The North Dakota Petroleum Council Study on Bakken Crude Properties

Bakken Crude Characterization Task Force

Prepared for the

NORTH DAKOTA PETROLEUM COUNCIL

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Executive Summary

This report documents the detailed sampling and testing program recently conducted on Bakken crude oil. This program is the most thorough and comprehensive study of crude quality from a tight oil production basin to date.

In the past year, considerable attention has been focused on transportation and quality issues related to Bakken crude oil. As a result of several high profile railcar incidents in the U.S. and Canada, various investigations have been launched by governmental and industry groups to better understand the safety aspects of moving Bakken crude by rail. Questions as to whether Bakken is materially different from other crude oils and if the current railroad materials classification is appropriate have been raised. Investigations are ongoing as to the cause of the railcar accidents and potential hazards to the public associated with crude oil rail movements in general. In response to these concerns, the North Dakota Petroleum Council (NDPC) commissioned a comprehensive sampling and testing program to answer questions regarding the chemical and physical composition of Bakken, issues regarding proper classification and establish a Bakken quality baseline. This program collected samples from seven rail terminals and 15 well sites. The crude producers that provided the well samples account for over 50% of total North Dakota (ND) production, and the rail facilities sampled represent a similar proportion of total ND crude-by-rail capacity. The sampling locations cover the entire producing region and include both "old" and "new" wells, giving a good representation of any property variations that result either from geography, production rate, or during processing and transit. At this time, we are not aware of any field-level crude oil quality assessments as extensive or as controlled as this study in the Bakken or elsewhere.

The NDPC commissioned this program to establish Bakken crude properties (Quality Characterization) and to understand if these properties pose transportation and handling risks unique to Bakken compared to other light crude oils. The results from the study will be used to help establish and maintain a Bakken quality baseline to ensure continued crude quality and consistency. The study was also used to evaluate the impact of field-operating conditions (ambient temperature, tank settling times/production rates, and field equipment operating temperatures and pressures) on Bakken qualities. These study results, together with follow-up efforts, will be used to establish "management best practices" for operating production field equipment to minimize the light ends content and vapor pressure of Bakken crude sent to rail-loading facilities and to meet the proposed quality specifications.

NDPC engaged Turner, Mason & Company (TM&C), an internationally recognized engineering consultancy with over 40 years of experience in the petroleum industry (including a significant background in crude oil quality and processing), to serve as project coordinator. The TM&C team

included engineers with extensive refining and crude characterization/evaluation experience and a chemist with over 40 years of laboratory experience in crude oil analyses who serves as Executive Director of the Crude Oil Quality Association and on the Board of the Canadian Crude Quality Technical Association. Analyses of all primary samples were conducted by SGS, a global leader in testing and inspection with over 135 years in the business. Both the local North Dakota and U.S. Gulf Coast SGS labs participated in the sampling and testing process.

The key findings were as follows:

Quality Characterization

- Bakken crude is a light sweet crude oil with an API gravity generally between 40° and 43° and a sulfur content <0.2 wt.%. As such, it is similar to many other light sweet crude oils produced and transported in the United States.
    - As a point of reference, the Energy Information Administration (EIA) categorizes crude oil that has an API gravity between 35° and 50° and less than 0.3 wt% sulfur as light sweet. Bakken falls in the middle of those ranges for both properties.
- Although testing for sulfur, Total Acid Number (TAN) and other corrosivity-specific testing were outside the scope of this project. Results from other test programs, as summarized below in Table 1, indicate that Bakken has very low sulfur and TAN properties.
- Table 1 compares key Bakken qualities to other important domestic and international crude oils:
    - Note the quality data in Table 1 for crudes other than Bakken came from sources without the extensive controls and systematic sampling procedures used in the NDPC study.

Table 1: Comparison of Crude Properties

Domestic Light Sweet Crudes	**API Gravity**	**Sulfur (wt. %)**	**TAN (mg KOH)**
Bakken (1) (2)	40 to 43*	0.1	< 0.1
WTI (4) (5)	37-42	0.42	0.28
LLS (2) (4)	36-40	0.39	0.4
Eagle Ford (2)	47.7	0.1	0.03
Eagle Ford Light (2)	58.8	0.04	0.02

International Crudes	**API Gravity**	**Sulfur (wt. %)**	**TAN (mg KOH)**
Light Sweet			
Brent (2) (6)	37-39	0.4	< 0.05
Medium			
Arabian Light (2)	33	1.98	< 0.1
Arabian Heavy (2)	27.7	2.99	< 0.1
Heavy			
Western Canadian Select (Heavy Sour) (3)	21.3	3.46	0.93
Dalia (High TAN) (2) (7)	23.1	0.51	1.6

Sources:	
1 - NDPC Study Data	5 - Crude Oil Quality Association
2 – Capline	6 - BP Crude Assay
3 - crudemonitor.ca	7 - ExxonMobil Crude Assay
4 - AFPM Bakken Report, 5/14/2014	* Majority of NDPC samples in this range

- The qualities of Bakken were very consistent within our sample population and throughout the supply chain – from wellhead to rail terminal to refining destination. Test results showed no evidence of "spiking" with Natural Gas Liquids (NGLs) before rail shipment.

- The test results from this study are also consistent with reported results from others, including the American Fuel & Petrochemical Manufacturers (AFPM) Bakken Report, the Pipeline and Hazardous Safety Materials Administration (PHMSA) Operation Safe Delivery Report, NDPC member-gathered data and other recent studies and presentations on the quality of Bakken crude oil.

Table 2: Bakken Quality Comparison, NDPC to AFPM and PHMSA

	NDPC Rail Avg (1)	AFPM Report	PHMSA Report (5)
API Gravity	41.7	42	Not Reported
Vapor Pressure (psi)	11.5	7.83 (2)	12.3
IBP (°F)	100.3	69.6 (3)	87.0
Light Ends (C2-C4s) (Liq. Vol. %)	4.95	3.5-11.9 (4)	4.65 (6)

Comments:

(1) Rail chosen because AFPM samples from Bakken at point of delivery, Rail data from NDPC closest to direct comparison.
(2) AFPM reported RVP, NDPC reported $VPCR_4$ (D6377) at 37.8°C. AFPM also reported $VPCR_4$ done at 50°C, results 13.9-16.7 psi.
(3) 87.3 Median, Multiple tests in AFPM data, some of which can report lower than D86, which skewed average lower.
(4) AFPM report, three respondents average 3.5%, fourth had 12 samples, range 5.9-11.9%.
(5) PHMSA data from Table E, data ranging from 3/17 to 5/2, to maximize overlap with NDPC study data timeframe.
(6) PHMSA does not report isobutane, and C2-C4 results do not appear to include isobutane. By comparison, NDPC C2-C4 without isobutane was 4.37 Liq. Vol. %.

- While the test results from PHMSA's report agreed closely with the NDPC results, PHMSA did make some assertions in their Executive Summary which do not appear to be supported by their study or our findings.

- The PHMSA report makes the statement that, "We conclude that while this product does not demonstrate the characteristics for a flammable gas, corrosive liquid or toxic material, it is more volatile than most other types of crude." No comparative data was provided to support this statement; and, as we note elsewhere in this report, the limited data available on other crudes (that we were able to obtain) would not support that conclusion.

- PHMSA also claims that a higher degree of volatility "correlates to increased ignitability and flammability." Again, no support is provided for this statement in the report. While we are aware that some groups, including API, are studying this very complex subject, we are not aware of any results or conclusions from those studies to date.

- During the time frame of our sampling program, Bakken had an average vapor pressure of between 11.5 and 11.8 psi, which is more than 60% below the vapor pressure threshold limit for liquids under the Hazardous Materials Regulations (43.5 psi).
  - It should be noted that the vapor pressure testing was done using the EPA approved method for crude oils (ASTM D6377), which results in readings about 1 psi higher than if the Reid Vapor Pressure (RVP) test method (ASTM D323) was used.

  - Test data from an NDPC member's rail terminal taken over a seven-month period from August 2013 through March 2014 showed RVP's in the range of 8 to 11 psi; consistent with the NDPC test results when adjusted for seasonality and test method.

  - It is difficult to compare the "typical" vapor pressure of Bakken to other crudes because of the dearth of consistent data (regarding sampling and testing methodologies) for other crudes. Most data show Bakken vapor pressure to be within 2 to 3 psi of other light sweet crudes (some higher, others lower). The AFPM Bakken Report contained the following comparison (versus key crudes), shown below in Table 3. Comparisons from other studies (which are shown later in this report) show similar results.

Table 3: AFPM Bakken Report, Crude Quality Comparison Table

	RVP (psi)	Vol. % Light Ends (C2-C5s)
LLS	4.18	3.0
WTI	5.90	6.1
Alberta Dilbit	7.18	7.30 wt. %
DJ Basin	7.82	8.0
Bakken	7.83	7.2
Eagle Ford	7.95	8.3
Brent	9.33	5.28 wt. %

- The flash point of Bakken is below 73°F, and the Initial Boiling Point (IBP) generally averaged between 95°F and 100°F, both of which are in the normal range for a light crude oil.

- The data supports the current Department of Transportation (DOT) Pipeline and PHMSA classification for Bakken crude as a Class 3 Flammable Liquid (similar to other crude oils, as well as gasoline, ethanol and other materials containing light components).

- As a result, Bakken crude oil meets all specifications for transport using existing DOT-111 tank cars.

- This conclusion is consistent with the recent AFPM Bakken Report, which stated "Bakken crude oil does not pose risks significantly different than other crude oils or other flammable liquids authorized for rail transport. Bakken and other crude oils have been classified as flammable liquids. As noted, Bakken crude poses a lower risk than other flammable liquids authorized for transport by rail in the same specification tank cars."

- Flammable liquids fall into packing groups (PG) depending on their IBP as defined by the ASTM D86 method. The testing performed in this study highlighted the difficulty with using this test method for packing group determination. The results showed significant (10°F+) variability between labs on the same sample.
  - This is because D86 was not developed for *wide boiling range* materials like crude oil, with no specifically defined lab-operating parameters specified. Therefore, different labs used different operating conditions during testing, resulting in a wide variability of values for the IBP.

- Because of the difficulty with achieving consistent IBP results, groups including API are working on recommendations to update the current regulations.
  - Based upon the findings of this study, the NDPC encourages all members to classify their BKN crude as a Class 3 PG I flammable liquid until a more definitive testing protocol is established.

- It is critical to note that the determination of PG I versus PG II has no impact on the type of rail car used or on first responder response to an incident and had no impact on any of the incidents in which Bakken was involved.

- The accuracy and precision of our test program were ratified by a series of round-robin tests between both SGS laboratories (Williston, ND and St. Rose, LA) and a second internationally recognized testing company.
  - The results of the round-robin testing, using identical samples (from four locations) of Bakken (tested at each of the three laboratories) showed excellent agreement on API gravity and vapor pressure.
  - Significant variance did occur in the measured IBP from the D86 testing, as noted earlier.

- A member company conducted a similar round-robin test comparison with samples of Bakken taken from four rail cars. Duplicate samples were sent to SGS and a second laboratory and the results of this testing also showed excellent agreement on API and vapor pressure and significant differences on D86 IBP.

- A series of side-by-side tests were performed using both the standard sealed glass jars (Boston Rounds, used for testing during the study) and Floating Piston Cylinders (FPCs) which have been suggested by some industry groups for testing vapor pressure.
    - Preliminary results proved inconclusive. Results of samples taken from the atmospheric tanks using the glass bottles came back with higher vapor pressure readings than when tested using either glass bottles or FPCs on the pressurized tank discharge.
    - Due to the requirement to sample from a pressurized tap with FPCs, there are difficulties with sampling and finding appropriate sample locations, which restricts where samples can be collected.
    - These initial results, though limited, indicate that sampling with the glass bottles was at least as representative as testing with FPCs for vapor pressure, and allowed for a greater variety of sample locations with greater consistency.

Table 4 below summarizes the results from the sampling and testing program.

- API gravity of Bakken was generally in the low 40's which falls in the range of what is considered a light crude oil.
- Vapor pressure (via ASTM D6377 at 37.8°C/100°F) was in a fairly tight range, averaging between 11.5 and 11.8 psi, with over 90% of well and 100% of rail samples measuring below 13 psi. As noted earlier, D6377 shows readings about 1 psi higher than the RVP test method (ASTM D323).
- D86 IBP showed a range of approximately 15°F on samples. All samples measured as either a PG I or II, with most of the test results close to the 95°F determination threshold. Because of the limitations of the test and variability of test conditions, the exact result varied depending on which laboratory conducted the testing.
- The light ends (C2-C4s) content of Bakken, which averaged just below 5.5 liquid volume %, is generally within 1 or 2% of other light crudes. Comprehensive data comparable to that obtained in this study for the other major Light Tight Oil (LTO) basins is not available. However, the data, which is available, indicates that Bakken light ends content is more consistent; and in many cases, lower than for most of the light crudes and condensates produced in the major LTO basins (including Eagle Ford, Utica, Niobrara and Permian basins).
- It is important to note that the DOT-111 cars used to transport this crude are rated for 100 psig, and the type of car used is the same for both PG I and PG II material transport.

Table 4: NDPC Bakken Crude Sampling Data Summary

Sample Date Range	3/25 to 4/24/2014		
Total (152 Samples)	**Avg**	**Min**	**Max**
API Gravity	41.0	36.7	46.3
Vapor Pressure (psi)	11.7	8.9	14.4
D86 IBP (°F)	99.5 (PG II)	91.9 (PG I)	106.8 (PG II)
Light Ends (C2-C4s)	5.45	3.33	9.30
Rail (49 Samples)	**Avg**	**Min**	**Max**
API Gravity	41.7	39.2	44.0
Vapor Pressure (psi)	11.5	9.6	12.9
D86 IBP (°F)	100.3 (PG II)	96.7 (PG II)	104.1 (PG II)
Light Ends (C2-C4s)	4.95	3.91	6.44
Well (103 Samples)	**Avg**	**Min**	**Max**
API Gravity	40.6	36.7	46.3
Vapor Pressure (psi)	11.8	8.9	14.4
D86 IBP (°F)	99.1 (PG II)	91.9 (PG I)	106.8 (PG II)
Light Ends (C2-C4s)	5.69	3.33	9.30

The results indicate that the well-to-well quality of Bakken is very consistent. Testing across the geographic area showed very limited geographical variation in key properties such as API, vapor pressure and light ends content. Data provided by one of the NDPC member companies (which involved testing over an eight-month period) showed that while there was some seasonality in vapor pressure, it was not significant (3 psi lower in summer months vs. winter months) and it agreed very closely with the AFPM seasonality data. The data was also consistent with the NDPC test results during the period when the sampling overlapped.

Bakken quality, throughout the supply chain in our sample pool, was also consistent. There was no evidence of "spiking" of Bakken crude with NGLs between the well and rail terminals, with rail terminals showing less variation and tighter averages than well-readings. This was expected, given that regional rail facilities receive oil from many wells. Additionally, limited sampling at both the rail terminal and destination refinery showed no significant weathering or off-gassing of light ends in transit.

Operating Conditions/Impact on Bakken Quality

In addition to characterizing the quality of Bakken crude, our study looked at the impact that well site operating conditions have on the quality. These conditions include ambient temperature, production volume flow rates/field tank settling time, vapor capture status and field equipment operating parameters such as separator and treater temperatures and pressures. All of these measurements were recorded during the sampling program and have been correlated to determine how they impact test results. Based on this analysis, we offer the following observations and conclusions:

- The samples were gathered during the spring season (late March to late April) and ambient temperatures varied from a low of 10°F to a high of 65°F (average of about 34°F).

- Vapor pressure will vary by season with lower vapor pressures (lower levels of dissolved light ends) in the hotter summer months and higher vapor pressures (higher levels of dissolved light ends) in the colder winter months. This was confirmed by the member-contributed data referred to earlier in this section (and included later in this report).
- The results during this sampling program were in the intermediate range due to the mid range ambient temperatures experienced during sampling.
- Although the temperature range was limited, vapor pressure levels did correlate with temperatures (consistent with the more extensive member contributed data and the AFPM data), and with higher measured vapor pressure for crude sampled with lower ambient temperatures.

- While the companies operating in the Bakken, which participated in our sampling program, use a variety of well site production equipment and operating conditions (production rates, equipment operating pressures and temperatures) varied across the study, key crude qualities from our study were distributed across a fairly narrow range.
  - The data consistency indicates that field equipment is limited in its ability to significantly impact vapor pressure and light ends content.
  - This is consistent with the expected capabilities of the equipment.
  - The field equipment is designed to separate gas, remove water and break emulsions to prepare crude for transport, and not remove significant levels of dissolved light ends from the crude.
- Despite the limitations of the field equipment, the data did show that the content of some of the lighter components, specifically ethane and propane, was reduced in a measureable way by running the equipment at higher temperatures.
  - The difference between running cold (50°F) and running at close to the maximum practical temperature (150°F) resulted in an average reduction of 0.13 liquid vol. % ethane and 0.25 liquid vol. % propane, and about 0.40 liquid vol. % of total light ends reduction.
  - Total ethane levels were almost universally below 0.20 liquid vol. % (and often closer to 0.10 liquid vol. %) when treaters were run at temperatures above 140°F, compared to levels averaging around 0.30 liquid vol. % (and as high as 0.40%) when temperatures were less than 100°F.
  - It is important to note that true “plant tests” were not conducted where the field equipment temperatures and pressures were varied systematically at individual well sites, but rather results correlated across all samples at all locations.

- Production rates were also obtained at the time of sampling in an effort to determine whether higher flowing wells retained more light ends and had a higher vapor pressure than lower flowing wells where there was more opportunity to "weather" off the light components.
  - The data from the study showed very limited correlation between production rates and vapor pressure.
  - There was also little difference observed in vapor pressure between samples which were obtained from wells which were directly connected to a gathering system (no settling time) versus those which were obtained from stock tanks (where there was an opportunity for settling).
  - As with the analysis of treater conditions impact on crude quality, the fact that this analysis was not done under systematic "plant test" conditions does not confirm that there is not some impact on vapor pressure, but rather that the impact is likely limited.

Conclusions and Recommended Action Steps

- Bakken is a light sweet crude oil with very consistent properties throughout the entire production basin, and the properties measured meet all the requirements of 49 CFR 171-180 for safe transport by rail or truck.

- Based on the results of this study, the NDPC has developed a set of Field Operations Recommended Best Practices. These cover the operation of the field treating equipment, Bakken crude oil quality, testing procedures and shipping classification, and are detailed in Table 5 below:

Table 5: BKN Field Operations Recommended Best Practices

Field Treating Equipment (In an effort to minimize light ends in crude oil presented for market)
• Design and operate all equipment within manufacturers recommended operating limits. • Operate Gas/Liquid Separator (if utilized) at the lowest pressure to accommodate gas sales and fluid delivery to the Emulsion Separator/Heater Treater. • Operate Emulsion Separator/Heater Treater pressure to the lowest operating pressure to safely accommodate gas sales and fluid delivery to the production tank battery. • Maintain all fired treating equipment (Emulsion Heater Treater, etc.) temperature between 90° and 120° F+ year round. • Provide maximum tank settling time possible prior to shipment. • Reduce stock tank pressure to lowest pressure possible to maintain vapor collection equipment (engineered flare, vapor recovery, etc.) operational integrity.

Typical **BKN** * Specifications (ranges reflect expected seasonality)

	Range	Typical
• API Gravity (hydrometer at 60°F)	35° to 45°	42°
• Vapor Pressure (ASTM D6377 @ 100°F)	8 to 15 psi	11.5 psi
• Initial Boiling Point (ASTM D86)	90°F to 105°F	95°F
• Sulfur	<0.3%	0.15%
• H_2S	<10 ppm	<1 ppm
• Light Ends (C2 – C4s)	3% to 9%	5%

***BKN** refers to light sweet crude aggregated at rail and pipeline terminals within the Williston Basin. This crude is predominantly sourced from the Bakken common source of supply, but also includes legacy production from various other producing formations located within the proximity of the Bakken field. **BKN** does not include nonstabilized condensate recovered from wet gas gathering pipelines or from product derived outside the U.S. Williston Basin. Individual well values may be higher or lower than the aggregated values observed at the rail terminals.

Testing Procedures

- Well Site Operators/Purchasers – Prior to each custody transfer or LACT EOM
  - API gravity corrected to 60° F using hydrometer
  - Basic Sediment & Water (BS&W) by field centrifugal grind-out
  - Spot test vapor pressure pending available field testing equipment
- Rail/Pipeline Terminal Operators
  - Test each unit train loading or tank shipment batch
    - API gravity corrected to 60° F using hydrometer
    - BS&W by field centrifugal grind-out
  - Test at least midmonth and EOM
    - ASTM D6377 @100° F vapor pressure using certified laboratory
- DOT PHMSA Hazmat Shipping Category
  - Flammable Liquid Category 3
  - Packing Group I**

** PG I is recommended even though the majority of samples tested for the study would fall within specifications for PG II. The margin of error for the test methodology can result in different labs testing the same sample with values meeting both PGs. PG I has the more stringent standards and is therefore recommended to avoid further confusion.

- Other recommended procedures
  - DO NOT deliver fluid recovered from gas pipe lines (a.k.a. "pigging operations") to crude oil sales system unless processed by stabilization unit capable of lowering vapor pressure below 10 psi at 100° F.
  - DO NOT blend non-Williston Basin crude oils into the BKN common stream.
  - DO NOT blend plant liquids (plant condensates, pentanes, butanes or propane) into the BKN common stream.

Introduction

Bakken crude has been produced for over 60 years, recently passing the one-billion-barrel produced milestone. Bakken is moved by rail, pipeline and truck, and has been for decades. In the last few years, crude-by-rail has increased rapidly as production has topped one million barrels per day, and as such, the opportunities for incidents to occur have increased. Bakken is finding its way to refining markets across the country, including along new routes to the East and West Coasts, increasing rail traffic on those tracks. Recently, several high profile incidents in which Bakken crude was being transported brought public attention on the potential hazards of crude-by-rail. Bakken has had an increased focus recently, in large part due to the disaster in Lac Megantic, Quebec, in July 2013, where 47 persons lost their lives. While human error played a significant role in the cause of the accident, the DOT-111 rail cars involved have been heavily scrutinized. The reality is that no rail car is designed to always withstand the full force of a high-speed derailment; and once containment is breached during such an event, there are countless ignition sources.

Government focus on these accidents has brought up the potential for changing regulations around the transport of Bakken (or other light crudes). The oil and gas industry has been building newer style rail cars since 2011, moving toward replacing the older DOT-111 cars with revised cars that have thicker side shells and other safety improvements. Additionally, regulations imposed since the accident in Quebec have required both increased testing of crudes and notification of routes before shipment. Industry focus is on ensuring that all activities are conducted with a focus on safety, but the industry expresses concerns about additional testing requirements, regulations, or transitions to new transportation or handling methods without a scientific basis that those changes will have a significant safety impact. The industry supports regulations that are implemented through scientific investigation and factual basis, not implemented emotionally. The PHMSA Bakken Blitz study was started for that purpose. While the federal government has been criticized for not moving immediately, they recognized the importance of researching the material, railcars and railcar movements to propose rules that increase overall safety. It is with the focus on maintaining a scientific basis for decisions that this study was commissioned.

The scope of this NDPC study was to perform a comprehensive, controlled sampling of Bakken from a wide range of geographic locations at both individual wells and rail terminals. The controlled sampling ensured the same, consistent sampling techniques were used. Samples were sent to a single laboratory for testing, and thus the same methods and equipment were used. This ensured the data would be more consistent than data aggregated from many member companies, each using different labs and sometimes different test methods.

In addition to the direct sampling of the seven rail terminals and 15 well sites, additional data was collected. In order to evaluate the impact that shipping may have on crude; samples were taken at the rail terminal in Fryburg, ND, as well as upon receipt in St. James, LA. The same rail cars were sampled in both locations, and samples were sent to the same testing provider for analyses. Another set of testing on an individual well was performed to determine laboratory test variability. Samples were taken at the same time, but sent to two different labs: SGS (the primary lab used for this study) and a second internationally recognized lab. This resulted in some variance, primarily around D86 IBP measurements, which are critical for proper PG determination. A third test was performed to compare D86 measurements between two SGS labs. One lab also did testing by varying some of the test parameters around D86 instrument setup. The results highlighted the opportunity for significant variability of results and the limitations of using the D86 test method on crude oil samples, which have wider boiling ranges than the method was intended.

Testing was conducted starting March 25 and continued through April 24, 2014. Through the course of testing, sample data was collected, including the following:

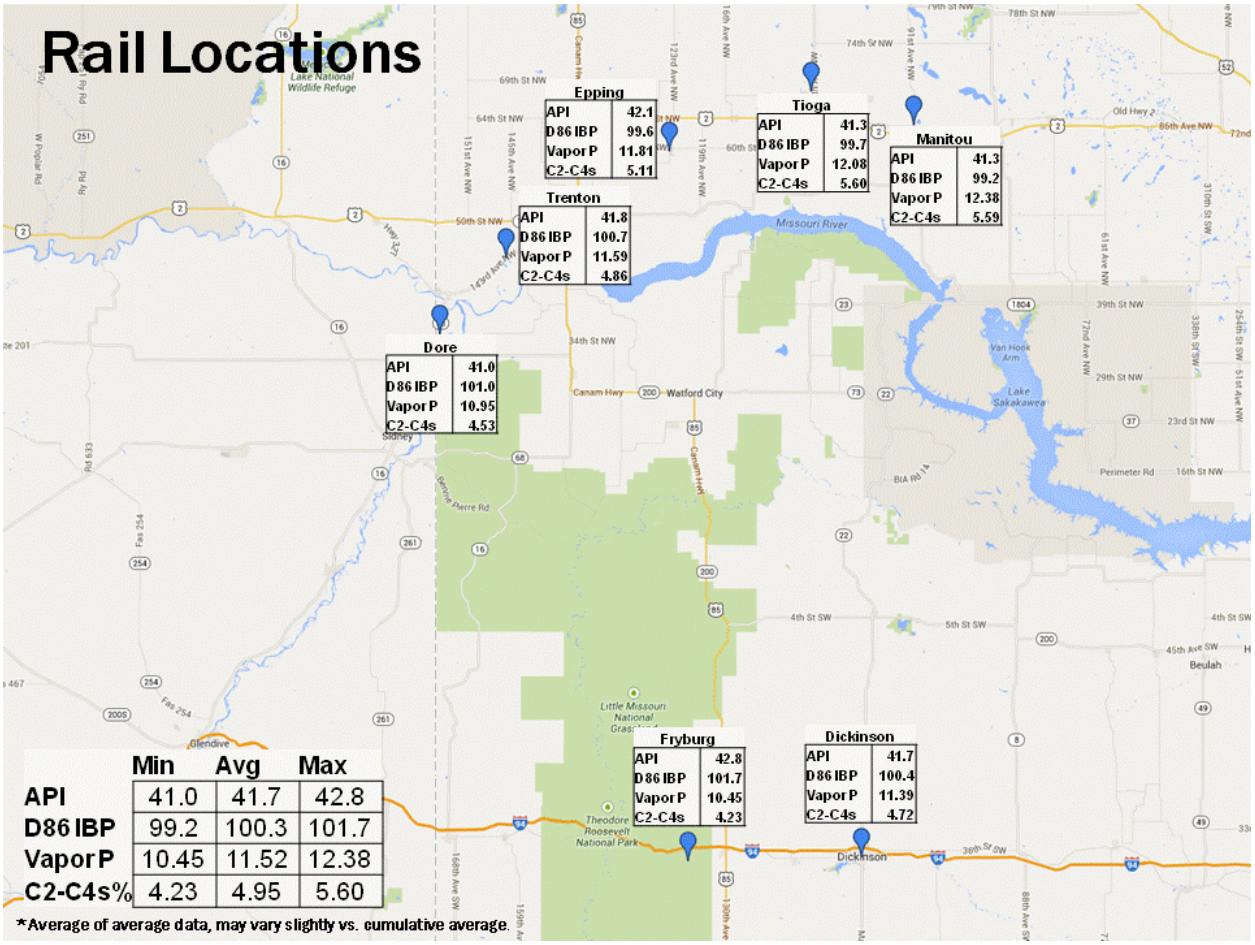
- Sample Date, Time, Company, Location (Geographic and Facility/Well ID);
- Ambient temperature at time of sampling;
- Size of tank where sample was pulled from;
- Location in tank (top, bottom, or composite) where sample was taken;
- For samples taken at well, operating conditions including treater/separator operating pressure and temperature, as well as production rates were recorded;
- API Gravity;
- D86 IBP;
- Vapor Pressure via D6377, as measured at 37.8°C/100°F with a 4:1 V/L ratio;
- Flash Point via D3278;
- Light Ends via IP344; and
- Simulated Distillation via D7169.

