SOUTHEAST WYOMING
DISPOSAL PIT EMISSION STUDY

INTERIM REPORT

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Prepared for: Wyoming Department of Environmental Quality
Air Quality Division

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1.0 EXECUTIVE SUMMARY

The Wyoming Department of Environmental Quality (WDEQ) – Air Quality Division (AQD) seeks to more accurately characterize volatile organic compound (VOC) emissions to air from open ponds or pits at oilfield waste disposal (OWD) facilities associated with oil and natural gas production, to better understand areas where these emissions could be reduced, and to fulfill tasks in their overall state ozone strategy. This report summarizes the results of field investigations conducted in August 2016 at two sites in eastern and southern Wyoming and ongoing activities to support AQD's development of a spreadsheet-based calculation tool to estimate VOC emissions from ponds based on water concentrations and site-specific meteorological information.

An initial prediction tool was developed based on data collected during August 2015 and March 2016 at two OWD facilities in the Upper Green River Basin (UGRB) of Wyoming. The current study is aimed at expanding on the previous UGRB study with the collection of additional data from facilities located in other parts of the state in order to validate and refine the predictive tool.

In August 2016, contemporaneous measurements of air and water-phase VOC concentrations and site specific meteorological data were collected from oilfield produced water disposal ponds operated by Grasslands Environmental near Douglas, Wyoming, and BP America Production near Wamsutter, Wyoming. In general, at both of these facilities only very low or non-detect concentrations were observed in water and air for most target chemical analytes. These data served to not only validate the initial calculation tool, but have been incorporated into a refined calibration now representing a broader range of potential site conditions.

Additional work is ongoing to assess statistical uncertainty and any potential bias associated with future model predictions on a chemical by chemical basis, as well as opportunities to perform additional analysis on data collected to date, both in the UGRB and in southeastern Wyoming. It is anticipated such efforts will lead to further refinements to the predictive tool.

2.0 PROJECT OVERVIEW

2.1 Background and Project Description

The WDEQ-AQD is seeking improved ways to characterize VOC emissions to air from OWD facilities associated with oil and natural gas production. In 2015, AQD initiated a study of emissions from two OWD facilities in the Upper Green River Basin, a region that has experienced exceedances of the 8-hour National Ambient Air Quality Standard (NAAQS) for ozone. Data collected during August 2015 and March 2016 at each of the two UGRB sites were used to develop a spreadsheet-based predictive tool for estimating average annual air emissions, based on source water concentrations, using a modified version of the USEPA regulatory model *Water9*. The current study is aimed at expanding on the work performed in the UGRB study with the collection of additional data from facilities located in other parts of the state in order to validate and refine the predictive tool.

2.2 Project Approach

To achieve overall project objectives, VOC emissions from a diverse selection of OWD ponds have been characterized under summer and winter conditions using multiple air monitoring technologies and a combination of mathematical emission models. The collection of concurrent surface water and meteorological data provides a basis for estimating VOC emissions from the ponds using theoretical and empirically-based mathematical emission models. The predictive tool developed for this project is calibrated to match predicted vs. observed emissions as closely as possible for all chemicals of concern.

This report summarizes the procedures and results of additional field investigations conducted in August 2016 at two sites in eastern and southern Wyoming and subsequent refinements to the predictive tool. Results of the earlier UGRB study and initial development of the predictive tool are detailed in the report, *Upper Green River Basin Disposal Pit Emission Study*, issued by GSI on 14 September 2016.

2.3 Participating Field Sites

Grasslands Environmental

The Grasslands Environmental facility is located in Converse County, approximately 36 miles north of Douglas near the establishment of Bill, Wyoming. This commercial facility receives flowback and produced waters from a variety of operators primarily in the Parkman and Sussex formations, and occasionally from the Niobrara, Tesla, and Teapot formations. The facility includes four major storage ponds, a settling basin, and two storm water detention ponds (see **Figure 1**). Received oilfield waste waters are filtered, treated with a biocide, and transferred through an oil water separator (OWS). Recovered oil is stored in tanks and the water is sent to a settling basin where residual oil is skimmed. From the settling basin, the water is transferred to one of four main ponds where evaporation fountains are used. These ponds are approximately equal in size and contain water of similar composition.

BP America Production, North Ponds

The BP northern produced water facility is located in Sweetwater County, approximately 12 miles north of Wamsutter, Wyoming. This facility receives flowback and produced waters exclusively from BP operations in the Wamsutter natural gas field and includes four main ponds of similar size and composition (see **Figure 2**). Received waters are unloaded into sumps, which drain by gravity into settling tanks from which oil is skimmed and recovered in tanks. The water is then transferred into the ponds where active evaporation systems known as "landsharks" are used.

2.4 Field Program Overview

During the week of August 15, 2016, air emissions measurements and water samples were collected from at least one produced water pond at each facility along with pond characteristics and other ancillary data on pond operations and background source activity. Data collection at each pond involved concurrent collection of water samples and air emissions monitoring. VOC emissions were measured at discrete locations on the pond surface using flux chambers; from each evaluated pond as a whole using OP-FTIR spectrometry and inverse modeling. Supplemental discrete-point air samples were collected at upwind and downwind locations around each pond to facilitate characterization of background conditions and interpretation of other air monitoring results. Meteorological instruments were used to record weather conditions during all sampling activities. Final sampling locations were selected in the field based on forecasted and actual weather conditions, as well as physical limitations at the ponds.

The field program was carried out in accordance with the Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) issued by GSI on 11 August 2016. All sampling locations, including OP-FTIR transects, flux chamber testing locations and water sampling points are shown on **Figure 3** for the Grasslands facility and **Figure 4** for the BP facility.

2.5 Target Chemical Parameters

In general, the field program aimed to quantify air emissions and water concentrations of volatile organic compounds (VOC), speciated hydrocarbons (C2-C10, in air only), alcohols, and specific carbonyl compounds considered to be key ozone precursors in air. Specific compounds evaluated in air and water are listed in the results presented in Sections 2 and 3, respectively.

3.0 AIR EMISSIONS MONITORING

3.1 Flux Chamber Method

Flux chamber sampling for the summer 2016 field program was conducted by researchers from the Bingham Research Center at Utah State University, located in Vernal, Utah. This procedure yields chemical emission rates occurring directly at the pond surface (water-air interface) before they are diluted and dispersed into the overlying air.

3.1.1 Overview of Approach

Emission measurements at the pond surface were collected using a modified version of the EPA emission isolation dynamic flux chamber. The flux chamber measures chemical emissions based on the difference in concentrations inside and outside the chamber. This differential concentration is multiplied by the flow rate and divided by the surface area covered by the chamber to calculate the emission (or deposition) flux. Emissions were measured for approximately 60 minutes at each test location to allow emission rates to stabilize, and to characterize variability in emissions. Detailed field data collection and analysis procedures for the flux chamber air emissions measurement program are described in Appendix B of the SAP/QAPP, issued 11 August 2016.

3.1.2 Field Measurements

Methane (CH_4) and Carbon Dioxide (CO_2) concentrations, and detailed meteorological data were collected at 20-second intervals during all emissions measurement periods. Meteorological data consisted of solar radiation, wind speed, wind direction, standard deviation of wind direction ("sigma theta"), ambient temperature, pressure, and relative humidity. In addition, air and water temperatures inside and outside the chamber were measured for each 20-second interval.

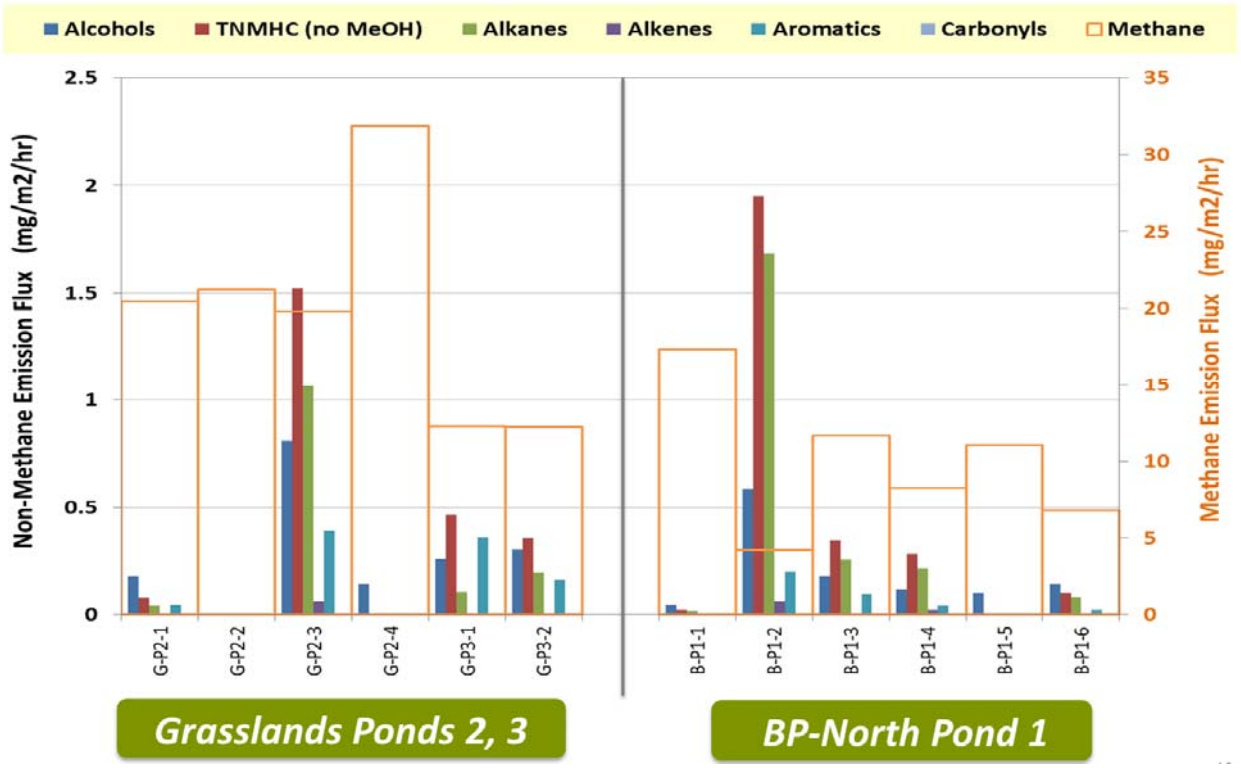
3.1.3 Air Sample Collection and Analysis

At each sampling location, air samples were collected from inside and outside the chamber, and analyzed for VOCs, speciated hydrocarbons, and carbonyl compounds. Chemical analyses of all air samples related to flux chamber measurements were performed by researchers in laboratories at Utah State University. Methane in flux chamber samples were measured in real time with a greenhouse gas analyzer located in the flux chamber equipment trailer. Samples for C2-C10 non-methane hydrocarbons and alcohols were collected in 6 L stainless steel Summa or Silonite-coated canisters and analyzed by EPA Method TO-15 (GC/MS) and PAMS (GC/FID/MS). Samples for carbonyls were collected on DNPH cartridges using sampling pumps and analyzed by EPA method TO-11A.

3.1.4 Air Emissions Estimation Results

The flux chamber emission rate measurements for each sampling location are presented on **Table 1** and summarized below on **Chart 1**.

Chart 1. Flux Chamber-Measured Emission Rates



3.2 OP-FTIR Spectrometry Method

Open path FTIR sampling was conducted by the Texas A&M Institute of Renewable Natural Resources (IRNR), located in San Antonio, Texas, with support for data analysis provided by Kassay Field Services of Mohrsville, Pennsylvania. Site specific meteorological data was collected with instrumentation provided by MSI Trinity Consultants of Salt Lake City, Utah.

3.2.1 Overview of Approach

Path-integrated gas concentrations were obtained using a RAM2000™ OP-FTIR spectrometer and retroreflector, oriented to measure air concentrations along the downwind side of each pond. The OP-FTIR operates by shooting a beam of mid-infrared light across a path to a retroreflector. Contaminants present in the beam path absorb energy transmitted by the beam source, and the signal from the returning beam is processed, generating interferograms, and ultimately path-integrated contaminant concentrations. Field data collection and analysis procedures for the OP-FTIR were performed in accordance with Appendix C of the SAP/QAPP, issued 11 August 2016.

Weather conditions were forecasted on a daily basis by a WDEQ-AQD meteorologist and wind conditions were continuously monitored in order to direct the path of the OP-FTIR beam perpendicular to the wind direction, to the extent practicable. On-site weather stations were used to log meteorological data in discrete 5-minute average intervals, synchronously with OP-FTIR path-integrated concentrations.

As some target compounds could be present at levels below those detectable by the OP-FTIR, depending on path length, humidity and other possible factors, a 15-minute flow-controlled summa canister was walked the length of each OP-FTIR measurement transect in order to collect a comparable path-integrated air sample for supplemental analysis in an outside commercial laboratory. These are referred to “walking” air samples in the discussion below. To supplement the understanding of background concentrations and 3D air dispersion characteristics, an array of multiple discrete-point air samples was also collected around each pond**.** Canister air samples and dinitrophenylhydrazine (DNPH) cartridges were used to collect ambient air samples over a minimum of one hour.

3.2.2 Field Measurements

FTIR interferograms measure total absorbance of infrared energy by chemicals present in the OP-FTIR beam. Interferograms collected by the OP-FTIR spectrometer were analyzed by EPA Method TO-16 and interpreted by Kassay Field Services to estimate path-integrated concentrations of target compounds and Total Hydrocarbons, based on reference absorbance spectra for those analytes.

Meteorological stations installed at each site were used to collect synchronous meteorological data, including 3D wind speeds, wind direction, standard deviation of wind direction (“sigma theta”), and ambient temperature, at 5-minute intervals during OP-FTIR sampling at all transect locations.

3.2.3 Air Sample Collection and Analysis

“Walking” air samples were collected by GSI in 6 L stainless steel Summa canisters with 15-minute flow controllers and analyzed for C2-C10 non-methane hydrocarbons, methanol, ethanol, and isopropanol by GC/MS and FID methods (TO15 and PAMS TO-15 w/FID) by Environmental Analytical Service, Inc. (EAS) in San Louis Obispo, California.

Discrete-point air samples were collected by MSI Trinity Consultants in arrays aligned with each open path transect and at appropriate background locations around each pond. This sampling strategy was designed to facilitate a greater understanding of background concentrations and 3D air dispersion characteristics that affect inverse modeling performed to calculate emissions from the OP-FTIR sampling results. Air samples were collected over durations of approximately 90 minutes using 6 L stainless steel Summa canisters and dinitrophenylhydrazine (DNPH) cartridges at locations distributed both vertically and laterally downwind along each open path transect, as well as at upwind locations. Canisters and cartridges were analyzed by EAS, by EPA method TO-15 for alcohols and aromatics, TO-15 with GC/FID for PAMS hydrocarbons, EPA method TO-11 for carbonyls, and ASTM method D3416 for methane (background locations only).

Results of the walking air samples for the summer and winter programs are summarized on **Table 2.** All air sampling locations for the Grasslands and BP facilities are shown on **Figures 3** and **4**, respectively.

3.2.4 Path-Integrated Air Concentration Results

Several challenges were encountered in the collection, analysis, and interpretation of OP-FTIR concentration data, which resulted in a substantial percentage of data collected for individual constituents not being usable for inverse modeling (i.e., emissions rate estimation). Often, during long periods of measurement wind directions varied frequently and did not match daily forecasted conditions, such that measurements do not accurately represent steady downwind concentrations resulting from pond emissions. In addition, frequent periods with wind speeds less than 2 m/s are not reliable for estimating emissions with air dispersion modeling.

Except for methane and alcohols, most target compounds for which water concentrations and flux chamber emissions were measured were not detected by the OP-FTIR instrument. At Grasslands, methane was consistently detected over both days of sampling from 2000 to 2682 ppb, with an average of 2310 ppb. Methanol was detected from 9 to 52 ppb during infrequent periods of measurement. Ammonia, a non-target but readily identifiable compound, was also consistently detected at an average of 24 ppb. Similarly, at BP, methane was continuously detected over both days of sampling from 1889 to 2269 ppb, with an average of 2027 ppb, and ethanol was infrequently detected from 45 to 128 ppb.

Neither speciated nor bulk hydrocarbons were detectable by OP-FTIR during any period of measurement at either facilty. This is most likely due to a combination of: i) low actual emissions of hydrocarbons, as evidenced by the flux chamber results, and consequently low corresponding air concentrations, as corroborated by air canister sampling, and ii) elevated OP-FTIR detection limits due to the presence of many compounds (even at very low concentrations) with similar infrared absorbance characteristics. Even bulk measures of total hydrocarbons in ranges C2-C8 and C9-C12 were not detectable by OP-FTIR during any measurement period at any pond. In addition, non-detect hydrocarbon concentrations could not be estimated from results of the walking air samples because methanol and ethanol were not detected in those samples.

Charts 2 to **5** below summarize the measureable alcohol (and ammonia) concentrations at both facilities together with wind direction and average windspeed during periods when meaningful emissions data could be collected. Yellow shaded bands on Charts 3 and 4 represent periods with relatively stable wind conditions and detected alchol concentrations, which were selected for inverse modeling to calculate emission rates, as discussed in Section 2.2.5.

