MEMORANDUM

FROM: ICF International

TO: Peter Zalzal, Environmental Defense Fund

DATE: April 22, 2016

SUBJECT: Breakeven Analysis for Four Flare Gas Capture Options

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This memorandum documents the technical analysis performed to estimate the natural gas volume required to breakeven on cost for the various flare gas capture options. This memo 1) discusses the background and various constraints to the capture of flare gas, 2) analyzes the various options to overcome these constraints, 3) reviews the cost estimates for the capture options, 4) presents the breakeven flare gas volume analysis, and 5) concludes with remarks on the findings. The memo focuses its analysis on producing oil wells with associated gas flaring.

Background

During the operation of oil wells, associated gas is typically produced along with the oil. Under the right circumstances the associated gas will be captured and routed to the gathering sales line for further processing at a gas plant. The conditions typically required to capture the gas are:

1. The gas must be of sufficient pressure to enter the existing sales line. Sales line pressure for natural gas gathering systems are typically on the order of 50-200 psia.
2. The gas must be of the appropriate quality to enter the sales line. Natural gas saturated with water or higher hydrocarbons requires processing at the wellhead to remove liquids prior to injection into the sales line.
3. Existing gathering infrastructure (i.e. sales pipeline) is typically required to transport the gas.

When one or more of the above conditions are not met the associated gas is typically vented or flared. Due to certain limitations on availability of venting and flaring data from individual wells, this memo focuses on estimating the volume and dollar value of associated gas that needs to be captured to breakeven on the costs to implement specific options to overcome the conditions that limit capture of vent and flare gas.

Options Analyzed to Capture Flare Gas

This memo analyzes the following options for capturing flare gas in upstream oil wells for processing and sales. Some additional detail is provided for each option and the specific technical constraint it overcomes.

1. **Installation of a Booster Compressor on a Low Pressure Well**

For wells with existing gathering pipeline infrastructure but with insufficient pressure at the low pressure separator outlet, associated gas cannot be fed into the sales line.

The installation of a booster compressor at the wellhead can overcome this constraint and provide the adequate pressure required for the gas to be injected into the sales line. This option assumes the gas is relatively dry and requires no wellhead processing for water or natural gas liquids (NGLs).

2. **<u>Installation of a Booster Compressor on a Low Pressure Well with a Joule-Thompson Skid for Treatment</u>**

This option for capturing flare gas is the same as Option #1 except the natural gas is assumed to be saturated with low volumes of natural gas liquids (NGLs). To remove the NGLs from the natural gas, a Joule Thomson skid is the additional wellhead equipment included in the analysis.

3. **<u>Compressed Natural Gas and Tube Truck Transport</u>**

For wells without existing gathering infrastructure the option of compressing the associated natural gas and transporting the gas in tube trucks was analyzed. This is one of the options for addressing flaring at wells otherwise not connected to pipeline infrastructure. The tube truck is used to transport the gas from the well site to either a plant for further processing or an appropriate sales terminal if of sufficient quality.

4. **<u>Compressed Natural Gas and Tube Truck Transport with a Joule-Thompson Skid for Treatment</u>**

This option for capturing flare gas is the same as Option #3 except the natural gas is assumed to be saturated with NGLs. To knock out the NGLs from the natural gas, a Joule Thomson skid is the additional wellhead equipment included in the analysis.

Each of these options is feasible and has been deployed in the field to address flaring.

Cost Data and Assumptions for Flare Gas Capture Options

Below are details regarding the cost data and general assumptions used for each flare gas capture option.

General Assumptions

- To develop the cost analysis the first step is to determine the size of equipment. Given the variation in well flows there are multiple sizes of equipment that can be analyzed in many combinations. To keep the analysis tractable, ICF used an average volume of flare gas that could potentially apply to a large population of wells that vent or flare. BLM provides data on flare gas volumes by lease and the number of wells in each of these leases. Many of the leases have small volumes of flare gas and hence to analyze the cost that are applicable to the vast majority of potential candidates, ICF used the flare gas volume per well at the 25th percentile of the BLM data. Therefore, in each flare gas capture option analyzed in this memo it was assumed that the average flare gas flow rate was 160 Mcf[1]/day as a metric for sizing, i.e., 75% of the wells in the BLM dataset are at or above this volume per well on an average[2]. This value was calculated to be the average flare gas flow rate across Federal,

[1] Thousand cubic feet.

