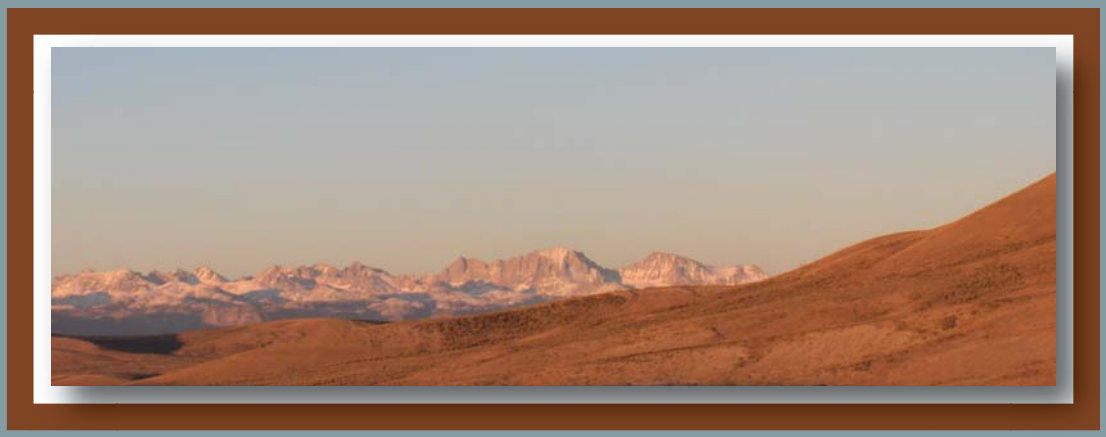
APPENDIX E



Memoranda On Data Validation and Data Review

APPENDIX E

MEMORANDA ON DATA VALIDATION AND DATA REVIEW

CONTENTS

Attachment E-1: Data Review and Validation Procedures

Attachment E-2: Technical Memorandum: Evaluation of Estimated Concentration Data

APPENDIX E
DATA REVIEW AND VALIDATION PROCEDURES

LOW-LEVEL PETROLEUM HYDROCARBON EVALUATION
PINEDALE ANTICLINE PROJECT AREA
SUBLETTE COUNTY, WYOMING

DATA REVIEW PROCESS

The objective of the data review is to identify any unreliable or invalid field and laboratory measurements, and qualify data for interpretive use. This is an important step in the quality assurance and quality control (QA/QC) process. Data review was performed in accordance with the Sampling and Analysis Plan (project SAP; *Sampling and Analysis Plan for Evaluating Potential Sources of Low-Level Petroleum Hydrocarbon Compound Detections, Pinedale Anticline Oil and Gas Exploration and Development Project, Sublette County, Wyoming, AMEC Geomatrix, Inc., November 2010*). Data review generally follows data validation procedures in the *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (EPA-540R-08-01; EPA 2008) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data* (EPA 540-R-10-011; EPA 2010), referred to herein as National Functional Guidelines. Additional information about the QA/QC process for this low-level petroleum hydrocarbon compounds (LLPHC) evaluation is in the project Plan of Study (POS; *Final Plan of Study for Evaluating Potential Sources of Low-Level Petroleum Hydrocarbon Compounds Detections, Interim Plan, PAPA ROD, Pinedale Anticline Oil and Gas Exploration and Development Project, Sublette County, Wyoming, AMEC Geomatrix, 2009, May 15, 2009*). The following steps were used to verify and validate field and laboratory analytical data obtained for the LLPHC evaluation:

- Field data were inspected for anomalous values and to confirm that proper procedures were used for collection of each measurement.

- Chain-of-custody forms and laboratory reports were checked to verify that samples were analyzed for the requested parameters and within specified holding times (i.e., time between sample collection and laboratory extraction or analysis). Samples that did not satisfy holding time and/or preservation requirements are noted or flagged (see chart of data qualifiers below).

- Laboratory sample receipt forms were reviewed to determine if sample coolers were received with an appropriate internal temperature ($4^{\circ}C \pm 2^{\circ}C$ for most analytes). Samples that were received above the recommended temperature are noted or flagged.

- Percent recoveries calculated for laboratory control samples and matrix spikes were reviewed to verify that they were within acceptable limits. If recoveries were outside limits, the results are noted or flagged.

- Relative percent difference (RPD) values calculated for field and laboratory duplicate samples were evaluated to determine if they were below acceptable limits specified in project SAP or established by the laboratory, respectively. If RPD values were greater than the specified limits, the results are noted or flagged.

- Surrogate recoveries calculated by laboratory were reviewed to verify that they were within acceptable limits. If recoveries for more than one surrogate were outside limits established by the laboratory, the results are noted herein or flagged.

- When parameters were detected above the laboratory reporting limit (i.e. practical quantitation limit or PQL) in blank samples, the associated natural sample results were noted or flagged. Natural sample results less than five times the concentrations detected in associated blanks are qualified as estimated; or as non-detect at the reported concentrations in the blank, if the detection in the blank was greater than the detection in the natural sample.

- All data were reviewed for transcription errors, reporting limit discrepancies, data omissions, and suspect or anomalous values.

Once laboratory data were reviewed and validated according to the steps described above, final qualified results were entered into the project database, along with field measurements and sample collection information. Data that did not meet acceptance criteria were flagged with an appropriate code from the list shown below. All letter codes (data qualifiers) indicate the parameters are considered estimated.

Data Qualifier	Description
<	The parameter was analyzed for but not detected at the practical quantitation limit (PQL) used for the method.
H	The required holding time for laboratory analysis was exceeded. Only parameters that do not meet the holding time for particular sample(s) will be flagged as "H".
F%	Field duplicate analysis has parameter concentration exceeding acceptable limits (relative percent difference determination). For any parameters that do not meet this criterion, all same parameters for all samples in the analytical batch will be flagged as estimated "JF%".
F	Field duplicate analysis has parameter concentration exceeding acceptable limits (PQL determination). For any parameters that do not meet this criterion, all same parameters for all samples in the analytical batch will be flagged as estimated "JF".

L%	Laboratory duplicate analysis has parameter concentration exceeding acceptable limits (relative percent difference determination). For any parameters that do not meet this criterion, all same parameters for all samples in the analytical batch will be flagged as estimated "JL%".
L	Laboratory duplicate analysis has parameter concentration exceeding acceptable limits (PQL determination). For any parameters that do not meet this criterion, all same parameters for all samples in the analytical batch will be flagged as estimated "JL".
M%	Laboratory matrix spike recovery has parameter concentration outside acceptable range. For any parameters that do not meet this criterion, all same parameters for all samples in the analytical batch will be flagged as estimated "JM%".
B	Laboratory method blank or field blank has parameter concentration detected above PQL. For any parameters that do not meet this criterion, all same parameters for all samples in the analytical batch will be flagged as estimated "JB".
S	Standard reference has parameter concentration outside acceptable range. For any parameters that do not meet this criterion, all same parameters for all samples in the analytical batch will be flagged as estimated "JS".
J	The associated parameter value is an estimated quantity.
R	The associated parameter value is unusable (rejected).