Details on the sample conditions at time of sampling were recorded to evaluate what parameters may have an impact on the sample results. All samples were taken in sealed one-quart glass bottles, consistent with testing for stock oil tanks. The process was similar to the procedure used for finished gasoline testing with RVPs up to 15 psi.

On the first visit to each location, samples were taken at both the top and bottom of the tank. This was done to determine if there was a variance or stratification taking place in tanks, either at the well or at the rail terminals. On subsequent visits, samples at each location were composite samples of the tanks.

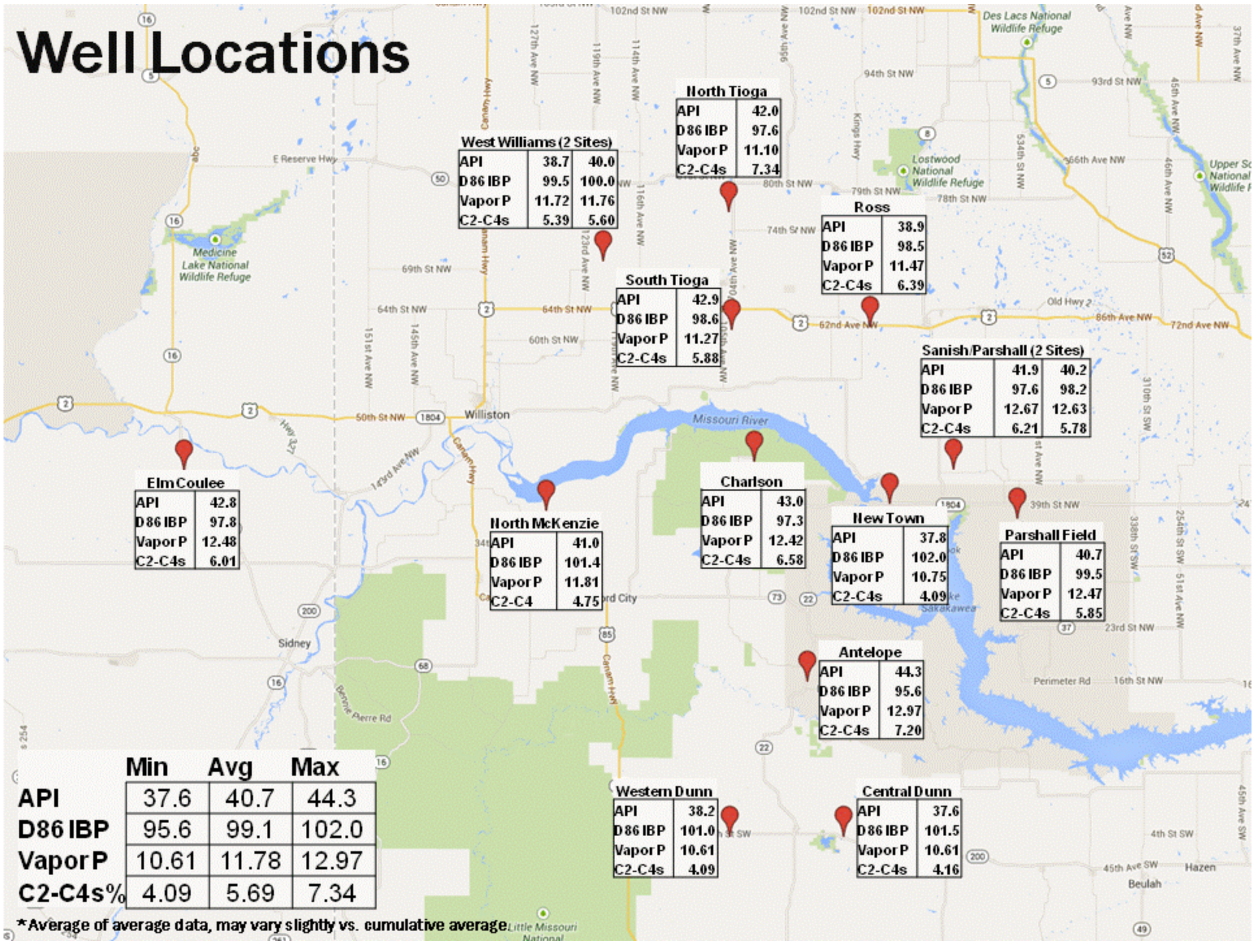
In order to capture any variances seen across the Bakken formation, sites were chosen to ensure a wide variety of locations. The points have been plotted on the maps below with corresponding average sample data for each location. The map of rail locations sampled, along with corresponding data is shown in Figure 1.

Figure 1: Rail Sample Locations, With Average Sample Results



The map of well locations sampled, along with corresponding data is shown in Figure 2.

Figure 2: Well Sample Locations, With Average Sample Results



Test Results/Analyses

Sampling was conducted beginning March 25, 2014. Each site was sampled from their stock or storage tank. For each location, a top and bottom tank sample was taken once, with the remainder of samples taken as a composite. Samples were spaced every few days to gain the most representative snapshot during the test period. All testing was completed on April 24, 2014. A complete listing of sample dates/times by location (along with all data) can be seen in the appendix. A breakdown of the samples is as follows:

- API Gravity: 152 Samples;
- D86 Initial Boiling Point (IBP): 152 Samples;
- Vapor Pressure (D6377): 152 Samples;
- Flash Point (D3278): 152 Samples;
- Light Ends (IP344): 152 Samples; and
- Simulated Distillation (D7169): 111 Samples.

API Gravity

API Gravity was measured on all samples taken. API is a common property used to compare the relative density of a given petroleum liquid. While reported in degrees API gravity, it inversely correlates to the measured density of the liquid tested. For light crudes, the API gravity is generally around 40-45 API. Of all Bakken samples tested, the API gravity ranged from 36.7 to 46.3 API, averaging 41.0 API. The average for rail samples was slightly higher at 41.7 API, but with a tighter range of 39.2 to 44.0 API. These are all within the range expected for light crudes. By comparison, the common benchmark conventional light crudes, West Texas Intermediate (WTI) and Light Louisiana Sweet (LLS), measure 36-42 API. Bakken is not substantially lighter than other conventional light crudes. Higher API crudes may, but do not necessarily correlate with higher vapor pressure crudes. Figure 3 shows the distribution of API gravity data, and Figure 4 shows a plot of API gravity vs. measured vapor pressure.

Figure 3: API Distribution; Total, Rail, Well

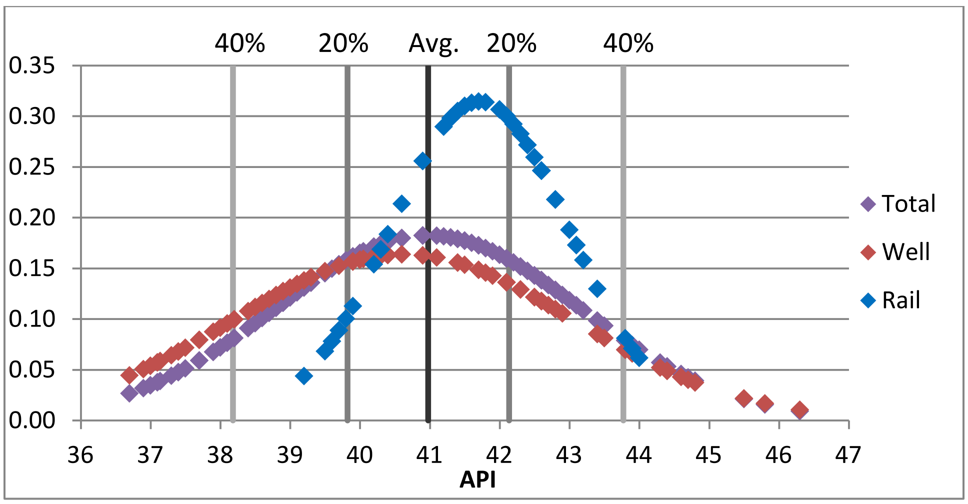
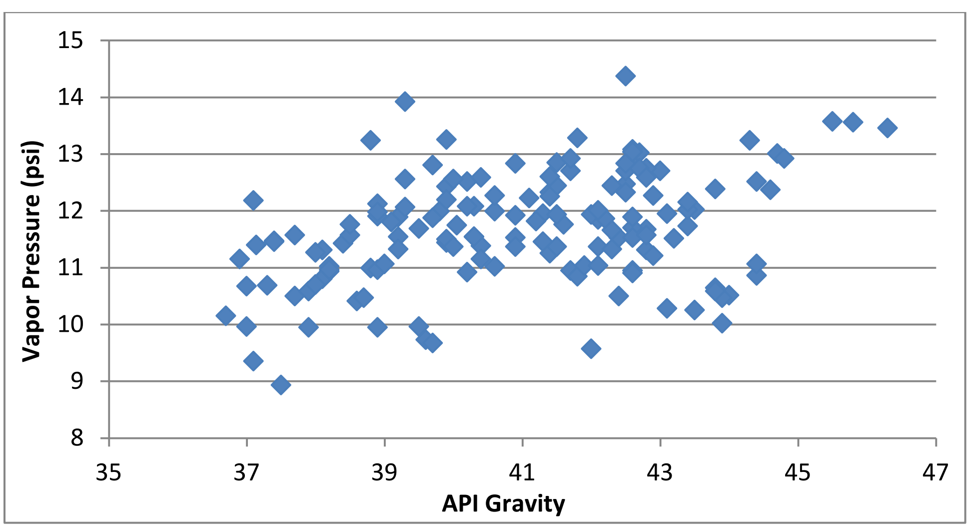


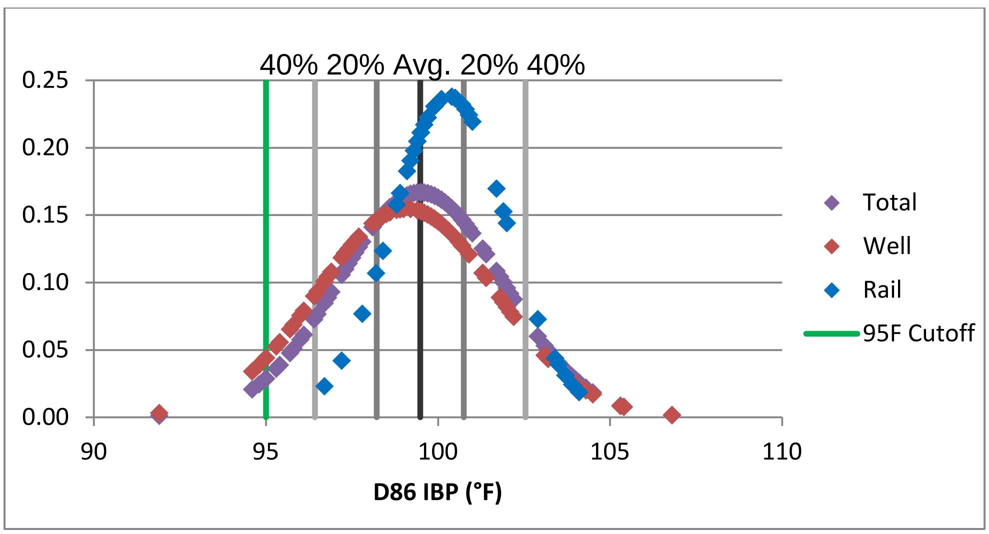
Figure 4: API Gravity vs. Measured Vapor Pressure ($VPCR_4$)



D86 IBP

D86 IBP measurements were conducted on all samples. As discussed in the summary section, the D86 distillation IBP is used for determining the appropriate PG for a flammable liquid. Measured D86 IBP ranged from 91.9°F to 106.8°F. Only 3 of the 152 readings, all of which were well samples, fell below the 95°F threshold for PG I versus PG II. The IBP results are clustered around the 95°F value. Thus, it is extremely difficult to properly define the PG because laboratory variance could indicate differing PG designations. While laboratory variance is a factor with any test, D86 is particularly susceptible because D86 distillation was never intended for wide boiling range materials; and, as a result, the test can have a significant amount of variance. Due to the importance of this test, and the proximity to the cutoff, additional laboratory comparisons were performed to determine the consistency of several properties, with special attention paid to D86 IBP. This will be discussed in detail in the section covering the interlaboratory (round-robin testing) later in this report. Figure 5 shows the distribution curve for measured D86 IBP measurements. The line in green shows the 95°F cutoff.

Figure 5: D86 IBP Distribution; Total, Rail, Well

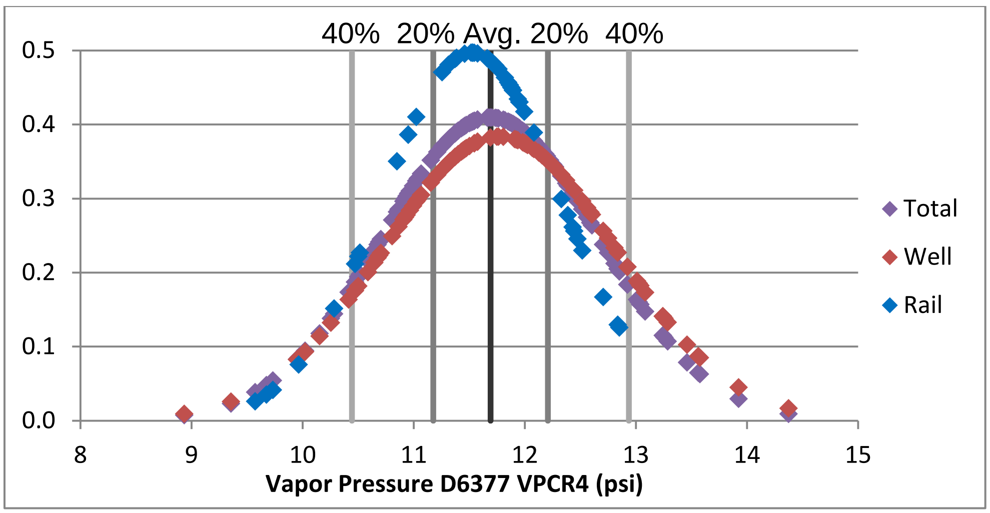


Vapor Pressure

Vapor pressure was measured using ASTM D6377, Test Method for Determination of Vapor Pressure of Crude Oil: VPCRx (Expansion Method) on all samples. It is important to note that the more traditional ASTM D323 Reid Vapor Pressure was not used. Within the past few years, ASTM D6377 has become widely accepted by industry and the U.S. EPA. For this reason, all vapor pressure analyses for this project were conducted using D6377, with the standard conditions of 100°F (37.8°C) and a vapor-liquid ratio of 4:1. In contrast, ASTM D323: Test Method for Vapor Pressure of Petroleum Products (Reid Method) is one of the oldest methods for determining vapor pressure of crude oils, and much of the older data in the public domain was obtained using this method. In the vapor pressure range of the samples tested in this study, the RVP values will tend to be about 1 psi lower than the VPCR values.

Vapor pressure samples in this study averaged 11.69 psi, well below the limit for the shipping classification. Rail averaged slightly lower at 11.52 psi, with a range of 9.57 to 12.85 psi. This is a more accurate representation of the quality being transported. This is in line with the vapor pressure of gasoline, which is transported under the same classification. Well vapor pressure averaged slightly higher at 11.77 psi, with a slightly broader range of 8.93 to 14.37 psi. The aggregation of crude and mixing that takes place at terminals, in addition to the potential slight losses of light ends during handling and storage, accounts for the difference in ranges and absolute vapor pressure seen between well and rail. Figure 6 shows the distribution of vapor pressures measured.

Figure 6: Vapor Pressure Distribution; Total, Rail, Well



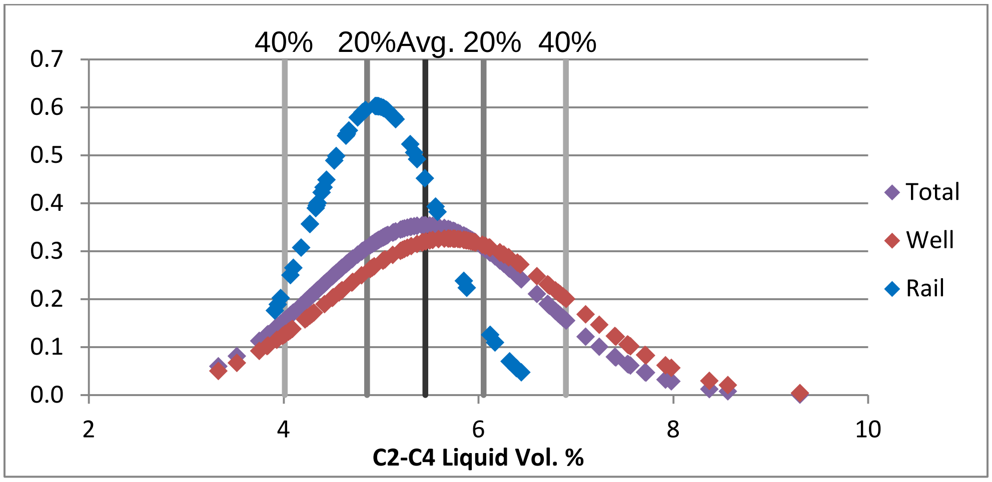
Flash Point

Flash point tested via D3278 was performed on all samples. All flash point readings were <73°F (<23°C), which is the threshold value to distinguish between PG I or II and PG III. This threshold means all Bakken samples tested would fall in the PG I or PG II categories, and the ultimate PG I vs. II determination would be based on the D86 IBP, as discussed above. Because all samples were <73°F, no data analysis was performed.

Light Ends

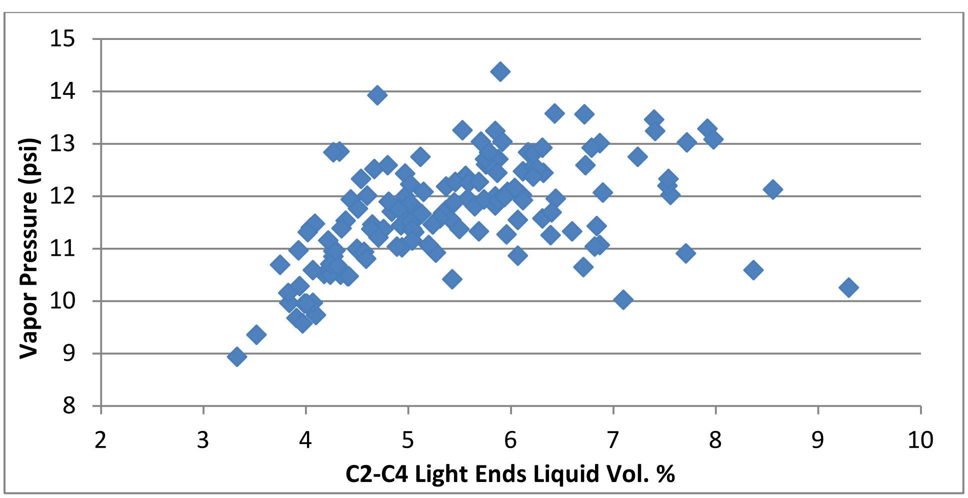
Light ends-testing via IP344 was performed on all samples. While the test measured concentrations of C1 (methane) to C6 (hexanes) individually by compound, the following light ends numbers account for the sum of C2-C4s only. Methane was excluded because it was at or below detection limits (0.01 liquid vol. %) for all samples, and C5+ has less impact on vapor pressure. The well samples had both a wider range (3.33-9.30 liquid vol. %) and average (5.69 liquid vol. %) concentration than rail (3.91-6.44 and 4.95 liquid vol. %, respectively). This is expected, as some small amount of light ends may be lost to storage tank vapor recovery systems while in atmospheric storage tanks at the well or rail terminals. Also, the mixing of various crudes into single tanks would help normalize any high or low concentration crudes. This corresponds with the vapor pressure readings in the previous section. Figure 7 shows the distribution of C2-C4s as measured.

Figure 7: C2-C4 Distribution: Total, Rail, Well



Light ends concentration was plotted versus measured vapor pressure on Figure 8, below. There is some correlation between the two, although significant scatter appears as the light ends concentration increases. With a rough correlation between measured vapor pressure and C2-C4s concentration, looking at seasonality data presented later, one could conclude that ambient temperature would have an effect on vapor pressure. Due to the short duration of testing, it was difficult to draw a clear correlation between the effects of ambient temperature on light ends content directly, although based on the seasonality data, colder temperatures would have the potential to leave greater amounts of light ends in the crude. The maps shown in the introduction section highlight the variance in properties from a geographic standpoint. While there is some variance in geographic measurements of light ends content, there does not appear to be any specific north to south or east to west correlations visible.

Figure 8: Light Ends (C2-C4s) Concentration vs. Vapor Pressure



Simulated Distillation

Simulated distillation (SimDist) via D7169 was conducted on 111 of the 152 samples. SimDist testing was performed on the first five samples for those samples that started on or around March 25, and three to four of the samples for the remaining few sites that had a more compressed sampling schedule. As testing progressed, the results appeared very consistent, and the importance of the SimDist results on overall analysis was determined to be limited. The test was subsequently excluded from later samples. Simulated distillation data showed consistent crude quality with the expected variance, ranging from an IBP of <97°F (minimum detection limit) to a final boiling point over 1200°F. Comparing Bakken to a pure liquid such as ethanol in a fire, the crude would vaporize more slowly in a fire should cars be heated versus ethanol, which has a single boiling point (173°F) where the entire cargo would vaporize. This temperature is roughly the SimDist 10% point for Bakken crude. Figure 9 and Table 6, below, show the distillation curve and average distillation data for well, rail and cumulative measurements.

Figure 9: Bakken Crude Distillation Curve

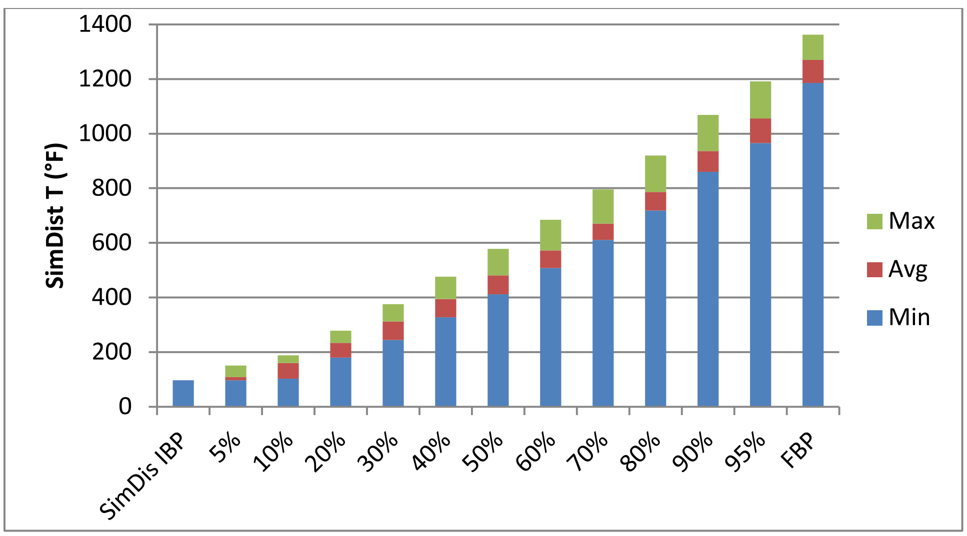


Table 6: Distillation Data; Well, Rail, Total

SimDist	Well	Rail	Total
IBP	< 97	< 97	< 97
5%*	106	113	108
10%*	153	165	157
20%	231	238	234
30%	310	316	312
40%	394	396	395
50%	481	482	481
60%	572	572	572
70%	671	670	671
80%	785	787	786
90%	935	939	936
95%	1053	1060	1056
FBP*	1305	1317	1309

All values shown are in °F.

*Adjusted averages to account for one or more values in group above/below detection limits (97 °F and 1382 °F). Adjusted by averaging detection limit for values, raw data in appendix.

Sample Consistency

Comparing the well versus rail properties for the API/D86 IBP/vapor pressure, as well as light ends and SimDist, the qualities are very close and consistently correlate, as expected, with some slightly lower light ends numbers for rail properties for reasons discussed above. The light ends showed on average lower numbers and distillation curves were very similar. This shows that there is no evidence of spiking of Bakken crudes with light materials as some news reports had conjectured. The rail terminals sampled accounted for approximately 50% of total rail capacity out of the Bakken. These terminals receive crudes from many regional wells, not just member companies that contributed data: and, given the span of testing, it is highly likely results would have reflected such activity.