[2] This average was derived by taking the total flare gas volume reported by each lease divided by the total number of wells on that lease. The data does not indicate how many wells within a lease are above or below this average. This could have an impact on how many wells can implement flare gas capture.

Indian, and Mixed land classifications according to the U.S. Bureau of Land Management docket ID BLM-2016-0001, for data in North Dakota and New Mexico in 2013 and 2014[3].

- For each flare gas capture option analyzed, it is assumed that the well operator would not purchase but rather lease the required equipment to capture the flare gas. Cost estimates for leasing are calculated by annualizing capital costs with a discount rate (%), equipment lifetime (years), and an initial capital outlay.
- Discount rates of 3 and 7% were analyzed based on values from the Bureau of Land Management's regulatory impact analysis document[4]. A discount rate of 12% was included in this analysis to provide a sensitivity scenario based on a higher discount rate.
- An equipment lifetime of 10 years was assumed for leasing options based on the Bureau of Land Management's regulatory impact analysis document[4].
- A Natural gas price of $4/Mcf was analyzed based on the Bureau of Land Management's regulatory impact analysis document[4]. Values of $2 and $3/Mcf were also analyzed to determine the sensitivity of breakeven gas volume to varying gas prices.
- Cost mark-ups for General and Administrative expense (15%), Maintenance (20%), and Profit (25%) were assumed based on past experience and judgement.
- For the breakeven analysis, the captured flare gas volume was valued assuming the entire volume was marketable natural gas. In reality some portion of the captured flare gas would yield NGLs and would be sold at a higher condensate price. This memo's economic analysis conservatively values the NGL volume at a natural gas price. It should be noted that the cost analysis does cost out the required equipment (i.e. pressurized storage tankage) to deal with handling of NGLs. It assumes, however, that transport options for NGLs are available, although that may not be case for some wells that vent or flare associated gas.
- An average API separator pressure of 50.5 psia was obtained as the estimate for the suction pressure requirement for compression, both in the low pressure option and the tube truck high compression option.
    - The 50.5 psia estimate was obtained from 2014 data from Subpart W[5] in EPA's Greenhouse Gas Reporting Program (GHGRP) as an average across all reporting wells.
- All dollar figures are in US Dollars (USD).

1. <u>Cost Data and Assumptions - Installation of a Booster Compressor on a Low Pressure Well</u>

To estimate the cost of leasing and installing a booster compressor at a wellhead with insufficient pressure to feed flare gas into the sales line, equipment vendors were consulted in addition to ICF subject matter experts. It was determined that to compress wellhead gas with a flow of 160 Mcf/day up to sales line pressure would require a single booster compressor costing approximately $75,000 with an installation cost of $25,000. A yearly variable fuel cost to run the compressor was determined to be $5,000 / year based on vendor input.

2. <u>Cost Data and Assumptions - Installation of a Booster Compressor on a Low Pressure Well with a Joule-Thompson Skid for Treatment</u>

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[3] File is listed under the "LeaseDist_NM_ND data" supporting documents folder and is named "BLM-2016-0001-0088.xlsx"

[4] Regulatory Impact Analysis for: Revisions to 43 CFR 3100 (Onshore Oil and Gas Leasing) and 43 CFR 3600 (Onshore Oil and Gas Operations). U.S. Bureau of Land Management. January 14th, 2016.

[5] Value estimated from table "W_SUB_BASIN" from Average Pressure data column for the Williston Basin (Basin Number 395). This was chosen to adequately characterize the Bakken Reservoir.

