- Gob Vent Boreholes
- Right of Ways
- Existing Coal Leases
- E Seam Mine Workings
- COC-1362 Lease (800 acres)
- COC-67232 Lease (920 acres)
- GMUG Forest Boundary
- Township Boundaries

Map 1: West Elk Mine Property

Showing Gob Vent Boreholes and Existing and Proposed Coal Leases

0 0.5 1 2 Miles

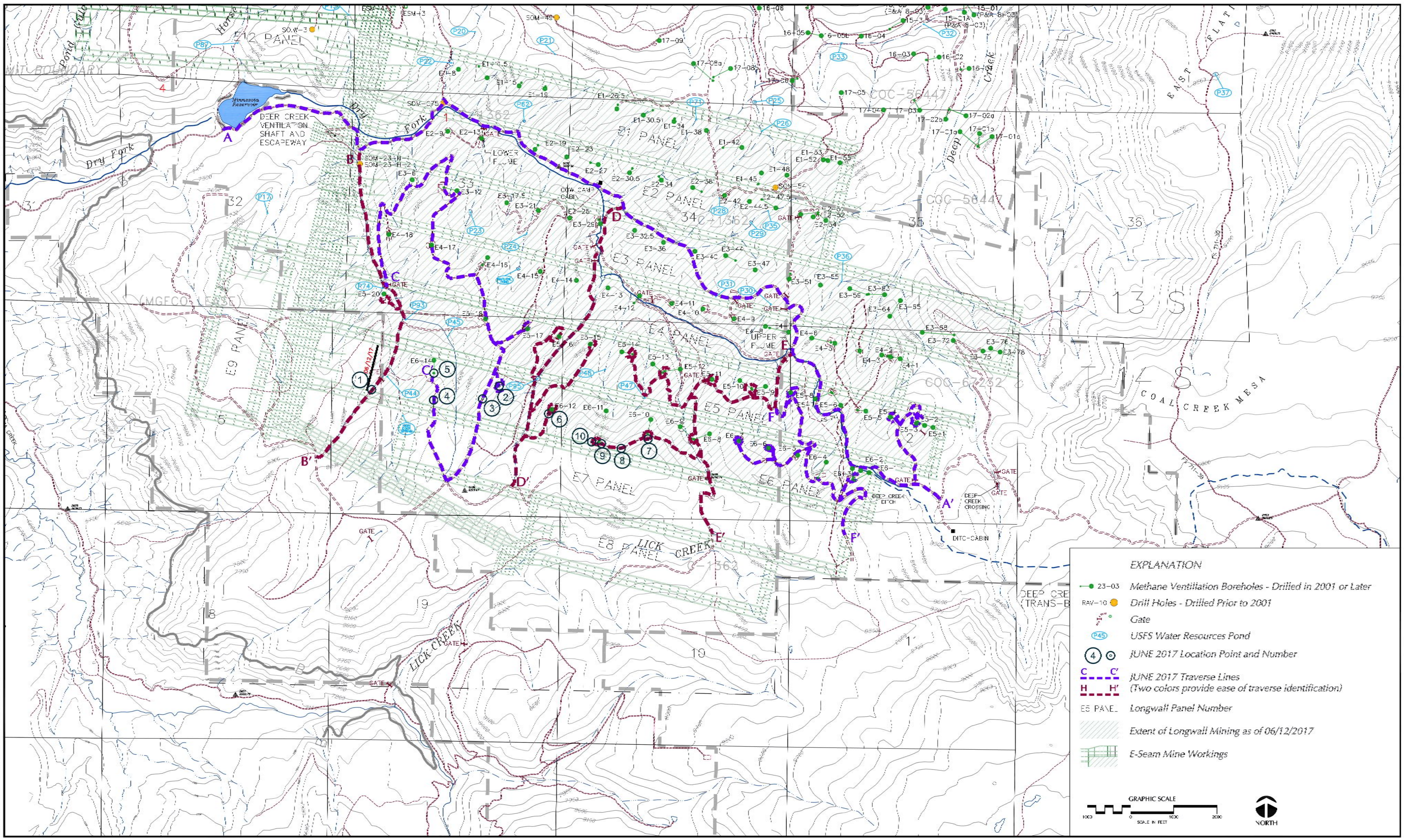
NAD_1983_UTM_Zone_13N

RAVEN RIDGE RESOURCES INCORPORATED

Exploration & Development Of Natural Resources

584 25 Road - Grand Junction, Colorado 81505
(970) 245-4088 - FAX (970) 245-2514

Exhibit 1



Plot Date/Time: 08/28/2017, 08:47:12 AM; Z:\PROJECT FILES\72-99\831-032\831-032.799\CAD-GIS\CAD\SPRING 2017\BASE-2017 SPRING.DWG-SOUTH OF DIVIDE (22X34)