**Chart 2. OP-FTIR Measured Concentration vs. Time:
Grasslands, Pond 2, 15 August 2016.**

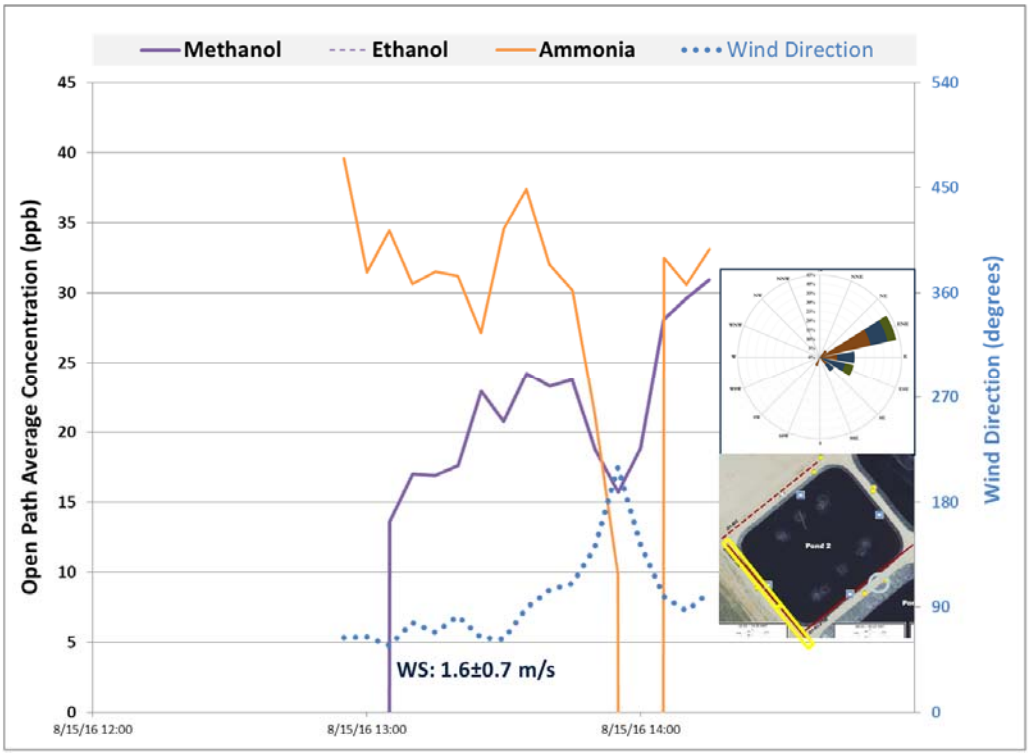


**Chart 3. OP-FTIR Measured Concentration vs. Time:
Grasslands, Pond 3, 16 August 2016. Emission Rates Modeled for Yellow Shaded Period.**

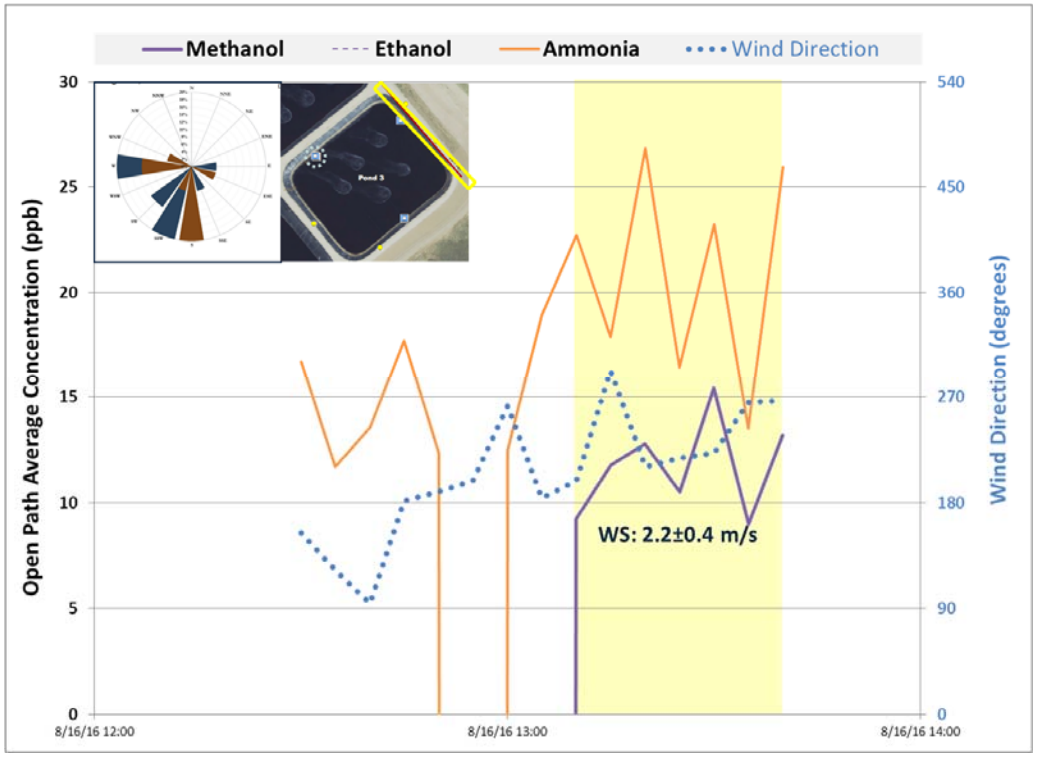


**Chart 4. OP-FTIR Measured Concentration vs. Time:
BP, North Pond 1, 17 August 2016. Emission Rates Modeled for Yellow Shaded Period.**

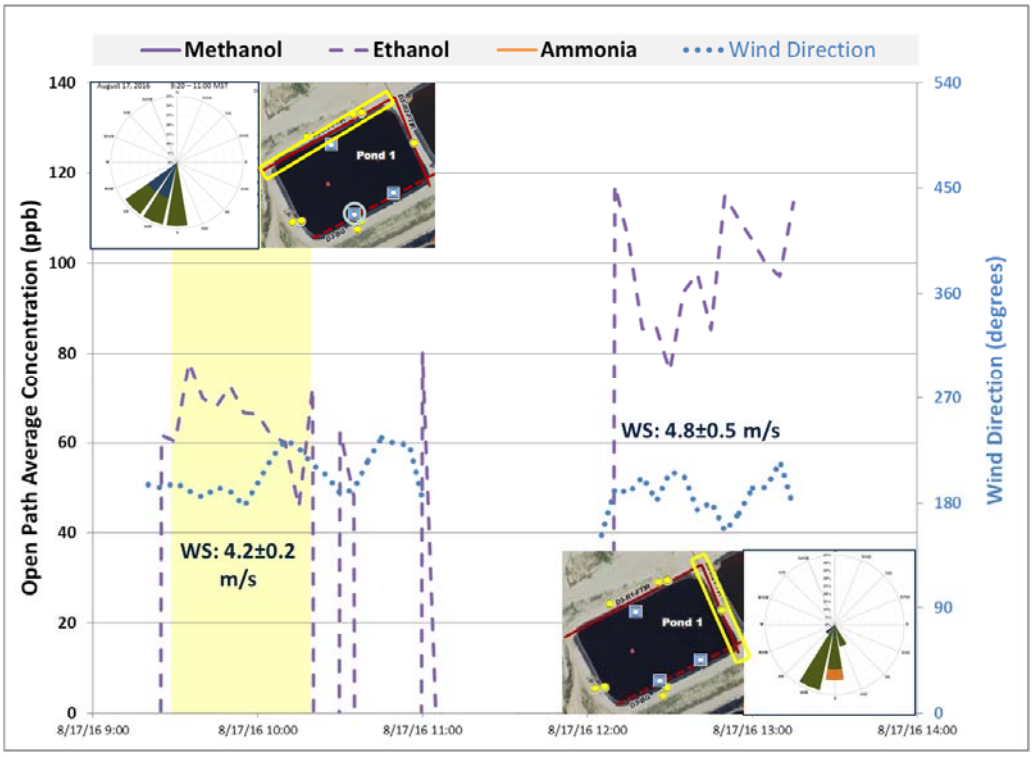
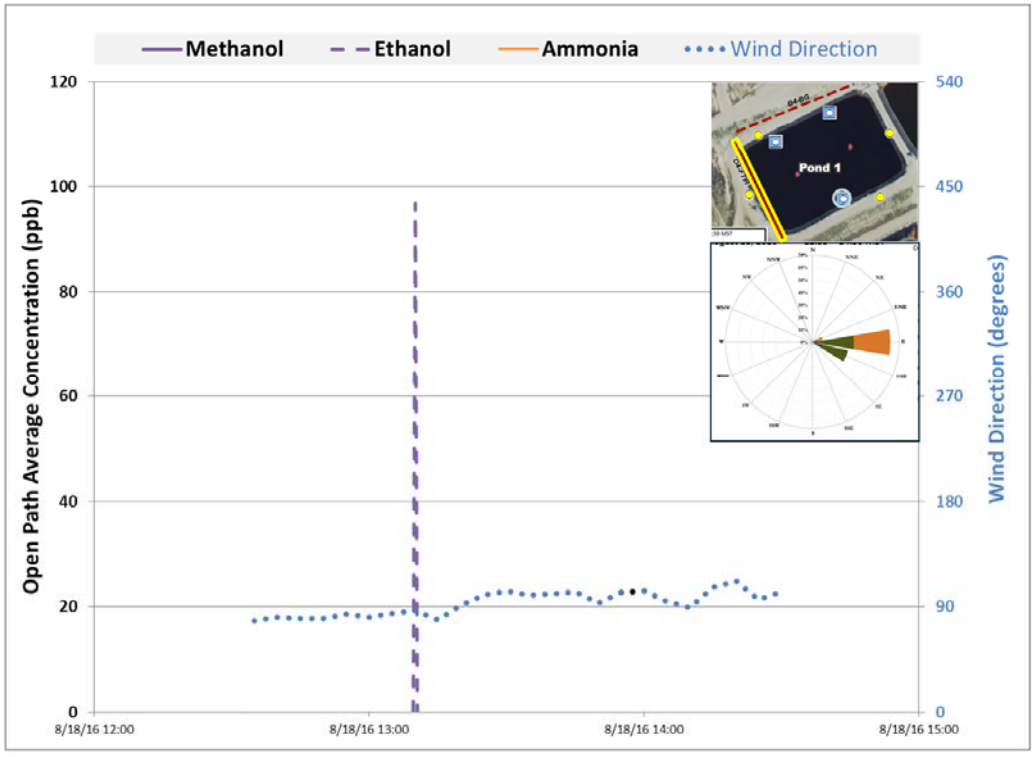


**Chart 5. OP-FTIR Measured Concentration vs. Time:
BP, North Pond 1, 18 August 2016.**



3.2.5 Air Modeling to Estimate Fluxes from OP-FTIR Data

Utah State University was contracted to calculate pond emission rates from OP-FTIR measurements. For this application, HEGADASS version 3.1, part of the HGSYSTEM (Post, 1994; Witlox and McFarlane, 1994), was selected for its ability to realistically characterize VOC concentrations immediately adjacent to the pond. This model is in the public domain and was approved as an Appendix B model in the EPA Modeling Guideline (USEPA, 2005). For each simulated period, HEGADASS predicts a unit mass of VOC emissions from the pond surface, which is then scaled to match observed path-integrated concentrations.

Flux calculations assume steady state emissions over the timescale of the measurements. Therefore, longer periods of consistent VOC concentrations and favorable wind conditions more reliably represent actual, steady-state pond emissions compared to shorter, less stable periods. All OP-FTIR measurements and related site-specific meteorological data from the field event were evaluated to identify the most appropriate data for air quality dispersion modeling of the OP-FTIR measurements in order to estimate pond emission rates. Suitable sampling periods were identified as being when mostly steady conditions were observed in conjunction with detectable alcohol concentrations. Sampling periods selected to be modeled are highlighted in yellow on Charts 3 and 5 above.

3.2.6 Air Emissions Estimation Results

For each modeled scenario, site-specific meteorological data was collected concurrently with the OP-FTIR data and evaluated to calculate average wind speed, relative humidity, temperature, and solar radiation values to be used as inputs to the HEGADASS model. The Pasquill atmospheric stability class, used as an input to HEGADASS to account for turbulence, was determined for all modeled scenarios to be Class D, or neutral, based on USEPA algorithms using wind speed and solar radiation.

- *Grasslands, Pond 3 (16 August 2016, 13:05-13:40):* The average calculated emission flux was 17 mg/m^2/hr for methane and 0.16 mg/m^2/hr for methanol, based on an average wind speed of 2.2 m/s, as measured at a height of 3.2 m above the top of the dike.

- *BP-North, Pond 1 (17 August 2016, 09:20-10:20):* The average calculated emission flux was 80 mg/m^2/hr for methane and 7.2 mg/m^2/hr for ethanol, based on an average wind speed of 4.2 m/s, as measured at a height of 3.2 m above the top of the dike.

In contrast to emission rates measured by flux chamber, OP-FTIR results represent pond-wide emissions. For methane, the results presented above are approximately 2 to 5 times greater than corresponding flux chamber measurements. The result for methanol at Grasslands is approximately 6 times greater the concurrent flux chamber sample. The result for ethanol at BP is approximately 1400 times greater than the concurrent flux chamber sample and approximately 40 times greater than the average of flux chamber measurements for the same day. Differences in emission rates estimated by OP-FTIR and inverse modeling versus flux chamber-measured rates could be due to a variety of factors, including: heterogeneity of fluxes across each pond surface; differences between actual wind speed across the pond surface versus inside the flux chamber, and short-term variability of background concentrations.

4.0 WATER SAMPLING

Water sample collection and analysis was conducted in accordance with the procedures described in Appendix D of the SAP/QAPP. A total of seven water samples and one duplicate sample were collected from Ponds 2 and 3 at the Grasslands facility, and six water samples and one duplicate were collected from Pond 1 at the BP facility, as shown on **Figures 3** and **4**, respectively. In general, samples were collected at the same time and location as flux chamber measurements.

4.1 Field Measurements

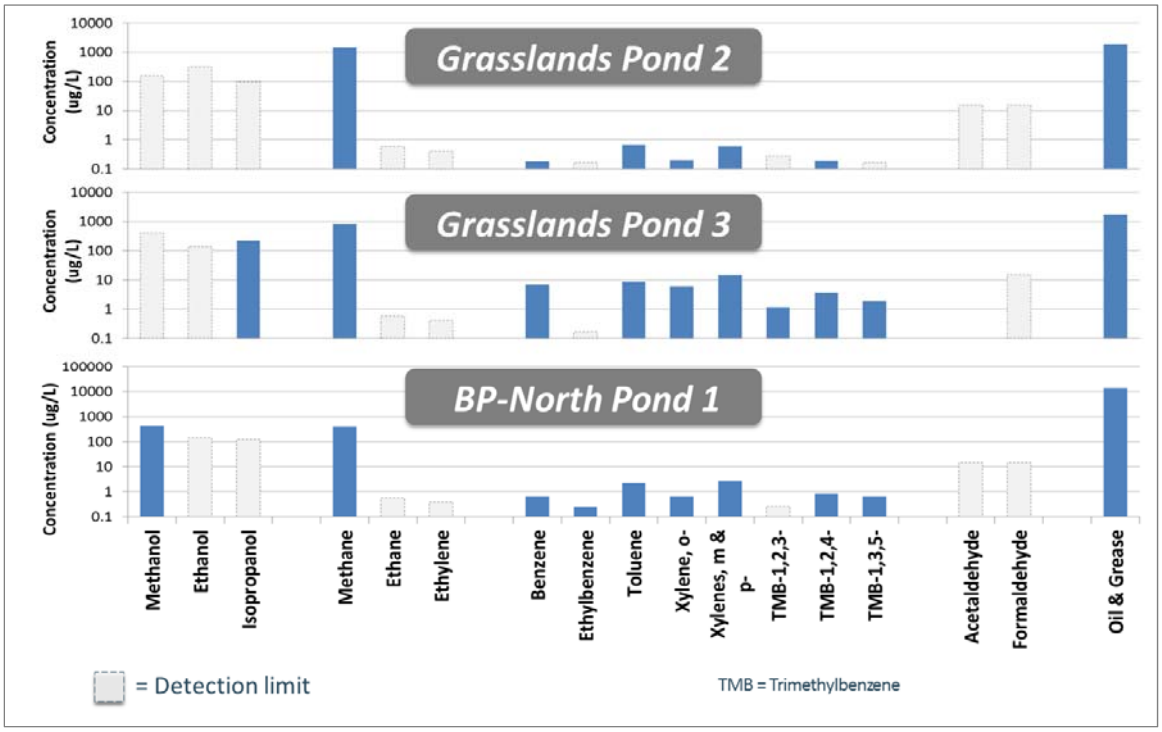
At each water sample location; temperature, pH, and specific conductance were measured. Observations such as any color, odor, or the presence of non-aqueous phase liquids were also recorded. Water temperature in Ponds 2 and 3 at the Grasslands facility had an average water temperature of approximately 25°C. Both ponds at Grasslands were similar in pH, with an average of 7.8. Water temperature in Pond 1 on the first sampling day at the BP facility averaged approximately 23°C, while colder air temperatures dropped the water temperature at the pond surface down to approximately 14°C on the second sampling day at BP. The water in Pond 1 was more basic than the Grasslands ponds, with an average pH of approximately 8.7. Specific conductivity values could not be obtained at all ponds containing produced water, due to apparently high salinity, as all readings were outside the field instrument's calibration range (>200 mS/cm).

4.2 Analytical Results

Analytical results from the summer water sampling program are summarized in **Table 3**. All water samples were analyzed by Test America, Inc., laboratories in Denver, Colorado, and Nashville, Tennessee, according to standard USEPA methods: 8260B (for BTEX), RSK 175 (for dissolved gases), 8015B (for alcohols), 8315A (for formaldehyde and acetaldehyde), and 1664A (for hexane-extractable oil & grease).

The analytical results of water samples showed primarily non-detected or very low concentrations for all constituents. At Grasslands, methane was the only constituent detected above reporting limits in all samples, with low-level concentrations ranging from 0.81 to 1.8 ppm. At BP, low levels of methane (0.27 to 0.53 ppm), toluene (0.0019 to 0.0025 ppm), and total xylenes (0.0024 to 0.0037 ppm) were the only constituents detected above reporting limits in all samples. As shown on Table 3, many constituents were detected above their respective method detection limit (MDL), yet were below their required reporting limits (RL). These results are flagged with a "J" per laboratory analytical protocols, indicating approximated concentration values. Chart 6 below provides a comparison of the measured water concentrations (including approximated values) for each facility from the summer water sampling program.