For flare gas capture option # 2, the same cost assumptions in option #1 were analyzed in addition to considering the cost of the Joule-Thompson skid to treat wet gas and a pressurized storage tank to store the accumulated NGLs. Upon consultation with Joule-Thompson skid vendors, it was determined that a single compressor skid with the appropriate associated equipment (e.g. nozzle, scrubber, etc.) would be sufficient to both treat the gas and discharge the gas to the sales line at adequate pressure. Thus to treat and compress wet wellhead gas with a flow of 160 Mcf/day up to sales line pressure (150-200 psia), a single Joule-Thompson skid costing approximately $150,000 with an installation cost of $50,000 was determined to be feasible. An annual variable fuel cost to run the skid was determined to be $10,000 / year based on vendor input. Finally, to store any accumulated NGLs from the treatment of wet gas, a pressurized storage tank was estimated to cost $40,000[6].

3. **<u>Cost Data and Assumptions - Compressed Natural Gas and Tube Truck Transport</u>**

For flare gas capture option # 3, four key costs were considered when determining the costs of compressing dry wellhead gas from a suction pressure of 50.5 psia to a compressed natural gas pressure of 3,600 psia[7]. The costs were specifically for:

a. Trailer[8] – physical apparatus of tubes to store the compressed natural gas.
b. Tractor –vehicle requirement for transporting the trailer assembly filled with natural gas from the well site to either a gas plant or if of sufficient quality to the end user or transmission pipeline.
c. Driver Cost – yearly cost of an individual to transport the tube truck 40 hours a week for 52 weeks.
d. Compression - the equipment required to physically compress the natural gas to a discharge pressure of 3,600 psia.

Upon consultation with a vendor who specializes in leasing CNG tractor/trailers, it was determined that the capital cost of a trailer assembly with three tubes (total capacity approximately 282,000 standard cubic feet) + tractor was $250,000 per trailer. For logistical reasons, it was assumed that a wellsite operator would need to lease a spare trailer assembly. The tube truck vendor quoted a cost of approximately $100,000 for a spare trailer assembly. Thus, at any given point in time there would be one trailer at the well site being filled with gas and the other being used to transport the gas.

For the driver, an hourly rate of $20.4/hr[9] or $42,500/year was assumed based on data from the Bureau of Labor Statistics. Finally, upon consultation with equipment vendors selling compressors able to discharge at 3,600 psia, a capital cost of the compressor was approximated to be $200,000 with an installation cost of $50,000. A yearly variable fuel cost to run the skid was determined to be $15,000 / year based on vendor input

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[6] Based on input from ICF experts for a tank capacity of approximately 200 barrels assuming approximately 30-50 bbls of liquids separate for every million cubic feet of gas processed.

[7] Value based on typical industry standard compressed natural gas pressure.

[8] While the number of tubes stored on a trailer assembly varies, a trailer with 3 tubes was assumed for this memo analysis.

[9] Mean hourly wage or Heavy and Tractor-Trailer Truck Drivers
http://www.bls.gov/oes/current/oes533032.htm

4. **<u>Cost Data and Assumptions - Compressed Natural Gas and Tube Truck Transport with a Joule-Thompson Skid for Treatment</u>**

For flare gas capture option # 4, the same cost assumptions in option #3 were analyzed in addition to considering the cost of the Joule-Thompson skid to treat wet gas and a pressurized storage tank to store the NGLs. At the time of this memo analysis it was determined for this capture option that it was not possible to combine the Joule-Thompson skid and the high pressure discharge requirement of 3,600[10]. Thus, in a two stage process, it was assumed that wet gas would be routed through a Joule-Thompson skid and then another compressor to compress the treated gas to the required 3,600 psia. Essentially this system has two compressors. Similar to capture option #3, two trailers were assumed to be required and costed out as such.

Upon consultation with the same Joule-Thompson skid vendor it was determined that a Joule-Thompson skid with a capital cost of $100,000 would be required with an annual fuel cost of $5,000. The additional high pressure compressor requirement was determined to cost approximately $200,000 with an installation cost of $50,000. A yearly variable cost to run the skid was determined to be $15,000 / year based on vendor input. Finally, to store any accumulated NGLs from the treatment of wet gas, a pressurized storage tank was estimated to cost $40,000[11].