WWE WRIGHT WATER ENGINEERS, INC.
2490 W. 26TH AVE. SUITE 100A
DENVER, CO 80211
(303)480-1700 FAX(303)480-1020

MOUNTAIN COAL COMPANY WEST ELK MINE

LOCATIONS OF OBSERVATIONS IN THE SOUTH OF DIVIDE AND DRY FORK MINING AREAS - JUNE 2017

DESIGN SDD
DETAIL JKG
CHECK CSD
DATE 08/01/2017
SCALE 1"=1320'

PROJECT NUMBER	DATE	MAP
831-032.799	06/17	1

Exhibit 2

WEST ELK MINE GOB GAS GATHERING SYSTEM COSTS

WEST ELK MINE								
"E" Seam Gathering								
Description								
MATERIAL	Quantity	Units	Unit Cost	Total cost		Category Totals	Comments .	
				8"	10"			
10" SDR 11	46,072	ft	16		737,152		Pricing has increase **4** fold on Poly pipe	
10" SDR 11- Winter temp	6,000		16		96,000			
6" SDR 11	188,218		5	941,090				
Valves	1 Lot		50,000	50,000			these valves are$200-500 each	
12" plg traps	1 Lot		60,000		60,000		Need more explanation; so left it alone	
				991,090	893,152			
Total Materials						1,884,242		
INSTALLATION								
10" SDR 11 (Per Petty Quote)	46072	ft	23		1,059,656			
10" Poly -Temp top of ground	6000	ft	20		120,000		Roustabout to set and hookup in one day	
6" SDR 11 (per Petty quote)	188,218		10	1,882,180			This is low pressure only for collapse resistance	
Pig Traps	3	each	35,000		105,000			
				1,882,180	1,284,656			
Total Installation						3,166,836		
PROJECT MANAGEMENT								
Engineering								
Coordination & Inspection	120		1,000	120,000				
Contingenecy 10%				517,108			% tangible	33.1%
Total Project Management						637,108	% intangible	66.9%
TOTAL GATHERING COST						**$ 5,688,185.80**		
Total costs for 6" Pipe	3,191,824							
Cost per foot	16.96							
Total costs for 10" Pipe	2,496,362							
Cost per foot	47.94							

Exhibit 2

WEST ELK MINE GOB GAS GATHERING SYSTEM COSTS

WEST ELK MINE						
MDW WELLHEADS						
Description						
MATERIAL	Quantity	Units	Unit Cost	Total cost	Category Totals	Comments .
Exhauster	owned	1		0		
Relief Valve	1 Lot			5,000		
Separator	1 Lot			10,000		
Water tank-Heater	1 Lot			10,000		
Screw Compressor	1 Lot			20,000		Plan to lease with maintanence agreement
Fuel Conditioning System	1 Lot			15,000		
Meter Run Skid	1 Lot			10,000		
Methanol Injection	1 Lot			5,000		
BTU Monitoring	1 Lot			5,000		
Sat Communications	1 Lot			10,000		
Misc Valves, Fittings	1 Lot			5,000		
Total Materials				95000	95,000	
INSTALLATION						
Exhauster	owned			0		
Screw Compressor	1					Roustabout to set and hookup in one day
Wellhead Equipment	1			5,000		This is low pressure only for collapse resistar
Total Installation				5000	5,000	
PROJECT MANAGEMENT						
Engineering						
Coordination & Inspection	5			10,000		
Contingenecy 10%				13,500		
Total Project Management					23,500	
TOTAL COST PER WELL					**123,500**	
Number of wells	5				**$ 617,500.00**	**Total**