Table 7: Quality Comparison – Well vs. Rail Test Results

	Well	Rail
API Gravity	40.6	41.7
D86 IBP (°F)	99.1	100
VPCR D6377 (psi)	11.8	11.5
Light Ends (Liquid Vol. %)		
Ethane	0.24	0.23
Propane	1.63	1.39
Isobutane	0.65	0.58
n-Butane	3.16	2.75
Isopentane	1.52	1.42
n-Pentane	2.90	2.72
C2-C4s	5.69	4.95
C2-C5s*	10.12	9.10

*Excludes Cyclopentane

Sample Methodology Comparison: Floating Piston Cylinder (FPC) versus Standard Glass Bottle

The sampling methodology employed in the NDPC Study was the industry standard technique of capturing material from tanks at either the well site or rail location in a glass bottle and sealing them with a screw-on cap. These quart-sized (32oz) glass bottles, referred to as "Boston Rounds" are the standard for sampling crude, gasoline and other hydrocarbons with similar vapor pressures to Bakken crude. Recently, a new technique has begun to gain acceptance as an alternate method, which involves the use of a FPC. The sample is captured under pressure in a cylinder with a hydraulic piston which minimizes any vapor space. The purpose of this is to minimize potential gas losses that could flash off from a liquid sample as it is captured at atmospheric pressure in a bottle, or is lost to the vapor space left when capturing a sample in a bottle.

In order to determine if there was any variance between the standard bottle sampling technique and the FPC, a set of four comparison tests at rail locations were performed. Rail locations were chosen because the floating piston cylinders require a pressurized sample location in order to overcome the pressure of the hydraulic piston in the cylinder. In each case, the samples were taken at the tap (spigot) located downstream of the loading pumps from the storage tanks to the rail car loading racks. Samples were taken while the line was in service and had flow (and adequate pressure) to fill the FPC's. By comparison, the samples taken during the NDPC testing were from the tank itself at atmospheric pressure upstream of the loading pumps where the FPC samples were taken.

The initial results from this testing proved inclusive. While some samples showed excellent agreement both with historic NDPC sampling and between the glass bottle and FPC samples at the pressurized sample point, others showed variation, with samples taken off the line having lower vapor pressure values than the samples collected from the tank. This implies that samples taken at the pressurized sample point downstream of the tank somehow lost light ends by comparison. This brings into question sampling techniques, sample point location and effects of sampling while under pressure in some locations such as after a pump. Further evaluation, regarding the comparison of FPC results to standard sampling with Boston Round glass jars, is being considered and will be provided as an addendum to this report if conducted.

Interlaboratory (Round-Robin) Testing

Due to the importance of ensuring both accuracy and precision in testing, and to gain a better understanding of potential laboratory variability, a series of round-robin tests were performed. These tests were designed to determine what, if any, differences the individual labs had for identical samples. SGS (the testing provider for this study) participated using both their St. Rose, LA and Williston, ND laboratories. Additionally, a second internationally recognized testing company participated to provide a third-party comparison (referred to as Lab M, in the Tables below). Four different well locations were sampled during this test. Three identical samples were taken, and one was sent to each of the three labs. Tests for API gravity, vapor pressure and D86 IBP were performed.

The results of this round-robin showed extremely good consistency between labs on both API gravity and vapor pressure. The consistency validated that the integrity of the samples were <u>not compromised</u> during this test and that they were <u>not affected</u> by handling or shipping. Table 8 shows the consistency among samples. Most samples had near zero maximum deltas between readings, with the exception of one vapor pressure sample that was slightly lower than the others.

Table 8: Round-Robin API and Vapor Pressure

API Gravity (Density, D5002)

Sample Location	Date @ Time	Lab M	SGS St. Rose	SGS Williston	Max Delta
1	5/1/14 @ 16:30	40.2	40.2	40.2	0.0
2	5/1/14 @ 16:30	43.0	42.9	42.9	0.1
3	4/30/14 @ 16:00	43.6	43.6	43.6	0.0
4	5/1/14 @ 16:30	43.0	42.9	42.9	0.1

Vapor Pressure (VPCR4, psi)

Sample Location	Date @ Time	Lab M	SGS St. Rose	SGS Williston	Max Delta
1	5/1/14 @ 16:30	10.1	10.3	10.1	0.2
2	5/1/14 @ 16:30	15.0	15.4	13.8	1.6
3	4/30/14 @ 16:00	10.6	10.6	10.6	0.0
4	5/1/14 @ 16:30	11.4	11.5	11.2	0.3

The consistency did not carry through for the D86 testing. There was noticeable inconsistency between each lab, with samples varying by as much as 19.5°F for a given sample. While all samples tested during this would fall within a Class 3 Flammable liquid, depending on the lab used, the same sample could fall above or below the 95°F mark for PG I vs. PG II. Table 9 shows the readings for each sample, and the maximum deltas measured.

Table 9: Round-Robin D86 IBP

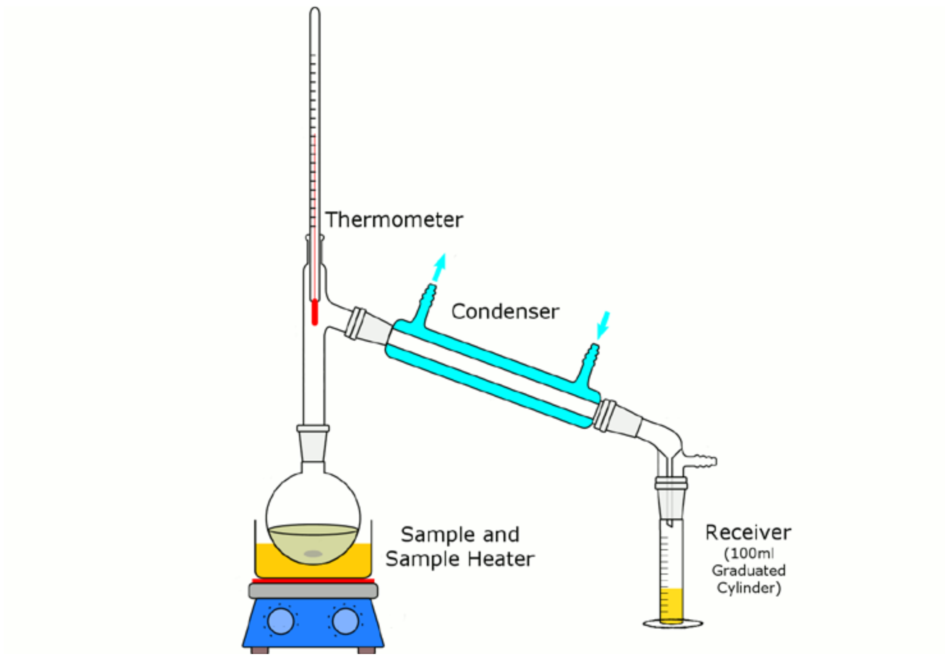
D86 IBP (°F)					
Sample Location	**Date @ Time**	**Lab M**	**SGS St. Rose**	**SGS Williston**	**Max Delta**
1	5/1/14 @ 16:30	89.9	95.4	101.8	11.9
2	5/1/14 @ 16:30	83.1	89.1	102.6	19.5
3	4/30/14 @ 16:00	87.8	90.7	105.5	17.7
4	5/1/14 @ 16:30	89.2	94.5	102.2	13.0

D86 Variation

The D86 testing showed that, in fact, there were problems with variability between labs. This is a result of the test not being designed for evaluating such a wide boiling range material, and thus different labs choose different heating, condenser temperature and receiver temperature parameters. In addition, the D86 distillation conditions do not allow for the accurate retention of butane and lighter material. Thus, samples containing significant quantities of butane and lighter material will not have this material detected and will still yield an IBP in the 80-100°F range. The C1-C4 compounds do not readily condense at the condenser temperatures the D86 test is conducted at, and thus are not accurately measured.

Before we discuss this further, a brief description of how a D86 distillation is performed is warranted. The setup consists of a flask of 100ml of liquid to be tested, a heater to boil the liquid, associated instrumentation to measure the temperature and volume, an overhead condenser which condenses the vapor boiled off and a receiver which collects the condensed material. While it is allowable to perform this test manually, almost all current analyses are conducted utilizing automatic instrumentation, which uses microprocessor controlled instrumentation to produce more precise results with minimal human intervention. All analyses conducted on this project utilized this type of automated instrumentation. Current D86 instruments are automatic; and typically, the type of liquid being tested will dictate parameters such as the condenser temperature and heat rate. The liquid is heated at the given rate dictated by the operator, and as it boils, it is condensed overhead, and drops into the receiver, which is maintained at a fixed temperature. The amount of liquid in the receiver is measured, and the distillation curve is generated. The liquid at the end is measured to determine the total recovery, as light components dissolved in the original sample can be lost if they are not able to be condensed at the condenser's operating temperature. Figure 10 shows a sample simple distillation, similar in principle to that used during D86 testing. The sample is heated, condenses, and is collected in the receiver. The volume at a given temperature is recorded to generate the distillation curve.

Figure 10: Simple Distillation Apparatus



Initial boiling point by D86 is defined as the overhead temperature (corrected for atmospheric pressure) observed at the instant the first drop of condensate falls from the lower end of the condenser tube. For a material such as gasoline, which typically has a boiling range of about 100-400°F, the liquid must first be heated at least some before enough vaporization occurs and vapor begins to condense. This is well above the condenser temperature, and as such, a more complete recovery is achieved. In the case of a light crude sample, which contains dissolved gases (C1-C4s) which do not condense at the typical condenser temperature, a lower recovery is achieved and less accurate actual IBP is measured.

The implications of this are that if parameters are not identical, the temperature with which the first drop is perceived to form can vary considerably. The difference for a given sample will normalize out as the 5% and 10% points are reached, but those values are not considered as part of the overall requirement for DOT classification. The rate at which the sample is heated can affect how well the sample was able to reach equilibrium temperature and drive off any light ends. The same goes for how cold the condenser is; the colder, the more it will condense. Faster heat rates and colder condenser temperatures tend to drive the IBP temperature lower than if the sample is more slowly heated with a higher condenser temperature.

Table 10 shows the impact that these parameters have on the boiling points. For the same sample, significant error can be introduced, over 14°F in the case of this set, for the same lab and same instrument, with slightly different operating parameters. This highlights a serious flaw in using the D86 test for compliance on determining PGs for materials such as Bakken crude. Because of the difficulty with achieving consistent IBP results, groups including API are working on recommendations to update the current regulations.

Table 10: D86 IBP Variability Testing

Lab	SGS St. Rose		SGS Williston		SGS Williston	
Condenser Temp	60°F		60°F		31°F	
Receiver Temp	73°F		81°F		81°F	
Sample	D86 IBP	Time to IBP	D86 IBP	Time to IBP	D86 IBP	Time to IBP
1	95.4	4 min 53 sec	101.8	7 min 56 sec	91.1	7 min 45 sec
2	89.1	3 min 22 sec	102.6	6 min 27 sec	88.7	6 min 07 sec
3	90.7	3 min 37 sec	105.5	7 min 26 sec	91.4	7 min 11 sec
4	94.5	3 min 42 sec	102.2	6 min 50 sec	94.4	8 min 00 sec

Rail Testing

A separate set of testing was conducted in order to evaluate whether there was merit in the claims that Bakken sees substantial weathering during transport. Five individual rail cars were sampled at their origin in Fryburg, ND, and destination of St. James, LA. Samples were tested by local labs in ND and LA of the same company for vapor pressure via D6377 at 100°F, flash point via D86, H_2S in vapor phase at 77°F via ITM 3468 and light ends analysis by modified D6730. The results were then compared to average NDPC test results from the same rail terminal. The testing showed that throughout transportation, vapor pressure and C2-C4 concentration were consistent, indicating there were no light ends losses. Additionally, no detectable H_2S was present in the samples. Comparing the samples tested at the two labs, the greatest variance in results was with the D86 IBP, for reasons discussed previously. Table 11 shows the table of average test data from both Fryburg and St. James and compares it to the other data collected at the Fryburg rail terminal. The appendix contains the full set of sample data for the cars.

Table 11: Rail Car Source and Destination Testing

Test	Units	Avg. ND Rail Terminal 5 Car Samples	Avg. St. James Rail Terminal 5 Car Samples	Avg. NDPC Data for ND Rail Terminal
VPCR 4 (37.8° C)	psi	10.47	10.61	10.45
IBP	°F	94.7	90.4	101.7
Flash Point	°F	<50	<50	<73
H_2S in Vapor Phase	ppm v/v	<1	<1	
C2-C4s	Vol %	4.00	4.08	4.23
C2-C5s*	Vol %	8.01	7.89	8.13

*Excludes Cyclopentane

Member Contributed Data

In addition to the data collected, member companies voluntarily submitted data to supplement data gathered in this study. The data contributed consisted of a smaller, less controlled round-robin sample test between one SGS laboratory and a second independent laboratory, and a NDPC member rail company terminal who contributed vapor pressure operating data collected over a seven-month period from late August 2013 to late March 2014.

A round-robin test was conducted by a NDPC member company who sent samples from four rail cars to both SGS and Lab M independently. The company had testing for API gravity, vapor pressure and D86 IBP measured on each sample. The results were similar to those found by NDPC conducted round-robin. API and vapor pressure had little variance, but the D86 IBP variance averaged over 13°F with a maximum variance of 15.6°F. This, again, highlights the difficulty with getting consistent and accurate D86 IBP measurements on a full boiling point material such as crude oil.

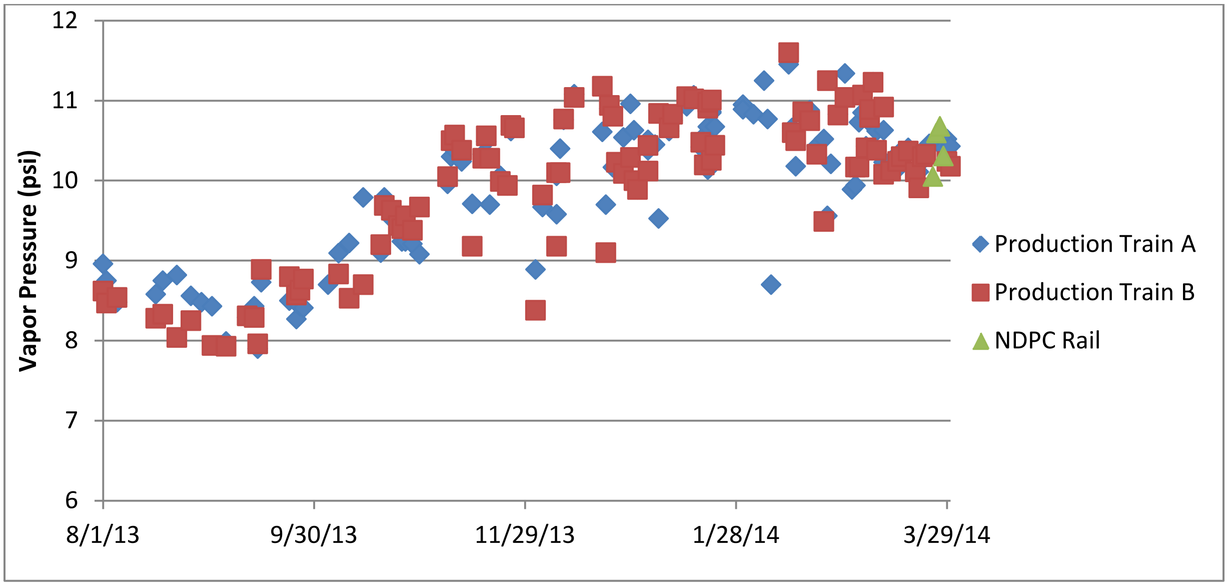
Table 12: Member Company Laboratory Comparison (Round-Robin)

Sample ID	API Gravity	D86 IBP (°F)	VPCR4 D6377 (psi)
Sample 1: SGS	44.0	101	10.52
Sample 1: Lab M	44.4	85.4	11.35
Sample 2: SGS	43.9	101.9	10.47
Sample 2: Lab M	44.3	92.4	11.47
Sample 3: SGS	42.4	100.5	10.50
Sample 3: Lab M	44.4	86.5	11.29
Sample 4: SGS	43.1	103.7	10.28
Sample 4: Lab M	44.2	89.9	11.29
Avg. Variance	1.0	13.2	0.91
Max Variance	2.0	15.6	1.01

A second member company contributed operating data collected over the course of normal operations on vapor pressure of Bakken crude being loaded into rail cars. It is known that as ambient temperature changes, the amount of light ends material separated from the raw crude at the wellhead, changes. Higher temperatures lead to higher gas separation, so winter and early spring conditions (when the NDPC test was performed) would highlight some of the higher vapor pressure Bakken crude throughout the year. The range of vapor pressure data collected shows that while there is some change, even the highest RVP readings in the winter peak at about 11 psi, nearly an order of magnitude below the 100 psig for which the DOT-111 rail cars are rated.

The samples from this member company were analyzed in their in-house lab and were measured for RVP versus $VPCR_4$ that was used throughout the NDPC testing. Due to the differences in test methodology, RVP readings typically are 1 psi lower than $VPCR_4$ readings. There was a brief overlap of time when sample data overlapped in late March, 2014. The data did correlate very well between measured vapor pressure at rail terminals tested compared to measurements at the member rail terminal when accounting for the testing difference. Figure 11 shows the chart of member contributed seasonality data, with NDPC test data overlaid, with the 1 psi correction.

Figure 11: Seasonality Data Collected by Member Company



The seasonality results are in line with the report from Transport Canada on the derailment in Quebec which showed RVP results ranging from 9.0-9.6 psi. The derailment took place in July 2013, and the RVP results recorded by Transport Canada are consistent with the summer results measured by the seasonality data above.

AFPM Report Comparison

AFPM released a report on Bakken crude titled, *"A Survey of Bakken Crude Oil Characteristics Assembled for the U.S. Department of Transportation"* dated May 14, 2014. The report assembled a variety of Bakken data and compared its results to the parameters as laid out by DOT PHMSA and other international regulations for shipping. While raw data was not given for analysis, a statistical breakdown and walkthrough of each captured parameter gave a good overview of Bakken crude properties from a broad data set.

- The APFM report concluded that Bakken was not materially different and posed no special hazards versus other light crude oils.
    - These findings coincide with the findings from this NDPC report.
- The AFPM report came to the same conclusions regarding the safety of Bakken in DOT-111 rail cars.
    - Vapor pressure was well below the allowable pressure for DOT-111 rail cars.
    - Bakken was well within all specifications for a Class 3 flammable liquid.
- Despite the same conclusions, a direct comparison between AFPM and NDPC cannot be performed on all data points collected.

- The AFPM report collected voluntary data submissions from its members, instead of a controlled study.
  - Its members consist largely of fuel producers who sample and test the Bakken as it arrives at their facility, versus at the well or rail terminal.
- Sampling procedures and test methods were not uniform across all data.
  - The AFPM report listed all test methods used for various properties.
  - Samples were run at different labs, resulting in increased variability.
- The report did not indicate if tests of differing methods were correlated in any way prior to comparison, nor what the minimum detection limits were or how samples were handled.

- This variety of testing led to certain peculiarities, such as the initial boiling point or flash point data having what appeared to be varying test ranges.

Of particular focus was the IBP testing. For the NDPC report, all data in the main data set was tested by a single testing provider, SGS. Samples were consistently collected and handled throughout the testing process, with all testing using the same ASTM D86 testing protocol. In contrast, the AFPM report used five different test methods for distillation alone, as discussed in their appendix. This resulted in IBP data ranging down to 32°F (0°C). In particular, gas chromatographic methods are referenced as being used. These methods, e.g. D2887, are known to yield much lower IBPs than the D86 method. Thus, this data must be both used and compared with caution. Based on our earlier discussion of how D86 testing is conducted, the D86 test method does not lend itself to measuring boiling points that low. The condenser does not operate at a temperature low enough (it would have to operate below 32°F to condense materials boiling at that temperature). Additionally, the initial sample is not cooled to that level before testing and the collector is held at roughly room temperature, meaning any collected sample would evaporate. Thus, any IBP results below about 60°F must, therefore, have been conducted with another test method, assumed to be a gas chromatographic simulated distillation method. Since there was no indication that the data was correlated to D86, and the regulations are based around D86 testing, it raises questions about what the equivalent boiling points were for those samples, based on DOT requirements. Similarly, other data that used multiple test methods did not show an indication of a correlation between the two methods and makes the data good for information only, but not from which to draw firm conclusions or correlations. Table 13 shown below gives a brief comparison of the results of the two tests.

Table 13: Comparison of NDPC to AFPM Study Data

	NDPC Average Well	NDPC Average Rail	NDPC Average Range	AFPM Study		Comments
API Gravity	40.6	41.7	36.7-46.3	API Gravity	42	Reported in crude comparison table.
D86 IBP (°F)	99.1	100.3	91.9-106.8	IBP (Various Tests)	69.6	87.3 median IBP, multiple tests in AFPM data, some of which can report lower than D86, which skewed average lower.
Vap. P D6377 (37.8C) (psi)	11.8	11.5	8.9-14.4	RVP (psi) (Various Tests)	7.83	RVP reported by AFPM. Also reported D6377 done at 50C (higher than NDPC), with range 13.9-16.7 psi.
Seasonality RVP (psi)	-	9.98	7.9-11.6	Seasonality RVP (psi)	8-12.5	AFPM 807 data points to 215 for NDPC, greater variety of locations.

NDPC Light Ends (Liquid Vol. %)	Well	Rail	Range	AFPM Light Ends (Liquid Vol. %)		Comments
Ethane	0.24	0.23	0.08-0.67	Ethane	0.5	
Propane	1.63	1.39	0.84-3.13	Propane	<1-2%	
Isobutane	0.65	0.58	0.35-0.95	Isobutane		
n-Butane	3.16	2.75	2.00-4.55	n-Butane	3-4%	Reported as ranges only.
Isopentane	1.52	1.42	1.10-1.93			
n-Pentane	2.90	2.72	2.07-3.70	n-Pentane	-	
C2-C4s	5.69	4.95	3.52-9.30	C2-C4s	3.5-11.9%	AFPM report, three respondents average 3.5%, fourth had 12 samples, range 5.9-11.9%
C2-C5s*	10.12	9.10	6.77-14.71	C2-C5	7.2	*Excludes Cyclopentane

The AFPM report did include additional data, which was not tested as part of the NDPC study. Many samples were tested for hydrogen sulfide (H_2S) in the vapor phase, and they were able to capture some samples that contained detectable H_2S. It is known that select pockets in legacy ND wells contain higher H_2S concentrations, but that crude is typically segregated from low H_2S Bakken crude for safety reasons. The AFPM study was also able to gather data on corrosivity using National Association of Corrosion Engineers (NACE) TM 172 testing, which confirmed the low corrosivity of Bakken crude. The AFPM paper also summarized data gathered on the pressure of rail cars measured as they reached their final destination. Over 380 cars were sampled, with a majority arriving to the refinery in the 7-10 psig range. The highest reported pressure recorded was 11.3 psig, well below the rated operating pressure of the DOT-111 rail cars or their minimum relief valve setting of 35 psig.

Despite the inability to draw a direct comparison between the AFPM and NDPC data, the results of both studies lead to the same conclusion. Bakken crude is a consistent product that clearly fits the classification of a Class 3 Flammable Liquid. The only point of debate would be the PG designation that is used, PG I versus PG II. That falls back to D86 testing of full boiling range materials, and the need for a reevaluation as to whether that is the most appropriate test method for the classification of materials such as Bakken for shipment.

The Pipeline and Hazardous Materials Safety Administration (PHMSA) Report Comparison

PHMSA released a report on July 23, 2014, which included the results of their findings as part of *Operation Safe Delivery*. PHMSA found that, "Operation Classification has determined that the current classification applied to Bakken crude is accurate under the current classification system." The PHMSA report outlined the efforts of their testing program, which began in August 2013, and spanned through May 2014. Sampling was unannounced and intended to capture a representative sample of Bakken crude. The initial phase, from August-November 2013, was focused on verifying that appropriate hazard classes that were being used; and as such, testing was limited to flash point and boiling point. The second phase from February-May 2014 was to gain a complete understanding of Bakken properties and more closely align with the NDPC study. This data from Phase 2 was the data used to compare to the NDPC report.

The results outlined showed good agreement with the data collected as part of the NDPC study, especially when comparing data collected for the same general time period. Since the NDPC testing was done during the period from late March to late April 2014, the data points that fell in this general time frame were separated out and compared (11 total samples), as was the entire data set (88 total samples). Since the last round of PHMSA sampling was conducted at rail-loading facilities, for consistency, comparisons were made specifically with the NDPC rail data. As seen in Table 14 below, the results agreed very well, despite not being identical samples nor identical locations. The variation is minimal, and ranges agree well, with a trend toward slightly lower D86 IBP readings from PHMSA; although as discussed earlier, those results are subject to variation based on exact testing parameters and procedures.

Table 14: Comparison of NDPC to PHMSA Study Data

	PHMSA Data Table E Mar-May (11 Samples)			NDPC Data Rail Only (49 Samples)		
	Dates:	3/17/14	to 5/2/14	Dates:	3/25/14	to 4/18/14
	Average	Min	Max	Average	Min	Max
Flash Point (°F)	<50	-	-	<73	-	-
D86 IBP (°F)	87.0	79.1	94.4	100.3	96.7	104.1
VPCR 4 @ 100 °F (psi)	12.28	10.22	14.28	11.52	9.57	12.85
Ethane (% Vol)	0.20	0.06	0.29	0.23	0.13	0.33
Propane (% Vol)	1.38	0.85	1.95	1.39	1.02	1.95
Butane* (% Vol)	3.49	3.01	4.44	3.32	2.63	4.24
C2-C4	4.65	0.00	6.68	4.95	3.91	6.44

	PHMSA Data Table E Total (88 Samples)			NDPC Data Total (152 Samples)		
	Dates:	2/24/14	to 5/2/14	Dates:	3/25/14	to 4/24/14
	Average	Min	Max	Average	Min	Max
Flash Point (°F)	<50	-	-	<73	-	-
D86 IBP (°F)	88.1	79.1	97.5	99.5	91.9	106.8
VPCR 4 @ 100 °F (psi)	12.42	10.10	15.10	11.69	8.93	14.37
Ethane (Liq Vol %)	0.23	0.06	0.40	0.24	0.08	0.67
Propane (Liq Vol %)	1.45	0.85	2.08	1.55	0.84	3.13
Butane* (Liq Vol %)	3.55	2.74	4.48	3.66	2.35	5.50
C2-C4s	5.17	0.00	6.88	5.45	3.33	9.30

*PHMSA report does not specify if isobutane was included in their measurements. For comparison purposes, this report assumes butane includes n-butane and isobutane.

In the conclusion of the report, PHMSA did note that, "We conclude that while this product does not demonstrate the characteristics for a flammable gas, corrosive liquid or toxic material, it is more volatile than most other types of crude." While PHMSA does say Bakken is currently classified appropriately as a Class 3 Flammable Liquid, PG 1 or 2, depending on D86 IBP, they claim that Bakken has "higher gas content, lower flash point, lower boiling point and higher vapor pressure than other crude oils." PHMSA makes this claim without testing or reporting what the values are for these other crude oils.