Breakeven Analysis Methodology and Results

For each of the flare gas capture options above, a similar methodology was performed to determine the required breakeven natural gas volume. The following steps describe the methodology followed in the breakeven analysis:

i. A total of 9 scenarios for each capture option were performed representing the permutations across discount rates of 3%, 7%, and 12%, and natural gas prices of $2/Mcf, $3/Mcf, and $4/Mcf.
ii. Capital costs were annualized at the model scenario's discount rate and an equipment lifetime of 10 years.
iii. Annualized capital costs were summed and used to generate the cost estimates for General Administrative (@15%), Maintenance (@20%), and Profit Markup (25%).
iv. All variable operating costs were summed up and combined with the sum total of annualized capital costs with markups. **This value represents the total cost to the operator required to breakeven with the value of flare gas that is captured**.
v. At the model scenario's value of natural gas price, the volume of natural gas (in Mcf) was varied until the revenue[12] from the natural gas volume equaled the total cost to the operator. This volume represents the breakeven volume of flare gas that needs to be captured to offset the investment.
vi. This analysis evaluated the breakeven values on a volumetric basis rather than per well or per facility basis. Thus, the breakeven volumes of gas represented in the analysis do not necessarily represent volumes from a single well or single well sites, but could be applied more broadly across a number of well sites depending on their relative proximity.

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[10] It may be technically feasible to identify a combined skid that treats wet gas and discharges the gas at 3,600 psia. Doing so may result in an overall capital savings.

[11] Based on input from ICF experts for a tank capacity of approximately 200 barrels assuming approximately 30-50 bbls of liquids separate for every million cubic feet of gas processed.

[12] Defined as the product of natural gas price ($/Mcf) and captured natural gas volume (Mcf).

The breakeven results for each flare gas capture option are outlined in Tables 1 through 4 below.

Table 1 – Breakeven Natural Gas Volumes for Installation of a Booster Compressor on a Low Pressure Well

Scenario Data	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
Equipment Lifetime (yr)	10	10	10	10	10	10	10	10	10
Cost of Capital (%)	3%	3%	3%	7%	7%	7%	12%	12%	12%
Natural Gas Price (thousand $/Mcf)	$2.0	$3.0	$4.0	$2.0	$3.0	$4.0	$2.0	$3.0	$4.0
Cost									
Capital Cost (thousand $)	$75.0	$75.0	$75.0	$75.0	$75.0	$75.0	$75.0	$75.0	$75.0
Installation cost of compressor (thousand $)	$25.0	$25.0	$25.0	$25.0	$25.0	$25.0	$25.0	$25.0	$25.0
Total Cost of Compression (thousand $)	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0
Annualized Cost (thousand $/yr)	$11.7	$11.7	$11.7	$14.2	$14.2	$14.2	$17.7	$17.7	$17.7
Compressor Fuel Cost (thousand $/yr)	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0
Total Costs without Markups (thousand $/y	$16.7	$16.7	$16.7	$19.2	$19.2	$19.2	$22.7	$22.7	$22.7
General G&A (@15%) (thousand $/yr)	$1.8	$1.8	$1.8	$2.1	$2.1	$2.1	$2.7	$2.7	$2.7
Maintenance (@20%) (thousand $/yr)	$2.3	$2.3	$2.3	$2.8	$2.8	$2.8	$3.5	$3.5	$3.5
Profit Markup (@25%) (thousand $/yr)	$2.9	$2.9	$2.9	$3.6	$3.6	$3.6	$4.4	$4.4	$4.4
Total Markups (thousand $/yr)	$7.0	$7.0	$7.0	$8.5	$8.5	$8.5	$10.6	$10.6	$10.6
Total Annualized Costs with Markups (thousand $/yr)	$23.8	$23.8	$23.8	$27.8	$27.8	$27.8	$33.3	$33.3	$33.3
Revenue									
Breakeven Volume of Natural Gas (Mcf/day)	33	22	16	38	25	19	46	30	23
Annual Revenue of Natural Gas (thousand $/year)	$23.8	$23.8	$23.8	$27.8	$27.8	$27.8	$33.3	$33.3	$33.3