Rejected (R-flagged) data were not used for any project-related analysis.

FIELD QUALITY CONTROL SAMPLES

To assure the usability and reliability of sampling and analysis data, field quality control samples were collected in accordance with the QA/QC program developed in the project SAP. Field quality control samples included field duplicates, trip blanks, field equipment blanks, and field blanks.

Field duplicate samples were collected contemporaneously with groundwater samples and shipped to the laboratory in the same coolers as the associated natural sample(s). The duplicate sample bottles were labeled in a manner that did not reveal their identity to the laboratory (e.g., no time stamp or location). A minimum frequency of one duplicate per 10 natural samples was collected from different locations and well sample groups (i.e., Control, LEL, PHC, and Study Groups) to ensure precision and accuracy in sampling procedure. Due to insufficient sample volumes during groundwater sampling using the HydraSleeves™, five duplicates were split between analyte groups. Field duplicates collected in 2010-2011 for the study include:

- **DUP 2**: Collected at MS 14-16 for volatile organic compounds (VOC), total petroleum hydrocarbons - gasoline range organics (TPH-GRO), total petroleum hydrocarbons – diesel range organics (TPH-DRO), total dissolved solids (TDS), alkalinity, anions, total metals, nitrogen, dissolved gas and stable carbon and hydrogen isotopes of water and stable carbon isotope of dissolved inorganic carbon, ammonia, and phosphate.

- **DUP 3**: Collected at SP 11-33 for semi-volatile organic compounds (SVOC).

- **DUP 5**: Collected at WB 7-15 for entire LLPHC analyte suite.
- **DUP 6**: Collected at: AN 15-23 for TPH-DRO, SVOC, total metals, TDS, alkalinity, nitrogen, ammonia, and phosphate; RB 16-30 for TPH-GRO and VOCs; and HWY 11 for dissolved gas and stable carbon and hydrogen isotopes of water and stable carbon isotope of dissolved inorganic carbon.
- **DUP 7**: Collected at: HWY 7 for TPH-DRO, TPH-GRO, VOC, total metals, TDS, alkalinity, nitrogen, stable carbon and hydrogen isotopes of water and stable carbon isotope of dissolved inorganic carbon, and phosphate; and RS 2-24 for SVOC.
- **DUP 2** (June 2011): Collected at: T-1-RW for SVOC and dissolved and total metals; T-1-SW for TPH-DRO, TPH-GRO, VOC, alkalinity, anions, nitrogen, and phosphate; and T-3-SW for dissolved gas.
- **T-10-RW**: A duplicate sample of well casing gas was collected at T-3-SW on February 3, 2011 and submitted to Isotech Laboratories for analysis of stable carbon and hydrogen isotopes of methane.

Trip blank samples consisted of laboratory-provided deionized water in volatile organics analysis (VOA) vials and were included in each cooler during sample shipment with a few exceptions. Laboratory analysis included VOC for assessment of sample contamination during handling and transport to the laboratory.

Field equipment rinse blank samples and field blank samples were collected for assessment of possible contamination introduced during the decontamination procedure and/or from ambient conditions. Two equipment rinse blanks were collected during groundwater sampling using a HydraSleeve™ (SLVBLK) and a decontaminated stainless steel HydraSleeve™ weight and clip (EB Weight). Equipment rinse blanks were collected in the same sample containers as the natural samples with laboratory-provided deionized water, and analyzed for the full suite of LLPHC parameters. One field blank sample (FB) was collected using distilled water and analyzed for the full suite of LLPHC parameters. Containers were labeled in a manner that did not reveal the sample time or location to the laboratory.

DATA VALIDATION RESULTS – FIELD DATA

Water level measurements made with an electronic water level probe and sonic water level meter were measured to the nearest 0.01 and 0.1 foot, respectively. Data recorded with the sonic water level meter were compensated in the field for ambient air and water temperature. To ensure accuracy, sonic water level measurements were also compensated using a correlation

curve (R^2 = 0.99) generated from a subset of water levels measured using both the electronic water level probe and the sonic water level meter.

DATA VALIDATION RESULTS – LABORATORY DATA

SECTION 1 – FIELD QUALITY CONTROL SAMPLES

No detections of TDS, alkalinity, anions, metals, purgeable and extractable hydrocarbons, or SVOCs were reported in the equipment rinse blanks or field blank. Total phosphorus was detected at the reporting limit (0.005 mg/L) and nitrate+nitrate was detected at a concentration of 0.02 mg/L in the equipment rinse blank collected from the decontaminated HydraSleeve™ weight and clip (EB Weight). Chloroform was detected in the field blank (FB) at an estimated concentration of 0.99 mg/L. Methane was detected at low levels in one equipment rinse blank sample (SLVBLK).

Trip blank samples were prepared by the laboratory and submitted with each cooler during the November/December 2010 and June 2011 groundwater sampling events. Detections of chloroform above and below the analytical reporting limit were present in several trip blanks during the June 2011 sampling event. According to Ms. Wynn Pippin at Energy Laboratories, Inc. in Billings, Montana, the deionized water added to the trip blanks did not undergo laboratory QA/QC procedures before shipment. All chloroform detects in trip blanks associated with June 2011 data are likely sourced from laboratory contamination and do not represent groundwater quality and/or shipment conditions. Thus, a B flag was applied to the estimated chloroform detection in the groundwater sample collected from T-4-SW in June 2011 in the project database.

Nitrate-nitrite and total phosphorus detections in the equipment rinse blank sample were less than five times the PQL, the detections may be representative of background and not a true detection. Qualification was not necessary for natural samples in the project database.

For four of five field duplicate samples collected, analytical results met the applicable thresholds established in the project SAP of 35% RPD, or absolute difference less than the Practical Quantitation Limit (PQL) for results less than five times the PQL with the exception of the following parameter concentrations:

- Iron for WB 7-15;
- Multiple metals for MS 14-16;

- Aluminum, iron, and nitrogen as nitrate-nitrite, carbonate, and phosphorus for multiple samples; and
- TPgH, TEH and toluene in multiple samples;

The qualifier "F" or "F%" was added to all results described above and to the associated analytical batch in the project database.

For one of five field duplicate samples collected, the 35% RPD was exceeded for all analytes in the sample. The analytical laboratory was notified and the field duplicate was subsequently not used for the assessment of laboratory precision for the following reasons: 1) analytical methods for metals differed between the duplicate and associated natural samples; and 2) field duplicate was not contemporaneously packaged, shipped and analyzed at the lab with the natural samples.