Exhibit 2

WEST ELK MINE GOB GAS GATHERING SYSTEM COSTS

WEST ELK MINE O&M							
Control System							
Description	Quanity		Unit Cost	Total cost	Sub- Totals	Annual Category Totals	Comments .
MATERIAL							
Chromatograph	1 Lot		75,000	75,000			
Control Valves	1 Lot		75,000	75,000			
Alarm Callout System	1 Lot		15,000	15,000			
SCADA System	1 Lot		50,000	50,000			
Gen Dehydrator	1 Lot		40,000	40,000			
Total Material			Monthly Rental			255,000	
INSTALLATION							
Chromatagraph	1 Lot		25,000	25,000			
Control Valves/Flare	1 Lot		50,000	50,000			
Gen Dehydrator	1 Lot		25,000	25,000			
SCADA / Alarm System	1 Lot		50,000	50,000			
TOTAL INSTALLATION						150,000	
TOTAL Control System Costs						**$ 405,000.00**	

Exhibit 2

WEST ELK MINE GOB GAS GATHERING SYSTEM COSTS

WEST ELK MINE O&M							
Basic Gathering System							
"E" Seam							
LABOR	Quantity	Unit Cost	w/30% Load	Total cost	Sub- Totals	Annual Category Totals	Comments .
Supervisor	0	100,000		100,000	0		
I&E Tech	1	80,000		80,000	80,000		
Mechanic / Operator	1	0		0	0		3 operators for 8 wells is more than a enough
Trucks (Field Operators)	1	18,000		54,000	18,000		vehicle, leasing, insurance, maintanence, fuel, etc
Annual Operating Total						98,000	
Methanol	50,000		3	150,000		150,000	
Compression			Monthly Rental				
Working Screw Type	6	400 Hp	3,000	18,000		18,000	
Sealed Screws	2	400 Hp	3,000	6,000		6,000	
Winter Operations							
Move Screw Compressors	11	12,500				0	
Move 10" temp poly							
Measurement/Scada	# of Meters	Cost/yr/Meter	Annual Sub				
Working ScreCompressors	5	10,000	50,000				
Sealed Screws	2	10,000	20,000				
System	2	10,000	20,000				
Total Measurement Costs						90,000	
							Office expense with 2 clerical personnel
Total Project Management							
TOTAL Annual Costs						**$ 362,000.00**	

Exhibit 3

BUDGETARY PROPOSAL

HIGH TEMPERATURE COMBUSTOR

PROJECT NAME	HTF COMBUSTOR
CLIENT	RAVEN RIDGE RESOURCES, INCORPORATED
CLIENT LOCATION	USA
SALES CONTACT	NED SOUTHWICK REGIONAL SALES MANAGER - ROCKIES & BAKKEN ERIE COLORADO OFFICE +1 502.357.0118 | MOBILE +1 502.727.9350 | AEREON.COM NSOUTHWICK@AEREON.COM
TECHNICAL CONTACT	PHANINDRA KONDAGARI OFFICE +1 512.836.9473 x 172 PKONDAGARI@AEREON.COM
QUOTE NUMBER	17-10397 REV 0
DATE:	September 29, 2017

Exhibit 3

1.0 TECHNICAL AND COMMERCIAL SUMMARY

1.1 TECHNICAL SUMMARY

ABUTEC HTF COMBUSTOR

THE HIGH TEMPERATURE FLARE (HTF) IS OUR CONTROLLABLE COMBUSTOR LINE THAT OFFERS UP TO 99.9% DESTRUCTION EFFICIENCY, ALONG WITH A COMPLETELY ENCLOSED FLAME. MANUFACTURED IN THE UNITED STATES, THIS UNIT HAS BEEN INSTALLED AT OVER 100 SITES INTERNATIONALLY AND HAS BEEN SUCCESSFULLY PROVEN THROUGHOUT THE OIL-AND-GAS MARKET. PLEASE SEE BELOW FOR A DETAIL BREAKDOWN ON THIS COMBUSTOR UNIT:

ITEM	QTY	DESCRIPTION	PRICE
		HTF 18.0 COMBUSTOR	

1	1	COMBUSTION CHAMBER:
		• ~8.50 FEET OUTER DIAMETER CHAMBER
		• ~ 40 FT OVERALL HEIGHT (INCLUDES BASE FRAME)
		• (3) TYPE K THERMOCOUPLE WITH THERMOWELLS FOR TEMPERATURE INDICATION AND CONTROL
		• SETS OF COMBUSTION AIR LOUVERS WITH MOTORIZED ACTUATORS
		• 3" THICK CERAMIC FIBER INSULATION FOR THE COMPLETE COMBUSTION CHAMBER
		• DESIGN PRESSURE = AMBIENT
		• MATERIAL OF CONSTRUCTION
		  • FLARE STACK ENCLOSURE: 304 STAINLESS STEEL
		  • BASE FRAME / STAND: PAINTED CARBON STEEL
		• INCLUDES PURGE AIR BLOWER (UNCLASSIFIED)	

2	1	INTERNAL MULTI-NOZZLE BURNER ASSEMBLY: • HIGH SMOKELESS TURNDOWN OF PROPOSED WASTE GAS • INTERNAL BURNER CIRCLES WITH MULTIPLE PROPRIETARY DESIGN NOZZLES AND MIXING TUBES • 8 INCH FLANGED INLET LINE (WASTE GAS) • FLANGED INLET LINE (ASSIST GAS) • 304 STAINLESS STEEL PIPING • BURNER MATERIAL: 316 / 304 STAINLESS STEEL OR EQUIVALENT	
3	1	8 INCH DETONATION ARRESTOR: • PROTEGO OR EQUAL BRAND • CARBON STEEL CONSTRUCTION W/ STAINLESS STEEL TRIM	
4	1	8 INCH ACTUATED BUTTERFLY VALVE: • TRIPLE OFFSET VALVE DESIGN • PNEUMATICALLY ACTUATED • CARBON STEEL BODY AND SST TRIM • LUG OR WAFER DESIGN • SHIPPED LOOSE	
5	1	4 INCH PRESSURE REGULATOR (KIMRAY OR EQUAL)	
6	2	PILOTS AND IGNITION SYSTEMS: • IGNITION TRANSFORMER	

Exhibit 3

- IGNITION ELECTRODE
- PILOT DETECTION VIA IN-BUILT UV SCANNER

7	1	PILOT GAS VALVE TRAIN CONSISTING OF: • VALVE TRAIN SHALL BE ½” • CARBON STEEL PIPING, THREADED COMPONENTS AND FITTINGS • QTY (1) MANUAL SHUT-OFF VALVE (BALL VALVE) • QTY (1) AUTOMATIC SHUT-OFF VALVE (SOLENOID VALVE) • QTY (1) STRAINER • QTY (1) PRESSURE GAUGE • QTY (1) BALL VALVE • QTY (1) PRESSURE REGULATOR
8	1	AUTOMATIC CONTROL SYSTEM FOR FLARE OPERATION MONITORING: • FULLY INTEGRATED CONTROL PANEL/CABINET (NEMA 4X 316SS CONTROLS ENCLOSURE) • ALLEN-BRADLEY 1769 COMPACTLOGIX PLC SYSTEM • TOUCHSCREEN HMI
9	1	DRAWING AND DOCUMENTATION PACKAGES: • OPERATING AND MAINTENANCE INSTRUCTIONS • PIPING & INSTRUMENTATION DRAWING • GENERAL ARRANGEMENT DRAWING • CONTROL PHILOSOPHY • ELECTRICAL/ CONTROL PANEL DRAWINGS • SPARE PARTS LIST
		OPTIONS
10	1	LADDER AND PLATFORMS: • ALLOWS ACCESS TO ALL TEMPERATURE MONITORS AND SAMPLE PORTS • FOLLOWS OSHA GUIDELINES • CARBON STEEL CONSTRUCTION, GALVANIZED

Exhibit 3

1.2 COMMERCIAL SUMMARY

1.21 PRICE SUMMARY

BASE SCOPE		
ITEMS	**QTY**	**PRICE**
ABUTEC HIGH TEMPERATURE FLARE SYSTEM	1	TBD
TOTAL FOR ABOVE ITEMS IN BASE SCOPE (EX-WORKS BASIS):		**$ 328,000.00**
OPTIONAL ITEMS		
ITEMS	**QTY**	**PRICE**
LADDER AND PLATFORMS	1	$ 17,230.00

1.22 VALIDITY

THE PRICES IN THIS QUOTATION ARE BUDGETARY.