Table 2 – Breakeven Natural Gas Volumes for Installation of a Booster Compressor on a Low Pressure Well with a Joule-Thompson Skid for Treatment

Scenario Data	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
Equipment Lifetime (yr)	10	10	10	10	10	10	10	10	10
Cost of Capital (%)	3%	3%	3%	7%	7%	7%	12%	12%	12%
Natural Gas Price ($/Mcf)	$2.0	$3.0	$4.0	$2.0	$3.0	$4.0	$2.0	$3.0	$4.0
Cost									
Combined JT Skid									
Capital Cost (thousand $)	$150	$150	$150	$150	$150	$150	$150	$150	$150
Installation Cost (thousand $)	$50	$50	$50	$50	$50	$50	$50	$50	$50
Total Cost of Compression (thousand $)	$200	$200	$200	$200	$200	$200	$200	$200	$200
Annualized Cost (thousand $/yr)	$23.4	$23.4	$23.4	$28.5	$28.5	$28.5	$35.4	$35.4	$35.4
JT Skid Fuel Cost (thousand $/yr)	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0
Pressurized Tank									
Capital Cost (thousand $)	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0
Annualized Cost (thousand $/yr)	$4.7	$4.7	$4.7	$5.7	$5.7	$5.7	$7.1	$7.1	$7.1
JT Skid + Low Pressure Compression Cost + Pressurized Tank without Mark Ups	$38.1	$38.1	$38.1	$44.2	$44.2	$44.2	$52.5	$52.5	$52.5
General G&A (@15%) (thousand $/yr)	$4.2	$4.2	$4.2	$5.1	$5.1	$5.1	$6.4	$6.4	$6.4
Maintenance (@20%) (thousand $/yr)	$5.6	$5.6	$5.6	$6.8	$6.8	$6.8	$8.5	$8.5	$8.5
Profit Markup (@25%) (thousand $/yr)	$7.0	$7.0	$7.0	$8.5	$8.5	$8.5	$10.6	$10.6	$10.6
Subtotal Costs (thousand $/yr)	$16.9	$16.9	$16.9	$20.5	$20.5	$20.5	$25.5	$25.5	$25.5
Total Annualized Cost with Mark Ups (thousand $/yr)	$55.0	$55.0	$55.0	$64.7	$64.7	$64.7	$78.0	$78.0	$78.0
Revenue									
Breakeven Volume of Natural Gas (Mcf/day)	75	50	38	89	59	44	107	71	53
Annual Revenue of Natural Gas (thousand $/year)	$55.0	$55.0	$55.0	$64.7	$64.7	$64.7	$78.0	$78.0	$78.0

Table 3 – Breakeven Natural Gas Volumes for Compressed Natural Gas and Tube Truck Transport