SECTION 2 – LABORATORY DATA: POTENTIAL SOURCE MATERIAL SAMPLES

Holding times were met for all analyses source samples, with the exception of the pump installation samples (e.g., pipe dope samples), which were held at the laboratory as requested by AMEC. As a result, recommended extraction holding times were exceeded for all samples and were flagged with a "J" by the laboratory. AMEC also applied an "H" flag to the data in the project database. Because the sample matrix was solid, it is likely that little to no volatilization occurred. These results are considered usable for data evaluation purposes.

VOCs and TPH-GRO were analyzed after their method-specified holding times in a sample of LNAPL (sample AN 1-16 PHC) collected in November 2010. The SVOC and TPH-DRO analyses associated with this sample met holding times. Associated analytes were flagged by the laboratory and noted in the project database. The LNAPL was re-sampled in December 2010 and VOCs and TPH-GRO analyses met holding times. Because of holding time exceedences, the SVOC and TPH-DRO results from the November 2010 sample and the VOC and TPH-GRO results from the December 2010 sample were used in data evaluation.

All shipments of samples were received at the laboratory with temperatures below the temperature threshold of 6˚C (4˚C ± 2˚C) as specified in the project SAP with the exception of the following.

- Pipe dope samples collected in September and November 2010 were received by the laboratory coolers with temperatures of 10.8 and 7˚C, respectively, and
- A cooler containing a sample of light non-aqueous phase liquid (LNAPL) (sample AN 1-16 PHC) was received by the lab with a temperature measured at 7°C.

Most temperature exceedence results are considered not to affect sample analytical results because the time between sample transport and receipt by the laboratory was brief.

Results for Laboratory Control Samples (LCS) were inspected to determine if accurate results were obtained by the laboratory. All percent recovery thresholds for LCS results were met by the laboratory.

Results for all matrix spike percent recoveries met all control limits established by the laboratory with the exception of the following instances:

- Four flowback fluid samples collected December 8, 2010; February 18 and 28, 2011; and March 17, 2011 had out-of-limit recoveries in the following matrix spike analytes, respectively:
    - 4-nitrophenol and sulfate for sample RS 9-2 FBF;
    - aluminum, potassium and mercury for sample MS 3-27-FBF;
    - boron, mercury and silicon for sample MS3C-33D FBF; and
    - chloroethane for sample MSD2-21 FBF.
- Three drilling mud samples collected December 9 and 10, 2010 had out-of-limit recoveries for laboratory matrix spikes with titanium.
- All six produced water samples had out-of-limit laboratory matrix spike recoveries for 3,3-dichlorobenzidene, silver, and sulfate. Matrix spike recoveries were also exceeded for produced water sample SP 13-33 PDW and for mercury and ammonia, respectively. Qualifiers were added to all associated analytical batch samples in the project database.
- One sample, RS 15-12 PHC, had laboratory matrix spike recoveries out-of-limit for titanium.
- One sample, RS 11-25 PHC collected November 19, 2010 had matrix spike recoveries exceeding acceptable limits for 4-nitrophenol and pyridine.

The qualifier "M%" was added to all results described above in the associated analytical batch in the project database.

Results for all laboratory duplicates met applicable thresholds established by laboratory, typically 20% RPD, or absolute difference less than the Practical Quantitation Limit (PQL) for results less than five times the PQL, with the exception of the following instances:

- Multiple organics, including naphthalene, 1-methlynaphthalene, and 2-methylnaphthalene, in three "flowback fluid" samples and one produced water sample.
- Total dissolved solids (TDS) for one flowback fluid sample (MS3-27 FBF).
- Multiple VOCs including toluene for sample RS 15-12 PHC collected November 14, 2010.

The qualifier "L%" or "L" was added to all results described above and to the associated analytical batch (including total extractable hydrocarbons and diesel range organics) in the project database.

Laboratory results indicated multiple samples with concentrations of analytes reported above the method detection limit (MDL), but below the reporting limit, or practical quantitation limit (PQL). The qualifier J was applied to these concentrations by the laboratory, which were retained in the project database. However, only detections at or exceeding the PQL were used in data evaluation.

Surrogate recoveries for individual samples were generally acceptable. However, the laboratory reported several instances where potential source material samples were diluted due to high level of organics in the sample. Subsequently, the surrogate used for DRO analysis (o-Terphenyl) was diluted to a low or zero percent recovery. Low recoveries are acceptable due to dilution and acceptable surrogate recoveries for method blanks, Laboratory Control Standards, and sample duplicates reported by the laboratory in the method 8015 QA/QC results.

Electronic Data Deliverables (EDD) generated by the laboratory were inspected for consistency with the chain-of-custody forms and project requirements. Any inaccurate sample names/identification were corrected, and dates were inserted for field QC samples that were assigned placeholder dates by the laboratory following EDD review.

SECTION 3 – LABORATORY DATA: GROUNDWATER SAMPLES

Holding times were met for all analyses for all groundwater samples.

All shipments of samples were received at the laboratory with temperatures below the temperature threshold of 6˚C (4˚C ± 2˚C) as specified in the project SAP with the exception of a shipment of groundwater samples that were received by the lab in coolers measured at 7°C. Most temperature exceedence results are considered not to affect sample analytical results because the time between sample transport and receipt by the laboratory was brief.

Results for Laboratory Control Samples (LCS) were inspected to determine if accurate results were obtained by the laboratory. All percent recovery thresholds for LCS results were met with

the exception of LCS recoveries for Trip Blank sample analyzed in association with QC samples, EB Weight and FB. Because there were no detections of analytes in the associated trip blank, the elevated LCS recoveries had no significant effect on the data of the QC samples. No qualification was necessary in the project database.

Results for all matrix spike percent recoveries met all control limits established by the laboratory with the exception of the following instances:

- Two QC groundwater samples (EB weight and FB) collected on November 21, 2010 had out-of-limit recoveries for laboratory matrix spikes in 4-nitrophenol and pyridine analytes.
- One groundwater sample (BO 12A-33) had out-of-limit laboratory matrix spike recoveries for 3,3-dichlorobenzidene, silver, sulfate, mercury and ammonia.
- Four groundwater samples (MS 14-16; MS 15-16; SP 11-33; and SP 11-34) had out-of-limit laboratory matrix spikes for nitrogen (ammonia and nitrate-nitrite), phosphorus, sulfate, titanium, and total dissolved solids. Sample MS 15-16 also had matrix spike recoveries out-of-limit for calcium and copper.
- One groundwater sample (RS 1-4) collected on November 15, 2010 had out-of-limit laboratory matrix spikes for 2-chloroethyl vinyl ether and silicon.
- Two groundwater samples (WB 16-5 and WB 7-15) had out-of-limit laboratory matrix spikes for n-nitrosodimethylamine, styrene, and sulfate.
- Two groundwater samples (AN 15-23 and RN 16-30) had out-of-limit laboratory matrix spikes for n-nitrosodimethylamine and 2-chloroethyl vinyl ether.
- Groundwater sample WB 7-4 collected December 6, 2010 had out-of-limit laboratory matrix spikes for 2-chloroethyl vinyl ether, aluminum, and silicon.
- Eleven groundwater samples collected November 19 and 20, 2010 had matrix spike recoveries exceeding acceptable limits for 4-nitrophenol and pyridine.
- In addition to the groundwater samples listed above, two groundwater samples (HW-7 and MS 12-28) had out-of-limit laboratory recoveries for sulfate and nitrate & nitrite as N, respectively.