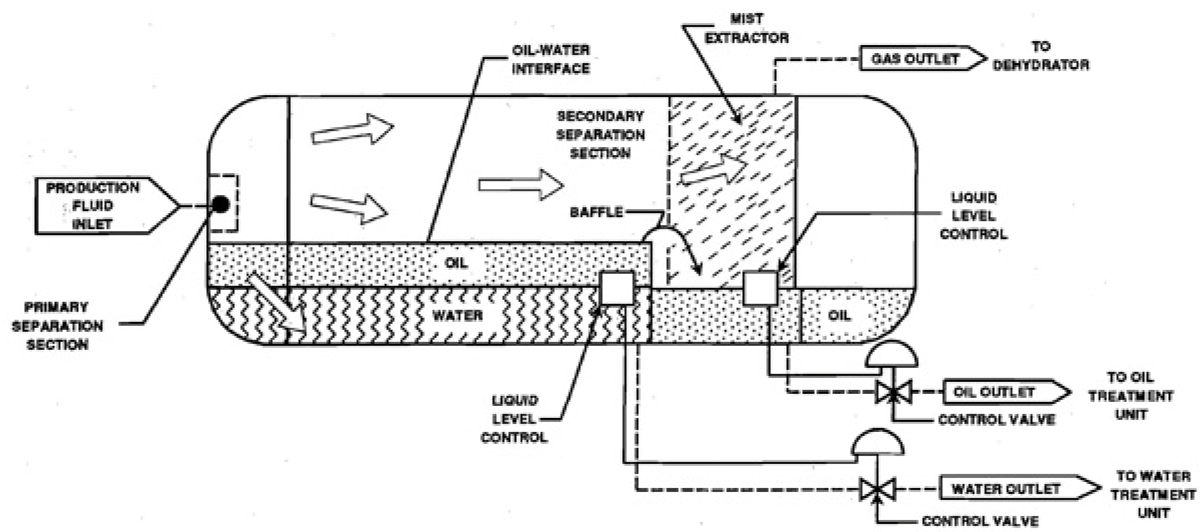
As we have noted previously, there have been no extensive or controlled sampling and testing programs for other light sweet crude oils, such as was done in both this NDPC study and the PHMSA program for Bakken; and, therefore, it is not possible to make a broad generalization on comparative properties. Based on limited information from the AFPM study, as well other publicly available data Bakken appears to be generally similar in vapor pressure and light ends content to most light crude oils, and there are certainly crudes, particularly those produced from tight oil formations, which are higher in those parameters. Additionally, making the claim that vapor pressure and light ends content correlates to increased ignitability and flammability is a broad statement that without extensive and complicated testing cannot be factually stated or supported.

Operating Conditions

As part of the sampling program, operating conditions at the time of sample collection were taken for each well location sampled. This was done in order to determine if there were additional factors which may affect crude qualities. The conditions recorded included ambient temperature, separator and treater temperature and pressure, well production rate, equipment size and configuration, and for wells not attached to a gathering system, the time the stock tank was isolated from the well.

In order to better understand the impact the operational conditions play, a brief overview of wellhead crude processing is warranted. Raw crude, as it comes out of the ground, is a mix of gas, liquid hydrocarbons and water. The amount of each varies depending on geology and ambient temperature. The raw crude stream requires separation to remove the gas phase and separate entrained water before it is transferred to the stock tank. This is achieved by passing the crude through a separator and/or treater unit before it is stored and transported. Often, a standard three-phase (gas/oil/water) separator drum is used to separate the bulk water and gas from the hydrocarbon stream, as seen in Figure 12. The raw crude stream enters the separator drum and settles. Gas passes over and through a mist extractor, essentially a fine metal mesh, to collect and knock out entrained liquid before passing out of the drum to either be flared or captured. The liquid settles and separates as it flows through the vessel. In a three-phase separator, the liquid level is controlled so that the oil layer passes over a baffle and out of the vessel to tankage or for additional treatment. The water, which collects behind the baffle, is drained off and treated. Some wells may instead use a simple gas/liquid separator followed by a second liquid/liquid separator. In this configuration the liquid passes out without separating water and hydrocarbons, which then passes directly to a second separator or treater designed to separate the liquid hydrocarbons and water.

Figure 12: Horizontal Three Phase (Gas/Liquid/Water) Separator Diagram[1]

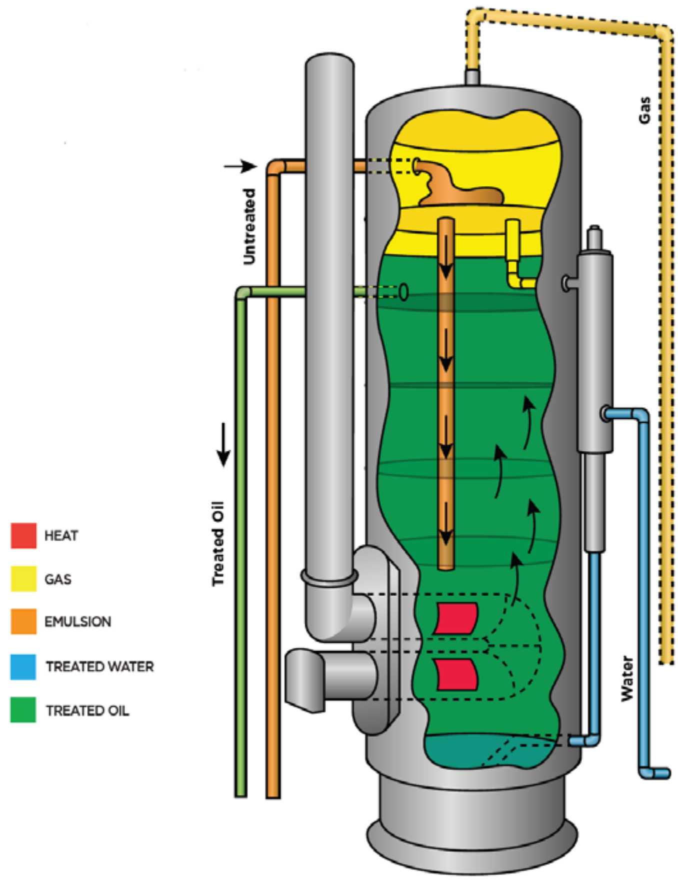


Often, the hydrocarbon stream that leaves a conventional separator still contains an emulsion of some water, the severity of which varies from well to well and on ambient conditions. In order to minimize water in the crude, the stream is often sent to a treater. A treater unit is, in effect, a second separator designed to help break the emulsion via the addition of heat and passing the crude through a coalescer or series of baffles to help separate out the remaining water. Heating the stream aids in separation of the oil and water in part by lowering the viscosity of the oil, which aids in coalescence of small water droplets to larger ones that can more easily separate.

Figure 13 shows how the untreated hydrocarbon stream, in orange, flows into the vessel and down through the heated section. In this section, the stream is heated and the water has a chance to separate. Similar to the separator, additional dissolved gasses evolved when the crude is heated are separated as well, and are either flared or collected. Some wells that do not have a lot of water in the crude, may use only a treater for oil treatment.

[1] Image: http://www.netl.doe.gov/Image%20Library/technologies/pwmis/BasSep_3PhaseSeparator.jpg

Figure 13: Vertical Treater Diagram[2]



The separator and treater operate at relatively constant conditions as set by the well operator. Typically, they operate under pressure (a range of 8-80 psig was recorded in this study) as the flow follows through the separator and treater to tankage. Adequate pressure is required to overcome any head pressure and allow movement of oil into the stock tank. When a treater is used, the stream is heated only enough to maximize separation of the emulsion (range up to 160°F was observed in this study), while minimizing the temperature to which the stream needs to be heated. There are several reasons to limiting temperature, including energy cost of heating, increased hydrocarbon losses to flare and potential for increased tank emissions.

Due to the difficulty and hazards associated with sampling a raw well stream, crude was sampled from the stock tank after it passed through the separator and/or treater. This is consistent with measuring the quality of the crude that would be transported via rail. Additional notes were taken on whether the wells were connected to gathering systems; small pipeline networks designed to take the oil to central facilities to be loaded to rail or major pipeline systems. Other wells fill stock tanks and require trucks to

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[2] Image: http://www.des-co.com/portfolioentry/heater-treaters/

haul crude away. Wells not on gathering systems were sampled from their full stock tanks after they were safely filled and isolated from the well.

As discussed previously, on the first visit to each location, samples were taken at both the top and bottom of the tank. This was done to determine if there was a variance or stratification taking place in tanks, either at the well or at the rail terminals. No stratification was observed, with relative uniformity of properties from the top to bottom. On subsequent visits, samples at each location were composite samples of the tanks. The average delta (top-bottom) for rail, well and overall samples is summarized in Table 15, with complete data available in the appendix.

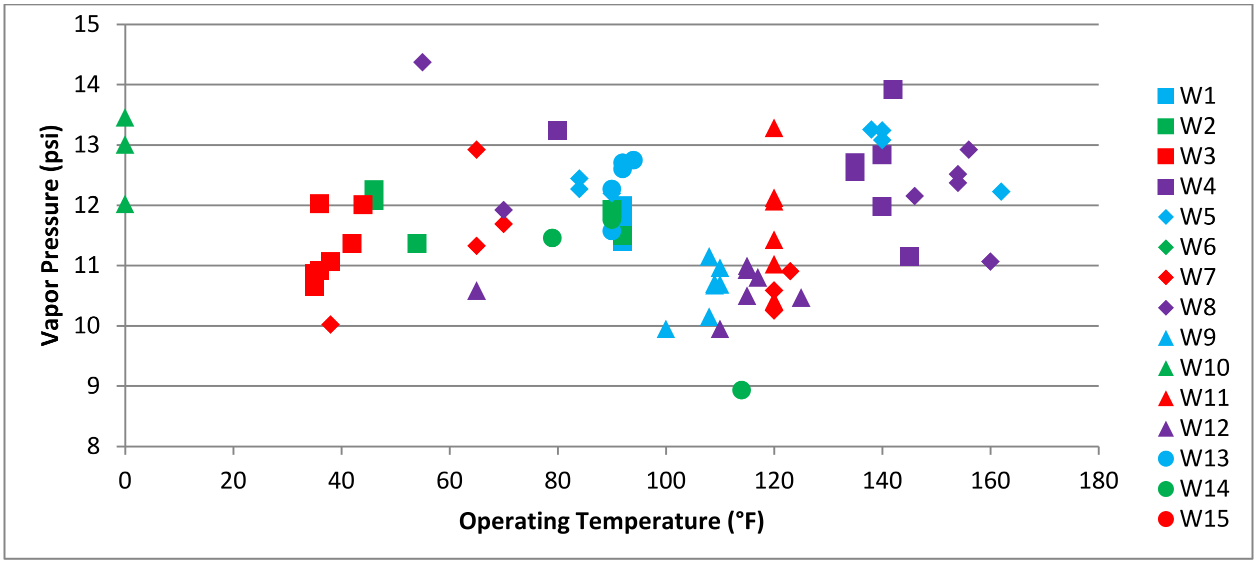
Table 15: Average Delta (Top-Bottom) of Tank, Rail and Overall Samples

Avg. Delta (Top-Bottom)	Rail	Well	Overall
API Gravity	0.0	0.2	0.1
D86 IBP (°F)	0.5	-0.9	-0.5
Vapor P (psi)	0.12	0.01	0.05
Light Ends (Liquid Vol. %)			
Ethane	0.00	0.02	0.01
Propane	0.00	0.05	0.03
Isobutane	0.00	0.01	0.01
n- Butane	0.00	0.05	0.03
Isopentane	0.00	0.01	0.01
n- Pentane	0.01	0.03	0.02
Cyclopentane	0.00	0.00	0.00
C2-C4s	-0.01	0.12	0.08
C2-C5s*	0.00	0.15	0.10

*Excludes Cyclopentane

Vapor pressure showed no clear correlation with operating conditions. Production rate did not show any appreciable impact on the vapor pressure (this is covered later in this report). The same was seen with both operating pressure and temperature. The measured vapor pressure was scattered throughout the range of temperatures and pressures, with no clear correlation. Figure 14, below, shows a plot of vapor pressure versus operational temperature. A plot of vapor pressure versus operating pressure can be seen in Figure 1-1 in the Appendix.

Figure 14: Vapor Pressure versus Operating Temperature



The results of the testing did show a slight correlation between operating temperature and light ends (ethane/propane) content, which would be expected. Otherwise, there was no clear correlation between either operating pressure or production rate and the subsequent vapor pressure or ethane/propane content in the crude. While both the separator and treater separate out gas phase from the mixed stream, they are not designed as “stabilizers” to treat the crude. Their purpose is to remove entrained gases and water. Stabilizers, often used in condensate (crude API 50°+) service separate out the lightest components from a given hydrocarbon stream. Those components are then transported separately as liquefied petroleum gas (LPG) and NGLs in pressurized rail cars alongside Bakken crude. This would ultimately be shifting responsibility from one type of rail car to another, concentrating and magnifying potential risks. As with any crude oil, some dissolved light ends will exist in Bakken, and will only be completely removed when the crude is fully fractionated in a refinery setting. This is true of any light crude oil, regardless of the separator and treater setup is used.

Figure 15 and Figure 16 show the effect of operating temperature on the ethane and propane concentrations. There is a slight trend toward lower concentrations at higher temperatures. This is plausible, as some of the lightest components will be driven off as the crude is heated. This would be most apparent in winter months when this test was conducted and ambient temperatures are low. In the summer months, ambient temperatures may reach 100°F or more, making use of the treater less impactful. Figures 1-2 through 1-5 in the Appendix show the charts of the ethane and propane versus operating pressure and production rate, for reference.

Figure 15: Ethane Liquid Vol. % versus Operating Temperature

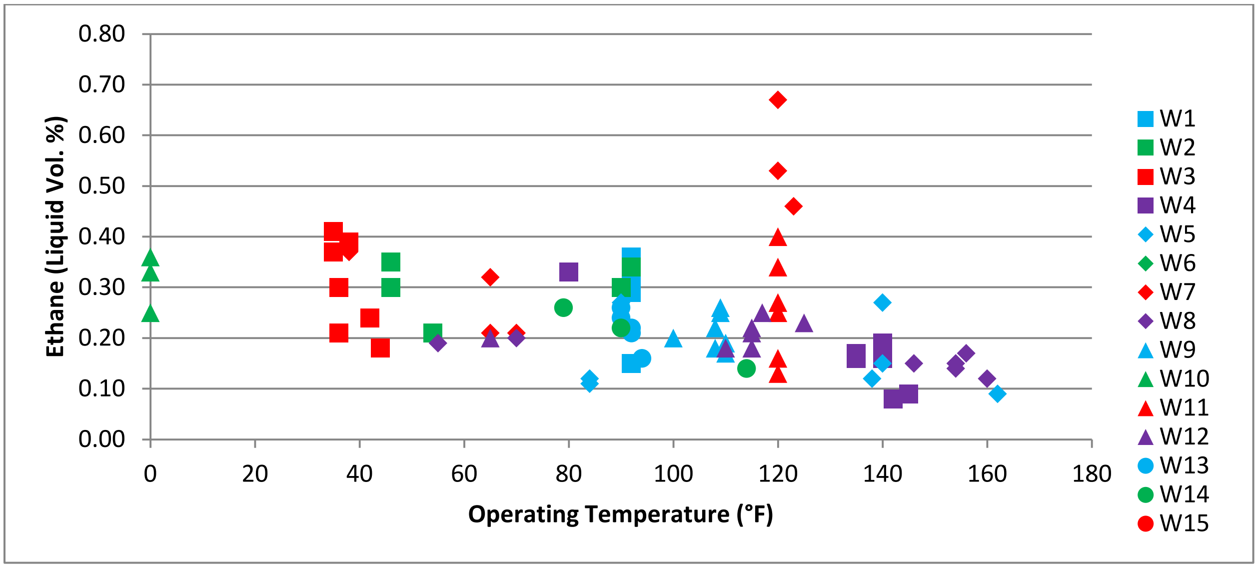
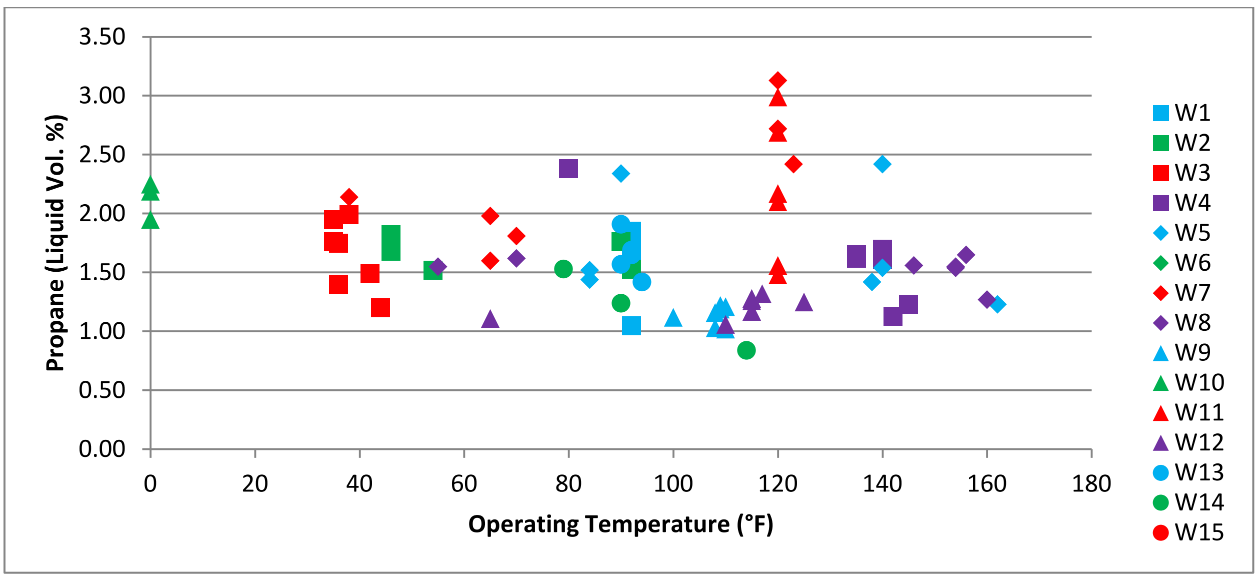


Figure 16: Propane Liquid Vol. % versus Operating Temperature



Based on these findings, a general correlation between the operating temperature of the treater and the ethane or propane concentration was developed. Excluding the few points that were anomalous from W7, the following correlations were developed (charts can be seen in the Appendix, Figures 1-6 and 1-7):

1. Ethane (Liquid Vol %) = -0.0013 * Temp (°F) + 0.3568; and
2. Propane (Liquid Vol %) = -0.0025 * Temp (°F) + 1.8414.

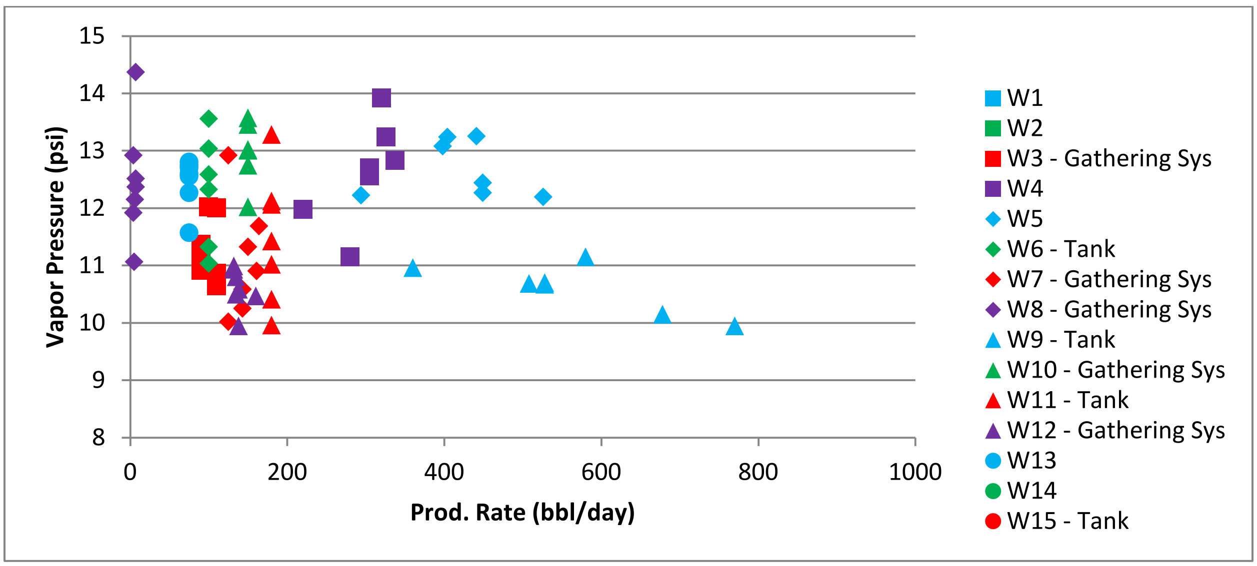
These equations hold that the difference in concentration between 50°F and 150°F operation is 0.13 and 0.25 liquid vol. % for ethane and propane, respectively. This represents approximately 0.4 liquid vol. %

of the total crude stream. It would stand that operating the treaters toward the higher end of their operating range would ensure maximum reduction of the light ends fractions of the crude oil with current equipment. Because of this, the NDPC recommends that operators run their treaters at the highest feasible operational temperature that allows for safe and consistent operation, to help minimize these components in the crude. This recognizes the limits of both treater design and the limits set forth for the safe storage of crude in stock tanks, which have upper bounds on crude storage temperature.

The impact of stock tanks for crude storage versus being connected to a gathering system on vapor pressure was also considered. Stock tanks hold produced crude and sit for a short time before being pumped out. In the case of this study, the duration between a filled stock tank and sample collection was as much as a day and a half. Because of this, there is a small opportunity for light ends to weather off. The comparison showed there was no appreciable trend between samples collected from wells on a gathering system versus those that used a stock tank and were isolated from the well before collection.

Figure 17 shows the data for this comparison, plotted for those wells with which we had distinct information on their configuration. This is expected, as tanks are designed to minimize evaporative emissions; so significant changes in vapor pressure would indicate the possibility of high tank emissions.

Figure 17: Vapor Pressure versus Well Production Rate



Overview of Sampling, Analytical Methods and Quality Control/Quality Assurance

Sampling

All samples were obtained at both the well and rail facilities by trained SGS personnel, based out of Williston, ND, following accepted industry practices for collection of crude oil samples. Sampling procedures in API Chapter 8.1 “Manual Sampling of Petroleum and Petroleum Products” formed the basis for their sampling methodology. SGS has also written in-house sampling procedures that supplement the API document, as part of their standard operating procedures.

The crude oil samples were collected in chilled one-quart glass bottles, immediately sealed, chilled, and transported to the Williston lab. This is very similar to sampling procedures used for finished gasoline, which has a RVP of up to 15 psi. All analyses in Williston were conducted within a few days of receipt.

As discussed before, on the first visit to each site, individual “top” and “bottom” level samples were obtained and analyzed. This was conducted to evaluate tank stratification. On subsequent visits to each site, “average” tank samples were collected.

On samples obtained from the last two visits to each site, the D7169 simulated distillation analysis was excluded. Results from this test were showing good consistency, and the continued analysis was adding little to the understanding of the light ends portion of the crude oil.

Analytical Methods and Quality Control/Quality Assurance

SGS, the primary contact lab utilized for the collection and analyses of the Bakken crude oil well and rail loading facility samples, is ISO 9001 certified at the corporate level. The St. Rose, LA lab, used to conduct the more sophisticated light ends and D7169 gas chromatographic simulated distillation analyses, is fully certified. The more recently acquired Williston, ND lab, used for the sample collection, API gravity, flash point, IBP by D86, and vapor pressure by D6377 analyses, is in the process of obtaining ISO 9001 certification.

ISO 9001:2008 is based on eight quality management principles:

- Customer focus;
- Leadership;
- Involvement of people;
- Process approach;
- System approach;
- Continual improvement;
- Fact-based decision making; and
- Mutually beneficial supplier relationships.

SGS follows standard ASTM methods. They ensure use of the most current standards by subscription to Tracker Alert biweekly, which provides prompt update notification. The updates are stored electronically for analyst referral at both labs.

Corporately, approximately 50 of the SGS labs participate in the ASTM Crude Oil Proficiency Program. This program, commonly referred to as a “round-robin” program, involves ASTM periodically preparing and supplying identical crude oil samples to labs all over the world. The labs then conduct their analyses and submit their results to ASTM. ASTM compiles the results and publishes the data, using lab code numbers to protect the identity of the labs. Each lab receives their own code number so they know their performance and how their results compare to the other participating labs, but do not know the identity of other participants. Programs such as this are vital for laboratories to evaluate their performance, take corrective action, and continually improve.

Specific QA/QC procedures for each of the analytical methods are described below.

- API Gravity by ASTM D5002 "Standard Test Method for Density and Relative Density of Crude Oils by Digital Density Meter" - This method is specifically for the measurement of crude oils. The instrumentation is calibrated with freshly distilled water as described in Section 10 of the method.

- Flash Point by ASTM D3278 (Williston lab) or ASTM D56 (St. Rose lab) - Flash point measures the tendency of the material to form a flammable mixture with air under controlled laboratory conditions. Section §173.120 of Hazardous Material Regulations allows for the use of either ASTM D56 or D3828. Both D56 and D3278 are very similar. ASTM D56 is the "Standard Method for Flash Point by Tag Closed Cup Tester," while ASTM D3278 is "Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus." Para-Xylene is used as a calibration/check standard for this method, and records were provided by SGS showing acceptable results for this material.

  In the case of flash point, it was not necessary to determine the exact flash point, but only to determine whether the value was above or below the critical value of 73°F, which distinguishes between PG II and PG III.

- IBP by ASTM D86 "Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure" - This method, originally approved by ASTM in 1921 is still utilized for certification of petroleum products such as gasoline and diesel fuel. Temperature bias is determined using reagent grade toluene as a standard, as described in Section 9 of the method. To verify the temperature measurement, pure n-hexadecane is used. SGS provided examples of the instrument printouts for the analyses of both of these reference materials.

  It should be noted that full boiling range crude oils are not within the scope of this method as described in Section 1. Thus, various labs have employed different conditions for the condenser and receiver temperatures. These parameters were shown to have a significant impact on the recorded IBP of whole crudes. However, these differences have only a minimal effect on the analysis of the standard materials. Thus, acceptable results on the standard materials do NOT ensure correct IBPs on whole crude.

- Vapor Pressure of Crude Oil (VPCRx) by ASTM D6377 "Standard Test Method for Determination of Vapor Pressure of Crude Oil: VPCRx (Expansion Method)" - This newer method (originally published in 1999) has become the method of choice for vapor pressure measurements of whole crude oils, and EPA recommended its use in a recent publication for determining storage tank compliance. Section 11 of the method describes Quality Control Checks and indicates that Pentane, 2,2-Dimethylbutane, or 2,3-Dimethylbutane may be used as acceptable reference fluids. SGS uses 2,2-Dimethylbutane, and provided results showing all values within the acceptable limits of 10.58 psi – 10.92 psi for this standard material.