1.23 DELIVERY

APPROVAL DRAWINGS SUBMITTALS:	**3 WEEKS AFTER ACCEPTANCE OF FIRM PO**
CLIENT REVIEW PERIOD:	AS REQUIRED, BUT NOT TO EXCEED 2 WEEKS
FABRICATION PERIOD:	**17 WEEKS AFTER RECEIPT OF APPROVED DRAWINGS**
TOTAL DELIVERY TIME:	**20 WEEKS AFTER ACCEPTANCE OF FIRM PO + CLIENT REVIEW**

* THE QUOTED DELIVERY IS BASED UPON OUR CURRENT PRODUCTION SCHEDULE / SHOP LOAD. AN UPDATED DELIVERY SCHEDULE WILL BE AVAILABLE AT TIME OF ORDER.

Exhibit 3

1.24 SHIPPING TERMS

☒ EX-WORKS: POINT OF MANUFACTURE

1.25 PACKING AND SHIPPING PREPARATION

EXPORT PACKING AND CRATING WHEN QUOTED AS AN OPTION ONLY INCLUDES TECHNOLOGY ITEMS AND DOES NOT INCLUDE STACKS, VESSELS, SKIDS, LADDERS AND PLATFORMS, OR UTILITY PIPING.

☒ INLAND FREIGHT PACKING

1.26 TERMS OF PAYMENT

PAYMENT TERMS SHALL BE FINALIZED AND ARE CURRENTLY UNDER NEGOTIATION.

1.27 INSTALLATION - COMMISSIONING

	DOMESTIC **
DAILY LABOR RATE	$1,400.00
TRAVEL RATE	$1,400.00
OVERTIME RATE	$200.00/HOUR
TRAVEL EXPENSES	COST + 20%
STANDARD WORK DAY	8-HOUR DAY

**DAILY RATE INCLUDES ACCOMMODATIONS, GENERAL EXPENSES, SUBSISTENCE, TOLLS, & LOCAL TRANSPORTATION

1.28 SPARE PARTS LIST

CONTROL SYSTEM	
PART	QUANTITY
HIGH TEMP STACK THERMOCOUPLE	1
IGNITION TRANSFORMER	1

Exhibit 3

2.0 TECHNICAL SUMMARY

2.1 DESIGN CONDITIONS

PROCESS DATA

GAS COMPOSITION	56.9% CH_4 and 43.1% AIR
MAX FLOW RATE	2.86 MMSCFD
RATED HEAT RELEASE PER HTF UNIT:	62 MMBTU/HR
INLET TEMPERATURE:	100°F MAX
INLET PRESSURE:	30 PSIG
RETENTION TIME:	MINIMUM 0.3 SEC
DESTRUCTION RATE EFFICIENCY:	99.9% DRE
OPERATING TEMPERATURE:	UP TO 1,800 °F
NOX EMISSIONS REQUIREMENT:	0.15 LBS/MMBTU
CO EMISSIONS REQUIREMENT:	0.2755 LBS/MMBTU

2.2 SITE CONDITIONS

AMBIENT TEMPERATURE:	30 – 100 °F
WIND SPEED FOR STRUCTURAL CALCULATIONS:	TBD
SEISMIC CLASSIFICATION:	TBD
ELEVATION (ABOVE MEAN SEA LEVEL):	TBD

2.3 UTILITIES

PILOT GAS:	IF NATURAL GAS IS USED: 65 SCFH @ 10 PSIG (PER IGNITOR)
ELECTRICAL:	1 PHASE, 60 HZ, 120VAC
ELECTRICAL AREA CLASSIFICATION	CLASS 1 DIV. 2
INSTRUMENT AIR:	N/A

Exhibit 3

2.4 DOCUMENTATION

FLARE INDUSTRIES WILL PROVIDE THE FOLLOWING DOCUMENTATION ALONG WITH THE EQUIPMENT ON THIS PROJECT:

- ☒ PIPING AND INSTRUMENTATION DIAGRAM (P&ID)
- ☒ MECHANICAL GENERAL ARRANGEMENT
- ☒ LADDER LOGIC DIAGRAMS
- ☒ CONTROL ENCLOSURES DRAWINGS
- ☒ OPERATING & MAINTENANCE MANUALS (UPON SHIPMENT)
- ☒ MANUFACTURING RECORD BOOKS (MRB)

2.5 QUALITY / NON-DESTRUCTIVE TESTING

- ☒ VISUAL INSPECTION
- ☒ DIMENSIONAL CHECK
- ☒ FACTORY ACCEPTANCE TEST: *IGNITION SYSTEM ONLY*
- ☒ DRY FILM THICKNESS: *PAINTED CARBON STEEL COMPONENTS ONLY*
- ☐ RADIOGRAPHY EXTENT: 100% FOR BUTT WELDS FOR PRODUCT CARRYING PIPE
- ☐ DYE PENETRANT EXAMINATION EXTENT: FILLET WELDS FOR PRODUCT CARRYING COMPONENTS
- ☐ ULTRASONIC TESTING EXTENT:
- ☐ MAGNETIC PARTICLE EXAMINATION EXTENT:
- ☐ HYDRO-TESTING EXTENT:
- ☒ PNEUMATIC TESTING EXTENT: ASME B31.3 ALLOWS PNEUMATIC TESTING AND THIS IS WHAT WE WILL PERFORM SINCE INTRODUCING WATER IN TO ASSEMBLED INSTRUMENTS AND VALVES IS NOT ADVISABLE. THUS PNEUMATIC TESTING SHALL BE CONSIDERED IN LIEU OF HYDROTESTING
- ☐ HARDNESS/IMPACT TESTING
- ☐ PMI

Exhibit 3

2.6 EXCLUSION LIST

THIS PROPOSAL IS OFFERED IN ACCORDANCE WITH THE BELOW TECHNICAL EXCLUSIONS. THESE ITEMS CAN BE INCLUDED IN OUR SCOPE OF WORK UPON CLIENT REQUEST, SUBJECT TO PRICE AND DELIVERY IMPACT.