The qualifier "M%" was added to all results described above in the associated analytical batch in the project database.

Results for all laboratory duplicates met applicable thresholds established by the laboratory, typically 20% RPD, or absolute difference less than the Practical Quantitation Limit (PQL) for results less than five times the PQL, with the exception of the following instances:

- TPH-DRO and TEH in groundwater samples from study wells T-2-RW, T-4-RW-b, and T-5-RW.
- Multiple organics, including naphthalene, 1-methlynaphthalene, and 2-methylnaphthalene, in two field QA/QC samples.
- Total alkalinity and total dissolved solids (TDS) for four groundwater samples and two field duplicates collected November 18-20, 2010.
- Fluoride in samples RS 1-4, RS 15-12, and SP 5-20 collected November 13-15, 2010.
- Multiple VOCs, including toluene and methyl ethyl ketone, for seven groundwater samples and two field duplicates collected November 12-15, 2010.

The qualifier "L%" or "L" was added to all results described above and to the associated analytical batch (including total extractable hydrocarbons and diesel range organics) in the project database.

Laboratory results indicated multiple samples with concentrations of analytes reported above the method detection limit (MDL), but below the reporting limit, or practical quantitation limit (PQL). The qualifier J was applied to these concentrations by the laboratory, which were retained in the project database. However, only detections at or exceeding the PQL were used in data evaluation.

Surrogate recoveries for groundwater samples were acceptable.

Electronic Data Deliverables (EDD) generated by the laboratory were inspected for consistency with the chain-of-custody forms and project requirements. Any inaccurate sample names/identification were corrected, and dates were inserted for field QC samples that were assigned placeholder dates by the laboratory following EDD review.

SECTION 4 –LABORATORY DATA: GAS AND ISOTOPE SAMPLES

Specific holding times were met for all groundwater and gas samples submitted for analysis of isotopes and gas composition. There are no temperature thresholds for handling and shipping gas and isotope samples. Groundwater samples for gas and isotope analysis contained a bactericide to prevent any bacterial activity prior to analysis. Packaging and shipping on ice was

not mandatory to preserve these samples; however, these samples were packaged and shipped on ice in accordance with the project SAP.

A QA/QC summary was submitted by Isotech Laboratories, Inc. (Isotech) that included lab duplicate RPDs, results for daily instrument checks, and analysis of internal check/reference standards related to the stray gas and dissolved gas analysis. All QA/QC results were reviewed and deemed valid with the exception of one field duplicate RPD for oxygen from sample DUP 6. An F% qualifier was added to the analyte and its associated sample, HWY 11.

On February 3, 2011, Geomatrix collected blind duplicate samples of gas that accumulated in the plugged casing of study well T-3-SW. After laboratory analysis, a difference of 11.2 per mil in the $\delta^2H[CH_4]$ value was reported between the duplicate and natural sample. The laboratory that performed the analysis, Isotech, was contacted to discuss variance between the samples.

Upon discovery of the discrepancy in the duplicate analysis, the laboratory reported having issues with the hydrogen (^2H) isotope analysis of hydrocarbon gases (e.g., methane), which involves a reaction with zinc by mass spectrometry using conventional off-line methods (i.e., chromatographic separation followed by combustion and analysis by dual-inlet isotope ratio mass spectrometry [IRMS]). A new formulation of zinc had been introduced in the laboratory that appeared to contain impurities, which was affecting the analysis. Based on this notification from the lab, AMEC requested a reanalysis the casing gas sample collected on February 3, 2011, as well as all groundwater and gas samples analyzed for carbon and hydrogen isotopes of methane after December 14, 2010 (Isotech Job numbers 14307, 14668, 14494, 14631, 14432, and 14561) to evaluate possible inaccuracies with additional $\delta^2H[CH_4]$ values. All samples fell within the laboratory's accepted range for duplicate analysis (RPD criteria of ±3 per mil); thus, data quality objectives were met with no further action. However, due to the new zinc formulation used by the laboratory, lab-specific reproducibility for hydrogen (^2H) isotope analysis in hydrocarbons was increased from ±1 per mil to ±3 per mil for all gas and groundwater samples.

Analytical precision also decreased from 0.1 to 0.3 per mil for carbon (^{13}C) isotope analysis of methane in well casing gas sample WB 7-4 due to a less-precise analytical method (on-line IRMS) used to compensate for the low methane concentration in the gas sample.

Several groundwater samples arrived at the laboratory with substantial headspace in the sampling container because of outgassing due to the high dissolved gas content in the groundwater samples. According to Mr. Steven Pelphery with Isotech, the calculated dissolved methane concentrations in milligrams per liter and cubic centimeters per liter are considered estimated due to the variable headspace and sample volumes in the sample containers, which

affects the calculation of the dissolved methane concentrations. Dissolved methane concentrations were subsequently flagged with a "J" qualifier in the project database.

Reporting limits for gas extracted by headspace equilibrium in groundwater samples ranged from 0.0001 % mol to 0.0002 % mol for methane and C2 (ethane) through C5 (pentane) analytes, respectively.

For the mobile laboratory analysis of gas composition (i.e., well casing and natural [production] gas samples), daily calibration checks were performed and records of the checks reviewed. According to Ms. Heidi Fabrizius, ACS Certified Chemist with Precision Analysis, the reporting limit for gas composition measurements is 0.001 mol %; however, results were reported to the fourth decimal in the report upon request. The qualifier "J" was added to the project database for concentrations detected at or below the fourth decimal point.

Reproducibility of results from the on-site mobile laboratory were evaluated based on three consecutive gas chromatography runs. The third run is usually selected for reporting as it typically has the least amount of atmospheric interference. According to Precision Analysis, reproducibility goals, which are specific to the method, are typically not met for non-pressurized gas samples due to low or ambient pressures during sample collection and changing gas composition as the analysis proceeds.