Scenario Data	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
Equipment Lifetime (yr)	10	10	10	10	10	10	10	10	10
Cost of Capital (%)	3%	3%	3%	7%	7%	7%	12%	12%	12%
Natural Gas Price ($/Mcf)	$2.0	$3.0	$4.0	$2.0	$3.0	$4.0	$2.0	$3.0	$4.0
Cost									
Tractor/Trailer Assembly and Driver									
Cost of Tractor (thousand $)	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0
Annual cost per tractor (thousand $/yr)	$29.0	$29.0	$29.0	$35.2	$35.2	$35.2	$43.7	$43.7	$43.7
Driver cost per hour (thousand $/hr)	$20.4	$20.4	$20.4	$20.4	$20.4	$20.4	$20.4	$20.4	$20.4
Driver cost per year (thousand $/yr)	$42.5	$42.5	$42.5	$42.5	$42.5	$42.5	$42.5	$42.5	$42.5
Extra Trailer									
Cost of trailer with Pipe Storage (thousand $)	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0
Annual cost of two trailers (thousand $/yr)	$11.7	$11.7	$11.7	$14.2	$14.2	$14.2	$17.7	$17.7	$17.7
Compression									
Capital cost of compressors (thousand $)	$200.0	$200.0	$200.0	$200.0	$200.0	$200.0	$200.0	$200.0	$200.0
Installation cost of compressor (thousand $)	$50.0	$50.0	$50.0	$50.0	$50.0	$50.0	$50.0	$50.0	$50.0
Total Compressor Cost (thousand $)	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0
Compressor Fuel Cost (thousand $/yr)	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0
Annualized Costs									
Compressor Cost (thousand $/yr)	$29.3	$29.3	$29.3	$35.6	$35.6	$35.6	$44.2	$44.2	$44.2
Driver Cost (thousand $/yr)	$42.5	$42.5	$42.5	$42.5	$42.5	$42.5	$42.5	$42.5	$42.5
Tractor/Trailer Cost (thousand $/yr)	$29.0	$29.0	$29.0	$35.2	$35.2	$35.2	$43.7	$43.7	$43.7
Spare Trailer Cost (thousand $/yr)	$11.7	$11.7	$11.7	$14.2	$14.2	$14.2	$17.7	$17.7	$17.7
Total Annualized Cost without Mark Ups	$112.5	$112.5	$112.5	$127.5	$127.5	$127.5	$148.2	$148.2	$148.2
General G&A (@15%) (thousand $/yr)	$16.9	$16.9	$16.9	$19.1	$19.1	$19.1	$22.2	$22.2	$22.2
Maintenance (@20%) (thousand $/yr)	$22.5	$22.5	$22.5	$25.5	$25.5	$25.5	$29.6	$29.6	$29.6
Profit Markup (@25%) (thousand $/yr)	$28.1	$28.1	$28.1	$31.9	$31.9	$31.9	$37.0	$37.0	$37.0
Subtotal Costs (thousand $/yr)	$67.5	$67.5	$67.5	$76.5	$76.5	$76.5	$88.9	$88.9	$88.9
Total Annualized Cost with Mark Ups + Compressor O&M (thousand $/yr)	$195.0	$195.0	$195.0	$219.0	$219.0	$219.0	$252.0	$252.0	$252.0
Revenue									
Breakeven Volume of Natural Gas (Mcf/day)	267	178	134	300	200	150	345	230	173
Annual Revenue of Natural Gas (thousand $/yr)	$195.0	$195.0	$195.0	$219.0	$219.0	$219.0	$252.0	$252.0	$252.0

Table 4 – Breakeven Natural Gas Volumes for Compressed Natural Gas and Tube Truck Transport with a Joule-Thompson Skid for Treatment