CLARIFICATIONS

TECHNICAL EXCLUSIONS

1. CIVIL AND FOUNDATION DESIGN FOR ANY EQUIPMENT INCLUDING DEAD MEN, ANCHOR BOLTS OR NUTS, DESIGN OF ANCHOR BOLT LENGTH OR PROJECTION AS THIS IS PART OF CIVIL ENGINEERING FOUNDATION DESIGN.
2. THIS DESIGN IS EXCLUSIVE OF ALL EXTERNAL LOADINGS DUE TO UPSTREAM PIPING. WIND, SEISMIC AND TEMPERATURE LOADINGS HAVE BEEN CONSIDERED. ALLOWABLE NOZZLE LOADS OTHER THAN THOSE PUBLISHED BY API-537 ARE NOT CONSIDERED.
3. BOLT KITS AT BATTERY LIMIT FLANGED CONNECTIONS.
4. SUPPLY TO CUSTOMER OF SHOP DETAILS, FABRICATION DRAWINGS OR PROPRIETARY CALCULATIONS
5. INSTALLATION OF EQUIPMENT INCLUDING SUPPLY OF CRANES AND/OR PERSONNEL. GENERAL INSTALLATION INSTRUCTIONS AND ASSEMBLY DRAWINGS WILL BE PROVIDED, HOWEVER, DETAILED ERECTION INSTRUCTIONS AND DRAWINGS ARE EXCLUDED. THESE INSTRUCTIONS ARE MEANT TO PROVIDE GUIDANCE AND GENERAL STEPS TO COMPLETE THE INSTALLATION. THESE PROCEDURES ARE NOT INTENDED TO BE A SUBSTITUTE FOR EXPERIENCED INSTALLATION PERSONNEL. FIELD ASSEMBLY AND ERECTION OF THE FLARE IS OUTSIDE THE SCOPE OF WORK TO BE PROVIDED BY FLARE INDUSTRIES AND IS THE SOLE RESPONSIBILITY OF OTHERS. IT IS UNDERSTOOD THAT THE FIELD CONTRACTOR RETAINED FOR THIS PURPOSE IS FAMILIAR WITH THE ASSEMBLY AND ERECTION OF TALL TOWERS.
6. **ALL INTERCONNECTING PIPING, WIRE, AND CONDUIT BETWEEN EQUIPMENT WITHIN THE SKID LIMITS WILL BE THE VENDOR RESPONSIBILITY. ALL PIPING, WIRE, AND CONDUIT LEAVING THE SKID WILL BE THE OWNER'S RESPONSIBILITY. PLEASE NOTE THAT ITEMS WILL BE IN OUR SCOPE WITH RESPECT TO VBU SKID LIMITS AND HTF SKID LIMITS. ITEMS LEAVING THESE SKIDS SHALL BE BY OTHERS (INCLUDING ITEMS BETWEEN VBU AND HTF).**
7. THE IGNITION SYSTEM / CONTROL PANEL / PILOTS AND RELATED VALVE TRAINS ARE A FLARE INDUSTRIES' STANDARD PACKAGE. AS SUCH, THEY ARE DESIGNED AND/OR MANUFACTURED ACCORDING TO OUR STANDARDS AND PROCEDURES, USING OUR STANDARD COMPONENTS. ALL VALVE TRAIN COMPONENTS HAVE THE FOLLOWING CHARACTERISTICS: ½ TO ¾ INCH DIAMETER, THREADED FITTINGS, CARBON STEEL CONSTRUCTION. NO OTHER MATERIALS, DIAMETERS, FLANGE RATINGS, PIPING SPECIFICATIONS, OR ADDITIONAL MATERIALS OR INSTRUMENTATION ARE INCLUDED, NOR DO ANY CLIENT SUPPLIED SPECIFICATIONS APPLY, UNLESS SPECIFICALLY AGREED TO IN WRITING BY FLARE INDUSTRIES.
8. DISPERSION CALCULATIONS, NOZZLE LOAD CALCULATIONS, FINITE ELEMENT ANALYSIS OR OTHER STRESS ANALYSIS, APART FROM STRUCTURAL CALCULATIONS OF THE STACK.
9. NACE COMPLIANT CARBON STEEL IS NOT INCLUDED, UNLESS SPECIFICALLY MENTIONED UNDER THE SCOPE OF WORK SECTION OF THE PROPOSAL.
10. IF NACE COMPLIANT CARBON STEEL IS PROPOSED, MATERIALS WHICH EXCEED THE REQUIREMENTS OF NACE MR-01-75 ARE NOT CONSIDERED.
11. PASSIVATION OR PICKLING OF STAINLESS STEEL MATERIALS OR PROCEDURE, POST WELD HEAT TREATMENT, PROCEDURES, OR ASSOCIATED CHARTS.

Exhibit 3

12. ANY TESTING OR PROCEDURES NOT MARKED AS INCLUDED IN THE QUALITY / TESTING SECTION OF PROPOSAL.
13. AEREON OR ABUTEC STANDARD WELD PROCEDURES APPLY TO OUR EQUIPMENT, UNLESS OTHERWISE STATED IN OUR PROPOSAL. ANY REQUEST TO ALTER OR MODIFY OUR CURRENT WELD PROCEDURES BASED UPON CLIENTS' INTERNAL SPECIFICATIONS IS CURRENTLY EXCLUDED FROM OUR SCOPE OF SUPPLY. IF NEW PROCEDURES ARE REQUESTED BY THE CLIENT, PRICE AND DELIVERY IMPACT WILL APPLY.
14. HYDRO-TESTING OR PROCEDURES OF ANY PIECE OF EQUIPMENT OTHER THAN STAMPED ASME PRESSURE VESSELS, UNLESS SPECIFICALLY INDICATED IN THE PROPOSAL.
15. PAINTING OR COATING FOR STAINLESS STEEL, INTERNAL SURFACES OF EQUIPMENT OR GALVANIZED EQUIPMENT.
16. EXTERNAL INSULATION, INSULATION CLIPS OR HEAT TRACING OF ANY KIND. REFRACTORY OR INSULATION IS INCLUDED FOR ENCLOSED COMBUSTION DEVICES.
17. ARMORED CABLE OR CABLE TRAY OF ANY KIND. WE ARE SUPPLYING OUR STANDARD WIRE AND CONDUIT WITHIN OUR BATTERY LIMITS. MATERIAL CERTIFICATION AS PER BSEN 10204, 3.2 (FORMERLY 3.1A AND 3.1C).