Reproducibility goals were achieved during the analysis of natural gas samples collected from wellheads or meter runs during this study. Reproducibility goals were generally not met during the analysis of well casing gas samples with the exception of the well casing gas sample collected at BO 12A-33 on February 23, 2012. Most variation was observed for analyte concentrations at or below reporting limits or for the higher carbon number hydrocarbon concentrations. The casing gas data was reviewed closely and is usable for data evaluation purposes, except for gas samples collected from the well casings at WB 7-4 and T-4-RW-b, where hydrocarbon concentrations are too low. For example, the mobile laboratory analyst noted that the gas was slowly being evacuated from the well casing at WB 7-4 and replaced by atmospheric gas during the three consecutive runs. Due to the evacuation of the well casing as analysis progressed, the most representative analysis at this well was the first run, which was reported by the laboratory and added to the project database. In addition, an attempt was made to confirm the low hydrocarbon concentrations in well casing gas from WB 7-4 on by confirmation sampling on February 23, 2012; however, hydrocarbon gas concentrations were too low to proceed with analysis. It is likely that the elevated LEL readings in well casing at WB 7-4 during the November/December 2010 sampling event were a transient or anomalous condition.

Gas concentrations for all samples, including the well casing gas samples at WB 7-4 and T-4-RWb, have been retained in the project database. However, gas component ratios were not calculated for these well casing gas samples, and this data was not used for evaluation purposes due to the low concentration of hydrocarbon gas in the sample.

EDDs generated by the laboratories were inspected for consistency with the chain-of-custody form and project requirements. Any inaccurate sample names/identifications were corrected and dates were inserted for field QC samples that were assigned placeholder dates by the laboratory following EDD review.

SECTION 5- DATA VALIDATION SUMMARY

The following statements are offered regarding precision, accuracy, representativeness, completeness, and comparability (PARCC):

Precision – Precision is a measure of the degree to which two or more measurements are in agreement. Laboratory tests of precision successfully met QC thresholds, with the exception of exceedences in multiple analytes for several groundwater samples, three flowback fluid samples, and one produced water sample. Instances where the RPD values for lab duplicates were greater than 20% were flagged (L% or L) in the database. Instances where the RPD values for field duplicates were greater than 35% were flagged in the database (F or F%), and appear to indicate instances where the field sampling process instead of the precision of the analytical method has resulted in precision outside of the control limits established in the project SAP.

Accuracy – Accuracy is the measurement of agreement between an observed value and an accepted reference value. Laboratory accuracy was evaluated by reviewing laboratory control samples (LCS) and matrix spike sample results. All LCS recoveries were within control limits with the exception of recoveries for Trip Blank samples analyzed associated with QC samples EB Weight, FB, and FLTRFB. No qualification was necessary in the project database. Natural samples associated with matrix spike results outside of control limits were flagged (M%) in the database.

Representativeness – Acceptance for representativeness is based on results of blank samples and review of the sampling design and sample collection techniques. Nitrate+nitrite as nitrogen was detected in two field blank samples at levels less than five times the natural concentration. All chloroform detects in trip blank samples associated with 2010-2011 groundwater data are likely sourced from laboratory contamination.

Completeness – The threshold of 95% completeness as specified in the project SAP was met. Multiple groundwater samples were broken upon arrival at associated laboratories; subsequent sample analysis occurred only if adequate volumes were present in

additional sample containers. Of the thousands of individual results from dissolved gas, stable isotopes, common ions, and PHC compounds collected and analyzed during 2010 and 2011, only the results of one field duplicate were rejected, although duplicate sample results are not used for evaluation of project quality data.

Comparability – Standard procedures identified in the project SAP were followed for field sampling and laboratory analyses. Standard methods including data review procedures specified in the National Functional Guidelines were followed by the laboratory, which allows comparison to other datasets obtained by similar methods. Only minor deviations to the project SAP occurred.

TECHNICAL MEMORANDUM

PROJECT: 0136550010

TO: File, Appendix E, LLPHC Report

FROM: Beth Johnson, AMEC
K. Bill Clark, NewFields

SUBJECT: Evaluation of Estimated Concentration Data
Technical Report for the Evaluation of Potential Sources of Low-Level Petroleum Hydrocarbon Compounds Detected in Groundwater
Pinedale Anticline Oil and Gas Exploration and Development Project,
Sublette County, Wyoming

This memorandum was prepared to support the Technical Report for the Evaluation of Potential Sources of Low-Level Petroleum Hydrocarbon Compounds (LLPHC) Detected in Groundwater (LLPHC report) for the Pinedale Anticline Oil and Gas Exploration Area (PAPA). This memorandum specifically addresses analytical data generated as part of the LLPHC study that were qualified as estimated because concentrations were below the analytical laboratory's routine reporting limit, termed the *practical quantitation limit* (PQL). Concentrations of constituents below the laboratory reporting limit are considered estimates, and were therefore qualified with a "J" (J-flagged) by the laboratory following standard laboratory practice. These estimated concentrations were retained in the project database; however, only constituent concentrations above the laboratory reporting limit are presented in data tables in the LLPHC report and subsequently used for data analysis or evaluation.

This memorandum summarizes the results of an evaluation into whether consideration of these data for estimated concentrations below the laboratory reporting limit would affect the data interpretations made in, and hence conclusions of, the LLPHC report. We evaluated what influence, if any, including these results would have on interpretations made in the LLPHC report. The background, approach, and findings of the evaluation are presented in the sections below.

Table 1 presents all of the results that were qualified as estimated (J-flagged) because concentrations were below the analytical laboratory's routine reporting limit.

BACKGROUND

To minimize the potential for false interpretations, analytical data generated during implementation of the *Sampling and Analysis Plan for Evaluating Potential Sources of Low-Level Petroleum Hydrocarbon Compound Detections* (SAP) (AMEC Geomatrix, 2010) were filtered based on the reported concentration relative to the laboratory's routine reporting limit and the analytical method detection limit (MDL). The *practical quantitation limit* or *reporting limit* is the lowest concentration of a constituent that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions. In contrast, the *method detection limit* is the minimum concentration of a constituent that can be present within a sample and be detected using the specified analytical method with 99 percent confidence that the true concentration is greater than zero. Concentrations that are below the reporting limit but above the MDL were reported by the laboratory as estimated concentrations and were identified with a "J" flag, or qualifier.

Since only concentrations above the reporting limit can be quantified with a certain degree of confidence by the laboratory, only those concentrations were used in data analysis.

A "J" qualifier may also be applied to analytical results with concentrations above the reporting limit, but considered estimated based on the results of quality assurance/quality control measures (EPA, 2008). In this study, for example, a constituent concentration would be qualified with "JL%" when the percent recovery for this constituent in an associated laboratory duplicate sample exceeded acceptable limits. Analytical results qualified as estimated based on such quality control criteria were retained in data tables in the report, were used along with non-qualified data in the report, and are not part of this evaluation.