- Light Ends in Crude Oil by IP344-88 (2010) “Determination of light hydrocarbons in stabilized crude oils- Gas Chromatography method” - This is an Institute of Petroleum (IP) method. IP is the British equivalent of ASTM. This is an internal standard gas chromatography (GC) method. No reference standard is used, but participation in the ASTM Crude Oil Proficiency program is used to evaluate the accuracy of the results from this analysis.

- Boiling Range Distribution by ASTM D7169 “Standard Test Method for Boiling Point Distribution of Samples with Residues Such as Crude Oils and Atmospheric and Vacuum Residues by High Temperature Gas Chromatography” - This newer method (originally published in 2005) is an external standard approach to obtain distillation type data for full-range crude oils. A reference gas oil is used for determination of detector response and evaluation of boiling points. This standard is run regularly. Blank runs are made to determine the baseline correction.

Documentation was also provided showing calibration information for balances and thermometers used in various laboratory methods.

Appendix 1: Additional Figures

Figure 1-1: Vapor Pressure versus Operating Pressure

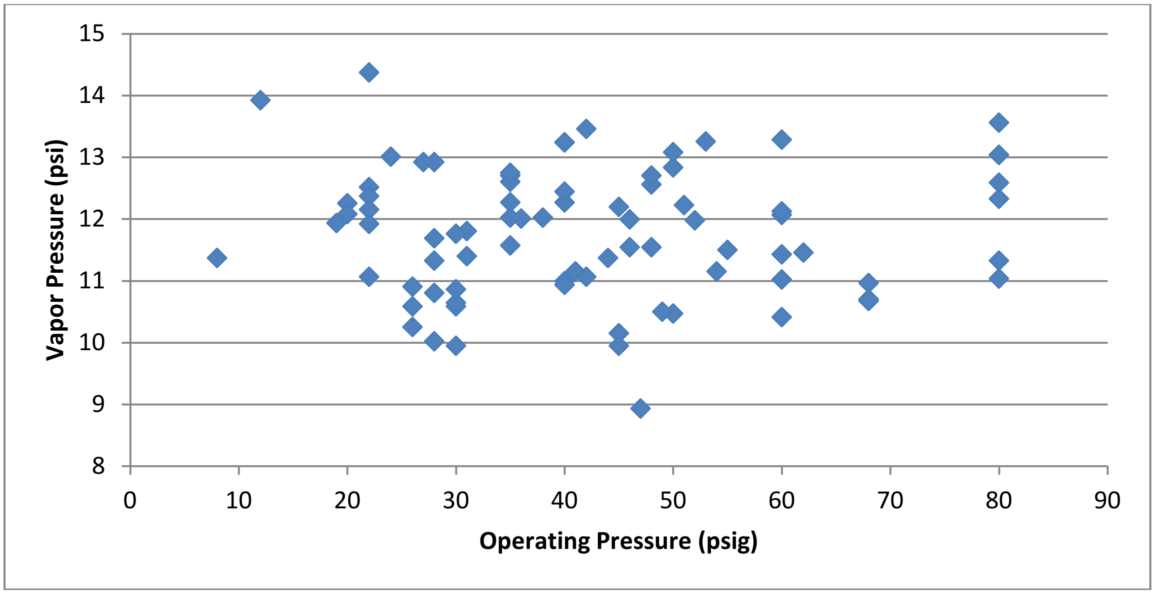
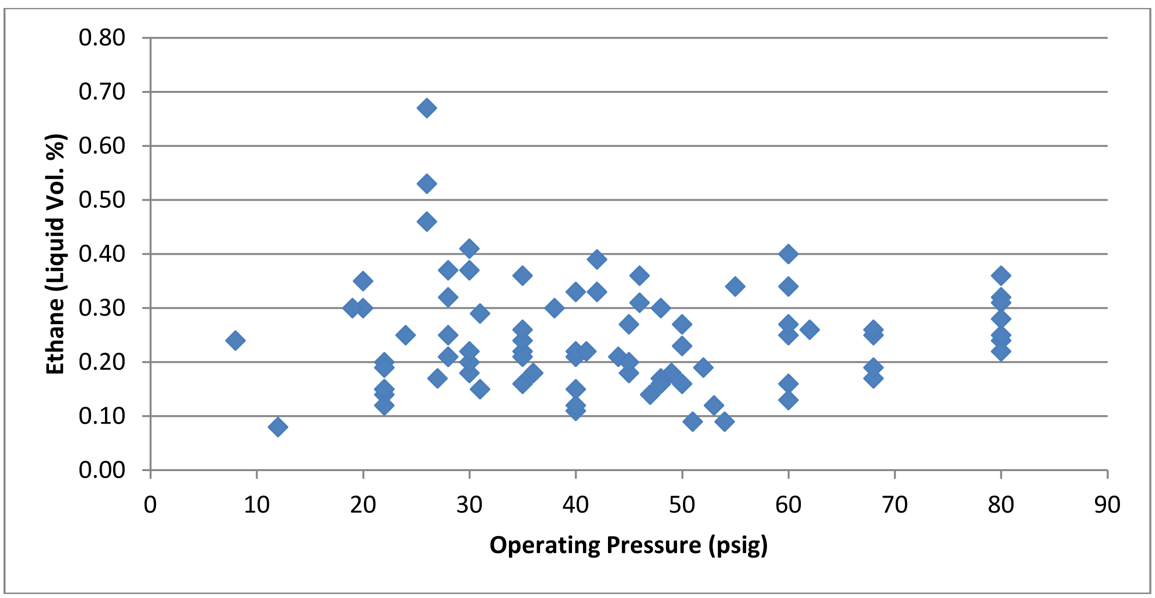


Figure 1-2: Ethane Liquid Vol. % versus Operating Pressure



Appendix 1: Additional Figures

Figure 1-3: Ethane Liquid Vol. % versus Production Rate

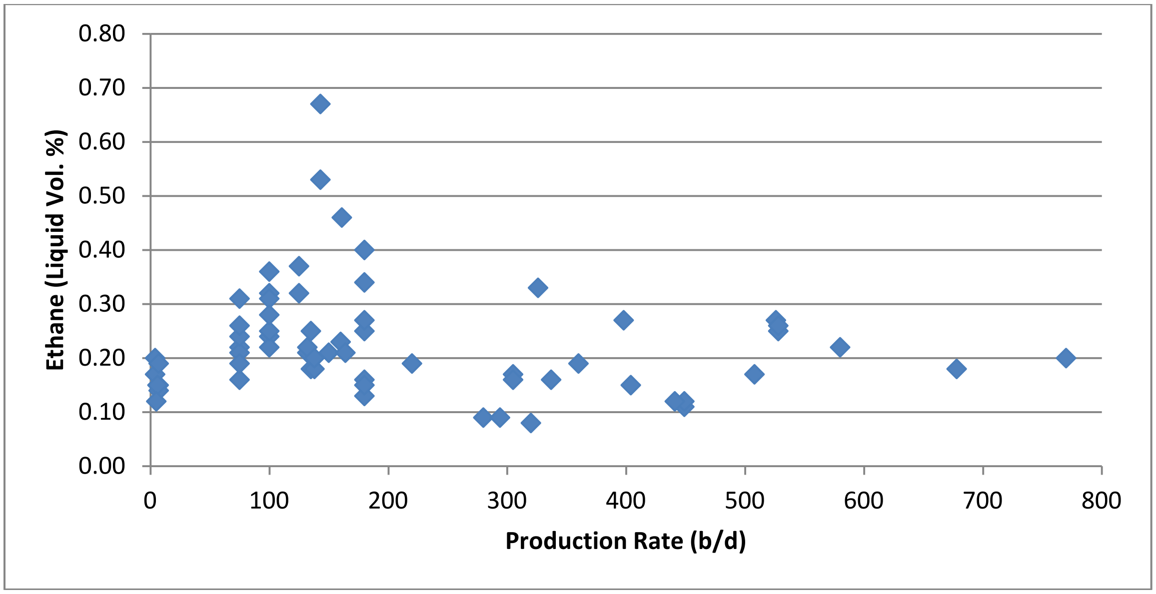
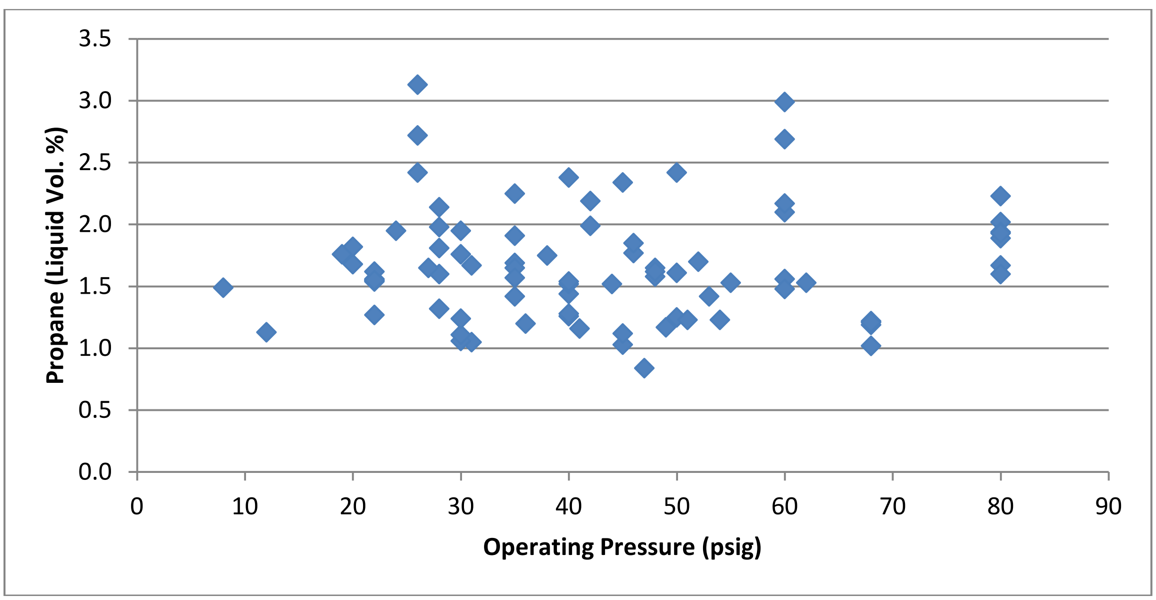


Figure 1-4: Propane Liquid Vol. % versus Operating Pressure



Appendix 1: Additional Figures

Figure 1-5: Propane Liquid Vol. % versus Production Rate

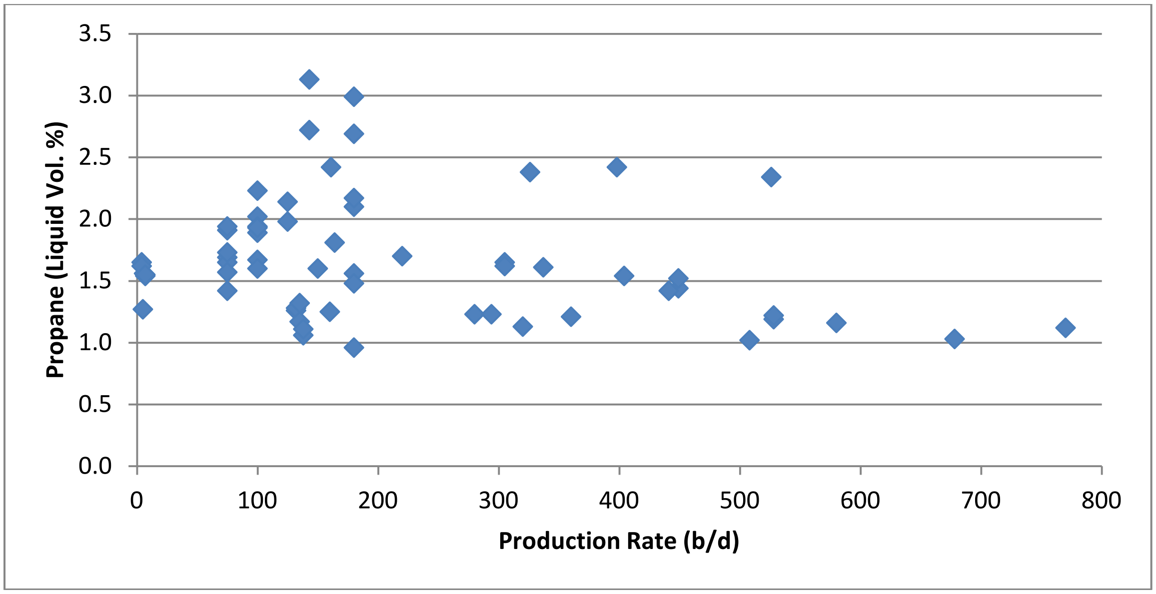
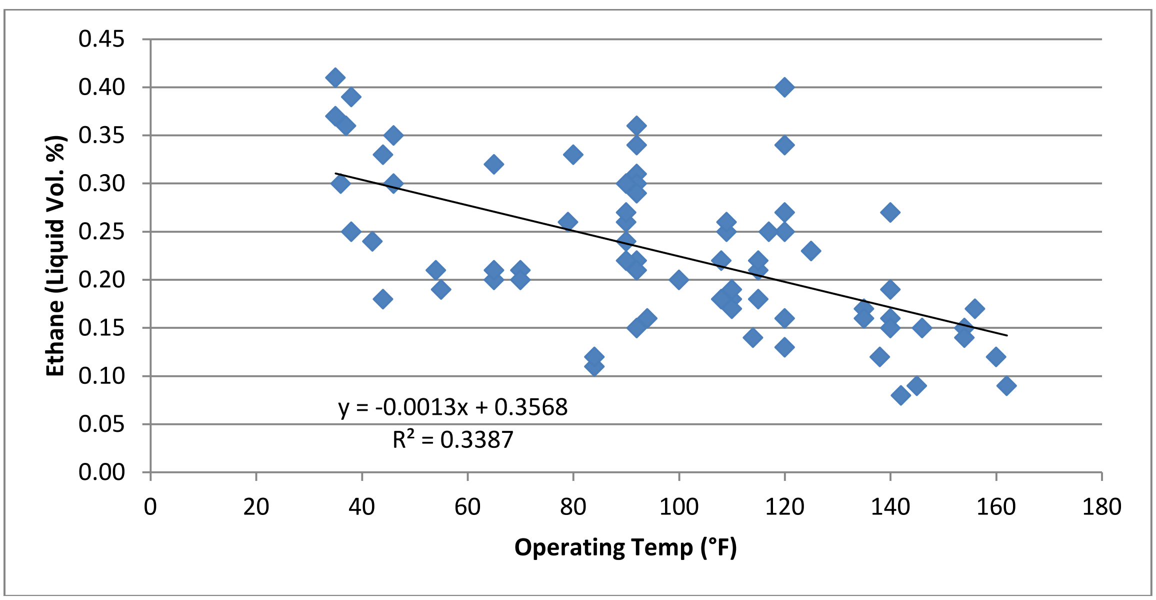
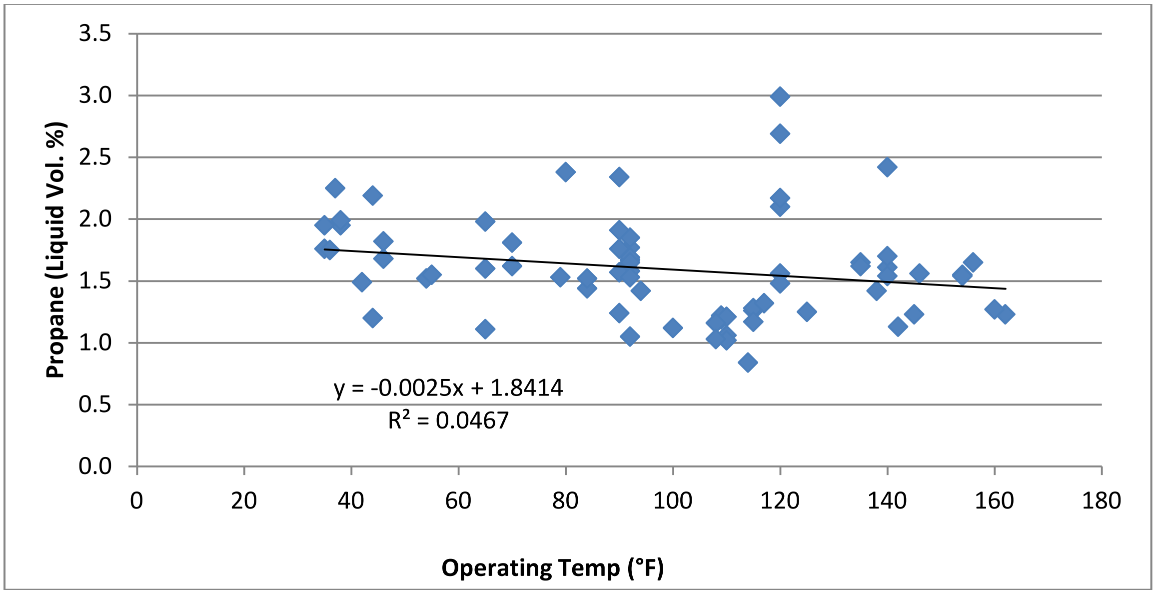


Figure 1-6: Ethane Liquid Vol. % versus Operating Temperature: Correlation
Note: anomalous readings from W7 excluded to improve correlation.



Appendix 1: Additional Figures

Figure 1-7: Propane Liquid Vol. % versus Operating Temperature: Correlation
Note: anomalous readings from W7 excluded to improve correlation.



Appendix 2 - Summary Data

	Total					Rail					Well				
	Count	Min	Avg	Max	StDev	Count	Min	Avg	Max	StDev	Count	Min	Avg	Max	StDev
Ambient Temp (°F)	108	10.0	**33.8**	65.0	13.7	37	10.0	**28.7**	47.0	9.8	71	11.0	**36.5**	65.0	14.7
API Gravity	152	36.7	**41.0**	46.3	2.2	49	39.2	**41.7**	44.0	1.3	103	36.7	**40.6**	46.3	2.4
D86 IBP (°F)	152	91.9	**99.5**	106.8	2.4	49	96.7	**100.3**	104.1	1.7	103	91.9	**99.1**	106.8	2.6
Vapor P via D6377 (100°F, 4:1 V/L) (psi)	152	8.93	**11.69**	14.37	0.97	49	9.57	**11.52**	12.85	0.80	103	8.93	**11.77**	14.37	1.04
Light Ends via IP344	**Count**	**Min**	**Avg**	**Max**	**StDev**	**Count**	**Min**	**Avg**	**Max**	**StDev**	**Count**	**Min**	**Avg**	**Max**	**StDev**
Methane	152	0.00	**0.00**	0.01	0.00	27	0.00	**0.00**	0.01	0.00	79	0.00	**0.00**	0.01	0.00
Ethane	152	0.08	**0.24**	0.67	0.08	49	0.13	**0.23**	0.33	0.04	103	0.08	**0.24**	0.67	0.09
Propane	152	0.84	**1.55**	3.13	0.41	49	1.02	**1.39**	1.95	0.24	103	0.84	**1.63**	3.13	0.45
Isobutane	152	0.35	**0.63**	0.95	0.13	49	0.46	**0.58**	0.73	0.07	103	0.35	**0.65**	0.95	0.15
n- Butane	152	2.00	**3.03**	4.55	0.56	49	2.17	**2.75**	3.51	0.33	103	2.00	**3.16**	4.55	0.60
Neopentane	150	0.00	**0.01**	0.01	0.00	49	0.00	**0.01**	0.01	0.00	101	0.00	**0.01**	0.01	0.00
Isopentane	152	1.10	**1.49**	1.93	0.20	49	1.17	**1.42**	1.69	0.11	103	1.10	**1.52**	1.93	0.23
n- Pentane	152	2.07	**2.84**	3.70	0.38	49	2.12	**2.72**	3.33	0.23	103	2.07	**2.90**	3.70	0.43
Cyclopentane	152	0.17	**0.22**	0.30	0.03	49	0.17	**0.21**	0.25	0.02	103	0.17	**0.23**	0.30	0.03
Hexanes	152	4.98	**6.33**	7.64	0.56	49	5.46	**6.33**	6.96	0.32	103	4.98	**6.34**	7.64	0.64
Simulated Distillation via D7169	**Count**	**Min**	**Avg**	**Max**	**StDev**	**Count**	**Min**	**Avg**	**Max**	**StDev**	**Count**	**Min**	**Avg**	**Max**	**StDev**
IBP	111	<97	**<97**	<97		111	<97	**<97**	<97		111	<97	**<97**	<97	
5%*	111	97	**108**	151	17	21	98	**113**	151	17	28	97	**106**	150	18
10%*	111	103	**157**	188	17	35	143	**165**	186	10	71	103	**153**	188	19
20%	111	180	**234**	278	20	35	216	**238**	264	11	76	180	**231**	278	23
30%	111	244	**312**	375	25	35	289	**316**	346	12	76	244	**310**	375	29
40%	111	327	**395**	476	29	35	364	**396**	436	15	76	327	**394**	476	34
50%	111	412	**481**	578	33	35	443	**482**	527	17	76	412	**481**	578	38
60%	111	508	**572**	684	35	35	527	**572**	623	19	76	508	**572**	684	41
70%	111	611	**671**	796	39	35	620	**670**	730	23	76	611	**671**	796	45
80%	111	718	**786**	920	42	35	733	**787**	850	25	76	718	**785**	920	48
90%	111	860	**936**	1069	43	35	888	**939**	1012	30	76	860	**935**	1069	48
95%	111	966	**1056**	1192	52	35	1000	**1060**	1180	44	76	966	**1053**	1192	55
FBP*	111	1186	**1309**	1362	44	21	1217	**1317**	1342	40	51	1186	**1305**	1362	45
Recovery (weight %)	111	95.7	**99.3**	100.0	1.1	35	95.9	**99.3**	100.0	1.1	76	95.7	**99.4**	100.0	1.1

* Items with astricks were adjusted averages, to account for one or more values that were above or below detection limits (97°F and 1382°F, respectively).
Those items were adjusted by averaging the detection limit for those values, and thus the averages may be slightly above or below the actual value.
Raw data can be seen in the other sheets for reference.

Appendix 3 - Sample Conditions - Rail Locations

Client ID	Sample Date	Sample Time	Ambient Temp (°F)	Sample Container	Tank Size (barrels)	Level Height in Tank	Sample Location
R1	3/25/2014	17:20	32	Glass Bottle	100,000	10ft	Top
R1	3/25/2014	17:00	32	Glass Bottle	100,000	10ft	Bottom
R1	3/27/2014	17:26	33	Glass Bottle	100,000	10ft	All Levels
R1	3/31/2014	14:08	19	Glass Bottle	100,000	16ft 2in	All Levels
R1	4/9/2014	10:38		Glass Bottle	100,000		All Levels
R1	4/16/2014	15:30		Glass Bottle	100,000		All Levels
R1	4/18/2014	11:00		Glass Bottle	100,000		All Levels
R2	3/25/2014	18:00	20	Glass Bottle	250,000		Top
R2	3/25/2014	18:00	20	Glass Bottle	250,000		Bottom
R2	3/27/2014	10:30	25	Glass Bottle	250,000		All Levels
R2	3/31/2014	12:30	13	Glass Bottle	250,000	46ft 9in	All Levels
R2	4/8/2014	10:20	45	Glass Bottle	250,000	43ft	All Levels
R2	4/15/2014	11:30		Glass Bottle	250,000	39ft 6in	All Levels
R2	4/18/2014	10:20	34	Glass Bottle	250,000	34ft	All Levels
R3	3/26/2014	14:30	29	Glass Bottle	50ft	41ft	Top
R3	3/26/2014	14:30	29	Glass Bottle	50ft	41ft	Bottom
R3	3/28/2014	13:30	32	Glass Bottle	50ft	42ft	All Levels
R3	4/1/2014	16:10	17	Glass Bottle	50ft	33ft	All Levels
R3	4/10/2014	14:50		Glass Bottle	50ft		All Levels
R3	4/15/2014	14:15	46	Glass Bottle	50ft	42ft	All Levels
R3	4/17/2014	13:00	32	Glass Bottle	50ft	42ft	All Levels
R4	3/25/2014	14:30	20	Glass Bottle	250,000	23ft	Top
R4	3/25/2014	14:30	20	Glass Bottle	250,000	23ft	Bottom
R4	3/27/2014	11:50	19	Glass Bottle	250,000	18ft	All Levels
R4	3/31/2014	11:20	10	Glass Bottle	250,000	17ft	All Levels
R4	4/7/2014	13:45	47	Glass Bottle	250,000	18ft	All Levels
R4	4/16/2014	12:35		Glass Bottle	250,000		All Levels
R4	4/18/2014	12:05	37	Glass Bottle	250,000	23ft	All Levels

Appendix 3 - Sample Conditions - Rail Locations

Client ID	Sample Date	Sample Time	Ambient Temp (°F)	Sample Container	Tank Size (barrels)	Level Height in Tank	Sample Location
R5	3/26/2014	12:00	36	Glass Bottle	45ft	39ft	Top
R5	3/26/2014	12:00	36	Glass Bottle	45ft	39ft	Bottom
R5	3/28/2014	12:00	32	Glass Bottle	45ft	32ft	All Levels
R5	4/1/2014	14:30	15	Glass Bottle	45ft	39ft	All Levels
R5	4/10/2014	13:15		Glass Bottle	45ft		All Levels
R5	4/15/2014	12:50	44	Glass Bottle	45ft	40ft	All Levels
R5	4/17/2014	11:40	32	Glass Bottle	45ft	28ft	All Levels
R6	3/26/2014	15:30	29	Glass Bottle	250,000		Top
R6	3/26/2014	15:30	29	Glass Bottle	250,000		Bottom
R6	3/27/2014	15:30	33	Glass Bottle	250,000		All Levels
R6	3/31/2014	14:00	13	Glass Bottle	250,000	27ft 4in	All Levels
R6	4/7/2014	15:00		Glass Bottle	250,000		All Levels
R6	4/15/2014	14:00		Glass Bottle	250,000	34ft 6in	All Levels
R6	4/17/2014	12:00		Glass Bottle	250,000	38ft 6in	All Levels
R7	3/26/2014	19:30	28	Glass Bottle	250,000	40ft	Top
R7	3/26/2014	19:30	28	Glass Bottle	250,000	40ft	Bottom
R7	3/28/2014	13:00	46	Glass Bottle	250,000	42ft	All Levels
R7	3/31/2014	17:00	22	Glass Bottle	250,000	35ft 6in	All Levels
R7	4/11/2014	10:50		Glass Bottle	250,000		All Levels
R7	4/14/2014	12:30	27	Glass Bottle	250,000	40ft	All Levels
R7	4/18/2014	10:00		Glass Bottle	250,000	33ft	All Levels