Chart 6. Measured Water Concentrations



4.3 QA/QC Procedures and Outcomes

The summer field program was conducted in accordance with the QA/QC requirements specified in the SAP/QAPP. One field duplicate was collected at each facility. Relative Percent Difference (RPD), a QA/QC measure of precision (or repeatability) calculated by determining the difference in results between analytical runs of a parent sample and its duplicate, were calculated for each duplicate pair. The RPDs for all constituents detected above reporting limits were below 30%, the acceptable range for duplicate sample pairs. In addition, Trip blanks were shipped with each sample shipment and resulted in non-detections for all constituents (VOCs).

5.0 WATER PREDICTIVE TOOL UPDATE

5.1 Overview

A modified model based on processes simulated in the USEPA regulatory model *Water9* was used as a baseline platform to develop a spreadsheet-based predictive tool for estimating and correlating air emissions to source water concentrations. *Water9* estimates air emissions of individual constituents in waste water mixtures based on the properties of the constituent and its concentration in water for various types of hazardous waste treatment, storage, and disposal facilities (USEPA, 1994). The predictive tool developed for this project consists of a user-friendly, project-specific modification of the *Water9* model developed in the Microsoft Excel© spreadsheet environment. It efficiently computes average air emission rates for multiple chemicals in units of mg/m^2/hr, g/s, or U.S. tons/yr using minimal key inputs, including:

- Pond identification and periods of interest.
- Constituents of concern (temperature-dependent chemical coefficients and partition coefficients for each constituent).
- For each period of interest:
  - Pond surface area occupied by water or ice
  - Average wind speed
  - Average daily high and low ambient air temperatures
  - Average water temperature
  - Water concentration of each constituent of concern (mg/L).

The predictive tool was initially calibrated with the result of summer and winter emissions studies performed at two commercial OWDs in the Upper Green River Basin, detailed in the report, *Upper Green River Basin Disposal Pit Emission Study,* issued 14 September 2016. Following are a recap of the tool's development, performance in predicting emissions measured in the present study at the Grasslands and BP facilities, and refinement to the calibration after incorporating the present study results.

5.2 Model Basis and Customization

Emission rate estimation based on pond water concentrations depends principally on three important variables: a liquid mass transfer coefficient (k_L), a gas mass transfer coefficient (k_G), and a partition coefficient (equilibrium constant, k_{eq}). These coefficients are combined into an overall mass transfer rate which is then multiplied by the impoundment surface area and the concentration of constituent in the liquid mass in order to approximate an overall air emission rate.

Many liquid mass transfer coefficients have been published in the past decade, leaving room to improve on methods historically used to calculate mass transfer coefficients in the current *Water9* model (Ro and Hunt, 2006). Consequently, an alternative method, developed by Ro and Hunt (2006), which utilizes more recent empirical data, has been adopted as the preferred alternative for calculating liquid mass transfer coefficients for most compounds evaluated in this study. However, as explained below, the original equations from *Water9* have been retained for calculating liquid mass transfer coefficients for high solubility compounds, including carbonyls and alcohols. In the current spreadsheet tool, the user defines a fixed solubility limit above which k_L values are calculated using the original *Water9* equations in lieu of the modified Ro and Hunt method. In all cases, the tool uses the original *Water9* equations (unmodified) to calculate gas mass transfer coefficient (k_G) values for all chemicals.

5.3 Calibration and Refinement

The predictive spreadsheet tool has been recalibrated for predictions to match, as reasonably as possible, measured VOC emission fluxes at the previously investigated UGRB facilities (during both summer and winter) as well as the Grasslands and BP facilities in southeastern Wyoming. Successive calibration efforts have focused on obtaining the best match of many pairs of predicted vs. observed emission rate fluxes by adjusting two key fitting factors in the Ro and Hunt liquid mass transfer coefficient. However, since liquid and gas mass transfer

coefficients adopted directly from *Water9* cannot be adjusted following the same rationale, calibrations have not influenced predictions for carbonyls and alcohols.

Charts 7 to 9 below illustrate predicted vs. measured VOC emission fluxes before and after refinement of the predictive tool, achieved by incorporating the results of the present study from the Grasslands and BP facilities. On these charts, a data point on the diagonal "1:1 Ratio Line" represents a perfect match of the modeled vs. measured result. Points above and to the left of the diagonal represent predictions that are greater than corresponding measurements. Likewise, points lying below and to the right of the diagonal show model predictions that are less than corresponding measurements.

Chart 7 illustrates the previous calibration of the predictive model for all compounds using UGRB study data only. **Chart 8** shows that the previous calibration also performed reasonably well in matching predicted vs. measured emission fluxes for the Grasslands and BP facilities. These results essentially validate the previous calibration for low-solubility speciated hydrocarbon by way of the consistency of both the spread and symmetry of points around the diagonal. In addition, the model predicted alcohol emissions greater than flux-chamber measured values at the Grasslands and BP facilities, similar to the model's performance with the UGRB data.

Following validation, the tool was further calibrated to explicitly incorporate the results of the present study. However, this process resulted in only minor modifications to the model fitting factors given the reasonably good performance of the original model in matching predictions to measurements from the Grasslands and BP facilities. **Chart 9** presents results of the refined model after minimizing the difference in predicted vs. measured results from the combined studies.

Chart 7. Predicted vs. Measured Emission Flux: Original Calibration, Upper Green River Basin Results Only *(Aug. 2015; Feb. 2016)*

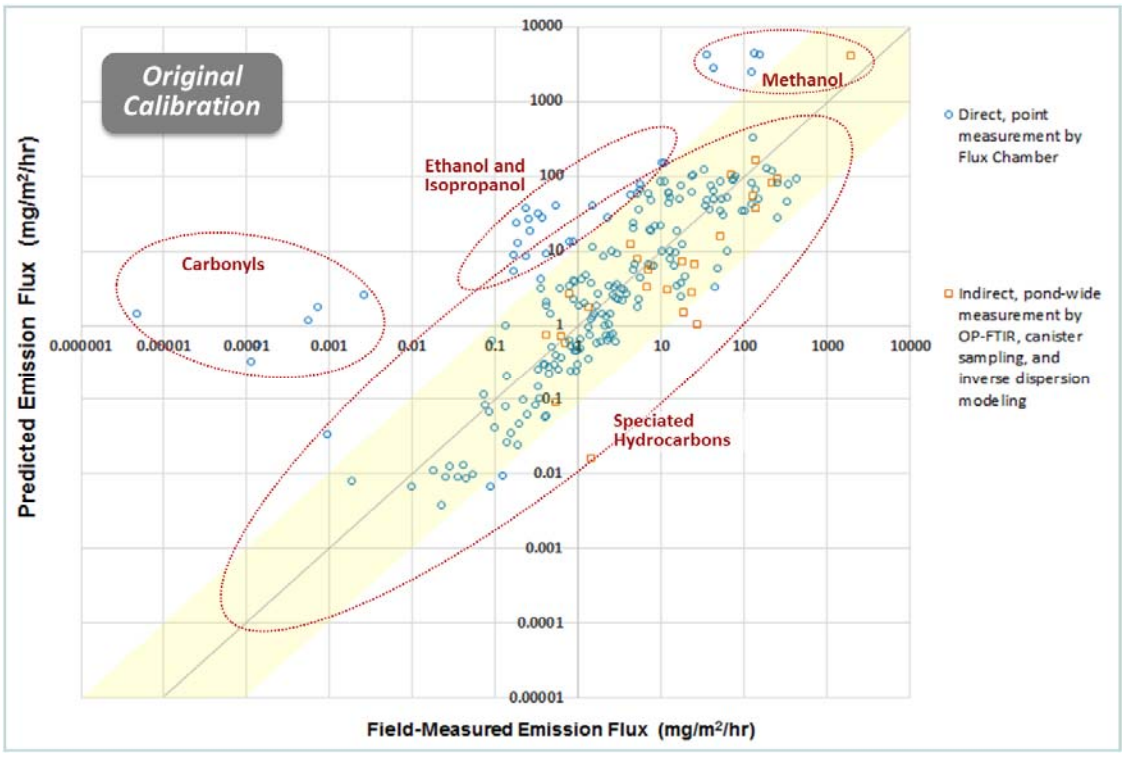


Chart 8. Predicted vs. Measured Emission Flux: Previous Calibration, Grasslands and BP Facility Results Only *(Aug. 2016)*

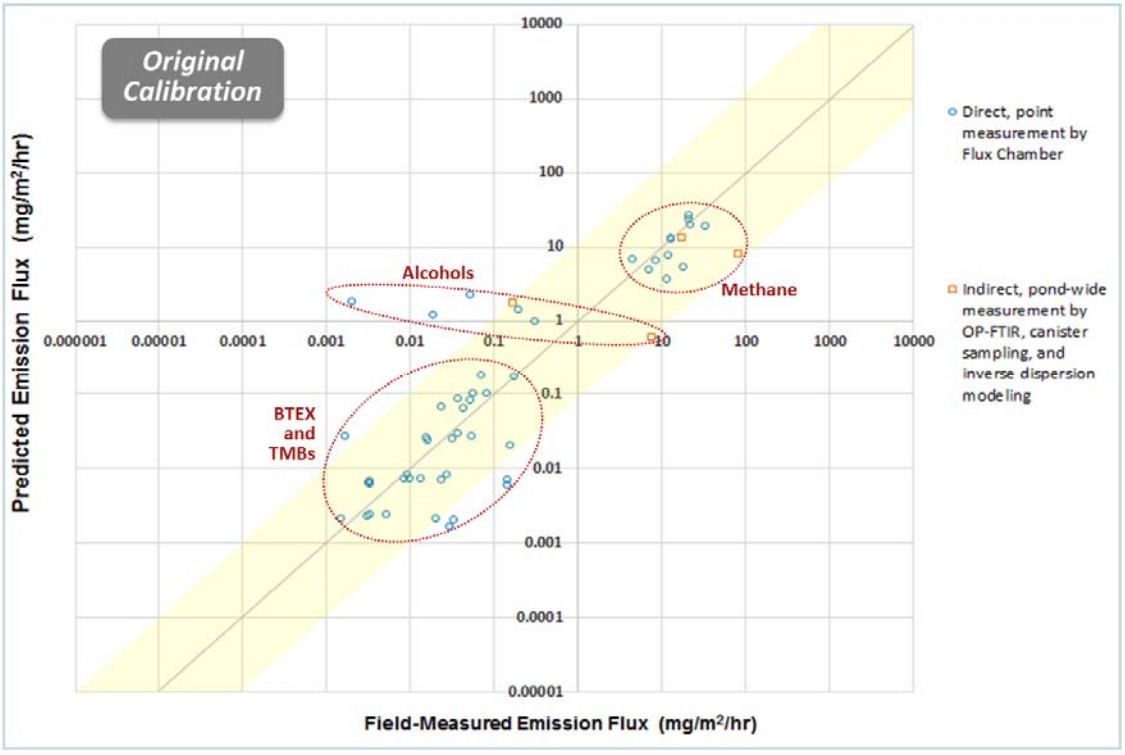
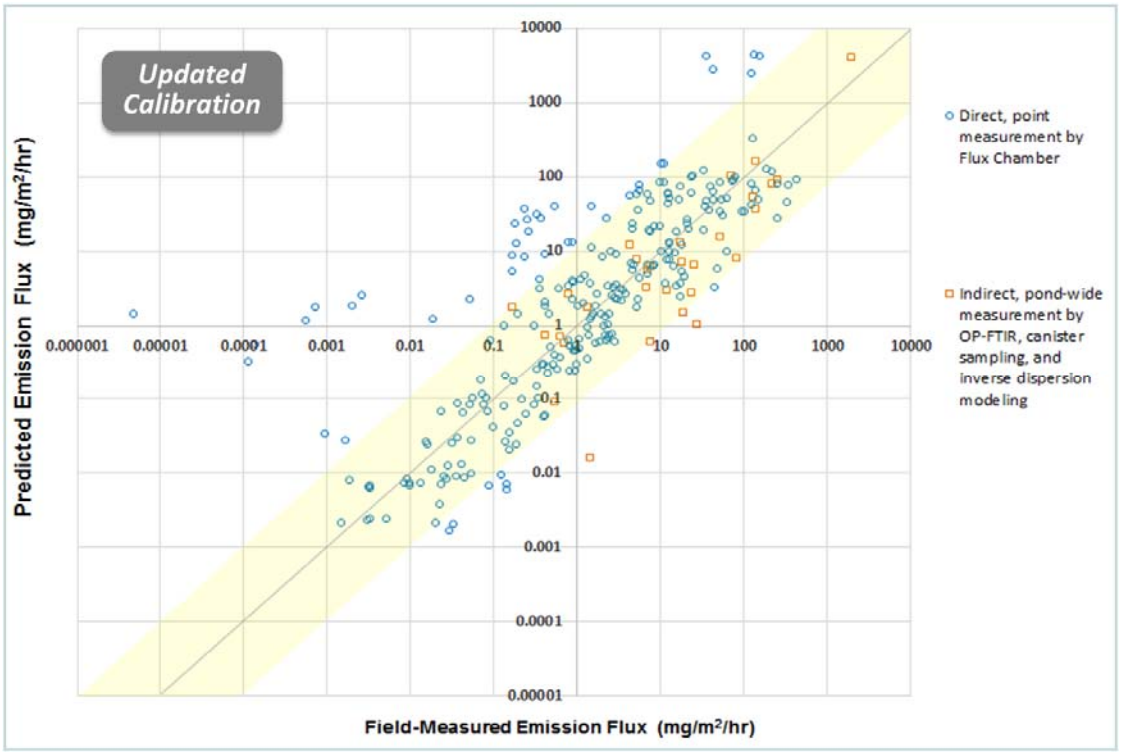


Chart 9. Predicted vs. Measured Emission Flux: Refined Calibration, Combined Studies



5.4 Interpretation and Implications of Results

For compounds besides carbonyls and alcohols, the model generally predicts emission fluxes within an order of magnitude of values measured using both the flux chamber and OP-FTIR technologies (indicated by yellow-shaded diagonal bands on Charts 7 to 9). AQD is undertaking further work to assess statistical uncertainty and potential biases associated with future model predictions on a chemical by chemical basis. This may result in additional modifications to the predictive tool.

As noted above, calibration efforts have not influenced predictions for carbonyls and alcohols due to their high solubility and, consequently, use of the original *Water9* equations instead of the fitted, empirical Ro and Hunt formulation. This results in the large outliers observed in Charts 7 to 9, as the *Water9* equations predict significantly higher emissions for carbonyls and alcohols than were measured by flux chamber at facilities in both the UGRB and southeastern Wyoming. Researchers at USU are currently investigating whether flux chamber-measured emission fluxes for alcohols might be biased low, potentially related to a combination of their very high solubility and induced air moisture conditions (e.g. increased humidity) inside the chamber that are unrepresentative of ambient air.

Ultimately, the predictive tool is intended for use by WDEQ-AQD and the regulated community to develop reasonable, reliable estimates of annual VOC emissions from oilfield waste disposal pits or ponds similar to those studied in the UGRB and southeastern Wyoming, based on readily available site-specific information, including pond concentrations, ambient temperatures, and

wind speeds during distinct periods of the year. The underlying model is deterministic in nature, meaning that, for any particular time period it considers only a single value for each input parameter, i.e., it does not account for the actual variability of any parameter during that period.