Scenario Data	S1	S2	S3	S4	S5	S6	S7	S8	S9
Equipment Lifetime (yr)	10	10	10	10	10	10	10	10	10
Cost of Capital (%)	3%	3%	3%	7%	7%	7%	12%	12%	12%
Natural Gas Price ($/Mcf)	$2.0	$3.0	$4.0	$2.0	$3.0	$4.0	$2.0	$3.0	$4.0
Cost									
JT Skid									
Capital Cost (thousand $)	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0
Annualized Cost (thousand $/year)	$11.7	$11.7	$11.7	$14.2	$14.2	$14.2	$17.7	$17.7	$17.7
JT Skid Fuel Cost (thousand $/year)	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0
Total Cost (thousand $/yr)	$16.7	$16.7	$16.7	$19.2	$19.2	$19.2	$22.7	$22.7	$22.7
Pressurized Tank									
Capital Cost (thousand $)	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0
Annualized Cost (thousand $/yr)	$4.7	$4.7	$4.7	$5.7	$5.7	$5.7	$7.1	$7.1	$7.1
Tractor/Trailer Assembly and Driver									
Cost of Tractor/Trailer (thousand $)	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0
Annual cost per tractor (thousand $/yr)	$29.3	$29.3	$29.3	$35.6	$35.6	$35.6	$44.2	$44.2	$44.2
Driver cost per hour (thousand $/hr)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Driver Cost per year (thousand $/yr)	$42.4	$42.4	$42.4	$42.4	$42.4	$42.4	$42.4	$42.4	$42.4
Extra Trailer									
Cost of trailer with Pipe Storage (thousand $)	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0
Annual cost of two trailors (thousand $/yr)	$11.7	$11.7	$11.7	$14.2	$14.2	$14.2	$17.7	$17.7	$17.7
Compression									
Capital cost of compressors (thousand $)	$200.0	$200.0	$200.0	$200.0	$200.0	$200.0	$200.0	$200.0	$200.0
Installation cost of compressor (thousand $)	$50.0	$50.0	$50.0	$50.0	$50.0	$50.0	$50.0	$50.0	$50.0
Total Compressor Cost (thousand $)	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0	$250.0
Compressor Fuel Cost (thousand $/yr)	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0
Annualized Costs									
Compressor Cost (thousand $/yr)	$29.3	$29.3	$29.3	$35.6	$35.6	$35.6	$44.2	$44.2	$44.2
Driver Cost (thousand $/yr)	$42.4	$42.4	$42.4	$42.4	$42.4	$42.4	$42.4	$42.4	$42.4
Tractor/Trailer Cost (thousand $/yr)	$29.3	$29.3	$29.3	$35.6	$35.6	$35.6	$44.2	$44.2	$44.2
Spare Trailer Cost (thousand $/yr)	$11.7	$11.7	$11.7	$14.2	$14.2	$14.2	$17.7	$17.7	$17.7
JT Cost (thousand $/yr)	$11.7	$11.7	$11.7	$14.2	$14.2	$14.2	$17.7	$17.7	$17.7
Pressurized Tank (thousand $/yr)	$4.7	$4.7	$4.7	$5.7	$5.7	$5.7	$7.1	$7.1	$7.1
Total Annualized Costs without Mark Ups (thousand $/yr)	$129.2	$129.2	$129.2	$147.8	$147.8	$147.8	$173.4	$173.4	$173.4
General G&A (@15%) (thousand $/yr)	$19.4	$19.4	$19.4	$22.2	$22.2	$22.2	$26.0	$26.0	$26.0
Maintenance (@20%) (thousand $/yr)	$25.8	$25.8	$25.8	$29.6	$29.6	$29.6	$34.7	$34.7	$34.7
Profit Markup (@25%) (thousand $/yr)	$32.3	$32.3	$32.3	$36.9	$36.9	$36.9	$43.4	$43.4	$43.4
Subtotal MarkUp Costs (thousand $/yr)	$77.5	$77.5	$77.5	$88.7	$88.7	$88.7	$104.0	$104.0	$104.0
Total Annualized Cost with Mark Ups + Compressor O&M (thousand $/yr)	$221.7	$221.7	$221.7	$251.5	$251.5	$251.5	$292.4	$292.4	$292.4
Revenue									
Breakeven Volume of Natural Gas (Mcf/day)	304	202	152	344	230	172	401	267	200
Annual Revenue of Natural Gas (thousand $/yr)	$221.7	$221.7	$221.7	$251.5	$251.5	$251.5	$292.4	$292.4	$292.4

Summary

Across the various capture options analyzed in this memo the breakeven natural gas volumes can be summarized as follows.

- Installation of a Booster Compressor on a Low Pressure Well
    - Breakeven volumes between **16 and 46 Mcf/day**
- Installation of a Booster Compressor on a Low Pressure Well with a Joule-Thompson Skid for Treatment
    - Breakeven volumes between **38 and 107 Mcf/day**
- Compressed Natural Gas and Tube Truck Transport
    - Breakeven volumes between **134 and 345 Mcf/day**
- Compressed Natural Gas and Tube Truck Transport with a Joule-Thompson Ski for Treatment
    - Breakeven volumes between **152 and 401 Mcf/day**

It is important to note that the breakeven volumes for captured natural gas are not required to be captured at a single well. Rather the figure represents the volume required to be captured in total to breakeven on the investment costed in this memo. It is possible to capture this volume across multiple wells in the same vicinity. Compared to the 160 Mcf/day flare volume average based on BLM data, some options would likely breakeven when applied to a single well and other options would likely breakeven by capturing gas from multiple wells.