Appendix 4 - Sample Conditions - Well

Client ID	Sample Date	Sample Time	Ambient Temp (°F)	Sample Container	Tank Size (barrels)	Level Height in Tank	Sample Location
W1	3/25/2014	19:45	18	Glass Bottle	400	15ft	Top
W1	3/25/2014	19:45	18	Glass Bottle	400	15ft	Bottom
W1	3/27/2014	18:15	26	Glass Bottle	400	15ft	All Levels
W1	3/30/2014	16:00	39	Glass Bottle	400	15ft	All Levels
W1	4/1/2014	11:00		Glass Bottle	400		All Levels
W1	4/7/2014	12:20	31	Glass Bottle	400	18ft	All Levels
W1	4/16/2014	11:30		Glass Bottle	400	14ft	All Levels
W2	3/26/2014	12:45	30	Glass Bottle	400	14ft	Top
W2	3/26/2014	12:45	30	Glass Bottle	400	14ft	Bottom
W2	3/29/2014	15:00	52	Glass Bottle	400	10ft	All Levels
W2	3/31/2014	10:00	12	Glass Bottle	400	15ft	All Levels
W2	4/7/2014	13:05	51	Glass Bottle	400	16ft	All Levels
W2	4/16/2014	12:00		Glass Bottle	400		All Levels
W2	4/19/2014	9:00		Glass Bottle	400		All Levels
W3	3/25/2014	12:30	15	Glass Bottle	400	10ft	Top
W3	3/25/2014	12:30	15	Glass Bottle	400	10ft	Bottom
W3	3/27/2014	10:00	24	Glass Bottle	400	10ft	All Levels
W3	3/31/2014	10:00	11	Glass Bottle	400	10ft	All Levels
W3	4/7/2014	12:50	42	Glass Bottle	400	12ft	All Levels
W3	4/16/2014	10:30		Glass Bottle	400	12ft	All Levels
W3	4/18/2014	11:20	37	Glass Bottle	400	10ft	All Levels
W4	3/26/2014	12:00	30	Glass Bottle	400	6ft	Top
W4	3/26/2014	12:00	30	Glass Bottle	400	6ft	Bottom
W4	3/28/2014	13:15	23	Glass Bottle	400	5ft 9in	All Levels
W4	4/3/2014	17:25	37	Glass Bottle	400	9ft	All Levels
W4	4/7/2014	18:14	49	Glass Bottle	400	10ft 6in	All Levels
W4	4/15/2014	16:00		Glass Bottle	400	7ft 7in	All Levels
W4	4/17/2014	14:30		Glass Bottle	400	7ft 2in	All Levels

Appendix 4 - Sample Conditions - Well

Client ID	Sample Date	Sample Time	Ambient Temp (°F)	Sample Container	Tank Size (barrels)	Level Height in Tank	Sample Location
W5	3/26/2014	15:50	30	Glass Bottle	400	5ft 6in	Top
W5	3/26/2014	15:50	30	Glass Bottle	400	5ft 6in	Bottom
W5	3/28/2014	13:50	23	Glass Bottle	400	5ft	All Levels
W5	4/4/2014	17:28	39	Glass Bottle	400	3ft	All Levels
W5	4/7/2014	19:08	46	Glass Bottle	400	6ft	All Levels
W5	4/15/2014	17:00	48	Glass Bottle	400	13ft 3in	All Levels
W5	4/17/2014	15:30	46	Glass Bottle	400	7ft 7in	All Levels
W6	4/6/2014	14:55	58	Glass Bottle	400	12ft 10.5in	Top
W6	4/6/2014	14:55	58	Glass Bottle	400	12ft 10.5in	Bottom
W6	4/8/2014	13:50	70	Glass Bottle	400	14ft 7in	All Levels
W6	4/15/2014	17:05	49	Glass Bottle	400	16ft 5.5in	All Levels
W6	4/17/2014	14:05	39	Glass Bottle	400	14ft 7.75in	All Levels
W6	4/21/2014	16:30	63	Glass Bottle	400	13ft 9in	All Levels
W6	4/24/2014	11:20	48	Glass Bottle	400	13ft 6in	All Levels
W7	3/25/2014	17:00	28	Glass Bottle	400	18ft	Top
W7	3/25/2014	17:00	28	Glass Bottle	400	18ft	Bottom
W7	3/27/2014	13:00	25	Glass Bottle	400	16ft	All Levels
W7	3/31/2014	13:00	16	Glass Bottle	400	15ft	All Levels
W7	4/7/2014	16:00	47	Glass Bottle	400	19ft	All Levels
W7	4/16/2014	14:20		Glass Bottle	400	7ft	All Levels
W7	4/21/2014	13:45	65	Glass Bottle	400	18ft	All Levels
W8	3/25/2014	14:53	27	Glass Bottle	400	13ft	Top
W8	3/25/2014	14:33	27	Glass Bottle	400	13ft	Bottom
W8	3/27/2014	15:30	32	Glass Bottle	400	7ft	All Levels
W8	3/31/2014	12:42	15	Glass Bottle	400	10ft	All Levels
W8	4/9/2014	12:30	65	Glass Bottle	400	8ft	All Levels
W8	4/16/2014	17:00		Glass Bottle	400	8ft 3in	All Levels
W8	4/18/2014	13:00		Glass Bottle	400	9ft	All Levels

Appendix 4 - Sample Conditions - Well

Client ID	Sample Date	Sample Time	Ambient Temp (°F)	Sample Container	Tank Size (barrels)	Level Height in Tank	Sample Location
W9	4/1/2014	11:20	13	Glass Bottle	400	13ft 6in	Top
W9	4/1/2014	12:10	13	Glass Bottle	400	13ft 6in	Bottom
W9	4/3/2014	13:00	25	Glass Bottle	400	13ft	All Levels
W9	4/8/2014	11:25	45	Glass Bottle	400	6ft 11in	All Levels
W9	4/15/2014	12:33	43	Glass Bottle	400	15ft	All Levels
W9	4/22/2014	11:35	63	Glass Bottle	400	12ft 1in	All Levels
W9	4/24/2014	14:20	53	Glass Bottle	400	18ft	All Levels
W10	4/15/2014	15:40	48	Glass Bottle	400	4ft	Top
W10	4/15/2014	15:40	48	Glass Bottle	400	4ft	Bottom
W10	4/17/2014	12:50	37	Glass Bottle	400	4ft	All Levels
W10	4/21/2014	15:30	58	Glass Bottle	400		All Levels
W10	4/24/2014	12:35	50	Glass Bottle	400	8ft	All Levels
W10	4/29/2014	11:00	32	Glass Bottle	400	10ft	All Levels
W11	4/7/2014	16:35	50	Glass Bottle	400	19ft	Top
W11	4/7/2014	16:35	50	Glass Bottle	400	19ft	Bottom
W11	4/11/2014	14:55	55	Glass Bottle	400	19ft	All Levels
W11	4/15/2014	15:00		Glass Bottle	400	16ft 4in	All Levels
W11	4/17/2014	13:30		Glass Bottle	400	12ft 2in	All Levels
W11	4/20/2014	11:00		Glass Bottle	400	17ft 2in	All Levels
W11	4/23/2014	13:00		Glass Bottle	400	16ft 4in	All Levels
W12	3/27/2014	12:46	27	Glass Bottle	400	12ft	Top
W12	3/27/2014	12:16	27	Glass Bottle	400	12ft	Bottom
W12	3/30/2014	13:00	42	Glass Bottle	400	18ft	All Levels
W12	4/1/2014	13:40	15	Glass Bottle	400	14ft	All Levels
W12	4/8/2014	13:20	59	Glass Bottle	400	10ft	All Levels
W12	4/17/2014	15:10	43	Glass Bottle	400	13ft	All Levels
W12	4/17/2014	15:30	35	Glass Bottle	400	8ft	All Levels

Appendix 4 - Sample Conditions - Well

Client ID	Sample Date	Sample Time	Ambient Temp (°F)	Sample Container	Tank Size (barrels)	Level Height in Tank	Sample Location
W13	3/26/2014	17:00	31	Glass Bottle	400	11ft	Top
W13	3/26/2014	17:00	31	Glass Bottle	400	11ft	Bottom
W13	3/28/2014	15:30	25	Glass Bottle	400	6ft	All Levels
W13	4/4/2014	15:15	39	Glass Bottle	400	6ft	All Levels
W13	4/8/2014	11:00	46	Glass Bottle	400	16ft	All Levels
W13	4/15/2014	19:30		Glass Bottle	400		All Levels
W13	4/19/2014	14:00		Glass Bottle	400		All Levels
W14	4/6/2014	16:20		Glass Bottle	400		Top
W14	4/6/2014	16:20		Glass Bottle	400		Bottom
W14	4/4/2014	11:55	34	Glass Bottle	400	2ft 6in	All Levels
W14	4/8/2014	12:30	50	Glass Bottle	400	6ft	All Levels
W14	4/18/2014	16:30		Glass Bottle	400		All Levels
W14	4/20/2014	14:00		Glass Bottle	400		All Levels
W14	4/22/2014	11:00		Glass Bottle	400		All Levels
W15	4/9/2014	17:20		Glass Bottle	40,000bbl/50 ft	30ft 6in	Top
W15	4/9/2014	17:20		Glass Bottle	40,000bbl/50 ft	30ft 6in	Bottom
W15	4/18/2014	19:30		Glass Bottle	40,000bbl/50 ft	22ft 9in	All Levels
W15	4/21/2014	18:30		Glass Bottle	40,000bbl/50 ft	36ft 2in	All Levels
W15	4/23/2014	13:00		Glass Bottle	40,000bbl/50 ft	37ft 4in	All Levels
W15	4/24/2014	16:30	57	Glass Bottle	40,000bbl/50 ft	32ft 9in	All Levels

Client ID	Sample Date	Sample Time	Tank Vapor Capture - Flare Stack or VRU	Production Rates from Producer(b/d)	Last Movement from Tank (Date and Time)	Separator Size	Separator Operating Pressure (psig)	Separator Operating Temp (°F)	Treater/Emulsion Heater Size	Treater/Emulsion Heater Operating Pressure (psig)	Treater/Emulsion Heater Operating Temp (°F)	Treater/Emulsion Heater Oil Line Dia (inches)	Treater/Emulsion Heater Oil Dump Valve Size/Style	Additional Field Info
W1	3/25/14	19:45								46	92			Treater
W1	3/25/14	19:45								46	92			Treater
W1	3/27/14	18:15								48	92			Treater
W1	3/30/14	16:00								31	92			Treater
W1	4/1/14	11:00												
W1	4/7/14	12:20								31	92			
W1	4/16/14	11:30												
W2	3/26/14	12:45								20	46			Treater
W2	3/26/14	12:45								20	46			Treater
W2	3/29/14	15:00								19	90			Treater
W2	3/31/14	10:00								55	92			Treater
W2	4/7/14	13:05								44	54			Treater
W2	4/16/14	12:00												
W2	4/19/14	9:00												
W3	3/25/14	12:30		110	N/A				6' x 20'	30	35	3"	3" Kimray	
W3	3/25/14	12:30		110	N/A				6' x 20'	30	35	3"	3" Kimray	
W3	3/27/14	10:00		90	N/A				6' x 20'	42	38	3"	3" Kimray	
W3	3/31/14	10:00		100	N/A				6' x 20'	38	36	3"	3" Kimray	
W3	4/7/14	12:50		110	N/A				6' x 20'	36	44	3"	3" Kimray	
W3	4/16/14	10:30		90	N/A				6' x 20'	44	36	3"	3" Kimray	
W3	4/18/14	11:20		90	N/A				6' x 20'	8	42	3"	3" Kimray	
W4	3/26/14	12:00	Flare Stack	305		N/A	N/A	N/A	6' x 22'	48	135	3"	3" Gas Operated	On Gathering System
W4	3/26/14	12:00	Flare Stack	305		N/A	N/A	N/A	6' x 22'	48	135	3"	3" Gas Operated	On Gathering System
W4	3/28/14	13:15	Flare Stack	337		N/A	N/A	N/A	6' x 22'	50	140	3"	3" Gas Operated	On Gathering System
W4	4/3/14	17:25	Flare Stack	280		N/A	N/A	N/A	6' x 22'	54	145	3"	3" Gas Operated	On Gathering System
W4	4/7/14	18:14	Flare Stack	320		N/A	N/A	N/A	6' x 22'	12	142	3"	3" Gas Operated	On Gathering System
W4	4/15/14	16:00	Flare Stack	220		N/A	N/A	N/A	6' x 22'	52	140	3"	3" Gas Operated	On Gathering System
W4	4/17/14	14:30	Flare Stack	326		N/A	N/A	N/A	6' x 22'	40	80	3"	3" Gas Operated	On Gathering System
W5	3/26/14	15:50	Both (Stack/VRU)	449		N/A	N/A	N/A	6' x 22'	40	84	3"	3" Gas Operated	On Gathering System
W5	3/26/14	15:50	Both (Stack/VRU)	449		N/A	N/A	N/A	6' x 22'	40	84	3"	3" Gas Operated	On Gathering System
W5	3/28/14	13:50	Both (Stack/VRU)	404		N/A	N/A	N/A	6' x 22'	40	140	3"	3" Gas Operated	On Gathering System
W5	4/4/14	17:28	Both (Stack/VRU)	294		N/A	N/A	N/A	6' x 22'	51	162	3"	3" Gas Operated	On Gathering System
W5	4/7/14	19:08	Both (Stack/VRU)	441		N/A	N/A	N/A	6' x 22'	53	138	3"	3" Gas Operated	On Gathering System
W5	4/15/14	17:00	Both (Stack/VRU)	526		N/A	N/A	N/A	6' x 22'	45	90	3"	3" Gas Operated	On Gathering System
W5	4/17/14	15:30	Both (Stack/VRU)	398		N/A	N/A	N/A	6' x 22'	50	140	3"	3" Gas Operated	On Gathering System
W6	4/6/14	14:55		100	4/5/14 11:00	30" x 10'	80		6' x 20'	30		3"	3" Steel	
W6	4/6/14	14:55		100	4/5/14 11:00	30" x 10'	80		6' x 20'	30		3"	3" Steel	
W6	4/8/14	13:50		100	4/7/14 11:00	30" x 10'	80		6' x 20'	30		3"	3" Steel	
W6	4/15/14	17:05		100	4/14/14 11:00	30" x 10'	80		6' x 20'	30		3"	3" Steel	
W6	4/17/14	14:05		100	4/16/14 11:00	30" x 10'	80		6' x 20'	30		3"	3" Steel	
W6	4/21/14	16:30		100	4/20/14 11:00	30" x 10'	80		6' x 20'	30		3"	3" Steel	
W6	4/24/14	11:20		100	4/23/14 11:00	30" x 10'	80		6' x 20'	30		3"	3" Steel	
W7	3/25/14	17:00	Flare Stack	143	N/A	30" x 10'			6' x 20'	26	120	3"	3" float operated	
W7	3/25/14	17:00	Flare Stack	143	N/A	30" x 10'			6' x 20'	26	120	3"	3" float operated	
W7	3/27/14	13:00	Flare Stack	161	N/A	30" x 10'			6' x 20'	26	123	3"	3" float operated	
W7	3/31/14	13:00	Flare Stack	125	N/A	30" x 10'			6' x 20'	28	38	3"	3" float operated	
W7	4/7/14	16:00	Flare Stack	150	N/A	30" x 10'			6' x 20'	28	65	3"	3" float operated	
W7	4/16/14	14:20	Flare Stack	125	N/A	30" x 10'			6' x 20'	28	65	3"	3" float operated	
W7	4/21/14	13:45	Flare Stack	164	N/A	30" x 10'			6' x 20'	28	70	3"	3" float operated	

Client ID	Sample Date	Sample Time	Tank Vapor Capture - Flare Stack or VRU	Production Rates from Producer(b/d)	Last Movement from Tank (Date and Time)	Separator Size	Separator Operating Pressure (psig)	Separator Operating Temp (°F)	Treater/Emulsion Heater Size	Treater/Emulsion Heater Operating Pressure (psig)	Treater/Emulsion Heater Operating Temp (°F)	Treater/Emulsion Heater Oil Line Dia (inches)	Treater/Emulsion Heater Oil Dump Valve Size/Style	Additional Field Info
W8	3/25/14	14:33	Flare Stack	7	N/A	30" x 10'			6' x 20'	22	154	3"	3" float operated	
W8	3/27/14	15:30	Flare Stack	4	N/A	30" x 10'			6' x 20'	27	156	3"	3" float operated	
W8	3/31/14	12:42	Flare Stack	6	N/A	30" x 10'			6' x 20'	22	146	3"	3" float operated	
W8	4/9/14	12:30	Flare Stack	5	N/A	30" x 10'			6' x 20'	22	160	3"	3" float operated	
W8	4/16/14	17:00	Flare Stack	4	N/A	30" x 10'			6' x 20'	22	70	3"	3" float operated	
W8	4/18/14	13:00	Flare Stack	7	N/A	30" x 10'			6' x 20'	22	55	3"	3" float operated	
W9	4/1/14	11:20	Flare Stack	528	3/31/14 8:30				6' x 20'	68	109		D3	Sunny, Still weather
W9	4/1/14	12:10	Flare Stack	528	3/31/14 8:30				6' x 20'	68	109		D3	Sunny, Still weather
W9	4/3/14	13:00	Flare Stack	508	4/3/14 10:20				6' x 20'	68	110		D3	Windy and Cloudy
W9	4/8/14	11:25	Flare Stack	360	Note Indicates N/A				6' x 20'	68	110		D3	Partially Cloudy
W9	4/15/14	12:33	Flare Stack	580	4/14/14 12:33				6' x 20'	41	108		D3	Partially Cloudy and windy
W9	4/22/14	11:35	Flare Stack	678	4/21/14 0:00				6' x 20'	45	108		D3	Sunny 20-25 mph winds
W9	4/24/14	14:20	Flare Stack	770	4/24/14 9:05				6' x 20'	45	100		D3	Sunny
W10	4/15/14	15:40		150	N/A (Comingled)				6' x 20'	35	37			Observed: 0.05% BS&W
W10	4/15/14	15:40		150	N/A (Comingled)				6' x 20'	35	37			Observed: 0.05% BS&W
W10	4/17/14	12:50		150	N/A (Comingled)		35	37	6' x 20'	35	37			
W10	4/21/14	15:30		150	N/A (Comingled)		42	44	6' x 20'	42	44			
W10	4/24/14	12:35		150	N/A (Comingled)		24	38	6' x 20'	24	38			
W10	4/29/14	11:00		150	N/A (Comingled)				6' x 20'	5	39			
W11	4/7/14	16:35	Flare Stack	180	4/7/14 16:35	30" x 10'	36		6' x 22'	60	120	3"	3"	Observed: 36 API at 75F, 0.05% BS&W
W11	4/7/14	16:35	Flare Stack	180	4/7/14 16:35	30" x 10'	36		6' x 22'	60	120	3"	3"	Observed: 36 API at 75F, 0.05% BS&W
W11	4/11/14	14:55	Flare Stack	180	4/11/14 14:55	30" x 10'	36		6' x 22'	60	120	3"	3"	Observed: 32 API at 76F, 0.05% BS&W
W11	4/15/14	15:00	Flare Stack	180	4/15/14 15:00	30" x 10'	36		6' x 22'	60	120	3"	3"	Observed: 34 API at 72F, 0.05% BS&W
W11	4/17/14	13:30	Flare Stack	180	4/17/14 13:30	30" x 10'	36		6' x 22'	60	120	3"	3"	Observed: 34 API at 73F, 0.05% BS&W
W11	4/20/14	11:00	Flare Stack	180	4/20/14 11:00	30" x 10'	36		6' x 22'			3"	3"	Observed: 36 API at 73F, 0.05% BS&W
W11	4/23/14	13:00	Flare Stack	180	4/23/14 15:30	30" x 10'	36		6' x 22'	60	120	3"	3"	Observed: 36 API at 75F, 0.05% BS&W
W12	3/27/14	12:46	Flare Stack	132	N/A	30" x 10'			6' x 20'	40	115	3"	3" float operated	
W12	3/27/14	12:16	Flare Stack	132	N/A	30" x 10'			6' x 20'	40	115	3"	3" float operated	
W12	3/30/14	13:00	Flare Stack	160	N/A	30" x 10'			6' x 20'	50	125	3"	3" float operated	
W12	4/1/14	13:40	Flare Stack	135	N/A	30" x 10'			6' x 20'	28	117	3"	3" float operated	
W12	4/8/14	13:20	Flare Stack	135	N/A	30" x 10'			6' x 20'	49	115	3"	3" float operated	
W12	4/17/14	15:10	Flare Stack	138	N/A	30" x 10'			6' x 20'	30	110	3"	3" float operated	
W12	4/17/14	15:30	Flare Stack	138	N/A	30" x 10'			6' x 20'	30	65	3"	3" float operated	
W13	3/26/14	17:00		75		80 bbl	35		500,000 btu/hr	35	92	3"	3" Kimray	Observed 42.3 API at 60F
W13	3/26/14	17:00		75		80 bbl	35		500,000 btu/hr	35	92	3"	3" Kimray	Observed 42.3 API at 60F
W13	3/28/14	15:30		75		80 bbl	35		500,000 btu/hr	35	90	3"	3" Kimray	Observed 42.3 API at 60F
W13	4/4/14	15:15		75		80 bbl	35		500,000 btu/hr	35	94	3"	3" Kimray	Observed 42.3 API at 60F
W13	4/8/14	11:00		75		80 bbl	35		500,000 btu/hr	36	90	3"	3" Kimray	Observed 42.3 API at 60F
W13	4/15/14	19:30		75		80 bbl	35		500,000 btu/hr			3"	3" Kimray	Observed 42.3 API at 60F
W13	4/19/14	14:00		75		80 bbl	35		500,000 btu/hr			3"	3" Kimray	Observed 42.3 API at 60F
W14	4/6/14	16:20												
W14	4/6/14	16:20												
W14	4/4/14	11:55					30	90		30	90			
W14	4/8/14	12:30					62	79		62	79			
W14	4/18/14	16:30												
W14	4/20/14	14:00												
W14	4/22/14	11:00					47	114		47	114			
W15	4/9/14	17:20			4/9/14 17:20									Observed 43 API
W15	4/9/14	17:20			4/9/14 17:20									Observed 43 API
W15	4/18/14	19:30			4/18/14 19:30									Observed 43 API
W15	4/21/14	18:30			4/21/14 18:30									Observed 43 API
W15	4/23/14	13:00			4/23/14 13:00									Observed 43 API
W15	4/24/14	16:30			4/24/14 16:30									Observed 43 API

Appendix 6 - Lab Data - Rail

Client ID	Sample Date	Sample Time	API Gravity	D86 IBP (°F)	Vapor P via D6377 (100°F, 4:1 V/L) (psi)	Vapor P via D6377 (100°F, 4:1 V/L) (kPa)	Flash Point D3278 (°F)
R1	3/25/2014	17:20	39.6	100.5	9.73	67.1	<73
R1	3/25/2014	17:00	39.5	102.9	9.96	68.7	<73
R1	3/27/2014	17:26	39.7	103.9	9.67	66.7	<73
R1	3/31/2014	14:08	42.8	100.5	11.31	78.0	<73
R1	4/9/2014	10:38	41.6	100.8	11.76	81.1	<73
R1	4/16/2014	15:30	42.1	98.4	11.85	81.7	<73
R1	4/18/2014	11:00	41.4	99.9	12.33	85.0	<73
R2	3/25/2014	18:00	43.4	99.9	11.73	80.9	<73
R2	3/25/2014	18:00	42.8	100.7	11.68	80.5	<73
R2	3/27/2014	10:30	43.8	99.5	12.39	85.4	<73
R2	3/31/2014	12:30	43.2	99.4	11.52	79.4	<73
R2	4/8/2014	10:20	40.3	100.5	11.55	79.6	<73
R2	4/15/2014	11:30	42.0	97.8	11.94	82.3	<73
R2	4/18/2014	10:20	39.2	99.6	11.89	82.0	<73
R3	3/26/2014	14:30	42.4	103.5	11.53	79.5	<73
R3	3/26/2014	14:30	42.6	101.9	11.70	80.7	<73
R3	3/28/2014	13:30	42.6	100.9	11.53	79.5	<73
R3	4/1/2014	16:10	41.7	102.0	10.95	75.5	<73
R3	4/10/2014	14:50	40.9	97.2	11.53	79.5	<73
R3	4/15/2014	14:15	41.3	98.2	11.46	79.0	<73
R3	4/17/2014	13:00	40.6	98.8	11.02	76.0	<73
R4	3/25/2014	14:30	41.3	99.9	11.95	82.4	<73
R4	3/25/2014	14:30	41.4	99.2	11.25	77.6	<73
R4	3/27/2014	11:50	43.1	99.9	11.95	82.4	<73
R4	3/31/2014	11:20	41.5	99.5	12.44	85.8	<73
R4	4/7/2014	13:45	41.5	99.5	12.85	88.6	<73
R4	4/16/2014	12:35	40.3	99.1	12.08	83.3	<73
R4	4/18/2014	12:05	39.8	100.5	11.99	82.7	<73

Appendix 6 - Lab Data - Rail

Client ID	Sample Date	Sample Time	API Gravity	D86 IBP (°F)	Vapor P via D6377 (100°F, 4:1 V/L) (psi)	Vapor P via D6377 (100°F, 4:1 V/L) (kPa)	Flash Point D3278 (°F)
R5	3/26/2014	12:00	44.0	101.0	10.52	72.5	<73
R5	3/26/2014	12:00	43.9	101.9	10.47	72.2	<73
R5	3/28/2014	12:00	42.4	100.5	10.50	72.4	<73
R5	4/1/2014	14:30	43.1	103.7	10.28	70.9	<73
R5	4/10/2014	13:15	42.6	100.4	10.95	75.5	<73
R5	4/15/2014	12:50	41.8	100.8	10.85	74.8	<73
R5	4/17/2014	11:40	42.0	103.4	9.57	66.0	<73
R6	3/26/2014	15:30	42.6	99.7	12.84	88.5	<73
R6	3/26/2014	15:30	42.5	98.9	12.47	86.0	<73
R6	3/27/2014	15:30	43.0	98.9	12.71	87.6	<73
R6	3/31/2014	14:00	41.2	99.4	11.82	81.5	<73
R6	4/7/2014	15:00	39.9	96.7	12.43	85.7	<73
R6	4/15/2014	14:00	40.2	100.8	12.52	86.3	<73
R6	4/17/2014	12:00	39.7	100.1	11.88	81.9	<73
R7	3/26/2014	19:30	42.3	104.1	11.66	80.4	<73
R7	3/26/2014	19:30	42.8	99.7	11.57	79.8	<73
R7	3/28/2014	13:00	42.6	99.5	11.89	82.0	<73
R7	3/31/2014	17:00	42.2	101.9	11.86	81.8	<73
R7	4/11/2014	10:50	40.9	99.3	11.37	78.4	<73
R7	4/14/2014	12:30	41.5	98.9	11.37	78.4	<73
R7	4/18/2014	10:00	40.4	101.7	11.39	78.5	<73