6.0 REFERENCES

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TABLES

TABLE 1
Pond Emission Rate Estimates by Flux Chamber Method
Southeast Wyoming Disposal Pit Emission Study

Sample ID:	G-P1-1	G-P1-2	G-P1-3	G-P1-4	G-P2-1	G-P2-2	G-P2-3	G-P2-4
Facility	Grasslands	Grasslands	Grasslands	Grasslands	Grasslands	Grasslands	Grasslands	Grasslands
Date	8/15/2016	8/15/2016	8/15/2016	8/15/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016
Start Time (MST)	9:03:20 AM	10:35:00 AM	12:40:00 PM	2:15:00 PM	7:45:00 AM	9:35:00 AM	11:50:00 AM	1:10:00 PM
End Time (MST)	10:00:00 AM	11:35:40 AM	1:39:40 PM	3:14:40 PM	8:44:40 AM	10:34:40 AM	12:37:40 PM	1:39:40 PM
Duration (min)	57	61	60	60	60	60	48	30
Analyte	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$
Carbon Dioxide	1.20E+02	1.25E+02	1.08E+02	1.44E+02	1.10E+02	9.42E+01	9.86E+01	1.40E+02
Methane	2.05E+01	2.12E+01	1.98E+01	3.19E+01	1.23E+01	1.22E+01	2.08E+01	8.14E+00
Ethane	2.43E-03	-8.60E-04	5.13E-03	-1.55E-03	3.21E-03	2.07E-03	2.56E-03	-1.54E-02
Propane	8.69E-03	-3.38E-03	1.54E-02	1.02E-03	9.47E-03	2.65E-03	9.70E-03	-1.93E-03
Iso-butane	2.19E-03	-1.44E-02	4.36E-02	4.56E-03	-3.22E-03	-2.18E-03	2.47E-03	-2.57E-02
N-butane	1.92E-03	-9.67E-02	2.30E-01	-1.24E-02	0.00E+00	1.03E-03	-8.75E-03	-1.34E-01
Trans-2-Butene	7.81E-04	-2.48E-03	1.06E-02	0.00E+00	-8.28E-03	0.00E+00	-2.70E-03	-6.14E-03
1-Butene	1.58E-03	4.59E-03	1.68E-02	7.81E-04	-3.11E-03	-1.00E-03	1.04E-03	-2.04E-02
Cis-2-butene	1.56E-03	-9.31E-05	6.17E-03	-4.94E-03	0.00E+00	1.53E-03	-7.67E-04	1.60E-03
isopentane	-1.32E-03	-1.17E-01	2.68E-01	0.00E+00	1.60E-02	-2.06E-02	3.01E-02	-1.73E-01
n-pentane	1.03E-03	-8.16E-02	1.64E-01	-8.62E-03	1.06E-02	1.10E-02	2.65E-03	-1.03E-01
trans-2-pentene	-1.93E-03	0.00E+00	2.07E-02	0.00E+00	7.76E-03	0.00E+00	2.59E-03	2.00E-03
1-pentene	-1.36E-02	0.00E+00	1.93E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cis-2-pentene	1.31E-03	-1.16E-04	5.47E-03	0.00E+00	-3.88E-03	0.00E+00	9.84E-04	2.00E-03
2,2-dimethylbutane	0.00E+00	-2.61E-03	-1.28E-03	2.40E-03	0.00E+00	-2.22E-04	1.59E-03	0.00E+00
cyclopentane/2,3-dimethylbutane	0.00E+00	0.00E+00	1.97E-03	4.35E-03	0.00E+00	0.00E+00	-2.51E-03	4.46E-03
2-methylpentane	8.11E-04	-4.35E-02	9.74E-02	2.40E-03	7.95E-03	1.66E-02	1.08E-02	-5.09E-02
3-methylpentane	0.00E+00	-1.53E-02	0.00E+00	-6.36E-05	6.36E-03	1.53E-02	2.01E-03	0.00E+00
Isoprene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-03	0.00E+00	-2.19E-03	0.00E+00
1-Hexene	0.00E+00	0.00E+00	0.00E+00	-1.23E-03	1.55E-03	-1.09E-04	-2.70E-03	1.10E-03
n-Hexane	2.40E-03	-2.54E-02	0.00E+00	0.00E+00	1.11E-02	3.88E-02	1.63E-02	-2.76E-02
Methylcyclopentane	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-6.21E-03	0.00E+00	7.77E-04	2.40E-03
2,4-Dimethylpentane	0.00E+00	0.00E+00	1.10E-02	0.00E+00	0.00E+00	-2.99E-03	0.00E+00	5.72E-03
Benzene	1.46E-03	-1.17E-02	1.93E-02	0.00E+00	5.04E-02	3.60E-02	1.59E-02	6.24E-02
Cyclohexane	0.00E+00	-2.55E-03	-3.75E-03	0.00E+00	0.00E+00	-2.51E-03	-2.50E-03	6.00E-03
2-Methylhexane	0.00E+00	0.00E+00	2.48E-02	-3.01E-03	1.66E-02	1.35E-02	-9.18E-03	1.07E-03
2,3-Dimethylpentane	1.40E-03	-7.39E-03	1.89E-02	-1.48E-04	0.00E+00	-2.59E-04	-4.35E-03	-2.65E-02
3-Methylhexane	1.40E-03	-1.48E-03	-4.46E-03	-2.94E-03	-7.39E-03	5.47E-03	5.55E-03	1.19E-03
2,2,4-Trimethylpentane	-1.05E-03	-6.57E-02	1.90E-01	-3.35E-03	2.11E-03	1.32E-02	1.58E-02	-1.17E-01

TABLE 1
Pond Emission Rate Estimates by Flux Chamber Method
Southeast Wyoming Disposal Pit Emission Study

Sample ID:	G-P1-1	G-P1-2	G-P1-3	G-P1-4	G-P2-1	G-P2-2	G-P2-3	G-P2-4
Facility	Grasslands	Grasslands	Grasslands	Grasslands	Grasslands	Grasslands	Grasslands	Grasslands
Date	8/15/2016	8/15/2016	8/15/2016	8/15/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016
Start Time (MST)	9:03:20 AM	10:35:00 AM	12:40:00 PM	2:15:00 PM	7:45:00 AM	9:35:00 AM	11:50:00 AM	1:10:00 PM
End Time (MST)	10:00:00 AM	11:35:40 AM	1:39:40 PM	3:14:40 PM	8:44:40 AM	10:34:40 AM	12:37:40 PM	1:39:40 PM
Duration (min)	57	61	60	60	60	60	48	30
Analyte	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$
n-Heptane	4.71E-04	1.40E-03	7.26E-03	1.40E-03	1.11E-02	4.36E-02	2.34E-02	-6.80E-03
Methylcyclohexane	9.24E-04	0.00E+00	1.62E-02	0.00E+00	2.90E-02	3.89E-02	2.72E-02	2.91E-02
2,3,4-Trimethylpentane	0.00E+00	-3.37E-03	0.00E+00	0.00E+00	4.21E-03	0.00E+00	0.00E+00	-1.06E-02
Toluene	2.59E-02	-7.75E-02	1.38E-01	8.29E-03	7.99E-02	5.45E-02	1.00E-02	-2.02E-02
2-Methylheptane	0.00E+00	0.00E+00	6.28E-03	-6.70E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3-Methylheptane	0.00E+00	0.00E+00	-1.70E-02	-3.35E-03	4.21E-03	2.82E-03	2.66E-03	0.00E+00
n-Octane	1.61E-03	6.26E-03	4.70E-03	0.00E+00	1.05E-03	1.56E-02	2.00E-02	1.14E-02
Ethylbenzene	5.91E-03	2.96E-03	2.04E-02	-3.27E-03	1.18E-02	-3.17E-03	4.94E-03	-2.56E-04
m/p-Xylene	-4.80E-04	2.22E-02	1.39E-01	-7.83E-05	1.66E-01	6.81E-02	3.95E-02	9.54E-02
Styrene	1.45E-03	-1.54E-03	1.43E-03	0.00E+00	1.92E-03	0.00E+00	-8.37E-03	0.00E+00
o-Xylene	2.96E-03	-3.13E-03	3.21E-02	-3.27E-03	4.11E-02	2.29E-02	4.43E-03	-4.05E-03
n-Nonane	1.79E-03	-1.06E-04	-1.21E-02	0.00E+00	-9.46E-03	3.50E-03	7.11E-03	-6.11E-03
Isopropylbenzene	0.00E+00	-1.77E-03	-1.78E-03	-1.76E-03	0.00E+00	-3.75E-03	0.00E+00	0.00E+00
n-Propbylbenzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.71E-03
m-Ethyltoluene	3.35E-03	3.35E-03	3.04E-03	0.00E+00	1.11E-02	1.31E-02	-7.72E-03	3.43E-03
p-Ethyltoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.64E-03	0.00E+00	6.86E-03
1,3,5-Trimethylbenzene	1.13E-03	-2.00E-04	1.32E-02	-3.52E-03	0.00E+00	0.00E+00	0.00E+00	3.43E-03
o-Ethyltoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-2.00E-03
1,2,4-Trimethylbenzene	5.02E-03	-5.32E-03	2.81E-02	-7.05E-03	-2.22E-03	0.00E+00	2.22E-03	4.26E-02
n-Decane	0.00E+00	7.69E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-5.94E-02	7.61E-02
1,2,3-Trimethylbenzene	0.00E+00	0.00E+00	-3.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
m-Diethylbenzene	1.26E-03	7.25E-03	3.69E-03	-3.94E-03	0.00E+00	-2.81E-02	-1.91E-02	0.00E+00
p-Diethylbenzene	0.00E+00	7.48E-03	-2.97E-04	-3.94E-03	0.00E+00	0.00E+00	0.00E+00	-4.15E-03
n-Undecane	1.74E-02	-5.13E-03	0.00E+00	-1.37E-02	0.00E+00	0.00E+00	-1.51E-02	0.00E+00
Methanol	3.49E-02	1.92E-02	1.67E-01	9.42E-03	6.56E-02	-9.88E-03	-5.27E-04	2.58E-02
Ethanol	1.66E-02	-2.23E-01	5.74E-01	4.31E-03	7.65E-03	1.77E-02	3.19E-02	-2.90E-01
Isopropanol	1.26E-01	1.35E-01	6.76E-02	1.28E-01	1.85E-01	2.96E-01	1.20E-01	3.24E-01
formaldehyde	-7.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-3.18E-05	5.08E-05
acetaldehyde	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.92E-04	-4.86E-04	-4.62E-05	
acrolein/acetone	1.96E-04	1.60E-04	3.49E-04	8.81E-05	2.01E-03	3.69E-03	1.43E-03	1.51E-03

TABLE 1
Pond Emission Rate Estimates by Flux Chamber Method
Southeast Wyoming Disposal Pit Emission Study

Sample ID:	B-P1-1	B-P1-2	B-P1-3	B-P1-4	B-P1-5	B-P1-6
Facility	BP-North	BP-North	BP-North	BP-North	BP-North	BP-North
Date	8/17/2016	8/17/2016	8/17/2016	8/18/2016	8/18/2016	8/18/2016
Start Time (MST)	9:20:00 AM	11:29:00 AM	1:29:00 PM	8:30:00 AM	10:10:00 AM	11:34:40 AM
End Time (MST)	10:19:00 AM	12:29:00 PM	2:29:00 PM	9:29:00 AM	11:09:20 AM	12:34:00 PM
Duration (min)	59	60	60	59	59	59
Analyte	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$
Carbon Dioxide	1.67E+02	2.04E+02	1.74E+02	1.53E+02	1.37E+02	1.52E+02
Methane	1.74E+01	4.23E+00	1.17E+01	8.27E+00	1.10E+01	6.82E+00
Ethane	-3.64E-03	-8.74E-03	-4.00E-02	2.60E-02	1.53E-03	1.63E-02
Propane	-1.07E-04	1.58E-02	-2.25E-02	1.43E-02	-3.86E-03	-1.18E-03
Iso-butane	-3.12E-03	8.77E-02	1.20E-02	1.50E-02	-2.07E-02	-1.13E-03
N-butane	-3.73E-03	3.37E-01	3.86E-02	3.63E-02	-7.95E-02	1.42E-02
Trans-2-Butene	2.54E-03	1.02E-02	0.00E+00	-1.03E-03	-4.27E-03	-8.58E-04
1-Butene	-6.15E-03	1.01E-02	4.19E-03	2.26E-02	-5.12E-03	9.18E-03
Cis-2-butene	-1.76E-03	5.02E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
isopentane	-1.85E-02	4.08E-01	4.12E-02	2.46E-02	-9.00E-02	1.49E-02
n-pentane	-6.78E-04	2.29E-01	3.04E-02	2.08E-02	-4.86E-02	1.05E-02
trans-2-pentene	2.12E-03	1.81E-02	-4.37E-03	0.00E+00	-2.13E-03	0.00E+00
1-pentene	0.00E+00	0.00E+00	-4.37E-03	0.00E+00	0.00E+00	0.00E+00
cis-2-pentene	0.00E+00	1.49E-02	-2.18E-03	-1.94E-03	0.00E+00	-2.15E-03
2,2-dimethylbutane	-2.70E-03	2.62E-03	-1.34E-03	1.26E-03	2.56E-03	2.59E-03
cyclopentane/2,3-dimethylbutane	-8.64E-05	0.00E+00	-2.43E-03	0.00E+00	2.32E-03	0.00E+00
2-methylpentane	2.32E-03	1.09E-01	1.99E-02	7.21E-03	-1.85E-02	7.67E-03
3-methylpentane	0.00E+00	8.78E-02	-8.05E-03	2.53E-03	-2.62E-03	-2.64E-03
Isoprene	2.06E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1-Hexene	0.00E+00	0.00E+00	1.27E-03	2.47E-03	1.19E-03	1.26E-03
n-Hexane	-1.45E-03	1.04E-01	-2.15E-02	4.69E-03	3.84E-03	1.42E-02
Methylcyclopentane	0.00E+00	-3.96E-03	0.00E+00	0.00E+00	3.75E-03	-1.31E-03
2,4-Dimethylpentane	0.00E+00	3.35E-02	0.00E+00	2.94E-03	-3.05E-03	0.00E+00
Benzene	9.45E-03	4.04E-02	8.94E-03	-7.92E-03	-7.13E-03	-2.39E-03
Cyclohexane	0.00E+00	0.00E+00	2.54E-03	0.00E+00	-3.84E-03	-6.44E-03
2-Methylhexane	0.00E+00	3.35E-02	1.36E-02	-5.54E-03	1.49E-03	0.00E+00
2,3-Dimethylpentane	-1.63E-03	0.00E+00	9.08E-03	0.00E+00	5.95E-03	0.00E+00
3-Methylhexane	7.57E-03	-6.28E-03	-4.68E-03	-3.69E-03	1.45E-03	3.01E-03
2,2,4-Trimethylpentane	1.73E-03	1.83E-01	3.23E-02	7.32E-03	-2.28E-02	5.12E-03

TABLE 1
Pond Emission Rate Estimates by Flux Chamber Method
Southeast Wyoming Disposal Pit Emission Study

Sample ID:	B-P1-1	B-P1-2	B-P1-3	B-P1-4	B-P1-5	B-P1-6
Facility	BP-North	BP-North	BP-North	BP-North	BP-North	BP-North
Date	8/17/2016	8/17/2016	8/17/2016	8/18/2016	8/18/2016	8/18/2016
Start Time (MST)	9:20:00 AM	11:29:00 AM	1:29:00 PM	8:30:00 AM	10:10:00 AM	11:34:40 AM
End Time (MST)	10:19:00 AM	12:29:00 PM	2:29:00 PM	9:29:00 AM	11:09:20 AM	12:34:00 PM
Duration (min)	59	60	60	59	59	59
Analyte	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$	$mg/m^2/hr$
n-Heptane	0.00E+00	3.96E-02	2.39E-02	1.08E-02	-1.52E-03	1.05E-02
Methylcyclohexane	3.11E-02	0.00E+00	4.81E-02	1.87E-02	1.31E-03	7.27E-03
2,3,4-Trimethylpentane	-3.58E-03	1.39E-02	3.45E-03	0.00E+00	6.78E-03	0.00E+00
Toluene	1.52E-02	1.50E-01	5.15E-02	3.05E-02	-3.28E-02	1.50E-02
2-Methylheptane	0.00E+00	0.00E+00	3.80E-02	0.00E+00	0.00E+00	0.00E+00
3-Methylheptane	-7.29E-03	3.37E-03	0.00E+00	-2.11E-03	0.00E+00	-6.32E-05
n-Octane	8.63E-03	1.72E-02	3.26E-02	1.51E-02	1.57E-03	-8.79E-03
Ethylbenzene	-3.33E-03	3.23E-03	-3.40E-03	3.11E-03	-7.83E-05	-5.87E-05
m/p-Xylene	1.60E-03	0.00E+00	3.49E-02	0.00E+00	-6.50E-03	-4.87E-03
Styrene	1.46E-03	3.17E-03	0.00E+00	0.00E+00	-1.58E-03	-7.97E-03
o-Xylene	3.21E-03	3.13E-03	1.28E-02	3.11E-03	3.07E-03	-5.87E-05
n-Nonane	9.69E-03	-4.02E-03	0.00E+00	1.32E-02	0.00E+00	3.85E-03
Isopropylbenzene	1.82E-03	0.00E+00	0.00E+00	0.00E+00	-5.48E-03	0.00E+00
n-Propbylbenzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
m-Ethyltoluene	0.00E+00	7.31E-03	0.00E+00	3.52E-03	-3.83E-03	0.00E+00
p-Ethyltoluene	0.00E+00	-1.88E-03	0.00E+00	0.00E+00	-3.66E-03	5.42E-03
1,3,5-Trimethylbenzene	0.00E+00	-3.77E-03	-3.74E-03	0.00E+00	0.00E+00	0.00E+00
o-Ethyltoluene	0.00E+00	7.31E-03	0.00E+00	1.76E-03	0.00E+00	0.00E+00
1,2,4-Trimethylbenzene	-3.77E-03	0.00E+00	0.00E+00	0.00E+00	-1.83E-03	0.00E+00
n-Decane	0.00E+00	0.00E+00	0.00E+00	8.34E-03	-4.33E-03	0.00E+00
1,2,3-Trimethylbenzene	0.00E+00	0.00E+00	-3.74E-03	0.00E+00	0.00E+00	0.00E+00
m-Diethylbenzene	-2.94E-02	0.00E+00	0.00E+00	7.87E-03	3.98E-03	8.07E-03
p-Diethylbenzene	8.12E-03	-4.21E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
n-Undecane	4.72E-03	4.61E-03	9.44E-03	0.00E+00	0.00E+00	-5.04E-03
Methanol	2.51E-02	2.59E-02	5.39E-02	5.60E-02	4.92E-02	1.92E-03
Ethanol	4.84E-03	5.62E-01	1.10E-01	6.17E-02	2.19E-02	2.93E-02
Isopropanol	1.44E-02	-2.24E-03	1.59E-02	6.26E-04	3.20E-02	1.12E-01
formaldehyde	-6.29E-05	1.31E-04	-5.39E-05	-4.94E-05	0.00E+00	-4.32E-05
acetaldehyde	3.74E-05	-1.16E-04	-8.00E-05	-6.56E-05	0.00E+00	-1.19E-04
acrolein/acetone	-1.20E-04	-2.25E-04	-5.72E-05	3.31E-06	-1.29E-05	-7.88E-05