APPROACH

All analytical data are stored in the project database and were validated in accordance with the SAP. Data were qualified with unique data qualifiers by AMEC, where necessary and as required by the SAP, as well as by the laboratory. A "J" qualifier is typically applied by the laboratory when the concentration is detected beyond the calibration range of the analytical apparatus (e.g., between the MDL and the reporting limit).

The approach followed to evaluate the estimated concentration data comprised the following steps:

1. The database was queried for estimated concentration data that were qualified with a "J" because the detected quantity was greater than the MDL but less than the reporting limit.

2. The queried data were tabulated and sorted by sample type (e.g., groundwater) and sample identification (e.g., WB 7-5).

3. Each constituent with an estimated concentration was then independently judged against all data collected from the respective sample, and generally with data gathered for this study. An approach using multiple lines of evidence was employed to assess what influence that considering the estimated concentration data would have on interpreting the chemical data generated during this study.

4. An assessment was made of the following:

    a. Whether including the estimated concentration data for potential source material samples would identify a potential indicator for a potential source material that would not be identified if these results were not considered; or

    b. Whether including the estimated concentration data for groundwater samples would identify potential source(s) of organic constituent detections that would not be identified if these results were not considered.

The findings of the evaluation and basis for deciding whether including the estimated concentration data would or would not change the interpretation of potential indicators and potential source materials are discussed below and summarized in **Table 1**.

FINDINGS

Groundwater samples collected from 8 study wells and 16 industrial water supply wells and 11 samples of potential source materials each exhibited at least one detected constituent with a concentration qualified as estimated because the result was less than the laboratory reporting limit. All of these estimated results were evaluated following the steps outlined in the previous section.

In all, 69 estimated concentration values were reported between the MDL and the reporting limit for volatile and semivolatile organic constituents determined by Method 8015, Method 8260, and Method 8270. These 69 estimated concentrations should be considered within the context of many thousands of results representing detected and non-detected analytes that were

reported for these analyses in groundwater and potential source material samples in this study. Of the 69 estimated concentration values, 16 results were reported in potential source material samples; the remaining 53 values were reported in groundwater samples collected from water wells (**Table 1**). Benzene, toluene, and total purgeable hydrocarbons (TPgH) were the most common constituents with estimated concentrations reported less than the laboratory reporting limit.

Effect of Estimated Concentration Data on Interpretation of Results for Potential Source Material Samples

Review of the 16 estimated concentration values reported in potential source materials sampled for this study determined that considering these results would not change interpretation of data regarding potential indicators of source materials using the multiple lines of evidence approach used in this study (**Table 1**).

About half of the constituents that were reported at an estimated concentration in a potential source material sample (eight estimated values) were detected above the reporting limit in another potential source material sample of the same type. Thus, these constituents with estimated concentrations would already be accounted for in that potential source material type, and omitting these results would not affect the assessment of whether these constituents could serve as a potential indicator for that potential source type. For example, pyrene was reported at an estimated concentration in the drill mud sample JEN 1A MUD but omitted from the analysis in the report. However, pyrene was detected at concentrations above the reporting limit in the other two drill mud samples collected for this study, and would therefore already be identified as a potential indicator of drill mud (see **Appendix H**).

Volatile organic compounds (VOCs) or the volatile organic fraction were detected in pump installation materials (pipe dope and grease) at estimated concentrations below the reporting limit (seven estimated values). These results are consistent with the detection of volatile constituents at relatively low concentrations that are above the reporting limit in several pump installation material samples (**Appendix H**). In general, the absence of detected volatile organic constituent detections, or detection of a single volatile organic constituent versus a suite of volatile organic constituents, is most characteristic of pump installation materials compared with the other potential source materials sampled for this study. Including these results would therefore not affect interpretation of these potential indicators.

One constituent, di-n-octyl phthalate, was detected at an estimated concentration in two samples of pipe dope. Phthalates were identified as a potential cross-contaminant (see **Section 5.5.2**), do not serve as an indicator of any potential source material, and are not used in

the interpretation of groundwater quality. Therefore, consideration of these estimated concentrations would not affect interpretation of data in this study.

Three different constituents were detected at estimated concentrations in three different flowback fluid samples (**Table 1**). These constituents are not considered potential indicators because they were detected at very low concentrations in only one of four flowback fluid samples collected. Two of these constituents were identified as potential indicators of produced water, which is a component of flowback fluid. None of these constituents was detected in groundwater samples, and therefore considering these estimated concentrations would not affect interpretations about potential indicators or sources.

Effect of Estimated Concentration Data on Interpretation of Results for Groundwater Samples

Consideration of the 53 estimated concentration values reported in groundwater samples would not change interpretation of potential sources of low-level organic constituents detected in those water wells where samples were collected (**Table 1**). Considering these data would have no effect on interpretations of these data for two main reasons:

- The constituent detected at an estimated concentration in the sample was complimentary to other constituents detected above the reporting limit in those samples and/or is consistent with other results that would be used to interpret potential source materials for the well (18 estimated values).
- The constituent detected at an estimated concentration in the sample was detected in the absence of a complimentary suite of volatile and semivolatile compound/fraction detections, reported tentatively identified compounds (TICs) (where applicable), and/or a diagnostic chromatographic profile that would provide evidence pointing to a specific potential source material in the well (17 estimated values).

In addition to these two main reasons, considering the estimated results would have no effect on interpreting the data in this study based on several other criteria:

- The constituent was identified as a potential cross-contaminant (six estimated values).
- The detection of the constituent is attributable to the presence of other detected constituent(s) that can be used to identify a potential source material (eight estimated values).

- The constituents were not detected in any potential source material sample and were either not typically associated with a petroleum substance or could be a potential cross-contaminant (two estimated values).
- The constituent was not detected when the well was re-sampled (one estimated value).
- The constituent was detected in a nearby study well, which can be considered in data interpretation (one estimated value).

Volatile organic fractions and individual VOCs, such as benzene and toluene, were detected at estimated concentrations below the reporting limit in both industrial water supply wells and study wells located near exploration and production activities as well as in study wells located away from exploration and production activities. In addition, low concentrations of a single volatile constituent above the reporting limit, particularly toluene, had a tendency to be detected in this study along with diesel-range organics/total extractable hydrocarbons in samples with no other diagnostic characteristics (i.e., a complementary suite of detected VOCs and semivolatile organic compounds, numerous reported TICs, and/or diagnostic chromatographic profile). These findings are consistent with characteristics of low-level wells in **Table 1** in which a single volatile organic constituent was detected at an estimated concentration below the laboratory reporting limit.