Appendix 7 - Lab Data - Well

Client ID	Sample Date	Sample Time	API Gravity	D86 IBP (°F)	Vapor P via D6377 (100°F, 4:1 V/L) (psi)	Vapor P via D6377 (100°F, 4:1 V/L) (kPa)	Flash Point D3278 (°F)
W1	3/25/2014	19:45	40.6	98.2	11.99	82.7	<73
W1	3/25/2014	19:45	39.2	102.1	11.55	79.6	<73
W1	3/27/2014	18:15	40.3	99.7	11.55	79.6	<73
W1	3/30/2014	16:00	39.1	99.2	11.81	81.4	<73
W1	4/1/2014	11:00	37.1	98.8	12.18	84	<73
W1	4/7/2014	12:20	37.1	99.9	11.40	78.6	<73
W1	4/16/2014	11:30	37.7	98.6	11.57	79.8	<73
W2	3/26/2014	12:45	41.4	100.6	12.26	84.5	<73
W2	3/26/2014	12:45	40.2	100.3	12.08	83.3	<73
W2	3/29/2014	15:00	41.5	100.7	11.94	82.3	<73
W2	3/31/2014	10:00	39.9	101.9	11.50	79.3	<73
W2	4/7/2014	13:05	40.0	98.9	11.37	78.4	<73
W2	4/16/2014	12:00	38.0	98.1	11.27	77.7	<73
W2	4/19/2014	9:00	38.9	99.8	11.91	82.1	<73
W3	3/25/2014	12:30	43.8	96.8	10.65	73.4	<73
W3	3/25/2014	12:30	44.4	99.7	10.86	74.9	<73
W3	3/27/2014	10:00	44.4	98.6	11.07	76.3	<73
W3	3/31/2014	10:00	43.4	98.1	12.02	82.9	<73
W3	4/7/2014	12:50	42.1	99.4	12.01	82.8	<73
W3	4/16/2014	10:30	40.2	98.4	10.92	75.3	<73
W3	4/18/2014	11:20	42.1	98.9	11.37	78.4	<73
W4	3/26/2014	12:00	40.0	98.5	12.56	86.6	<73
W4	3/26/2014	12:00	41.7	97.7	12.71	87.6	<73
W4	3/28/2014	13:15	42.5	98.6	12.84	88.5	<73
W4	4/3/2014	17:25	40.4	98.2	11.15	76.9	<73
W4	4/7/2014	18:14	39.3	97.3	13.92	96	<73
W4	4/15/2014	16:00	38.9	97.4	11.98	82.6	<73
W4	4/17/2014	14:30	38.8	99.5	13.24	91.3	<73

Client ID	Sample Date	Sample Time	API Gravity	D86 IBP (°F)	Vapor P via D6377 (100°F, 4:1 V/L) (psi)	Vapor P via D6377 (100°F, 4:1 V/L) (kPa)	Flash Point D3278 (°F)
W5	3/26/2014	15:50	42.9	97.3	12.27	84.6	<73
W5	3/26/2014	15:50	42.3	99.6	12.44	85.8	<73
W5	3/28/2014	13:50	44.3	98.2	13.24	91.3	<73
W5	4/4/2014	17:28	41.1	100.9	12.23	84.3	<73
W5	4/7/2014	19:08	39.9	94.6	13.26	91.4	<73
W5	4/15/2014	17:00	39.9	95.4	12.20	84.1	<73
W5	4/17/2014	15:30	42.6	97.5	13.08	90.2	<73
W6	4/6/2014	14:55	42.6	97.2	13.04	89.9	<73
W6	4/6/2014	14:55	42.6	96.5	13.04	89.9	<73
W6	4/8/2014	13:50	42.1	97.7	11.04	76.1	<73
W6	4/15/2014	17:05	42.5	96.7	12.33	85	<73
W6	4/17/2014	14:05	42.8	97.4	12.59	86.8	<73
W6	4/21/2014	16:30	42.3	98.9	11.33	78.1	<73
W6	4/24/2014	11:20	45.8	96.4	13.56	93.5	<73
W7	3/25/2014	17:00	43.5	97.6	10.25	70.7	<73
W7	3/25/2014	17:00	43.8	98.3	10.59	73	<73
W7	3/27/2014	13:00	42.6	99.9	10.91	75.2	<73
W7	3/31/2014	13:00	43.9	96.9	10.02	69.1	<73
W7	4/7/2014	16:00	39.2	96.7	11.33	78.1	<73
W7	4/16/2014	14:20	41.7	94.8	12.92	89.1	<73
W7	4/21/2014	13:45	39.5	99	11.69	80.6	<73
W8	3/25/2014	14:53	44.4	95	12.52	86.3	<73
W8	3/25/2014	14:33	44.6	99.2	12.37	85.3	<73
W8	3/27/2014	15:30	44.8	99	12.92	89.1	<73
W8	3/31/2014	12:42	43.4	97.5	12.15	83.8	<73
W8	4/9/2014	12:30	39.0	101.3	11.07	76.3	<73
W8	4/16/2014	17:00	40.9	96.1	11.92	82.2	<73
W8	4/18/2014	13:00	42.5	96.8	14.37	99.1	<73

Appendix 7 - Lab Data - Well

Client ID	Sample Date	Sample Time	API Gravity	D86 IBP (°F)	Vapor P via D6377 (100°F, 4:1 V/L) (psi)	Vapor P via D6377 (100°F, 4:1 V/L) (kPa)	Flash Point D3278 (°F)
W9	4/1/2014	11:20	38.0	104.3	10.70	73.8	<73
W9	4/1/2014	12:10	37.0	104	10.67	73.6	<73
W9	4/3/2014	13:00	37.3	101.4	10.69	73.7	<73
W9	4/8/2014	11:25	38.2	102	10.96	75.6	<73
W9	4/15/2014	12:33	36.9	101.4	11.15	76.9	<73
W9	4/22/2014	11:35	36.7	105.4	10.15	70	<73
W9	4/24/2014	14:20	38.9	91.9	9.95	68.6	<73
W10	4/15/2014	15:40	42.7	95	13.02	89.8	<73
W10	4/15/2014	15:40	42.8	95.4	12.75	87.9	<73
W10	4/17/2014	12:50	43.5	97.3	12.02	82.9	<73
W10	4/21/2014	15:30	46.3	95	13.46	92.8	<73
W10	4/24/2014	12:35	44.7	95.3	13.01	89.7	<73
W10			45.5	95.8	13.58	93.6	<73
W11	4/7/2014	16:35	38.6	96	10.41	71.8	<73
W11	4/7/2014	16:35	38.2	97.3	11.02	76	<73
W11	4/11/2014	14:55	41.8	95.7	13.29	91.6	<73
W11	4/15/2014	15:00	38.4	98.1	11.43	78.8	<73
W11	4/17/2014	13:30	39.3	99.4	12.07	83.2	<73
W11	4/20/2014	11:00	37.0	104.5	9.96	68.7	<73
W11	4/23/2014		38.9	98.3	12.13	83.6	<73
W12	3/27/2014	12:46	38.8	100.1	10.99	75.8	<73
W12	3/27/2014	12:16	38.2	101.3	10.94	75.4	<73
W12	3/30/2014	13:00	38.7	101.9	10.47	72.2	<73
W12	4/1/2014	13:40	38.1	102.2	10.81	74.5	<73
W12	4/8/2014	13:20	37.7	98.9	10.50	72.4	<73
W12	4/17/2014	15:10	37.9	101.8	9.95	68.6	<73
W12	4/17/2014	15:30	37.9	100.7	10.59	73	<73

Appendix 7 - Lab Data - Well

Client ID	Sample Date	Sample Time	API Gravity	D86 IBP (°F)	Vapor P via D6377 (100°F, 4:1 V/L) (psi)	Vapor P via D6377 (100°F, 4:1 V/L) (kPa)	Flash Point D3278 (°F)
W13	3/26/2014	17:00	42.5	100.4	12.71	87.6	<73
W13	3/26/2014	17:00	41.4	99.9	12.60	86.9	<73
W13	3/28/2014	15:30	40.6	100.7	12.27	84.6	<73
W13	4/4/2014	15:15	42.7	99.4	12.75	87.9	<73
W13	4/8/2014	11:00	38.5	98.9	11.57	79.8	<73
W13	4/15/2014	19:30	39.3	98.3	12.56	86.6	<73
W13	4/19/2014	14:00	39.7	99	12.81	88.3	<73
W14	4/6/2014	16:20	37.4	99.8	11.47	79.1	<73
W14	4/6/2014	16:20	38.1	98.3	11.31	78	<73
W14	4/4/2014	11:55	38.5	103.1	11.76	81.1	<73
W14	4/8/2014	12:30	37.4	100.7	11.46	79	<73
W14	4/18/2014	16:30	38.9	100.2	10.96	75.6	<73
W14	4/20/2014	14:00	37.1	105.3	9.35	64.5	<73
W14	4/22/2014	11:00	37.5	106.8	8.93	61.6	<73
W15	4/9/2014	17:20	40.1	100	11.75	81	<73
W15	4/9/2014	17:20	39.9	101.3	11.44	78.9	<73
W15	4/18/2014	19:30	40.9	101.8	12.84	88.5	<73
W15	4/21/2014	18:30	40.4	103.2	12.59	86.8	<73
W15	4/23/2014	13:00	41.9	99.9	11.04	76.1	<73
W15	4/24/2014	16:30	42.9	102.2	11.21	77.3	<73

Appendix 8 - Light Ends Data - Rail

			Light Ends IP344 - All results in liquid volume %									
Client ID	Sample Date	Sample Time	Methane	Ethane	Propane	Isobutane	n- Butane	Neopentane	Isopentane	n- Pentane	Cyclopentane	Hexanes
R1	3/25/2014	17:20	<0.01	0.18	1.16	0.49	2.27	0.01	1.22	2.21	0.21	5.64
R1	3/25/2014	17:00	<0.01	0.17	1.14	0.49	2.27	0.01	1.22	2.21	0.21	5.66
R1	3/27/2014	17:26	0.00	0.18	1.10	0.46	2.17	0.00	1.17	2.12	0.20	5.46
R1	3/31/2014	14:08	<0.01	0.25	1.46	0.62	2.73	0.01	1.46	2.67	0.21	6.48
R1	4/9/2014	10:38	0.00	0.25	1.46	0.62	2.74	0.01	1.44	2.67	0.20	6.38
R1	4/16/2014	15:30	0.01	0.23	1.35	0.60	2.78	0.01	1.59	2.84	0.21	6.68
R1	4/18/2014	11:00	0.00	0.20	1.23	0.55	2.56	0.01	1.41	2.65	0.20	6.50
R2	3/25/2014	18:00	<0.01	0.28	1.56	0.62	2.91	0.01	1.46	2.87	0.21	6.49
R2	3/25/2014	18:00	<0.01	0.27	1.55	0.62	2.90	0.01	1.47	2.86	0.21	6.49
R2	3/27/2014	10:30	<0.01	0.26	1.60	0.66	3.04	0.01	1.57	2.98	0.21	6.88
R2	3/31/2014	12:30	0.01	0.26	1.45	0.59	2.75	0.01	1.44	2.74	0.21	6.56
R2	4/8/2014	10:20	0.00	0.25	1.46	0.58	2.74	0.01	1.38	2.66	0.21	6.10
R2	4/15/2014	11:30	0.00	0.18	1.16	0.52	2.58	0.01	1.41	2.79	0.21	6.60
R2	4/18/2014	10:20	0.00	0.21	1.37	0.56	2.81	0.01	1.43	2.80	0.23	6.49
R3	3/26/2014	14:30	<0.01	0.27	1.46	0.58	2.69	0.01	1.37	2.62	0.19	6.45
R3	3/26/2014	14:30	<0.01	0.25	1.39	0.57	2.63	0.01	1.35	2.58	0.20	6.08
R3	3/28/2014	13:30	0.01	0.28	1.44	0.58	2.68	0.01	1.36	2.62	0.19	6.13
R3	4/1/2014	16:10	0.00	0.20	1.18	0.50	2.39	0.01	1.27	2.46	0.18	5.61
R3	4/10/2014	14:50	0.00	0.21	1.20	0.52	2.46	0.01	1.33	2.55	0.19	6.19
R3	4/15/2014	14:15	0.00	0.25	1.31	0.54	2.55	0.01	1.35	2.59	0.19	6.22
R3	4/17/2014	13:00	0.01	0.24	1.35	0.58	2.77	0.01	1.49	2.88	0.22	6.96
R4	3/25/2014	14:30	<0.01	0.33	1.95	0.73	3.43	0.01	1.60	3.13	0.22	6.60
R4	3/25/2014	14:30	<0.01	0.32	1.92	0.73	3.42	0.01	1.60	3.13	0.22	6.62
R4	3/27/2014	11:50	<0.01	0.28	1.62	0.64	3.04	0.01	1.48	2.93	0.22	6.46
R4	3/31/2014	11:20	<0.01	0.27	1.81	0.73	3.51	0.01	1.69	3.33	0.24	6.52
R4	4/7/2014	13:45	0.00	0.13	1.09	0.51	2.60	0.01	1.37	2.74	0.20	5.97
R4	4/16/2014	12:35	0.00	0.22	1.44	0.60	2.89	0.01	1.49	2.97	0.21	6.69
R4	4/18/2014	12:05	0.00	0.20	1.35	0.58	2.84	0.01	1.47	2.93	0.21	6.62
R5	3/26/2014	12:00	<0.01	0.19	1.10	0.50	2.39	0.01	1.33	2.60	0.18	6.36
R5	3/26/2014	12:00	<0.01	0.22	1.20	0.53	2.46	0.01	1.34	2.60	0.18	6.29
R5	3/28/2014	12:00	<0.01	0.21	1.17	0.52	2.44	0.01	1.33	2.60	0.19	6.33
R5	4/1/2014	14:30	0.01	0.18	1.04	0.47	2.25	0.01	1.25	2.42	0.17	5.69
R5	4/10/2014	13:15	0.01	0.23	1.25	0.54	2.50	0.01	1.34	2.59	0.18	6.21
R5	4/15/2014	12:50	0.01	0.20	1.13	0.51	2.43	0.01	1.35	2.62	0.19	6.48
R5	4/17/2014	11:40	0.00	0.17	1.02	0.48	2.30	0.01	1.30	2.54	0.19	6.33

Appendix 8 - Light Ends Data - Rail

Client ID	Sample Date	Sample Time	Methane	Ethane	Propane	Isobutane	n- Butane	Neopentane	Isopentane	n- Pentane	Cyclopentane	Hexanes
R6	3/26/2014	15:30	<0.01	0.26	1.84	0.69	3.38	0.01	1.56	2.96	0.25	6.38
R6	3/26/2014	15:30	<0.01	0.26	1.81	0.69	3.36	0.01	1.56	2.96	0.25	6.40
R6	3/27/2014	15:30	<0.01	0.25	1.71	0.66	3.26	0.01	1.54	2.94	0.25	6.43
R6	3/31/2014	14:00	<0.01	0.26	1.71	0.66	3.22	0.01	1.53	2.95	0.24	6.49
R6	4/7/2014	15:00	0.00	0.19	1.38	0.57	2.83	0.01	1.40	2.71	0.22	5.89
R6	4/15/2014	14:00	0.00	0.14	1.20	0.54	2.79	0.01	1.46	2.85	0.23	6.53
R6	4/17/2014	12:00	0.00	0.22	1.53	0.62	3.08	0.01	1.52	2.93	0.24	6.61
R7	3/26/2014	19:30	<0.01	0.25	1.48	0.60	2.80	0.01	1.42	2.74	0.20	6.30
R7	3/26/2014	19:30	<0.01	0.29	1.55	0.61	2.85	0.01	1.43	2.74	0.20	6.27
R7	3/28/2014	13:00	<0.01	0.22	1.35	0.56	2.68	0.01	1.40	2.71	0.20	6.38
R7	3/31/2014	17:00	0.01	0.28	1.45	0.58	2.71	0.01	1.39	2.67	0.20	6.25
R7	4/11/2014	10:50	0.00	0.23	1.34	0.56	2.63	0.01	1.37	2.64	0.19	6.27
R7	4/14/2014	12:30	0.00	0.22	1.29	0.55	2.58	0.01	1.36	2.62	0.19	6.21
R7	4/18/2014	10:00	0.01	0.21	1.18	0.51	2.45	0.01	1.34	2.57	0.20	6.34

Appendix 9 - Light Ends Data - Well

Client ID	Sample Date	Sample Time	Methane	Ethane	Propane	Isobutane	n- Butane	Neopentane	Isopentane	n- Pentane	Cyclopentane	Hexanes
			Light Ends IP344 - All results in liquid volume %									
W1	3/25/2014	19:45	0.01	0.31	1.77	0.65	3.12	0.01	1.46	2.73	0.25	6.02
W1	3/25/2014	19:45	0.01	0.36	1.85	0.67	3.19	0.01	1.48	2.76	0.25	6.02
W1	3/27/2014	18:15	0.01	0.30	1.58	0.60	2.94	0.01	1.42	2.68	0.25	6.04
W1	3/30/2014	16:00	0.01	0.29	1.67	0.63	3.06	0.01	1.45	2.73	0.25	6.13
W1	4/1/2014	11:00	0.01	0.31	1.59	0.59	2.88	0.01	1.39	2.64	0.24	5.94
W1	4/7/2014	12:20	0.00	0.15	1.05	0.46	2.39	0.01	1.28	2.46	0.23	5.75
W1	4/16/2014	11:30	0.01	0.25	1.50	0.60	2.96	0.01	1.47	2.78	0.26	6.37
W2	3/26/2014	12:45	<0.01	0.30	1.68	0.61	3.00	0.01	1.42	2.71	0.24	6.10
W2	3/26/2014	12:45	0.01	0.35	1.82	0.65	3.15	0.01	1.47	2.81	0.25	6.29
W2	3/29/2014	15:00	0.01	0.30	1.76	0.63	3.05	0.01	1.42	2.73	0.24	6.14
W2	3/31/2014	10:00	0.01	0.34	1.53	0.53	2.62	0.01	1.28	2.48	0.23	5.92
W2	4/7/2014	13:05	0.00	0.21	1.52	0.56	2.75	0.01	1.31	2.52	0.23	5.43
W2	4/16/2014	12:00	0.00	0.29	1.79	0.66	3.22	0.01	1.49	2.84	0.25	6.36
W2	4/19/2014	9:00	0.00	0.26	1.78	0.66	3.18	0.01	1.46	2.77	0.24	6.12
W3	3/25/2014	12:30	0.01	0.41	1.95	0.75	3.60	0.01	1.76	3.55	0.24	7.01
W3	3/25/2014	12:30	0.01	0.37	1.76	0.68	3.26	0.01	1.59	3.21	0.21	6.79
W3	3/27/2014	10:00	0.01	0.39	1.99	0.78	3.71	0.01	1.81	3.65	0.24	7.17
W3	3/31/2014	10:00	<0.01	0.30	1.75	0.70	3.36	0.01	1.63	3.28	0.22	7.00
W3	4/7/2014	12:50	0.00	0.18	1.20	0.54	2.68	0.01	1.38	2.82	0.19	5.95
W3	4/16/2014	10:30	0.00	0.21	1.40	0.61	3.05	0.01	1.57	3.19	0.22	6.93
W3	4/18/2014	11:20	0.00	0.24	1.49	0.64	3.13	0.01	1.58	3.21	0.22	6.91
W4	3/26/2014	12:00	<0.01	0.17	1.65	0.66	3.33	0.01	1.54	2.87	0.26	6.22
W4	3/26/2014	12:00	<0.01	0.16	1.62	0.65	3.32	0.01	1.53	2.85	0.26	6.19
W4	3/28/2014	13:15	<0.01	0.16	1.61	0.66	3.36	0.01	1.57	2.43	0.26	6.34
W4	4/3/2014	17:25	0.00	0.09	1.23	0.58	3.14	0.01	1.53	2.90	0.26	6.36
W4	4/7/2014	18:14	0.00	0.08	1.13	0.55	2.94	0.00	1.49	2.79	0.25	6.13
W4	4/15/2014	16:00	0.00	0.19	1.70	0.67	3.38	0.00	1.58	2.95	0.27	6.49
W4	4/17/2014	14:30	0.01	0.33	2.38	0.81	3.89	0.01	1.66	3.02	0.30	6.31
W5	3/26/2014	15:50	<0.01	0.11	1.44	0.65	3.49	0.01	1.66	3.14	0.28	6.77
W5	3/26/2014	15:50	<0.01	0.12	1.52	0.67	3.56	0.01	1.68	3.17	0.28	6.81
W5	3/28/2014	13:50	<0.01	0.15	1.54	0.66	3.50	0.01	1.66	3.15	0.28	6.84
W5	4/4/2014	17:28	0.00	0.09	1.23	0.57	3.13	0.01	1.53	2.89	0.26	6.10
W5	4/7/2014	19:08	0.00	0.12	1.42	0.63	3.36	0.01	1.61	3.06	0.27	6.60
W5	4/15/2014	17:00	0.00	0.27	2.34	0.86	4.06	0.01	1.86	3.46	0.30	7.23
W5	4/17/2014	15:30	0.00	0.27	2.42	0.88	4.41	0.01	1.88	3.51	0.29	7.19

Appendix 9 - Light Ends Data - Well

Client ID	Sample Date	Sample Time	Methane	Ethane	Propane	Isobutane	n- Butane	Neopentane	Isopentane	n- Pentane	Cyclopentane	Hexanes
W6	4/6/2014	14:55	0.00	0.24	1.67	0.73	3.28	0.01	1.61	3.11	0.17	6.38
W6	4/6/2014	14:55	0.00	0.22	1.60	0.71	3.18	0.01	1.56	3.01	0.17	6.19
W6	4/8/2014	13:50	0.00	0.32	2.02	0.83	3.65	0.01	1.72	3.30	0.18	6.82
W6	4/15/2014	17:05	0.00	0.36	2.23	0.92	4.03	0.01	1.88	3.60	0.20	7.40
W6	4/17/2014	14:05	0.00	0.31	1.94	0.82	3.66	0.01	1.76	3.38	0.19	7.07
W6	4/21/2014	16:30	0.00	0.25	1.89	0.82	3.64	0.01	1.74	3.34	0.19	6.96
W6	4/24/2014	11:20	0.00	0.28	1.93	0.83	3.68	0.01	1.75	3.35	0.21	6.87
W7	3/25/2014	17:00	0.01	0.67	3.13	0.95	4.55	0.01	1.82	3.58	0.27	6.74
W7	3/25/2014	17:00	<0.01	0.53	2.72	0.88	4.24	0.01	1.78	3.50	0.27	6.84
W7	3/27/2014	13:00	0.01	0.46	2.42	0.82	4.01	0.01	1.74	3.47	0.27	6.96
W7	3/31/2014	13:00	<0.01	0.37	2.14	0.77	3.82	0.01	1.71	3.41	0.27	6.96
W7	4/7/2014	16:00	0.00	0.21	1.60	0.63	3.25	0.01	1.52	3.05	0.24	6.30
W7	4/16/2014	14:20	0.00	0.32	1.98	0.74	3.75	0.01	1.72	3.43	0.27	7.06
W7	4/21/2014	13:45	0.00	0.21	1.81	0.72	3.66	0.01	1.70	3.39	0.27	7.03
W8	3/25/2014	14:53	<0.01	0.15	1.55	0.83	3.73	0.01	1.93	3.37	0.28	7.26
W8	3/25/2014	14:33	<0.01	0.14	1.54	0.83	3.71	0.01	1.93	3.37	0.28	7.26
W8	3/27/2014	15:30	<0.01	0.17	1.65	0.83	3.66	0.01	1.89	3.40	0.27	7.53
W8	3/31/2014	12:42	<0.01	0.15	1.56	0.80	3.53	0.01	1.80	3.25	0.25	7.22
W8	4/9/2014	12:30	0.00	0.12	1.27	0.68	3.13	0.01	1.68	3.20	0.26	6.84
W8	4/16/2014	17:00	0.00	0.20	1.62	0.79	3.51	0.01	1.80	3.19	0.27	7.37
W8	4/18/2014	13:00	0.00	0.19	1.55	0.76	3.40	0.01	1.80	3.27	0.30	7.64
W9	4/1/2014	11:20	0.01	0.25	1.19	0.47	2.33	0.01	1.18	2.21	0.21	5.27
W9	4/1/2014	12:10	0.01	0.26	1.22	0.47	2.36	0.01	1.19	2.23	0.21	5.30
W9	4/3/2014	13:00	0.00	0.17	1.02	0.42	2.14	0.00	1.10	2.07	0.19	4.98
W9	4/8/2014	11:25	0.00	0.19	1.21	0.48	2.41	0.01	1.20	2.24	0.20	5.24
W9	4/15/2014	12:33	0.01	0.22	1.16	0.47	2.37	0.01	1.22	2.29	0.21	5.52
W9	4/22/2014	11:35	0.01	0.18	1.03	0.43	2.19	<0.01	1.15	2.18	0.20	5.35
W9	4/24/2014	14:20	<0.01	0.20	1.12	0.45	2.24	0.01	1.14	2.15	0.20	5.19
W10	4/15/2014	15:40	0.00	0.37	2.29	0.94	4.12	0.01	1.91	3.70	0.20	7.41
W10	4/15/2014	15:40	0.00	0.29	2.08	0.90	3.97	0.01	1.89	3.67	0.20	7.49
W10	4/17/2014	12:50	0.00	0.36	2.25	0.92	4.03	0.01	1.88	3.64	0.19	7.36
W10	4/21/2014	15:30	<0.01	0.33	2.19	0.90	3.98	0.01	1.82	3.52	0.19	7.02
W10	4/24/2014	12:35	<0.01	0.25	1.95	0.86	3.81	0.01	1.82	3.54	0.19	7.23
W10			0.00	0.20	1.76	0.81	3.66	0.01	1.78	3.46	0.19	7.09