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TABLE 2: SUMMA AIR SAMPLE RESULTS - SUMMER 2016 SAMPLING EVENT

	Sample ID:	1-GRA0815161040	2A-GRA0815161040	2B-GRA0815161040	3-GRA0815161040	4-GRA0815161040
	Sample Date:	Grasslands-2	Grasslands-2	Grasslands-2	Grasslands-2	Grasslands-2
	Sample Time:	8/15/2016	8/15/2016	8/15/2016	8/15/2016	8/15/2016
Method	**Analyte**	ppbV	ppbV	ppbV	ppbV	ppbV
TO-15	Benzene	0.96	0.58 J	0.69 J	0.66 J	0.54 J
TO-15	Butylbenzene, i-	<0.33	<0.49	<0.52	<0.48	<0.52
TO-15	Butylbenzene, tert-	<0.33	<0.49	<0.52	<0.48	<0.52
TO-15	Ethanol	27.51	<1.46	<1.57	<1.43	<1.55
TO-15	Ethylbenzene	1.07	<0.24	<0.26	<0.24	<0.26
TO-15	Ethyltoluene, 4-	0.48	<0.24	<0.26	<0.24	0.35 J
TO-15	Methanol	25.03	<2.43	<2.62	<2.39	<2.59
TO-15	Propanol, i-	11.18	<0.97	<1.05	<0.96	<1.04
TO-15	Propylbenzene, i-	0.19 J	<0.24	<0.26	<0.24	<0.26
TO-15	Propylbenzene, n-	0.18 J	<0.24	<0.26	<0.24	<0.26
TO-15	Toluene	40.34	0.5 J	0.31 J	0.36 J	0.42 J
TO-15	Trimethylbenzene, 1,2,4-	0.57	<0.24	<0.26	<0.24	<0.26
TO-15	Trimethylbenzene, 1,3,5-	0.21 J	<0.24	<0.26	<0.24	<0.26
TO-15	Xylene, o-	1.46	<0.24	<0.26	<0.24	<0.26
TO-15	Xylenes, m & p-	3.67	0.27 J	<0.26	<0.24	<0.26
TO-15 (FID)	Acetylene	2.33	<0.73	<0.79	<0.72	<0.78
TO-15 (FID)	Butane, i-	4.61	<0.36	<0.39	<0.36	0.75 J
TO-15 (FID)	Butane, n-	3.32	<0.36	0.73 J	<0.36	0.68 J
TO-15 (FID)	Butene, 1-	<0.25	<0.36	<0.39	<0.36	<0.39
TO-15 (FID)	Butene, cis-2-	<0.25	<0.36	<0.39	<0.36	<0.39
TO-15 (FID)	Butene, trans-2-	<0.25	<0.36	<0.39	<0.36	<0.39
TO-15 (FID)	Cyclohexane	0.33 J	<0.24	<0.26	<0.24	<0.26
TO-15 (FID)	Cyclopentane	0.76	<0.29	<0.31	<0.29	<0.31
TO-15 (FID)	Decane, n-	2.78	<0.18	<0.2	<0.18	<0.2
TO-15 (FID)	Diethylbenzene, 1,3-	<0.13	<0.18	<0.2	<0.18	<0.2
TO-15 (FID)	Diethylbenzene, 1,4-	<0.13	<0.18	<0.2	<0.18	<0.2
TO-15 (FID)	Dimethylbutane, 2,2-	<0.17	<0.24	<0.26	<0.24	<0.26
TO-15 (FID)	Dimethylbutane, 2,3-	1.56	<0.24	<0.26	<0.24	<0.26
TO-15 (FID)	Dimethylpentane, 2,3-	<0.14	<0.21	<0.22	<0.2	<0.22
TO-15 (FID)	Dimethylpentane, 2,4-	1.24	<0.21	<0.22	<0.2	<0.22
TO-15 (FID)	Ethane	11.19	6.07	2.67	3.24	3.21
TO-15 (FID)	Ethene	0.97 J	<0.73	<0.79	<0.72	1.58 J
TO-15 (FID)	Ethyltoluene, 2-	0.9	<0.21	<0.22	<0.2	<0.22
TO-15 (FID)	Ethyltoluene, 3-	1.5	<0.21	<0.22	<0.2	<0.22
TO-15 (FID)	Heptane, n-	2.01	0.42 J	<0.28	<0.26	0.38 J
TO-15 (FID)	Hexane, n-	2.77	0.82	<0.26	0.4 J	0.51 J
TO-15 (FID)	Isoprene	<0.2	<0.29	<0.31	<0.29	<0.31
TO-15 (FID)	Methylcyclohexane	<0.18	0.98	<0.28	<0.26	<0.28
TO-15 (FID)	Methylcyclopentane	0.5	<0.24	<0.26	<0.24	<0.26
TO-15 (FID)	Methylheptane, 2-	0.78	<0.23	<0.25	<0.23	<0.25
TO-15 (FID)	Methylheptane, 3-	0.52	<0.23	<0.25	<0.23	<0.25
TO-15 (FID)	Methylhexane, 2-	1.55	<0.21	<0.22	<0.2	<0.22
TO-15 (FID)	Methylhexane, 3-	2.58	<0.21	<0.22	<0.2	0.84
TO-15 (FID)	Methylpentane, 2-	0.89	0.42 J	<0.26	<0.24	0.8
TO-15 (FID)	Methylpentane, 3-	2.27	<0.24	<0.26	<0.24	<0.26
TO-15 (FID)	Nonane, n-	0.78	0.32 J	<0.22	<0.2	<0.22
TO-15 (FID)	Octane, n-	1.2	<0.23	<0.25	<0.23	<0.25
TO-15 (FID)	Pentane, i-	31.95	7.29	0.64 J	0.57 J	0.75 J
TO-15 (FID)	Pentane, n-	33.22	17.09	0.65 J	0.68 J	0.67 J
TO-15 (FID)	Pentene, 1-	1.36	<0.29	<0.31	<0.29	<0.31
TO-15 (FID)	Pentene, cis-2-	0.57 J	<0.29	<0.31	<0.29	<0.31
TO-15 (FID)	Pentene, trans-2-	1.56	1.63	<0.31	<0.29	<0.31
TO-15 (FID)	Propane	5.58	2.51	1.3 J	<0.48	1.64
TO-15 (FID)	Propene	2.53	<0.49	<0.52	<0.48	<0.52
TO-15 (FID)	Styrene	<0.16	<0.23	<0.25	<0.23	<0.25
TO-15 (FID)	TNMHC - C1	3170.61	324.27	194.13 J	105.66 J	1555.88
TO-15 (FID)	TNMHC - C6	528.44	54.05	32.36 J	17.61 J	259.31
TO-15 (FID)	Trimethylbenzene, 1,2,3-	<0.14	<0.21	<0.22	<0.2	0.45 J
TO-15 (FID)	Trimethylpentane, 2,2,4-	0.44 J	<0.23	<0.25	<0.23	<0.25
TO-15 (FID)	Trimethylpentane, 2,3,4-	0.55	<0.23	<0.25	<0.23	<0.25
TO-15 (FID)	Undecane, n-	1.66	<0.18	<0.19	<0.17	<0.19

Notes:

1. Samples analyzed by Environmental Analytical Service, Inc.
2. Less than (<) symbol indicates the analyte was not found at the stated limit.
3. ppbV = parts per billion by volume; TNMHC = total non-methane hydrocarbons.

TABLE 2: SUMMA AIR SAMPLE RESULTS - SUMMER 2016 SAMPLING EVENT

	Sample ID:	1-GRA0815161330	2A-GRA0815161330	2B-GRA0815161330	3-GRA0815161330	4-GRA0815161330	4 DUP-GRA0815161330
	Sample Date:	Grasslands-2	Grasslands-2	Grasslands-2	Grasslands-2	Grasslands-2	Grasslands-2
	Sample Time:	8/15/2016	8/15/2016	8/15/2016	8/15/2016	8/15/2016	8/15/2016
Method	**Analyte**	ppbV	ppbV	ppbV	ppbV	ppbV	ppbV
TO-15	Benzene	0.57 J	1.01 J	0.47 J	0.53 J	0.76 J	0.56 J
TO-15	Butylbenzene, i-	<0.42	<0.47	<0.46	<0.44	<0.43	<0.41
TO-15	Butylbenzene, tert-	<0.42	<0.47	<0.46	<0.44	<0.43	<0.41
TO-15	Ethanol	<1.25	<1.42	<1.37	<1.33	<1.3	<1.22
TO-15	Ethylbenzene	<0.21	<0.24	<0.23	<0.22	<0.22	<0.2
TO-15	Ethyltoluene, 4-	<0.21	<0.24	<0.23	<0.22	<0.22	<0.2
TO-15	Methanol	<2.08	<2.36	<2.29	<2.21	<2.16	<2.04
TO-15	Propanol, i-	<0.83	<0.94	<0.92	<0.88	<0.86	<0.82
TO-15	Propylbenzene, i-	<0.21	<0.24	<0.23	<0.22	<0.22	<0.2
TO-15	Propylbenzene, n-	<0.21	<0.24	<0.23	<0.22	<0.22	<0.2
TO-15	Toluene	1.08	2.69	<0.23	0.23 J	13.75	<0.2
TO-15	Trimethylbenzene, 1,2,4-	<0.21	<0.24	<0.23	<0.22	<0.22	<0.2
TO-15	Trimethylbenzene, 1,3,5-	<0.21	<0.24	<0.23	<0.22	<0.22	<0.2
TO-15	Xylene, o-	<0.21	<0.24	<0.23	<0.22	<0.22	<0.2
TO-15	Xylenes, m & p-	<0.21	<0.24	<0.23	<0.22	0.51 J	<0.2
TO-15 (FID)	Acetylene	<0.62	<0.71	<0.69	<0.66	<0.65	<0.61
TO-15 (FID)	Butane, i-	<0.31	<0.35	<0.34	<0.33	1.37	<0.31
TO-15 (FID)	Butane, n-	<0.31	<0.35	<0.34	<0.33	1.42	<0.31
TO-15 (FID)	Butene, 1-	<0.31	<0.35	<0.34	<0.33	<0.32	<0.31
TO-15 (FID)	Butene, cis-2-	<0.31	<0.35	<0.34	<0.33	<0.32	<0.31
TO-15 (FID)	Butene, trans-2-	<0.31	<0.35	<0.34	<0.33	<0.32	<0.31
TO-15 (FID)	Cyclohexane	<0.21	<0.24	<0.23	<0.22	<0.22	<0.2
TO-15 (FID)	Cyclopentane	<0.25	<0.28	<0.27	<0.27	<0.26	<0.24
TO-15 (FID)	Decane, n-	<0.16	<0.18	<0.17	<0.17	<0.16	<0.16
TO-15 (FID)	Diethylbenzene, 1,3-	<0.16	<0.18	<0.17	<0.17	<0.16	<0.16
TO-15 (FID)	Diethylbenzene, 1,4-	<0.16	<0.18	<0.17	<0.17	<0.16	<0.16
TO-15 (FID)	Dimethylbutane, 2,2-	<0.21	<0.24	<0.23	<0.22	<0.22	<0.2
TO-15 (FID)	Dimethylbutane, 2,3-	<0.21	<0.24	<0.23	<0.22	0.31 J	<0.2
TO-15 (FID)	Dimethylpentane, 2,3-	<0.18	<0.2	<0.2	<0.19	<0.19	<0.17
TO-15 (FID)	Dimethylpentane, 2,4-	<0.18	<0.2	<0.2	<0.19	<0.19	<0.17
TO-15 (FID)	Ethane	2.3	2.9	1.32 J	2.15	2.45	1.97
TO-15 (FID)	Ethene	0.98 J	1.08 J	<0.69	<0.66	<0.65	0.73 J
TO-15 (FID)	Ethyltoluene, 2-	<0.18	<0.2	<0.19	<0.19	<0.18	<0.17
TO-15 (FID)	Ethyltoluene, 3-	<0.18	<0.2	<0.19	<0.19	<0.18	<0.17
TO-15 (FID)	Heptane, n-	<0.23	<0.26	<0.25	<0.24	0.45 J	<0.22
TO-15 (FID)	Hexane, n-	<0.21	<0.24	0.66 J	<0.22	0.67	<0.2
TO-15 (FID)	Isoprene	<0.25	<0.28	<0.27	<0.27	<0.26	<0.24
TO-15 (FID)	Methylcyclohexane	<0.23	<0.26	<0.25	<0.24	0.77	<0.22
TO-15 (FID)	Methylcyclopentane	<0.21	<0.24	<0.23	<0.22	0.29 J	<0.2
TO-15 (FID)	Methylheptane, 2-	<0.2	<0.22	<0.22	<0.21	<0.21	<0.19
TO-15 (FID)	Methylheptane, 3-	<0.2	<0.22	<0.22	<0.21	<0.21	<0.19
TO-15 (FID)	Methylhexane, 2-	<0.18	<0.2	<0.2	<0.19	<0.19	<0.17
TO-15 (FID)	Methylhexane, 3-	<0.18	<0.2	<0.2	<0.19	0.58	<0.17
TO-15 (FID)	Methylpentane, 2-	<0.21	<0.24	<0.23	<0.22	12.74	0.66
TO-15 (FID)	Methylpentane, 3-	<0.21	1.01	<0.23	<0.22	0.56 J	0.72
TO-15 (FID)	Nonane, n-	<0.18	<0.2	<0.19	0.32 J	<0.18	<0.17
TO-15 (FID)	Octane, n-	<0.2	<0.22	<0.22	<0.21	<0.21	<0.19
TO-15 (FID)	Pentane, i-	1.5	1.77	<0.27	<0.27	11.79	0.99
TO-15 (FID)	Pentane, n-	0.65 J	1.1	<0.27	<0.27	9.87	1.36
TO-15 (FID)	Pentene, 1-	<0.25	<0.28	<0.27	<0.27	<0.26	<0.24
TO-15 (FID)	Pentene, cis-2-	<0.25	<0.28	<0.27	<0.27	<0.26	<0.24
TO-15 (FID)	Pentene, trans-2-	<0.25	<0.28	<0.27	<0.27	<0.26	<0.24
TO-15 (FID)	Propane	<0.42	0.92 J	<0.46	<0.44	1.25 J	0.81 J
TO-15 (FID)	Propene	<0.42	<0.47	<0.46	<0.44	<0.43	0.74 J
TO-15 (FID)	Styrene	<0.2	<0.22	<0.22	<0.21	<0.21	<0.19
TO-15 (FID)	TNMHC - C1	172.31 J	1067.97	<82.44	112.52 J	995.26	128.45 J
TO-15 (FID)	TNMHC - C6	28.72 J	177.99	<13.74	18.75 J	165.88	21.41 J
TO-15 (FID)	Trimethylbenzene, 1,2,3-	<0.18	<0.2	<0.19	<0.19	<0.18	0.78
TO-15 (FID)	Trimethylpentane, 2,2,4-	<0.2	<0.22	<0.22	<0.21	0.84	<0.19
TO-15 (FID)	Trimethylpentane, 2,3,4-	<0.2	<0.22	<0.22	<0.21	<0.21	<0.19
TO-15 (FID)	Undecane, n-	<0.15	<0.17	<0.17	<0.16	<0.16	<0.15

Notes:

1. Samples analyzed by Environmental Analytical Service, Inc.
2. Less than (<) symbol indicates the analyte was not found at the stated limit.
3. ppbV = parts per billion by volume; TNMHC = total non-methane hydrocarbons.