Exhibit 3

COMMERCIAL EXCLUSIONS

1. WHEREAS REGARDS STATEMENTS IN CLIENT SPECIFICATIONS OR PURCHASE ORDERS CONCERNING SPECIFICATION ORDER OF PRECEDENCE, PLEASE BE ADVISED THAT FLARE INDUSTRIES' PROPOSAL, INCLUDING ITS INTEGRAL EXCLUSION LIST, PRECEDES AND PRECLUDES ALL OTHER DOCUMENTS OR AGREEMENTS WHETHER WRITTEN OR VERBAL.
2. FREIGHT COSTS AND LOGISTICS WILL BE OFFERED TO OUR CLIENTS AS AN OPTIONAL PRICE OR AS PART OF THE BASE PRICE, BUT NOT AT COST AS THE PHRASE "PREPAY AND ADD" IS SOMETIMES INTERPRETED.
3. FLARE INDUSTRIES STRICTLY PROHIBITS THE USE OR SALE OF OUR EQUIPMENT IN COUNTRIES SANCTIONED BY THE UNITED STATES GOVERNMENT SUCH AS: IRAN, SYRIA, SUDAN, NORTH KOREA, AND CUBA.
4. THIRD PARTY INSPECTION
5. ALL DOCUMENTATION WILL BE SUPPLIED IN ACROBAT PDF FORMAT, NOT WORD, EXCEL, AUTOCAD, OR ANY OTHER FORMAT.
6. PLEASE NOTE THAT DOCUMENTATION AND DRAWING DELIVERY DATES ARE AS STATED IN OUR PROPOSAL, HOWEVER, IF A VDS APPLIES TO THE PROJECT, ALL DELIVERY DATES MUST BE AGREED TO IN WRITING ON A DOCUMENT BY DOCUMENT BASIS.
7. DOCUMENTATION LEGALIZATION COSTS.
8. OUR OPERATING AND MAINTENANCE MANUALS AND QUALITY DOSSIERS WILL BE PROVIDED IN THE ENGLISH LANGUAGE. TRANSLATION OF THE OHM MANUALS IS AVAILABLE AT AN ADDITIONAL COST, HOWEVER, ONLY TEXT GENERATED BY FI WILL BE TRANSLATED. DRAWINGS, CUT SHEETS, DATA SHEETS AND/OR STANDARD DOCUMENTS WILL BE PROVIDED IN ENGLISH.
9. NO FI PRESENCE AT MEETINGS (INCLUDING, BUT NOT LIMITED TO, KICK-OFF MEETINGS, HAZOP MEETINGS, DRAWING REVIEW AND INSPECTION / CERTIFICATION MEETINGS) IS INCLUDED, UNLESS EXPLICITLY MENTIONED IN SECTION 1.3.
10. SPARE PARTS WHEN QUOTED DO NOT INCLUDE CROSS SECTIONAL DRAWINGS, EXPORT PACKING OR FREIGHT.
11. THERE ARE NO BANK GUARANTEES, PERFORMANCE BONDS, OR WARRANTY BONDS INCLUDED IN OUR SCOPE OF SUPPLY OR PRICE. COST FOR THESE REQUIREMENTS WILL BE ADDED ON TO OUR BASE PRICE QUOTED AS OPTIONS. ALL BOND AND/OR BANK GUARANTEE FORMATS, IF APPLICABLE, MUST BE AGREED TO IN WRITING BY FLARE INDUSTRIES.
12. STORAGE OF EQUIPMENT AFTER NOTIFICATION OF READINESS FOR SHIPMENT.

Exhibit 3

3.0 TERMS AND CONDITIONS

OUR PROPOSAL IS BASED UPON FLARE INDUSTRIES' "STANDARD TERMS AND CONDITIONS OF SALE." WE HAVE ATTACHED A COPY FOR YOUR REFERENCE.