Client ID	Sample Date	Sample Time	Methane	Ethane	Propane	Isobutane	n- Butane	Neopentane	Isopentane	n- Pentane	Cyclopentane	Hexanes
W11	4/7/2014	16:35	0.00	0.16	1.56	0.62	3.09	0.01	1.42	2.63	0.24	5.62
W11	4/7/2014	16:35	0.00	0.13	1.48	0.60	3.01	0.01	1.39	2.58	0.24	5.52
W11	4/11/2014	14:55	0.00	0.34	2.69	0.86	4.03	0.01	1.60	2.91	0.26	5.99
W11	4/15/2014	15:00	0.00	0.25	2.10	0.77	3.72	0.01	1.62	2.98	0.27	6.41
W11	4/17/2014	13:30	0.00	0.27	2.17	0.77	3.69	0.01	1.59	2.92	0.27	6.23
W11	4/20/2014	11:00	0.00	0.15	0.96	0.41	2.32	0.01	1.24	2.59	0.23	6.22
W11	4/23/2014		<0.01	0.40	2.99	0.92	4.25	0.01	1.65	2.98	0.26	6.00
W12	3/27/2014	12:46	0.00	0.21	1.26	0.50	2.53	0.01	1.26	2.41	0.21	5.57
W12	3/27/2014	12:16	0.00	0.22	1.28	0.51	2.56	0.01	1.28	2.42	0.22	5.59
W12	3/30/2014	13:00	0.01	0.23	1.25	0.49	2.45	0.01	1.22	2.31	0.21	5.48
W12	4/1/2014	13:40	0.01	0.25	1.32	0.51	2.51	0.01	1.24	2.35	0.21	5.52
W12	4/8/2014	13:20	0.00	0.18	1.17	0.48	2.41	0.01	1.22	2.32	0.21	5.42
W12	4/17/2014	15:10	0.01	0.18	1.06	0.45	2.30	0.00	1.22	2.35	0.22	5.77
W12	4/17/2014	15:30	0.01	0.20	1.11	0.46	2.30	0.01	1.21	2.32	0.21	5.63
W13	3/26/2014	17:00	<0.01	0.22	1.69	0.69	3.25	0.01	1.49	2.72	0.22	5.85
W13	3/26/2014	17:00	<0.01	0.21	1.65	0.68	3.22	0.01	1.49	2.72	0.22	5.88
W13	3/28/2014	15:30	0.01	0.24	1.57	0.63	3.02	0.01	1.45	2.68	0.22	5.93
W13	4/4/2014	15:15	0.00	0.16	1.42	0.61	2.93	0.01	1.38	2.52	0.20	5.34
W13	4/8/2014	11:00	0.00	0.26	1.91	0.74	3.40	0.01	1.51	2.73	0.22	5.84
W13	4/15/2014	19:30	0.00	0.19	1.73	0.74	3.56	0.01	1.69	3.10	0.25	6.84
W13	4/19/2014	14:00	0.00	0.31	1.94	0.68	3.29	0.01	1.47	2.80	0.24	6.12
W14	4/6/2014	16:20	0.01	0.22	1.12	0.43	2.32	0.01	1.20	2.49	0.21	5.63
W14	4/6/2014	16:20	0.01	0.21	1.10	0.42	2.29	0.00	1.20	2.48	0.21	5.63
W14	4/4/2014	11:55	<0.01	0.22	1.24	0.48	2.57	0.01	1.32	2.73	0.23	6.35
W14	4/8/2014	12:30	0.00	0.26	1.53	0.56	2.89	0.01	1.38	2.81	0.23	6.20
W14	4/18/2014	16:30	0.01	0.16	1.00	0.42	2.35	0.01	1.25	2.58	0.22	6.11
W14	4/20/2014	14:00	0.01	0.16	0.89	0.37	2.10	0.00	1.16	2.45	0.22	6.13
W14	4/22/2014	11:00	<0.01	0.14	0.84	0.35	2.00	<0.01	1.11	2.33	0.21	5.84
W15	4/9/2014	17:20	0.00	0.25	1.41	0.58	2.67	0.01	1.38	2.61	0.20	6.12
W15	4/9/2014	17:20	0.00	0.24	1.42	0.58	2.69	0.01	1.38	2.62	0.20	6.14
W15	4/18/2014	19:30	0.00	0.21	1.16	0.50	2.40	0.01	1.33	2.55	0.20	6.22
W15	4/21/2014	18:30	<0.01	0.24	1.38	0.56	2.62	0.01	1.36	2.59	0.20	6.13
W15	4/23/2014	13:00	<0.01	0.24	1.40	0.58	2.67	0.01	1.38	2.60	0.20	6.13
W15	4/24/2014	16:30	0.00	0.18	1.31	0.56	2.66	0.01	1.40	2.66	0.21	6.26

Appendix 10 - Simulated Distillation Data - Rail

Simulated Distillation by ASTM D7169- All results reported in °F

Client ID	Sample Date	Sample Time	SimDis IBP	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	FBP	Recovery (weight %)	Additional Comments - Field or Lab
R1	3/25/2014	17:20	<97	151	186	264	343	430	517	609	710	823	967	1071	1278	100.0	Oil Temp 35°F
R1	3/25/2014	17:00	<97	151	183	263	346	436	527	623	730	850	1012	1150	>1382	97.6	
R1	3/27/2014	17:26	<97	104	176	252	332	423	513	608	713	828	973	1076	1307	100.0	
R1	3/31/2014	14:08	<97	127	177	239	315	391	473	559	650	760	903	1009	1217	100.0	
R1	4/9/2014	10:38	<97	<97	153	222	300	376	459	549	647	761	909	1019	1246	100.0	
R1	4/16/2014	15:30															
R1	4/18/2014	11:00															
R2	3/25/2014	18:00	<97	135	168	235	313	388	470	557	651	763	909	1017	1226	100.0	
R2	3/25/2014	18:00	<97	138	178	246	320	388	477	564	659	772	921	1033	1317	99.7	
R2	3/27/2014	10:30	<97	98	158	223	289	364	443	527	620	733	888	1013	>1382	99.1	
R2	3/31/2014	12:30	<97	107	164	232	302	376	454	540	630	742	889	1000	1219	100.0	
R2	4/8/2014	10:20	<97	<97	143	216	295	379	468	561	664	783	936	1048	1257	100.0	
R2	4/15/2014	11:30															
R2	4/18/2014	10:20															
R3	3/26/2014	14:30	<97	112	175	245	325	405	488	576	675	788	933	1039	1244	100.0	Oil Temp 37°F
R3	3/26/2014	14:30	<97	146	177	251	326	408	492	581	679	791	935	1040	1256	100.0	Oil Temp 37°F
R3	3/28/2014	13:30	<97	<97	157	235	317	403	490	583	686	805	957	1073	1309	100.0	Oil Temp 49°F
R3	4/1/2014	16:10	<97	<97	162	235	320	405	496	591	696	820	994	1180	>1382	95.9	
R3	4/10/2014	14:50	<97	<97	158	238	317	398	486	577	678	795	946	1062	>1382	99.1	
R3	4/15/2014	14:15															
R3	4/17/2014	13:00															
R4	3/25/2014	14:30	<97	111	156	234	314	393	480	573	674	796	962	1107	>1382	99.8	
R4	3/25/2014	14:30	<97	133	167	237	318	399	484	574	673	792	950	1077	>1382	98.9	
R4	3/27/2014	11:50	<97	<97	163	238	320	403	489	581	682	800	954	1072	1318	100.0	
R4	3/31/2014	11:20	<97	103	168	239	318	399	486	575	674	791	945	1065	>1382	99.1	
R4	4/7/2014	13:45	<97	<97	157	233	305	385	474	563	663	779	925	1029	1220	100.0	
R4	4/16/2014	12:35															
R4	4/18/2014	12:05															
R5	3/26/2014	12:00	<97	117	168	236	314	390	475	563	660	775	927	1049	>1382	98.7	
R5	3/26/2014	12:00	<97	<97	159	234	315	394	481	575	675	796	959	1089	1341	100.0	
R5	3/28/2014	12:00	<97	<97	160	233	311	389	475	564	662	777	924	1037	1276	100.0	
R5	4/1/2014	14:30	<97	<97	151	227	306	385	474	569	671	792	957	1116	>1382	96.6	
R5	4/10/2014	13:15	<97	<97	158	236	306	385	466	555	651	764	910	1019	1272	99.8	
R5	4/15/2014	12:50															
R5	4/17/2014	11:40															

Appendix 10 - Simulated Distillation Data - Rail

Client ID	Sample Date	Sample Time	SimDis IBP	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	FBP	Recovery (weight %)	Additional Comments - Field or Lab
R6	3/26/2014	15:30	<97	116	156	232	310	388	471	558	650	758	900	1008	1342	99.5	
R6	3/26/2014	15:30	<97	131	165	235	315	394	476	562	654	762	900	1004	1230	100.0	
R6	3/27/2014	15:30	<97	<97	162	236	315	395	481	570	665	778	929	1056	>1382	98.5	
R6	3/31/2014	14:00	<97	106	168	237	320	404	490	580	680	797	962	1126	>1382	96.7	
R6	4/7/2014	15:00	<97	<97	152	225	302	383	466	555	650	763	909	1021	1308	100.0	
R6	4/15/2014	14:00															
R6	4/17/2014	12:00															
R7	3/26/2014	19:30	<97	138	171	237	316	394	479	570	668	783	931	1040	1278	100.0	
R7	3/26/2014	19:30	<97	146	179	255	330	418	504	596	700	822	987	1122	>1382	98.7	
R7	3/28/2014	13:00	<97	114	176	242	322	403	488	580	683	803	962	1086	>1382	98.8	
R7	3/31/2014	17:00	<97	127	179	254	327	409	496	587	691	811	971	1099	>1382	98.4	
R7	4/11/2014	10:50	<97	<97	154	236	313	391	480	575	647	792	941	1052	1297	100.0	
R7	4/14/2014	12:30															
R7	4/18/2014	10:00															

Simulated Distillation by ASTM D7169- All results reported in °F

Client ID	Sample Date	Sample Time	SimDis IBP	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	FBP	Recovery (weight %)	Additional Comments - Field or Lab
W1	3/25/2014	19:45	<97	135	178	259	342	428	517	610	713	827	974	1086	1329	100.0	
W1	3/25/2014	19:45	<97	150	188	272	355	442	531	623	725	839	987	1102	1337	100.0	
W1	3/27/2014	18:15	<97	119	179	257	334	422	510	601	703	815	958	1071	>1382	98.8	
W1	3/30/2014	16:00	<97	142	180	262	344	432	524	621	726	846	1011	1176	>1382	96.7	
W1	4/1/2014	11:00	<97	<97	148	224	310	396	488	584	688	803	947	1050	1248	100.0	
W1	4/7/2014	12:20															
W1	4/16/2014	11:30															
W2	3/26/2014	12:45	<97	143	179	261	342	424	508	596	693	803	952	1072	1328	100.0	
W2	3/26/2014	12:45	<97	140	184	263	342	422	505	590	685	793	937	1050	1303	100.0	
W2	3/29/2014	15:00	<97	108	165	237	318	400	482	569	661	768	903	1004	1248	99.7	
W2	3/31/2014	10:00	<97	136	178	255	329	412	492	577	670	774	910	1013	1244	100.0	
W2	4/7/2014	13:05	<97	<97	154	235	316	398	481	570	664	772	911	1018	1316	100.0	
W2	4/16/2014	12:00															
W2	4/19/2014	9:00															
W3	3/25/2014	12:30	<97	<97	157	232	304	383	462	548	639	748	895	1016	>1382	98.6	
W3	3/25/2014	12:30	<97	<97	161	234	310	384	464	547	638	744	886	995	1283	99.8	
W3	3/27/2014	10:00	<97	<97	159	230	300	374	456	545	638	750	903	1037	>1382	98.1	
W3	3/31/2014	10:00	<97	97	159	230	298	371	453	537	629	737	879	990	>1382	99.4	
W3	4/7/2014	12:50	<97	<97	154	224	297	372	453	537	628	737	880	992	1329	100.0	
W3	4/16/2014	10:30															
W3	4/18/2014	11:20															
W4	3/26/2014	12:00	<97	100	158	236	318	406	491	579	675	788	940	1076	>1382	97.7	
W4	3/26/2014	12:00	<97	110	165	239	319	405	488	575	667	774	914	1023	>1382	99.4	
W4	3/28/2014	13:15	<97	119	169	243	322	409	493	581	678	792	947	1082	>1382	98.2	
W4	4/3/2014	17:25	<97	<97	104	207	286	373	460	552	648	760	904	1014	1273	100.0	
W4	4/7/2014	18:14	<97	<97	152	233	315	402	490	582	683	801	966	1121	>1382	98.3	
W4	4/15/2014	16:00															
W4	4/17/2014	14:30															
W5	3/26/2014	15:50	<97	101	160	234	312	390	475	562	656	767	914	1028	1289	100.0	
W5	3/26/2014	15:50	<97	<97	146	216	292	374	458	548	642	753	898	1008	1257	100.0	
W5	3/28/2014	13:50	<97	<97	156	225	300	377	458	547	640	751	896	1010	1272	100.0	
W5	4/4/2014	17:28	<97	<97	132	205	280	366	454	548	645	757	903	1020	>1382	98.7	
W5	4/7/2014	19:08	<97	<97	135	209	285	364	448	538	633	747	894	1009	1322	100.0	
W5	4/15/2014	17:00															
W5	4/17/2014	15:30															
W6	4/6/2014	14:55	<97	<97	129	204	277	349	436	528	629	751	914	1037	>1382	98.9	
W6	4/6/2014	14:55	<97	<97	103	189	264	336	420	513	613	734	891	1004	1218	99.9	
W6	4/8/2014	13:50	<97	<97	156	236	304	377	461	554	658	789	977	1157	>1382	96.6	
W6	4/15/2014	17:05	<97	<97	<97	188	257	331	419	510	611	734	895	1010	1217	100.0	
W6	4/17/2014	14:05	<97	<97	145	206	278	348	433	521	622	741	899	1011	1214	100.0	
W6	4/21/2014	16:30															
W6	4/24/2014	11:20															

Client ID	Sample Date	Sample Time	SimDis IBP	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	FBP	Recovery (weight %)	Additional Comments - Field or Lab
W7	3/25/2014	17:00	<97	118	155	231	302	376	453	536	623	727	867	975	1220	100.0	
W7	3/25/2014	17:00	<97	135	177	252	326	404	484	568	661	777	955	1192	>1382	95.7	
W7	3/27/2014	13:00	<97	<97	104	204	285	366	450	538	633	747	905	1035	1328	100.0	
W7	3/31/2014	13:00	<97	<97	156	221	296	372	453	536	627	735	883	1007	>1382	98.7	
W7	4/7/2014	16:00	<97	<97	132	208	282	356	437	520	611	718	860	971	1220	100.0	
W7	4/16/2014	14:20															
W7	4/21/2014	13:45															
W8	3/25/2014	14:53	<97	128	157	231	305	386	471	560	653	766	932	1121	>1382	96.5	
W8	3/25/2014	14:33	<97	112	153	217	290	370	452	535	623	726	861	966	1198	100.0	
W8	3/27/2014	15:30	<97	<97	158	219	294	376	461	549	643	755	914	1079	>1382	96.9	
W8	3/31/2014	12:42	<97	104	163	232	311	391	477	566	660	776	937	1060	1293	100.0	
W8	4/9/2014	12:30	<97	<97	153	222	301	381	459	545	629	734	870	976	1230	100.0	
W8	4/16/2014	17:00															
W8	4/18/2014	13:00															
W9	4/1/2014	11:20	<97	141	187	278	373	470	570	672	783	903	1044	1139	1320	100.0	Stock Tank ID 43047
W9	4/1/2014	12:10	<97	137	180	276	375	476	578	684	796	920	1069	1182	>1382	97.8	Stock Tank ID 43047
W9	4/3/2014	13:00	<97	97	178	265	358	456	558	660	772	893	1037	1134	1362	99.7	Stock Tank ID 43043
W9	4/8/2014	11:25	<97	<97	174	263	353	451	549	649	758	879	1025	1124	1331	100.0	Stock Tank ID 43043
W9	4/15/2014	12:33	<97	<97	157	243	341	439	538	641	754	876	1023	1118	1284	100.0	Stock Tank ID 43054
W9	4/22/2014	11:35															Stock Tank ID 43054
W9	4/24/2014	14:20															Stock Tank ID 43048
W10	4/15/2014	15:40	<97	<97	126	200	267	344	432	525	631	754	912	1019	1209	100.0	
W10	4/15/2014	15:40	<97	<97	145	205	278	349	437	528	630	750	901	1005	1186	100.0	
W10	4/17/2014	12:50	<97	<97	<97	182	251	330	419	513	621	749	906	1013	1209	100.0	
W10	4/21/2014	15:30	<97	<97	<97	180	244	327	413	509	615	740	900	1010	1222	100.0	
W10	4/24/2014	12:35	<97	<97	<97	181	246	327	412	508	613	738	896	1005	1219	100.0	
W10																	
W11	4/7/2014	16:35	<97	<97	132	211	289	375	466	560	657	769	913	1023	1255	100.0	
W11	4/7/2014	16:35	<97	<97	131	213	292	377	467	561	658	771	915	1025	1260	100.0	
W11	4/11/2014	14:55	<97	<97	150	219	298	383	469	561	656	769	913	1023	>1382	99.2	
W11	4/15/2014	15:00	<97	<97	146	213	289	371	455	546	639	752	898	1007	1210	100.0	
W11	4/17/2014	13:30	<97	<97	<97	204	283	370	459	554	653	769	916	1026	1241	100.0	
W11	4/20/2014	11:00															
W11	4/23/2014																
W12	3/27/2014	12:46	<97	<97	164	254	343	439	536	636	748	869	1015	1114	1327	100.0	
W12	3/27/2014	12:16	<97	<97	168	260	346	443	542	642	754	877	1025	1127	>1382	99.4	
W12	3/30/2014	13:00	<97	141	181	267	354	451	547	647	756	878	1022	1120	1308	100.0	
W12	4/1/2014	13:40	<97	146	184	270	359	454	552	652	763	886	1036	1140	>1382	99.0	
W12	4/8/2014	13:20	<97	100	179	266	355	453	550	651	762	885	1031	1130	1337	100.0	
W12	4/17/2014	15:10															
W12	4/17/2014	15:30															

Appendix 11 - Simulated Distillation Data - Well

Client ID	Sample Date	Sample Time	SimDis IBP	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	FBP	Recovery (weight %)	Additional Comments - Field or Lab
W13	3/26/2014	17:00	<97	110	165	240	327	418	503	589	684	792	938	1063	>1382	98.5	
W13	3/26/2014	17:00	<97	<97	155	231	313	403	490	578	674	783	924	1042	>1382	98.9	
W13	3/28/2014	15:30	<97	120	175	247	332	425	514	602	702	814	978	1165	>1382	96.5	
W13	4/4/2014	15:15	<97	<97	136	219	303	394	488	582	683	797	959	1141	>1382	96.2	
W13	4/8/2014	11:00	<97	<97	154	233	313	400	488	576	670	777	913	1018	1270	100.0	
W13	4/15/2014	19:30															
W13	4/19/2014	14:00															
W14	4/6/2014	16:20	<97	<97	149	229	315	397	484	574	670	780	926	1044	>1382	99.5	
W14	4/6/2014	16:20	<97	<97	168	248	325	409	495	584	679	789	936	1053	1298	100.0	
W14	4/4/2014	11:55	<97	<97	137	217	300	384	473	563	661	774	923	1039	1262	100.0	
W14	4/8/2014	12:30	<97	<97	155	236	315	392	477	565	660	768	910	1018	1257	100.0	
W14	4/18/2014	16:30	<97	98	174	244	328	411	496	585	681	790	931	1035	1225	100.0	
W14	4/20/2014	14:00	<97	110	181	250	331	416	500	587	683	792	931	1035	1225	100.0	
W14	4/22/2014	11:00	<97	<97	153	238	320	403	489	579	677	789	932	1040	1262	100.0	
W15	4/9/2014	17:20	<97	<97	158	237	313	390	477	570	671	789	942	1053	1282	100.0	
W15	4/9/2014	17:20	<97	<97	154	235	309	388	476	570	672	790	945	1058	1307	100.0	
W15	4/18/2014	19:30	<97	<97	153	232	307	389	478	572	674	794	947	1054	1251	100.0	
W15	4/21/2014	18:30	<97	<97	147	221	301	383	472	566	670	791	946	1055	1263	100.0	
W15	4/23/2014	13:00															
W15	4/24/2014	16:30															

Appendix 12 - Seasonality Data (Member Contributed)

	RVP (psi)	
DATE	Prod. Train A	Prod. Train B
8/1/2013	8.96	8.62
8/2/2013	8.75	8.47
8/5/2013	8.48	8.54
8/16/2013	8.58	8.28
8/18/2013	8.75	8.33
8/22/2013	8.82	8.04
8/26/2013	8.56	8.25
8/29/2013	8.48	
9/1/2013	8.43	7.94
9/5/2013	7.99	7.93
9/11/2013	8.29	8.31
9/13/2013	8.43	8.29
9/14/2013	7.90	7.96
9/15/2013	8.73	8.89
9/23/2013	8.50	8.80
9/25/2013	8.27	8.57
9/26/2013	8.43	8.63
9/27/2013	8.41	8.77
10/4/2013	8.70	
10/7/2013	9.09	8.83
10/10/2013	9.22	8.53
10/14/2013	9.79	8.70
10/19/2013	9.10	9.20
10/20/2013	9.79	9.69
10/22/2013	9.53	9.63
10/24/2013		9.44
10/25/2013	9.24	9.40
10/26/2013	9.24	9.56
10/28/2013	9.21	9.38

	RVP (psi)	
	Prod. Train A	Prod. Train B
10/30/2013	9.08	9.67
11/7/2013	9.96	10.05
11/8/2013	10.30	10.50
11/9/2013	10.38	10.57
11/11/2013	10.24	10.38
11/14/2013	9.71	9.18
11/17/2013	10.33	10.28
11/18/2013	10.49	10.56
11/19/2013	9.70	10.28
11/22/2013	10.06	9.99
11/24/2013	9.94	9.94
11/25/2013	10.62	10.69
11/26/2013	10.69	10.66
12/2/2013	8.89	8.38
12/4/2013	9.67	9.82
12/8/2013	10.06	10.10
12/8/2013	9.58	9.18
12/9/2013	10.40	10.10
12/10/2013	10.76	10.77
12/13/2013	11.08	11.04
12/21/2013	10.61	11.18
12/22/2013	9.70	9.10
12/23/2013	10.90	10.94
12/24/2013	10.17	10.81
12/25/2013	10.21	10.23
12/27/2013	10.54	10.09
12/29/2013	10.96	10.29
12/30/2013	10.63	10.00
12/31/2013	9.89	9.89

	RVP (psi)	
	Prod. Train A	Prod. Train B
1/3/2014	10.51	10.12
1/3/2014	10.38	10.44
1/5/2014	10.45	
1/6/2014	9.53	10.84
1/9/2014	10.62	10.66
1/10/2014	10.75	10.83
1/14/2014	10.93	11.05
1/16/2014	11.07	11.02
1/18/2014	10.42	10.48
1/19/2014	10.56	10.20
1/20/2014	10.14	10.91
1/20/2014	10.67	10.98
1/21/2014	10.86	11.01
1/21/2014	10.85	10.25
1/22/2014	10.67	10.44
1/30/2014	10.95	
1/30/2014	10.89	
2/2/2014	10.83	
2/5/2014	11.25	
2/6/2014	10.77	
2/7/2014	8.70	
2/12/2014	11.45	11.60
2/13/2014	10.66	
2/13/2014	10.62	10.60
2/14/2014	10.18	10.50
2/16/2014	10.81	10.86
2/18/2014	10.88	10.75
2/20/2014	10.43	10.33
2/22/2014	10.52	9.49

	RVP (psi)	
	Prod. Train A	Prod. Train B
2/23/2014	9.56	11.25
2/24/2014	10.21	
2/26/2014	10.83	10.82
2/28/2014	11.34	11.04
3/2/2014	9.89	
3/3/2014	9.94	10.17
3/4/2014	10.73	10.17
3/5/2014	10.85	11.07
3/6/2014	10.43	10.41
3/7/2014	10.73	10.79
3/7/2014	10.91	10.89
3/8/2014	11.23	11.23
3/9/2014	10.62	10.38
3/11/2014	10.23	10.08
3/11/2014	10.63	10.92
3/13/2014	10.25	10.12
3/15/2014	10.15	10.24
3/16/2014	10.37	10.30
3/18/2014	10.41	10.37
3/20/2014	10.12	10.11
3/21/2014	10.11	9.91
3/22/2014	10.25	10.30
3/22/2014	10.25	10.30
3/23/2014		10.33
3/24/2014	10.46	
3/28/2014	10.41	
3/29/2014	10.52	10.24
3/30/2014	10.43	10.18

Appendix 13 - Interlaboratory (Round-Robin) Data

Lab	Sample	API	Vapor P D6377 (kPa)	Vapor P D6377 (psi)	D86 IBP (°F)	Condenser T (°F)	Reciever T (°F)
Lab M	1	42.98	103.3	14.98	83.1	32.9	60.0
SGS (St. Rose)		42.91	106.5	15.44	89.1	60	73
SGS (Williston)		42.86	95.0	13.78	102.6	60	81
					88.7	31	82
Lab M	2	40.22	69.7	10.11	89.9	32.9	60.0
SGS (St. Rose)		40.18	70.7	10.26	95.4	60	73
SGS (Williston)		40.17	69.7	10.11	101.8	60	80
					91.1	31	82
Lab M	3	43.63	73.2	10.62	87.8	32.9	60.0
SGS (St. Rose)		43.56	73.4	10.64	90.7	60	73
SGS (Williston)		43.61	73.0	10.59	105.5	60	81
					91.4	31	81
Lab M	4	42.97	78.8	11.43	89.2	32.9	60.0
SGS (St. Rose)		42.89	79.5	11.53	94.5	60	73
SGS (Williston)		42.88	77.3	11.21	102..2	60	81
					94.4	31	82

Lab	SGS (St. Rose)		SGS (Williston)		SGS (Williston)	
Condenser Temp (°F)	60		60		31	
Receiver Temp (°F)	73		81		81	
Sample	**D86 IBP**	**D86 IBP (°F)**	**D86 IBP (°F)**	**Time to IBP**	**D86 IBP (°F)**	**Time to IBP**
1	89.1	3 min 22 sec	102.6	6 min 27 sec	88.7	6 min 07 sec
2	95.4	4 min 53 sec	101.8	7 min 56 sec	91.1	7 min 45 sec
3	90.7	3 min 37 sec	105.5	7 min 26 sec	91.4	7 min 11 sec
4	94.5	3 min 42 sec	102.2	6 min 50 sec	94.4	8 min 00 sec

Appendix 14 – Glossary of Terms

AFPM – American Fuel & Petrochemical Manufacturers

API – American Petroleum Institute

ASTM – American Society for Testing and Materials

BKN – Bakken

BS&W – Basic Sediment & Water

DOT – Department of Transportation

EPA – Environmental Protection Agency

FPCs – Floating Piston Cylinders

H_2S – Hydrogen Sulfide

IBP – Initial Boiling Point

LLS – Light Louisiana Sweet

LPG - Liquefied Petroleum Gas

LTO – Light Tight Oil

NACE – National Association of Corrosion Engineers

ND – North Dakota

NDPC – North Dakota Petroleum Council

NGL – Natural Gas Liquids

PG – Packing Group

PHMSA – Pipeline and Hazardous Safety Materials Administration

psi – Pounds per Square Inch

psig – Pounds per Square Inch Gauge

QA/QC – Quality Assurance/ Quality Control

RVP – Reid Vapor Pressure

SGS – Laboratory Testing Provider

Appendix 14 – Glossary of Terms

SimDist – Simulated Distillation

TAN – Total Acid Number

TM&C – Turner, Mason & Company

VPCR – ASTM D6377 Vapor Pressure

WTI – West Texas Intermediate