TABLE 2: SUMMA AIR SAMPLE RESULTS - SUMMER 2016 SAMPLING EVENT

	Sample ID:	1-GRA0816160935	2A-GRA0816160935	2B-GRA0816160935	3-GRA0816160935	4-GRA0816160935
	Sample Date:	Grasslands-3	Grasslands-3	Grasslands-3	Grasslands-3	Grasslands-3
	Sample Time:	8/16/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016
Method	**Analyte**	ppbV	ppbV	ppbV	ppbV	ppbV
TO-15	Benzene	<0.33	<0.43	0.51 J	<0.43	<0.45
TO-15	Butylbenzene, i-	<0.33	<0.43	<0.48	<0.43	<0.45
TO-15	Butylbenzene, tert-	<0.33	<0.43	<0.48	<0.43	<0.45
TO-15	Ethanol	<1	4.89	<1.43	<1.3	<1.34
TO-15	Ethylbenzene	<0.17	<0.21	<0.24	<0.22	<0.22
TO-15	Ethyltoluene, 4-	<0.17	<0.21	<0.24	0.42 J	<0.22
TO-15	Methanol	<1	<2.13	<2.39	<2.17	<2.24
TO-15	Propanol, i-	<0.66	<0.85	<0.96	<0.87	<0.9
TO-15	Propylbenzene, i-	<0.17	<0.21	<0.24	<0.22	<0.22
TO-15	Propylbenzene, n-	<0.17	<0.21	<0.24	<0.22	<0.22
TO-15	Toluene	0.46 J	2.42	0.86	<0.22	<0.22
TO-15	Trimethylbenzene, 1,2,4-	<0.17	<0.21	<0.24	<0.22	<0.22
TO-15	Trimethylbenzene, 1,3,5-	<0.17	<0.21	<0.24	<0.22	<0.22
TO-15	Xylene, o-	0.25 J	<0.21	<0.24	<0.22	<0.22
TO-15	Xylenes, m & p-	0.66	<0.21	<0.24	<0.22	<0.22
TO-15 (FID)	Acetylene	<0.5	<0.64	<0.72	<0.65	<0.67
TO-15 (FID)	Butane, i-	<0.25	1.26	0.87 J	<0.33	<0.34
TO-15 (FID)	Butane, n-	1.99	3.06	3	2.17	2.22
TO-15 (FID)	Butene, 1-	<0.25	<0.32	<0.36	<0.33	<0.34
TO-15 (FID)	Butene, cis-2-	<0.25	<0.32	<0.36	<0.33	<0.34
TO-15 (FID)	Butene, trans-2-	<0.25	<0.32	<0.36	<0.33	<0.34
TO-15 (FID)	Cyclohexane	<0.17	<0.21	<0.24	<0.22	<0.22
TO-15 (FID)	Cyclopentane	<0.2	<0.26	<0.29	<0.26	<0.27
TO-15 (FID)	Decane, n-	<0.13	<0.16	<0.18	<0.16	<0.17
TO-15 (FID)	Diethylbenzene, 1,3-	<0.13	<0.16	<0.18	<0.16	<0.17
TO-15 (FID)	Diethylbenzene, 1,4-	<0.13	<0.16	<0.18	<0.16	<0.17
TO-15 (FID)	Dimethylbutane, 2,2-	<0.17	<0.21	<0.24	<0.22	<0.22
TO-15 (FID)	Dimethylbutane, 2,3-	<0.17	<0.21	<0.24	<0.22	<0.22
TO-15 (FID)	Dimethylpentane, 2,3-	<0.14	<0.18	<0.2	<0.19	<0.19
TO-15 (FID)	Dimethylpentane, 2,4-	<0.14	<0.18	<0.2	<0.19	<0.19
TO-15 (FID)	Ethane	5.37	7.7	6.12	6.34	6.95
TO-15 (FID)	Ethene	1.32 J	1.33 J	1.6 J	<0.65	<0.67
TO-15 (FID)	Ethyltoluene, 2-	<0.14	<0.18	<0.2	<0.18	<0.19
TO-15 (FID)	Ethyltoluene, 3-	<0.14	0.61	<0.2	<0.18	<0.19
TO-15 (FID)	Heptane, n-	<0.18	<0.23	<0.26	<0.24	<0.24
TO-15 (FID)	Hexane, n-	<0.17	0.46 J	<0.24	<0.22	<0.22
TO-15 (FID)	Isoprene	<0.2	<0.26	<0.29	<0.26	<0.27
TO-15 (FID)	Methylcyclohexane	<0.18	<0.23	<0.26	<0.24	<0.24
TO-15 (FID)	Methylcyclopentane	<0.17	<0.21	<0.24	<0.22	<0.22
TO-15 (FID)	Methylheptane, 2-	<0.16	<0.2	<0.23	<0.21	<0.21
TO-15 (FID)	Methylheptane, 3-	<0.16	<0.2	<0.23	<0.21	<0.21
TO-15 (FID)	Methylhexane, 2-	<0.14	<0.18	<0.2	<0.19	<0.19
TO-15 (FID)	Methylhexane, 3-	<0.14	0.96	<0.2	<0.19	<0.19
TO-15 (FID)	Methylpentane, 2-	<0.17	0.77	<0.24	1.66	<0.22
TO-15 (FID)	Methylpentane, 3-	<0.17	0.67	<0.24	<0.22	<0.22
TO-15 (FID)	Nonane, n-	0.32 J	<0.18	<0.2	<0.18	<0.19
TO-15 (FID)	Octane, n-	0.45 J	<0.2	<0.23	<0.21	<0.21
TO-15 (FID)	Pentane, i-	1.65	2.85	<0.29	1.08	0.73 J
TO-15 (FID)	Pentane, n-	0.59 J	3.03	1.03	1.97	0.75 J
TO-15 (FID)	Pentene, 1-	<0.2	<0.26	<0.29	<0.26	<0.27
TO-15 (FID)	Pentene, cis-2-	<0.2	<0.26	<0.29	<0.26	<0.27
TO-15 (FID)	Pentene, trans-2-	<0.2	<0.26	<0.29	<0.26	<0.27
TO-15 (FID)	Propane	5.1	5.41	5.81	5.97	5.84
TO-15 (FID)	Propene	0.92 J	<0.43	<0.48	<0.43	<0.45
TO-15 (FID)	Styrene	<0.16	<0.2	<0.23	<0.21	<0.21
TO-15 (FID)	TNMHC - C1	106 J	618.88	248.11 J	225.1 J	88.61 J
TO-15 (FID)	TNMHC - C6	17.67 J	103.15	41.35 J	37.52 J	14.77 J
TO-15 (FID)	Trimethylbenzene, 1,2,3-	<0.14	<0.18	<0.2	<0.18	<0.19
TO-15 (FID)	Trimethylpentane, 2,2,4-	<0.16	0.45 J	<0.23	<0.21	<0.21
TO-15 (FID)	Trimethylpentane, 2,3,4-	<0.16	<0.2	<0.23	<0.21	<0.21
TO-15 (FID)	Undecane, n-	<0.12	<0.15	<0.17	<0.16	<0.16

Notes:

1. Samples analyzed by Environmental Analytical Service, Inc.
2. Less than (<) symbol indicates the analyte was not found at the stated limit.
3. ppbV = parts per billion by volume; TNMHC = total non-methane hydrocarbons.

TABLE 2: SUMMA AIR SAMPLE RESULTS - SUMMER 2016 SAMPLING EVENT

	Sample ID:	1-WAM0817160920	2A-WAM0817160920	2B-WAM0817160920	3-WAM0817160920	4-WAM0817160920
	Sample Date:	Wamsutter-1	Wamsutter-1	Wamsutter-1	Wamsutter-1	Wamsutter-1
	Sample Time:	8/17/2016	8/17/2016	8/17/2016	8/17/2016	8/17/2016
Method	**Analyte**	ppbV	ppbV	ppbV	ppbV	ppbV
TO-15	Benzene	0.68 J	0.85 J	1.16	0.49 J	0.5 J
TO-15	Butylbenzene, i-	<0.47	<0.38	<0.27	<0.48	<0.5
TO-15	Butylbenzene, tert-	<0.47	<0.38	<0.27	<0.48	<0.5
TO-15	Ethanol	<1.42	<1.13	27.83	<1.44	<1.49
TO-15	Ethylbenzene	<0.24	2.11	4.53	<0.24	<0.25
TO-15	Ethyltoluene, 4-	<0.24	0.39 J	0.84	<0.24	<0.25
TO-15	Methanol	<2.36	<1.89	50.27	<2.4	<2.48
TO-15	Propanol, i-	<0.94	<0.76	22.95	<0.96	<0.99
TO-15	Propylbenzene, i-	<0.24	<0.19	0.31 J	<0.24	<0.25
TO-15	Propylbenzene, n-	<0.24	<0.19	0.31 J	<0.24	<0.25
TO-15	Toluene	0.51 J	40.37	63.73	0.83	0.37 J
TO-15	Trimethylbenzene, 1,2,4-	<0.24	0.35 J	0.76	<0.24	<0.25
TO-15	Trimethylbenzene, 1,3,5-	<0.24	<0.19	0.26 J	<0.24	<0.25
TO-15	Xylene, o-	<0.24	2.03	4.11	<0.24	<0.25
TO-15	Xylenes, m & p-	0.35 J	5.6	12.05	<0.24	<0.25
TO-15 (FID)	Acetylene	<0.71	<0.57	0.43 J	<0.72	<0.74
TO-15 (FID)	Butane, i-	<0.35	5.2	8.21	0.94 J	1.01 J
TO-15 (FID)	Butane, n-	1.51	3.35	5.12	1.6	1.86
TO-15 (FID)	Butene, 1-	<0.35	<0.28	<0.2	<0.36	<0.37
TO-15 (FID)	Butene, cis-2-	<0.35	3.15	<0.2	<0.36	<0.37
TO-15 (FID)	Butene, trans-2-	<0.35	2.41	<0.2	<0.36	<0.37
TO-15 (FID)	Cyclohexane	<0.24	<0.19	3.11	<0.24	<0.25
TO-15 (FID)	Cyclopentane	<0.28	0.35 J	<0.16	<0.29	<0.3
TO-15 (FID)	Decane, n-	<0.18	<0.14	<0.1	<0.18	<0.19
TO-15 (FID)	Diethylbenzene, 1,3-	<0.18	<0.14	<0.1	<0.18	<0.19
TO-15 (FID)	Diethylbenzene, 1,4-	<0.18	1.23	<0.1	<0.18	<0.19
TO-15 (FID)	Dimethylbutane, 2,2-	<0.24	<0.19	0.26 J	<0.24	<0.25
TO-15 (FID)	Dimethylbutane, 2,3-	<0.24	<0.19	0.33 J	0.49 J	<0.25
TO-15 (FID)	Dimethylpentane, 2,3-	<0.2	0.56	0.95	0.22 J	<0.21
TO-15 (FID)	Dimethylpentane, 2,4-	<0.2	0.82	0.28 J	0.23 J	<0.21
TO-15 (FID)	Ethane	14.15	13.11	15.27	10.41	10.46
TO-15 (FID)	Ethene	0.93 J	1.33 J	1.38	1.43 J	1.55 J
TO-15 (FID)	Ethyltoluene, 2-	<0.2	<0.16	0.83	<0.2	0.52 J
TO-15 (FID)	Ethyltoluene, 3-	<0.2	<0.16	2.08	<0.2	0.26 J
TO-15 (FID)	Heptane, n-	<0.26	1.41	2.49	0.44 J	0.34 J
TO-15 (FID)	Hexane, n-	<0.24	2.34	4.51	0.63 J	0.53 J
TO-15 (FID)	Isoprene	<0.28	<0.23	<0.16	<0.29	<0.3
TO-15 (FID)	Methylcyclohexane	<0.26	1.91	3.85	0.65 J	0.53 J
TO-15 (FID)	Methylcyclopentane	<0.24	<0.19	0.45	<0.24	<0.25
TO-15 (FID)	Methylheptane, 2-	<0.22	0.35 J	0.7	<0.23	<0.24
TO-15 (FID)	Methylheptane, 3-	<0.22	0.32 J	0.71	<0.23	<0.24
TO-15 (FID)	Methylhexane, 2-	<0.2	0.53	1.04	0.27 J	<0.21
TO-15 (FID)	Methylhexane, 3-	<0.2	1.62	2.69	0.69	0.5 J
TO-15 (FID)	Methylpentane, 2-	<0.24	0.95	1.71	1.64	0.38 J
TO-15 (FID)	Methylpentane, 3-	<0.24	13.37	2.29	0.41 J	<0.25
TO-15 (FID)	Nonane, n-	<0.2	0.66	0.28 J	0.2 J	<0.21
TO-15 (FID)	Octane, n-	<0.22	0.65	1.45	0.28 J	<0.24
TO-15 (FID)	Pentane, i-	0.79 J	46.82	88.53	<0.29	4.16
TO-15 (FID)	Pentane, n-	0.69 J	17.13	43.4	4.97	0.84 J
TO-15 (FID)	Pentene, 1-	<0.28	0.48 J	1.05	0.42 J	<0.3
TO-15 (FID)	Pentene, cis-2-	<0.28	<0.23	0.88	<0.29	<0.3
TO-15 (FID)	Pentene, trans-2-	<0.28	<0.23	3.23	<0.29	<0.3
TO-15 (FID)	Propane	4.46	6.69	9.24	4.27	4.48
TO-15 (FID)	Propene	<0.47	0.97 J	1.28	1.01 J	1.16 J
TO-15 (FID)	Styrene	<0.22	<0.18	5.98	0.84	0.31 J
TO-15 (FID)	TNMHC - C1	354.78	2255.37	4200.08	616.69	307.22
TO-15 (FID)	TNMHC - C6	59.13	375.9	700.01	102.78	51.2
TO-15 (FID)	Trimethylbenzene, 1,2,3-	<0.2	<0.16	<0.11	<0.2	1.36
TO-15 (FID)	Trimethylpentane, 2,2,4-	<0.22	1.83	3.21	0.39 J	<0.24
TO-15 (FID)	Trimethylpentane, 2,3,4-	<0.22	0.48 J	0.93	<0.23	<0.24
TO-15 (FID)	Undecane, n-	<0.17	<0.14	1.83	<0.17	<0.18

Notes:

1. Samples analyzed by Environmental Analytical Service, Inc.
2. Less than (<) symbol indicates the analyte was not found at the stated limit.
3. ppbV = parts per billion by volume; TNMHC = total non-methane hydrocarbons.

TABLE 2: SUMMA AIR SAMPLE RESULTS - SUMMER 2016 SAMPLING EVENT

	Sample ID:	1-WAM0817161205	2A-WAM0817161205	2B-WAM0817161205	3-WAM0817161205	4-WAM0817161205	4 DUP-WAM0817161205
	Sample Date:	Wamsutter-1	Wamsutter-1	Wamsutter-1	Wamsutter-1	Wamsutter-1	Wamsutter-1
	Sample Time:	8/17/2016	8/17/2016	8/17/2016	8/17/2016	8/17/2016	8/17/2016
Method	**Analyte**	ppbV	ppbV	ppbV	ppbV	ppbV	ppbV
TO-15	Benzene	0.53 J	0.71 J	0.84 J	0.62 J	0.6 J	0.61 J
TO-15	Butylbenzene, i-	<0.44	<0.5	<0.42	<0.53	<0.5	<0.48
TO-15	Butylbenzene, tert-	<0.44	<0.5	<0.42	<0.53	<0.5	<0.48
TO-15	Ethanol	<1.31	<1.49	<1.27	<1.6	<1.49	<1.43
TO-15	Ethylbenzene	<0.22	<0.25	0.63	<0.27	<0.25	<0.24
TO-15	Ethyltoluene, 4-	<0.22	<0.25	1.1	<0.27	<0.25	<0.24
TO-15	Methanol	<2.19	<2.49	<2.12	<2.66	<2.48	<2.39
TO-15	Propanol, i-	<0.88	<1	<0.85	<1.06	<0.99	<0.96
TO-15	Propylbenzene, i-	<0.22	<0.25	0.45 J	<0.27	<0.25	<0.24
TO-15	Propylbenzene, n-	<0.22	<0.25	0.27 J	<0.27	<0.25	<0.24
TO-15	Toluene	<0.22	0.77	49.71	2.52	<0.25	1.03
TO-15	Trimethylbenzene, 1,2,4-	<0.22	<0.25	1.12	<0.27	<0.25	<0.24
TO-15	Trimethylbenzene, 1,3,5-	<0.22	<0.25	0.45 J	<0.27	<0.25	<0.24
TO-15	Xylene, o-	<0.22	<0.25	0.75	<0.27	<0.25	<0.24
TO-15	Xylenes, m & p-	<0.22	<0.25	2	<0.27	<0.25	<0.24
TO-15 (FID)	Acetylene	<0.66	0.76 J	<0.64	<0.8	<0.74	<0.72
TO-15 (FID)	Butane, i-	0.87 J	0.95 J	5.38	1.43	0.58 J	0.96 J
TO-15 (FID)	Butane, n-	1.67	2.07	3.24	2.61	1.07 J	2.23
TO-15 (FID)	Butene, 1-	<0.33	<0.37	<0.32	<0.4	<0.37	<0.36
TO-15 (FID)	Butene, cis-2-	<0.33	<0.37	5.25	<0.4	<0.37	<0.36
TO-15 (FID)	Butene, trans-2-	<0.33	<0.37	2.96	<0.4	<0.37	<0.36
TO-15 (FID)	Cyclohexane	<0.22	<0.25	2.18	<0.27	0.58 J	0.4 J
TO-15 (FID)	Cyclopentane	<0.26	<0.3	0.8	<0.32	<0.3	<0.29
TO-15 (FID)	Decane, n-	<0.17	<0.19	<0.16	0.31 J	<0.19	<0.18
TO-15 (FID)	Diethylbenzene, 1,3-	<0.17	<0.19	<0.16	0.35 J	<0.19	<0.18
TO-15 (FID)	Diethylbenzene, 1,4-	<0.17	<0.19	<0.16	0.23 J	<0.19	<0.18
TO-15 (FID)	Dimethylbutane, 2,2-	<0.22	<0.25	<0.21	<0.27	<0.25	<0.24
TO-15 (FID)	Dimethylbutane, 2,3-	<0.22	<0.25	1.28	<0.27	<0.25	<0.24
TO-15 (FID)	Dimethylpentane, 2,3-	<0.19	<0.21	0.71	<0.23	<0.21	<0.2
TO-15 (FID)	Dimethylpentane, 2,4-	<0.19	<0.21	0.44 J	<0.23	<0.21	<0.2
TO-15 (FID)	Ethane	10.8	11.05	12.52	16.57	8.82	8.26
TO-15 (FID)	Ethene	1 J	1.35 J	1.57 J	0.97 J	0.9 J	0.75 J
TO-15 (FID)	Ethyltoluene, 2-	<0.18	<0.21	<0.18	<0.22	<0.21	<0.2
TO-15 (FID)	Ethyltoluene, 3-	0.29 J	<0.21	<0.18	<0.22	<0.21	<0.2
TO-15 (FID)	Heptane, n-	<0.24	<0.27	1.34	0.37 J	<0.27	0.41 J
TO-15 (FID)	Hexane, n-	0.46 J	0.45 J	2.07	0.86	0.28 J	0.62 J
TO-15 (FID)	Isoprene	<0.26	<0.3	<0.25	<0.32	<0.3	<0.29
TO-15 (FID)	Methylcyclohexane	0.31 J	0.45 J	1.99	0.71 J	0.42 J	0.6 J
TO-15 (FID)	Methylcyclopentane	<0.22	<0.25	<0.21	<0.27	<0.25	<0.24
TO-15 (FID)	Methylheptane, 2-	<0.21	<0.24	0.38 J	<0.25	<0.24	<0.23
TO-15 (FID)	Methylheptane, 3-	<0.21	<0.24	0.27 J	<0.25	<0.24	<0.23
TO-15 (FID)	Methylhexane, 2-	<0.19	<0.21	0.76	<0.23	<0.21	<0.2
TO-15 (FID)	Methylhexane, 3-	<0.19	0.55 J	1.74	<0.23	0.52 J	0.63
TO-15 (FID)	Methylpentane, 2-	<0.22	0.65 J	<0.21	0.86	<0.25	<0.24
TO-15 (FID)	Methylpentane, 3-	<0.22	<0.25	<0.21	1.33	<0.25	<0.24
TO-15 (FID)	Nonane, n-	<0.18	<0.21	0.51 J	<0.22	<0.21	<0.2
TO-15 (FID)	Octane, n-	<0.21	<0.24	0.5 J	<0.25	<0.24	<0.23
TO-15 (FID)	Pentane, i-	<0.26	1.55	38.34	5.9	1.1	1.44
TO-15 (FID)	Pentane, n-	3.04	1.37	22.56	3.49	0.74 J	1.25
TO-15 (FID)	Pentene, 1-	<0.26	<0.3	0.5 J	<0.32	<0.3	<0.29
TO-15 (FID)	Pentene, cis-2-	<0.26	<0.3	<0.25	<0.32	<0.3	<0.29
TO-15 (FID)	Pentene, trans-2-	<0.26	<0.3	1	<0.32	<0.3	<0.29
TO-15 (FID)	Propane	3.99	3.76	5.11	5.36	2.82	2.85
TO-15 (FID)	Propene	0.61 J	<0.5	0.9 J	0.56 J	<0.5	<0.48
TO-15 (FID)	Styrene	<0.21	0.45 J	<0.2	<0.25	<0.24	<0.23
TO-15 (FID)	TNMHC - C1	207.04 J	201.86 J	2309.71	370.27	237.8 J	266.99
TO-15 (FID)	TNMHC - C6	34.51 J	33.64 J	384.95	61.71	39.63 J	44.5
TO-15 (FID)	Trimethylbenzene, 1,2,3-	<0.18	0.66	<0.18	<0.22	<0.21	<0.2
TO-15 (FID)	Trimethylpentane, 2,2,4-	<0.21	0.31 J	2.47	0.4 J	<0.24	<0.23
TO-15 (FID)	Trimethylpentane, 2,3,4-	<0.21	<0.24	0.46 J	<0.25	<0.24	<0.23
TO-15 (FID)	Undecane, n-	<0.16	<0.18	0.5	<0.19	<0.18	<0.17

Notes:
1. Samples analyzed by Environmental Analytical Service, Inc.
2. Less than (<) symbol indicates the analyte was not found at the stated limit.
3. ppbV = parts per billion by volume; TNMHC = total non-methane hydrocarbons.