REFERENCES

AMEC Geomatrix, Inc. (AMEC Geomatrix), 2010. Sampling and Analysis Plan for Evaluating Potential Sources of Low-Level Petroleum Hydrocarbon Compound Detections, Pinedale Anticline Project Area, Sublette County, Wyoming, November.

U.S. Environmental Protection Agency (EPA), 2008. USEPA Contract Laboratory Program, National Functional Guidelines for Superfund Organic Methods Data Review. OSWER 9240.1-48/USEPA-540-R-08-01. June.

TABLE

TABLE 1
ESTIMATED CONCENTRATIONS OF ANALYTES IN GROUNDWATER AND POTENTIAL SOURCE MATERIAL SAMPLES
Low-Level Petroleum Hydrocarbon Evaluation
Pinedale Anticline Project Area, Sublette County, Wyoming

Sample ID[1]	Laboratory Number	Sample Type	Constituent	Result	Units[2]	Qualifier[3]	Reporting Limit[4]	QC[5]	Change Interpretation?	Rationale[6]
T-1-RW	B11061828-002	Groundwater	Toluene	0.19	µg/L	J	1	N	No	8,13
T-2-RW	B11062112-006	Groundwater	Benzene	0.5	µg/L	J	1	N	No	8
T-2-RW	B11062112-006	Groundwater	m+p-Xylenes	0.5	µg/L	J	1	N	No	8
T-2-RW	B11062112-006	Groundwater	Xylenes, Total	0.5	µg/L	J	1	N	No	5
T-3-SW	B11061828-003	Groundwater	bis(2-Ethylhexyl) phthalate	3.5	µg/L	J	10	N	No	3
T-3-SW	B11061828-003	Groundwater	Ethylbenzene	0.81	µg/L	J	1	N	No	6
T-3-SW	B11061828-003	Groundwater	o-Xylene	0.71	µg/L	J	1	N	No	6
T-3-SW	B11061828-003	Groundwater	Styrene	0.32	µg/L	J	1	N	No	9
T-4-SW	B11062112-004	Groundwater	Chloroform	0.24	µg/L	J	1	N	No	3
T-4-RWb	B12021940-008	Groundwater	Adamantane	0.35	µg/L	J	1	F	No	10
T-7-RW	B11061811-007	Groundwater	Benzene	0.16	µg/L	J	0.5	N	No	8,12
T-7-RW	B11061811-007	Groundwater	Total purgeable hydrocarbons	14	µg/L	J	20	N	No	8,12
T-7-SW	B11061811-008	Groundwater	Toluene	0.15	µg/L	J	0.5	N	No	8,12,13
X-3-SW	B11062106-009	Groundwater	Total purgeable hydrocarbons	18	µg/L	J	20	N	No	5,12
RN 13-29	B10111952-011	Groundwater	Total purgeable hydrocarbons	8.7	µg/L	J, JF%	20	N	No	5
RS 2-24	B10111952-005	Groundwater	Di-n-octyl phthalate	5.8	µg/L	J	10	N	No	3
RS 2-24	B10111952-005	Groundwater	Total purgeable hydrocarbons	12	µg/L	J, JF%	20	N	No	8
AN 1-16	B10111952-001	Groundwater	Benzene	0.49	µg/L	J	1	N	No	6
BO 12A-33	B10121230-007	Groundwater	Di-n-octyl phthalate	4.1	µg/L	J	10	N	No	3
BO 12A-33	B10121230-007	Groundwater	Total purgeable hydrocarbons	16	µg/L	J	20	N	No	5
WB 7-5	B10111952-007	Groundwater	Benzene	0.91	µg/L	J	1	N	No	8
WB 7-5	B10111952-007	Groundwater	Gasoline range organics (GRO)	18	µg/L	J	20	N	No	5
WB 7-5	B10111952-007	Groundwater	Toluene	0.96	µg/L	J, JF	1	N	No	8,13
HW-11	B10111952-003	Groundwater	Toluene	0.28	µg/L	J, JF	1	N	No	8,13
HW-11	B10111952-003	Groundwater	Total purgeable hydrocarbons	5.6	µg/L	J, JF%	20	N	No	5
MS 12-28	B10111952-012	Groundwater	Di-n-octyl phthalate	3.8	µg/L	J	10	N	No	3
MS 14-16	B10111368-007	Groundwater	Methyl ethyl ketone	17	µg/L	J	20	D	No	7
MS 14-16	B10111368-007	Groundwater	Toluene	0.85	µg/L	J, JF%	1	D	No	8,13
MS 14-16	B12021940-001	Groundwater	Acetone	15	µg/L	J	20	F	No	8
RN 16-30	B10111952-013	Groundwater	Benzene	0.42	µg/L	J	1	D	No	8
RN 16-30	B10111792-002	Groundwater	Benzene	0.55	µg/L	J	1	N	No	8
RS 1-4	B10111442-001	Groundwater	m+p-Xylenes	0.54	µg/L	J	1	N	No	8
RS 1-4	B10111442-001	Groundwater	Xylenes, Total	0.54	µg/L	J	1	N	No	5
RS 1-4	B12021940-005	Groundwater	2-Ethylhexanoic Acid	2.9	µg/L	J	10	F	No	11

TABLE 1
ESTIMATED CONCENTRATIONS OF ANALYTES IN GROUNDWATER AND POTENTIAL SOURCE MATERIAL SAMPLES
Low-Level Petroleum Hydrocarbon Evaluation
Pinedale Anticline Project Area, Sublette County, Wyoming