TABLE 2: SUMMA AIR SAMPLE RESULTS - SUMMER 2016 SAMPLING EVENT

	Sample ID:	1-WAM0818161420	2A-WAM0818161420	2B-WAM0818161420	3-WAM0818161420	4-WAM0818161420
	Sample Date:	Wamsutter-1	Wamsutter-1	Wamsutter-1	Wamsutter-1	Wamsutter-1
	Sample Time:	8/18/2016	8/18/2016	8/18/2016	8/18/2016	8/18/2016
Method	**Analyte**	ppbV	ppbV	ppbV	ppbV	ppbV
TO-15	Benzene	0.51 J	0.5 J	0.48 J	0.57 J	0.44 J
TO-15	Butylbenzene, i-	<0.37	<0.35	<0.36	<0.43	<0.37
TO-15	Butylbenzene, tert-	<0.37	<0.35	<0.36	<0.43	<0.37
TO-15	Ethanol	<1.12	2.35 J	<1.08	<1.28	1.36 J
TO-15	Ethylbenzene	<0.19	<0.17	<0.18	<0.21	<0.19
TO-15	Ethyltoluene, 4-	<0.19	<0.17	<0.18	<0.21	<0.19
TO-15	Methanol	<1.87	<1.73	<1.8	<2.13	<1.86
TO-15	Propanol, i-	<0.75	<0.69	<0.72	<0.85	4.16
TO-15	Propylbenzene, i-	<0.19	<0.17	<0.18	1.29	<0.19
TO-15	Propylbenzene, n-	<0.19	<0.17	<0.18	<0.21	<0.19
TO-15	Toluene	0.29 J	0.74	0.3 J	0.26 J	0.71
TO-15	Trimethylbenzene, 1,2,4-	<0.19	<0.17	<0.18	<0.21	<0.19
TO-15	Trimethylbenzene, 1,3,5-	<0.19	<0.17	<0.18	<0.21	<0.19
TO-15	Xylene, o-	<0.19	<0.17	<0.18	<0.21	<0.19
TO-15	Xylenes, m & p-	<0.19	<0.17	<0.18	0.33 J	<0.19
TO-15 (FID)	Acetylene	<0.56	<0.52	<0.54	<0.64	<0.56
TO-15 (FID)	Butane, i-	<0.28	<0.26	0.29 J	<0.32	0.39 J
TO-15 (FID)	Butane, n-	0.51 J	<0.26	0.59 J	0.59 J	0.79 J
TO-15 (FID)	Butene, 1-	<0.28	<0.26	<0.27	<0.32	<0.28
TO-15 (FID)	Butene, cis-2-	<0.28	<0.26	<0.27	<0.32	<0.28
TO-15 (FID)	Butene, trans-2-	<0.28	<0.26	<0.27	<0.32	<0.28
TO-15 (FID)	Cyclohexane	<0.19	<0.17	<0.18	<0.21	<0.19
TO-15 (FID)	Cyclopentane	<0.22	<0.21	<0.22	<0.26	<0.22
TO-15 (FID)	Decane, n-	0.19 J	<0.13	<0.14	0.26 J	<0.14
TO-15 (FID)	Diethylbenzene, 1,3-	<0.14	<0.13	<0.14	<0.16	<0.14
TO-15 (FID)	Diethylbenzene, 1,4-	<0.14	<0.13	<0.14	0.16 J	0.31 J
TO-15 (FID)	Dimethylbutane, 2,2-	<0.19	<0.17	<0.18	<0.21	<0.19
TO-15 (FID)	Dimethylbutane, 2,3-	<0.19	0.37 J	<0.18	<0.21	<0.19
TO-15 (FID)	Dimethylpentane, 2,3-	<0.16	<0.15	<0.15	<0.18	<0.16
TO-15 (FID)	Dimethylpentane, 2,4-	<0.16	<0.15	<0.15	<0.18	<0.16
TO-15 (FID)	Ethane	3.88	3.25	4.62	4.53	4.34
TO-15 (FID)	Ethene	<0.56	<0.52	0.56 J	1.41 J	0.71 J
TO-15 (FID)	Ethyltoluene, 2-	<0.16	<0.15	<0.15	<0.18	<0.16
TO-15 (FID)	Ethyltoluene, 3-	<0.16	<0.15	<0.15	<0.18	<0.16
TO-15 (FID)	Heptane, n-	<0.2	0.24 J	<0.2	<0.23	<0.2
TO-15 (FID)	Hexane, n-	<0.19	0.85	<0.18	0.23 J	<0.19
TO-15 (FID)	Isoprene	<0.22	<0.21	<0.22	<0.26	<0.22
TO-15 (FID)	Methylcyclohexane	0.26 J	0.38 J	<0.2	<0.23	0.23 J
TO-15 (FID)	Methylcyclopentane	<0.19	<0.17	<0.18	<0.21	<0.19
TO-15 (FID)	Methylheptane, 2-	<0.18	<0.16	<0.17	<0.2	<0.18
TO-15 (FID)	Methylheptane, 3-	<0.18	<0.16	<0.17	<0.2	<0.18
TO-15 (FID)	Methylhexane, 2-	<0.16	<0.15	<0.15	0.28 J	<0.16
TO-15 (FID)	Methylhexane, 3-	0.36 J	0.17 J	0.29 J	0.46 J	0.29 J
TO-15 (FID)	Methylpentane, 2-	0.42 J	0.19 J	0.22 J	0.38 J	0.43 J
TO-15 (FID)	Methylpentane, 3-	0.45 J	0.18 J	0.28 J	0.44 J	0.55 J
TO-15 (FID)	Nonane, n-	<0.16	<0.15	<0.15	0.23 J	<0.16
TO-15 (FID)	Octane, n-	<0.18	<0.16	<0.17	<0.2	<0.18
TO-15 (FID)	Pentane, i-	0.42 J	<0.21	0.34 J	1.63	2.86
TO-15 (FID)	Pentane, n-	0.29 J	2.3	0.4 J	0.36 J	1.97
TO-15 (FID)	Pentene, 1-	<0.22	<0.21	<0.22	<0.26	<0.22
TO-15 (FID)	Pentene, cis-2-	<0.22	<0.21	<0.22	<0.26	<0.22
TO-15 (FID)	Pentene, trans-2-	<0.22	<0.21	<0.22	<0.26	<0.22
TO-15 (FID)	Propane	1.45	1.48	1.48	1.9	1.86
TO-15 (FID)	Propene	<0.37	0.39 J	<0.36	0.68 J	0.8 J
TO-15 (FID)	Styrene	<0.18	<0.16	<0.17	<0.2	<0.18
TO-15 (FID)	TNMHC - C1	176.11 J	185.79 J	78.58 J	417.02	211.9
TO-15 (FID)	TNMHC - C6	29.35 J	30.96 J	13.1 J	69.5	35.32
TO-15 (FID)	Trimethylbenzene, 1,2,3-	<0.16	<0.15	0.3 J	<0.18	<0.16
TO-15 (FID)	Trimethylpentane, 2,2,4-	<0.18	<0.16	<0.17	<0.2	<0.18
TO-15 (FID)	Trimethylpentane, 2,3,4-	<0.18	<0.16	<0.17	<0.2	<0.18
TO-15 (FID)	Undecane, n-	<0.14	<0.13	<0.13	<0.15	<0.14

Notes:

1. Samples analyzed by Environmental Analytical Service, Inc.
2. Less than (<) symbol indicates the analyte was not found at the stated limit.
3. ppbV = parts per billion by volume; TNMHC = total non-methane hydrocarbons.

TABLE 2: SUMMA AIR SAMPLE RESULTS - SUMMER 2016 SAMPLING EVENT

	Sample ID:	WALK-GRA0815161355	WALKING-GRA0815161120	WALK-GRA0816161055	WALK-GRA0816161305
	Sample Date:	Grasslands-2	Grasslands-2	Grasslands-3	Grasslands-3
	Sample Time:	8/15/2016	8/15/2016	8/16/2016	8/16/2016
Method	**Analyte**	ppbV	ppbV	ppbV	ppbV
TO-15	Benzene	0.77 J	1.11 J	<0.74	<0.77
TO-15	Butylbenzene, i-	<0.75	<0.81	<0.74	<0.77
TO-15	Butylbenzene, tert-	<0.75	<0.81	<0.74	<0.77
TO-15	Ethanol	<2.24	<2.44	<2.22	<2.3
TO-15	Ethylbenzene	<0.38	<0.41	<0.37	<0.39
TO-15	Ethyltoluene, 4-	<0.38	<0.41	<0.37	<0.39
TO-15	Methanol	<3.74	<4.06	<3.7	<3.84
TO-15	Propanol, i-	<1.5	<1.62	<1.48	<1.54
TO-15	Propylbenzene, i-	<0.38	<0.41	<0.37	<0.39
TO-15	Propylbenzene, n-	<0.38	<0.41	<0.37	<0.39
TO-15	Toluene	<0.38	<0.41	<0.37	<0.39
TO-15	Trimethylbenzene, 1,2,4-	<0.38	<0.41	<0.37	<0.39
TO-15	Trimethylbenzene, 1,3,5-	<0.38	<0.41	<0.37	<0.39
TO-15	Xylene, o-	<0.38	<0.41	<0.37	<0.39
TO-15	Xylenes, m & p-	<0.38	<0.41	<0.37	<0.39
TO-15 (FID)	Acetylene	<1.12	<1.22	<1.11	<1.15
TO-15 (FID)	Butane, i-	<0.56	<0.61	<0.56	<0.58
TO-15 (FID)	Butane, n-	0.62 J	0.96 J	1.53 J	3.95
TO-15 (FID)	Butene, 1-	<0.56	<0.61	<0.56	<0.58
TO-15 (FID)	Butene, cis-2-	<0.56	<0.61	<0.56	<0.58
TO-15 (FID)	Butene, trans-2-	<0.56	<0.61	<0.56	<0.58
TO-15 (FID)	Cyclohexane	<0.37	<0.41	<0.37	<0.38
TO-15 (FID)	Cyclopentane	<0.45	<0.49	<0.44	<0.46
TO-15 (FID)	Decane, n-	<0.28	<0.31	<0.28	<0.29
TO-15 (FID)	Diethylbenzene, 1,3-	<0.28	<0.31	<0.28	<0.29
TO-15 (FID)	Diethylbenzene, 1,4-	<0.28	<0.31	<0.28	<0.29
TO-15 (FID)	Dimethylbutane, 2,2-	<0.37	<0.41	<0.37	<0.38
TO-15 (FID)	Dimethylbutane, 2,3-	<0.37	<0.41	<0.37	<0.38
TO-15 (FID)	Dimethylpentane, 2,3-	<0.32	<0.35	<0.32	<0.33
TO-15 (FID)	Dimethylpentane, 2,4-	<0.32	<0.35	<0.32	<0.33
TO-15 (FID)	Ethane	3.5	2.33 J	5.72	2.75 J
TO-15 (FID)	Ethene	2.43 J	<1.22	<1.11	1.22 J
TO-15 (FID)	Ethyltoluene, 2-	<0.32	<0.34	<0.31	<0.32
TO-15 (FID)	Ethyltoluene, 3-	<0.32	<0.34	<0.31	<0.32
TO-15 (FID)	Heptane, n-	<0.41	<0.44	<0.4	<0.42
TO-15 (FID)	Hexane, n-	<0.37	<0.41	<0.37	<0.38
TO-15 (FID)	Isoprene	<0.45	<0.49	<0.44	<0.46
TO-15 (FID)	Methylcyclohexane	<0.41	<0.44	<0.4	<0.42
TO-15 (FID)	Methylcyclopentane	<0.37	<0.41	<0.37	<0.38
TO-15 (FID)	Methylheptane, 2-	<0.36	<0.39	<0.35	<0.36
TO-15 (FID)	Methylheptane, 3-	<0.36	<0.39	<0.35	<0.36
TO-15 (FID)	Methylhexane, 2-	<0.32	<0.35	<0.32	<0.33
TO-15 (FID)	Methylhexane, 3-	0.96	<0.35	<0.32	<0.33
TO-15 (FID)	Methylpentane, 2-	1.5	<0.41	1.24	<0.38
TO-15 (FID)	Methylpentane, 3-	0.72 J	<0.41	<0.37	<0.38
TO-15 (FID)	Nonane, n-	<0.32	<0.34	<0.31	<0.32
TO-15 (FID)	Octane, n-	0.81 J	<0.39	<0.35	<0.36
TO-15 (FID)	Pentane, i-	1.64	<0.49	<0.44	1.54
TO-15 (FID)	Pentane, n-	<0.45	0.8 J	1.49	1.4
TO-15 (FID)	Pentene, 1-	<0.45	<0.49	<0.44	<0.46
TO-15 (FID)	Pentene, cis-2-	<0.45	<0.49	<0.44	<0.46
TO-15 (FID)	Pentene, trans-2-	<0.45	<0.49	<0.44	<0.46
TO-15 (FID)	Propane	1.11 J	<0.81	3.86	1.58 J
TO-15 (FID)	Propene	1.06 J	<0.81	<0.74	<0.77
TO-15 (FID)	Styrene	<0.36	<0.39	<0.35	<0.36
TO-15 (FID)	TNMHC - C1	313.8 J	220.73 J	<133.2	161.75 J
TO-15 (FID)	TNMHC - C6	52.3 J	36.79 J	<22.2	26.96 J
TO-15 (FID)	Trimethylbenzene, 1,2,3-	<0.32	<0.34	0.84 J	<0.32
TO-15 (FID)	Trimethylpentane, 2,2,4-	<0.36	<0.39	<0.35	<0.36
TO-15 (FID)	Trimethylpentane, 2,3,4-	<0.36	<0.39	<0.35	<0.36
TO-15 (FID)	Undecane, n-	<0.27	<0.3	<0.27	<0.28

Notes:
1. Samples analyzed by Environmental Analytical Service, Inc.
2. Less than (<) symbol indicates the analyte was not found at the stated limit.
3. ppbV = parts per billion by volume; TNMHC = total non-methane hydrocarbons.