Well/Sample ID[1]	Laboratory Number	Sample Type	Constituent	Result	Units[2]	Qualifier[3]	Reporting Limit[4]	QC[5]	Change Interpretation?	Rationale[6]
RS 11-25	B10111952-006	Groundwater	2-Methylnaphthalene	4.3	µg/L	J	10	N	No	6
RS 11-25	B10111952-006	Groundwater	Ethylbenzene	0.34	µg/L	J	1	N	No	6
RS 11-25 PHC	B10111952-004	Groundwater[7]	Anthracene	1.6	µg/L	J	10	N	No	6
RS 11-25 PHC	B10111952-004	Groundwater[7]	Benzene	0.28	µg/L	J	1	N	No	6
RS 11-25 PHC	B10111952-004	Groundwater[7]	Fluorene	6.4	µg/L	J	10	N	No	6
RS 11-25 PHC	B10111952-004	Groundwater[7]	Naphthalene	7.4	µg/L	J	10	N	No	6
RS 11-25 PHC	B10111952-004	Groundwater[7]	Phenanthrene	6.7	µg/L	J	10	N	No	6
RS 15-12	B10111442-007	Groundwater	m+p-Xylenes	0.58	µg/L	J	1	N	No	6
RS 15-12	B10111442-007	Groundwater	o-Xylene	0.17	µg/L	J	1	N	No	6
RS 15-12	B10111442-007	Groundwater	Xylenes, Total	0.75	µg/L	J	1	N	No	6
RS 15-12 PHC	B10111368-009	Groundwater[7]	Ethylbenzene	0.18	µg/L	J	1	N	No	6
RS 15-12 PHC	B10111368-009	Groundwater[7]	m+p-Xylenes	0.69	µg/L	J	1	N	No	6
RS 15-12 PHC	B10111368-009	Groundwater[7]	o-Xylene	0.26	µg/L	J	1	N	No	6
RS 15-12 PHC	B10111368-009	Groundwater[7]	Xylenes, Total	0.95	µg/L	J	1	N	No	6
SP 5-20	B10111442-003	Groundwater	Benzene	0.18	µg/L	J	1	N	No	8
SP 5-20	B10111442-003	Groundwater	Toluene	0.3	µg/L	J	1	N	No	8,13
WB 7-15	B10111765-004	Groundwater	o-Cresol	1.7	µg/L	J	10	D	No	6
WB 8-6	B10111952-009	Groundwater	Di-n-octyl phthalate	7.1	µg/L	J	10	N	No	3
RS 11-14	B10111952-010	Groundwater	Gasoline range organics (GRO)	16	µg/L	J	20	N	No	5
JEN 1A MUD	B10121229-002	Drill Mud	Pyrene	18	mg/kg	J	25	N	No	1
MS3C-33D FBF	B11030216-001	Flowback Fluid	Tetrachloroethene	1.7	µg/L	J	5	N	No	4
MSD2-21 FBF	B11031650-001	Flowback Fluid	Phenanthrene	384	µg/L	J	1000	N	No	4
RS 9-2 FBF	B10121089-001	Flowback Fluid	Fluorene	3.6	µg/L	J	10	N	No	4
Riverside 11-14-Pump	B10121017-002	Black Film	Di-n-octyl phthalate	26	mg/kg	J, JH	86	N	No	3
WB 16-5-Pump-2	B10121017-007	Pipe Dope	Gasoline range organics (GRO)	11	mg/kg	J, JH	13	N	No	1
WB 7-15-Pump	B10121017-001	Pipe Dope	Di-n-octyl phthalate	15	mg/kg	J, JH	32	N	No	3
WB 7-15-Pump	B10121017-001	Pipe Dope	Ethylbenzene	0.25	mg/kg	J, JH	1.6	N	No	2
WB 7-15-Pump	B10121017-001	Pipe Dope	o-Xylene	0.23	mg/kg	J, JH	1.6	N	No	1
WB 7-15-Pump	B10121017-001	Pipe Dope	Toluene	0.52	mg/kg	J, JH	1.6	N	No	2
WB 7-5-1	B10111974-003	Pipe Dope	Total purgeable hydrocarbons	25	mg/kg	J, JH	43	N	No	1
Riverside 1-4-Pump	B10121017-005	Pipe Dope and Grease	Ethylbenzene	0.35	mg/kg	J, JH	0.92	N	No	2
Riverside 1-4-Pump	B10121017-005	Pipe Dope and Grease	o-Xylene	0.58	mg/kg	J, JH	0.92	N	No	1
AN 1-9 PDW	B10121230-004	Produced Water	Fluorene	5.5	µg/L	J	10	N	No	1
AN 1-9 PDW	B10121230-004	Produced Water	Phenanthrene	3.8	µg/L	J	10	N	No	1
RN 16-30 PW	B10121230-002	Produced Water	Phenanthrene	7.5	µg/L	J	10	N	No	1

TABLE 1
ESTIMATED CONCENTRATIONS OF ANALYTES IN GROUNDWATER AND POTENTIAL SOURCE MATERIAL SAMPLES
Low-Level Petroleum Hydrocarbon Evaluation
Pinedale Anticline Project Area, Sublette County, Wyoming

Notes:
1 - Groundwater samples RN 13-29 and RN 16-30 were collected from well/pad location RB 13-29 and RB 16-30, respectively.
AN = Antelope; RB and RN = Rainbow; BO = Boulder; RS = Riverside; MS = Mesa; SP = Stewart Point; T and X = Study Well; HWY = Highway; WB = Warbonnet; JEN = Jensen
2 - µg/L = micrograms per liter; mg/kg = milligrams per kilogram.
3 - Data qualifiers:
J = result is considered an estimate because value is less than laboratory's routine reporting limit.
JH = Holding time exceedance
JL% = Relative percent difference in laboratory duplicate samples exceeds project-specific quality control criterion
JF = Difference in results for field duplicate samples does not meet quality control criterion since difference exceeds the laboratory routine reporting limit
JF% = Relative percent difference in results for field duplicate samples exceeds project-specific quality control criterion
4 - Laboratory's routine reporting limit, which is equal to the practical quantitative limit (PQL)
5 - QC = quality control: N = natural sample; D = duplicate sample; F = follow-up sample
6 - Rationale:
1- Constituent was present in other samples of this source material and is accounted for as a potential indicator in the material summary for source material; no impact on interpretation.
2- Supports the potential for this constituent (e.g., trace volatile organic compound) to be associated with pump installation materials; no impact on interpretation.
3- Constituent identified in report as a potential cross-contaminant in source materials and/or groundwater and is not used as an indicator or in the interpretation of groundwater quality; no impact on interpretation.
4 - Constituent was not detected in any groundwater sample; no impact on interpretation.
5- Detection is attributable to presence of other detected constituent(s) that were considered in interpretation; no impact on interpretation.
6- Constituent detection is complimentary to other constituents detected above the reporting limit and/or is not inconsistent with potential source material identified; no impact on interpretation.
7- Well re-sampled (confirmation sampling) and constituent not detected; no impact on interpretation.
8- The detection of the organic constituent without a suite of complimentary volatile and semivolatile organic compound/fraction detections, numerous, reported tentatively identified compounds (where applicable), and/or a diagnostic chromatographic profile is not characteristic of most potential source materials sampled for this study; no impact on interpretation.
9- Constituent was not detected in potential source materials and may be a cross-contaminant from rubber or plastics; no impact on interpretation.
10- Constituent was detected in a nearby study well and used in potential source interpretation; no impact on interpretation.
11- Constituent was not detected in any potential source material sample and is not typcially associated with crude or refined petroleum substances; no impact on interpretation.
12- Constituent is detected in a well located away from exploration and production activity.
13- This constituent tends to accompany detections of diesel-range organics/total extractable hydrocarbons where pump/well installation materials are identified as a possible source.
7 - Groundwater sample collected from the top of the water column in the well using a disposable bailer.