TABLE 2: SUMMA AIR SAMPLE RESULTS - SUMMER 2016 SAMPLING EVENT

	Sample ID:	WALK-WAM0817161040	WALK-WAM0817161302	WALK-WAM0818161250
	Sample Date:	Wamsutter-1	Wamsutter-1	Wamsutter-1
	Sample Time:	8/17/2016	8/17/2016	8/18/2016
Method	**Analyte**	ppbV	ppbV	ppbV
TO-15	Benzene	1.26 J	1.04 J	0.89 J
TO-15	Butylbenzene, i-	<0.79	<0.97	<0.77
TO-15	Butylbenzene, tert-	<0.79	<0.97	<0.77
TO-15	Ethanol	<2.37	<2.92	<2.32
TO-15	Ethylbenzene	<0.4	<0.49	<0.39
TO-15	Ethyltoluene, 4-	<0.4	<0.49	<0.39
TO-15	Methanol	<3.95	<4.87	<3.86
TO-15	Propanol, i-	<1.58	<1.95	<1.54
TO-15	Propylbenzene, i-	<0.4	<0.49	<0.39
TO-15	Propylbenzene, n-	<0.4	<0.49	<0.39
TO-15	Toluene	2.23	1.63	0.53 J
TO-15	Trimethylbenzene, 1,2,4-	<0.4	<0.49	<0.39
TO-15	Trimethylbenzene, 1,3,5-	<0.4	<0.49	<0.39
TO-15	Xylene, o-	<0.4	<0.49	<0.39
TO-15	Xylenes, m & p-	0.59 J	<0.49	<0.39
TO-15 (FID)	Acetylene	<1.19	<1.46	<1.16
TO-15 (FID)	Butane, i-	0.71 J	1.48 J	1.99
TO-15 (FID)	Butane, n-	6.81	2.34	1.69 J
TO-15 (FID)	Butene, 1-	<0.59	<0.73	<0.58
TO-15 (FID)	Butene, cis-2-	<0.59	<0.73	<0.58
TO-15 (FID)	Butene, trans-2-	<0.59	<0.73	<0.58
TO-15 (FID)	Cyclohexane	<0.4	<0.49	<0.39
TO-15 (FID)	Cyclopentane	<0.47	<0.58	<0.46
TO-15 (FID)	Decane, n-	<0.3	<0.37	<0.29
TO-15 (FID)	Diethylbenzene, 1,3-	<0.3	<0.37	<0.29
TO-15 (FID)	Diethylbenzene, 1,4-	<0.3	<0.37	<0.29
TO-15 (FID)	Dimethylbutane, 2,2-	<0.4	<0.49	<0.39
TO-15 (FID)	Dimethylbutane, 2,3-	0.87 J	<0.49	<0.39
TO-15 (FID)	Dimethylpentane, 2,3-	<0.34	<0.42	<0.33
TO-15 (FID)	Dimethylpentane, 2,4-	<0.34	<0.42	<0.33
TO-15 (FID)	Ethane	8.18	14.59	10.81
TO-15 (FID)	Ethene	1.96 J	2.61 J	1.63 J
TO-15 (FID)	Ethyltoluene, 2-	<0.33	<0.41	<0.33
TO-15 (FID)	Ethyltoluene, 3-	0.44 J	<0.41	<0.33
TO-15 (FID)	Heptane, n-	3.92	0.74 J	<0.42
TO-15 (FID)	Hexane, n-	7.43	0.88 J	<0.39
TO-15 (FID)	Isoprene	<0.47	<0.58	<0.46
TO-15 (FID)	Methylcyclohexane	0.65 J	0.74 J	<0.42
TO-15 (FID)	Methylcyclopentane	<0.4	<0.49	<0.39
TO-15 (FID)	Methylheptane, 2-	0.38 J	<0.46	<0.37
TO-15 (FID)	Methylheptane, 3-	0.45 J	<0.46	<0.37
TO-15 (FID)	Methylhexane, 2-	0.43 J	<0.42	<0.33
TO-15 (FID)	Methylhexane, 3-	0.69 J	0.98 J	0.78 J
TO-15 (FID)	Methylpentane, 2-	<0.4	0.95 J	1.63
TO-15 (FID)	Methylpentane, 3-	0.84 J	1.27 J	1.58
TO-15 (FID)	Nonane, n-	0.71 J	<0.41	<0.33
TO-15 (FID)	Octane, n-	<0.38	<0.46	<0.37
TO-15 (FID)	Pentane, i-	3.41	2.91	<0.46
TO-15 (FID)	Pentane, n-	10.27	2.24	1.01 J
TO-15 (FID)	Pentene, 1-	<0.47	<0.58	<0.46
TO-15 (FID)	Pentene, cis-2-	<0.47	<0.58	<0.46
TO-15 (FID)	Pentene, trans-2-	<0.47	<0.58	<0.46
TO-15 (FID)	Propane	4.41	5.46	4.87
TO-15 (FID)	Propene	<0.79	<0.97	0.88 J
TO-15 (FID)	Styrene	<0.38	<0.46	<0.37
TO-15 (FID)	TNMHC - C1	402.01 J	413.61 J	275.76 J
TO-15 (FID)	TNMHC - C6	67 J	68.94 J	45.96 J
TO-15 (FID)	Trimethylbenzene, 1,2,3-	0.62 J	<0.41	<0.33
TO-15 (FID)	Trimethylpentane, 2,2,4-	<0.38	0.51 J	<0.37
TO-15 (FID)	Trimethylpentane, 2,3,4-	<0.38	<0.46	<0.37
TO-15 (FID)	Undecane, n-	<0.29	<0.35	<0.28

Notes:
1. Samples analyzed by Environmental Analytical Service, Inc.
2. Less than (<) symbol indicates the analyte was not found at the stated limit.
3. ppbV = parts per billion by volume; TNMHC = total non-methane hydrocarbons.

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TABLE 3: WATER SAMPLING RESULTS - SUMMER 2016

	Sample ID:	BPP1-S3-1		BPP1-S3-2	BPP1-S3-3	BPP1-S4-1	BPP1-S4-2	BPP1-S4-3	GLP2-S1-1	GLP2-S1-2	GLP2-S1-3	GLP2-S1-4	GLP3-S2-1		GLP3-S2-2	GLP3-S2-3
	Sample Location:	Pond 1		Pond 1	Pond 1	Pond 1	Pond 1	Pond 1	Pond 2	Pond 2	Pond 2	Pond 2	Pond 3		Pond 3	Pond 3
	Sample Date:	8/17/16		8/17/16	8/17/16	8/18/16	8/18/16	8/18/16	8/15/16	8/15/16	8/15/16	8/15/16	8/16/16		8/16/16	8/16/16
	Sample Type:	N	Dup	N	N	N	N	N	N	N	N	N	N	Dup	N	N
Method	**Analyte**	mg/L	mg/L	mg/kg	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1664A	HEM (Oil & Grease)	**18 J H**	**16.5 J H**	**12 J H**	**18 J H**	**10 J**	**14 J H**	**13.5 J H**	**2.5 J F1**	**1.2 J**	<1.1	**1.8 J**	**<1.2 J3**	**2.4 J J3**	**2.6 J**	**1.5 J**
8015B	Ethanol	<1.4	<1.4	<1.4	<0.14	<0.14	<0.14	<0.14	<0.31	<0.31	<0.31	<0.31	<0.14	<0.14	**0.24 J**	<0.14
8015B	Methanol	<4.1	<4.1	<4.1	<0.41	<0.41	0.56 J	0.43 J	<0.15	<0.15	<0.15	<0.15	<0.41	<0.41	<0.41	<0.41
8015B	Propanol, i-	<1.2	<1.2	<1.2	<0.12	<0.12	<0.12	<0.12	<0.096	<0.096	<0.096	<0.096	**0.32 J J3**	**0.18 J J3**	**0.18 J**	**0.14 J**
8260B	Benzene	**0.00066 J**	**0.00061 J**	**0.00061 J**	**0.0007 J**	**0.00065 J**	**0.00068 J**	**0.00065 J**	**0.00017 J**	**0.00019 J**	**0.00018 J**	**0.00017 J**	**0.007**	**0.0072**	**0.0072**	**0.0066**
8260B	Ethylbenzene	**0.00023 J J3**	**0.00016 J J3**	**0.00018 J**	**0.00026 J**	**0.00024 J**	**0.00025 J**	**0.00026 J**	<0.00016	<0.00016	<0.00016	<0.00016	<0.00016	<0.00016	<0.00016	<0.00016
8260B	Toluene	**0.0023**	**0.002**	**0.0019**	**0.0025**	**0.0024**	**0.0023**	**0.0025**	**0.0007 J**	**0.00068 J**	**0.00062 J**	**0.00061 J**	**0.009**	**0.0096**	**0.0091**	**0.008**
8260B	Trimethylbenzene, 1,2,3-	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	**0.0011 J**	**0.0014 J**	**0.0012 J**	**0.0011 J**
8260B	Trimethylbenzene, 1,2,4-	**0.00077 J J3**	**0.00054 J J3**	**0.00068 J**	**0.00094 J**	**0.0009 J**	**0.00082 J**	**0.0009 J**	**0.00022 J**	**0.00018 J**	**0.00016 J**	**0.00017 J**	**0.0037**	**0.0048**	**0.004**	**0.0036**
8260B	Trimethylbenzene, 1,3,5-	**0.00057 J**	**0.00042 J**	**0.0005 J**	**0.00075 J**	**0.00068 J**	**0.00069 J**	**0.00066 J**	<0.00016	<0.00016	<0.00016	<0.00016	**0.0018**	**0.0023**	**0.0019**	**0.0017**
8260B	Xylene, o-	**0.00062 J**	**0.00049 J**	**0.00051 J**	**0.0007 J**	**0.00067 J**	**0.00064 J**	**0.0007 J**	**0.00021 J**	**0.00019 J**	**0.00019 J**	<0.00019	**0.006**	**0.0067**	**0.0062**	**0.0052**
8260B	Xylenes, m & p-	**0.0026 J3**	**0.0019 J J3**	**0.0021**	**0.0027**	**0.0027**	**0.0027**	**0.003**	**0.00066 J**	**0.0006 J**	**0.00052 J**	**0.00055 J**	**0.015**	**0.018**	**0.016**	**0.014**
8260B	Xylenes, Total	**0.0032**	**0.0024**	**0.0026**	**0.0034**	**0.0034**	**0.0033**	**0.0037**	**0.00087 J**	**0.00079 J**	**0.00071 J**	**0.00055 J**	**0.021**	**0.025**	**0.022**	**0.019**
8315A	Acetaldehyde	<0.075	<0.075	<0.075	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
8315A	Formaldehyde	<0.075	<0.075	<0.075	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
RSK-175	Ethane	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057	<0.00057
RSK-175	Ethene	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
RSK-175	Methane	**0.38**	**0.39**	**0.47**	**0.53**	**0.47**	**0.27**	**0.36**	**1.5**	**1.3**	**1.8**	**1.2**	**0.84**	**0.9**	**0.87**	**0.81**

Notes:

1. Samples analyzed by TestAmerica Laboratories, Inc., Arvada, Colorado. Detections are shown in**bold.**
2. HEM = n-hexane extractable material.
3. Less than (<) symbol indicates the analyte was not found at the stated limit. Dash (-) indicates that compound was not analyzed.
4. Flag Definitions:

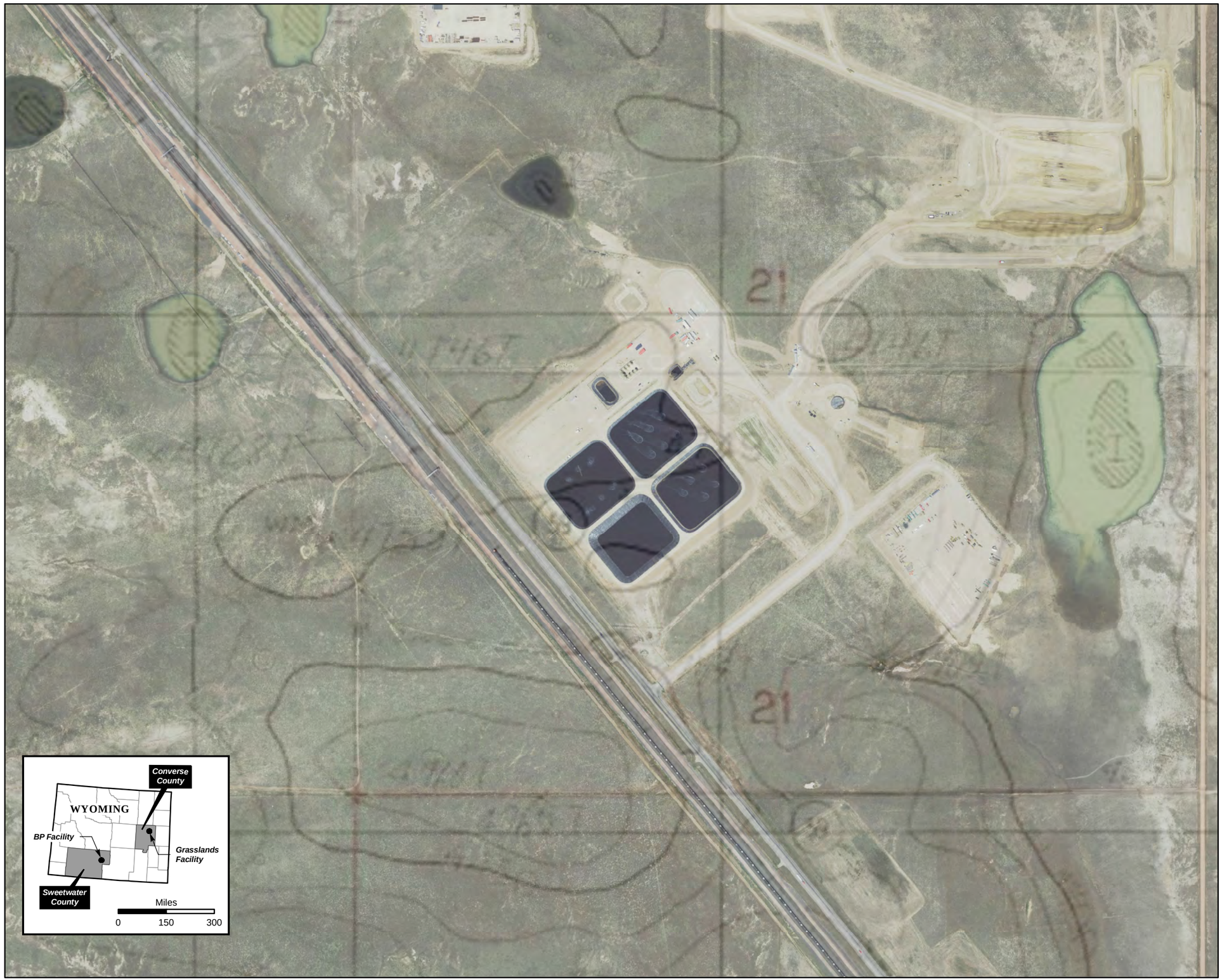
   H - Sample was prepped or analyzed beyond the specified holding time.

   J - result is less than the reporting limit (RL) but greater than or equal to the method detection limit (MDL) and the concentration is an approximate value.

   F1 - The matrix spike (MS) and/or matrix spike duplicate (MSD) recovery is outside acceptance limits.

   J3 - The relative percent difference (%RPD) between the sample and duplicate is greater than 30%.

FIGURES



N

LEGEND

Topographic contour

Notes

Background Imagery: USGS Orthoimagery: Esri, National Map, USGS, and the GIS User Community.

Feet
0 300 600

Projected Coordinate System
Datum: NAD 1983
UTM: Zone 13N

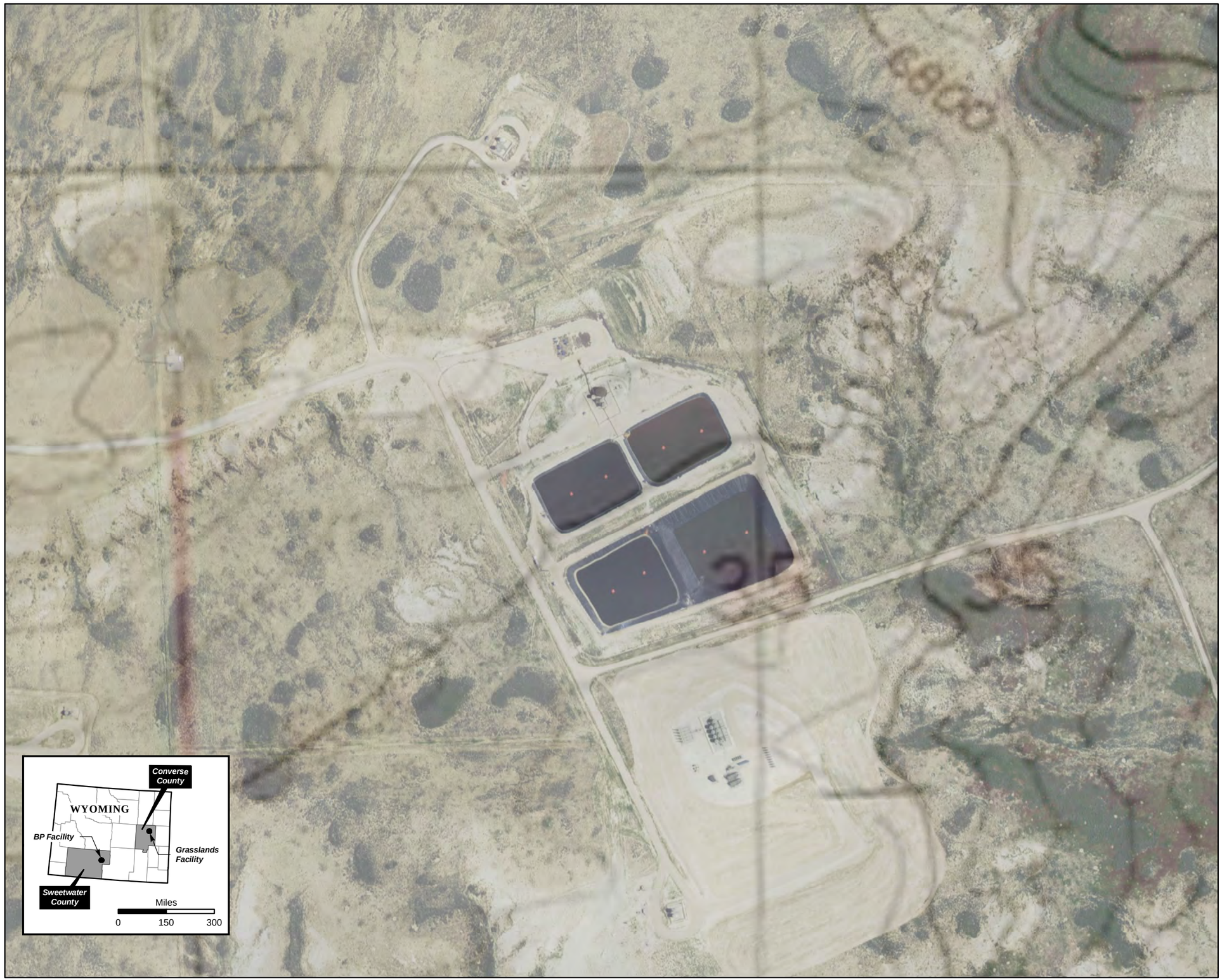
GSI ENVIRONMENTAL

GRASSLANDS FACILITY SITE MAP

Disposal Pit Emission Study
Eastern Wyoming Site
Converse County, Wyoming

GSI Job No. G-4194	Drawn By: CDM
Issued: 10-Mar-2017	Chk'd By: JAL
Map ID: **005_01**	Appv'd By: RLB

FIGURE 1



N

LEGEND

Topographic contour

Notes

Background Imagery: USGS Orthoimagery: Esri, National Map, USGS, and the GIS User Community.

Feet
0 150 300

Projected Coordinate System
Datum: NAD 1983
UTM: Zone 12N

GSI ENVIRONMENTAL

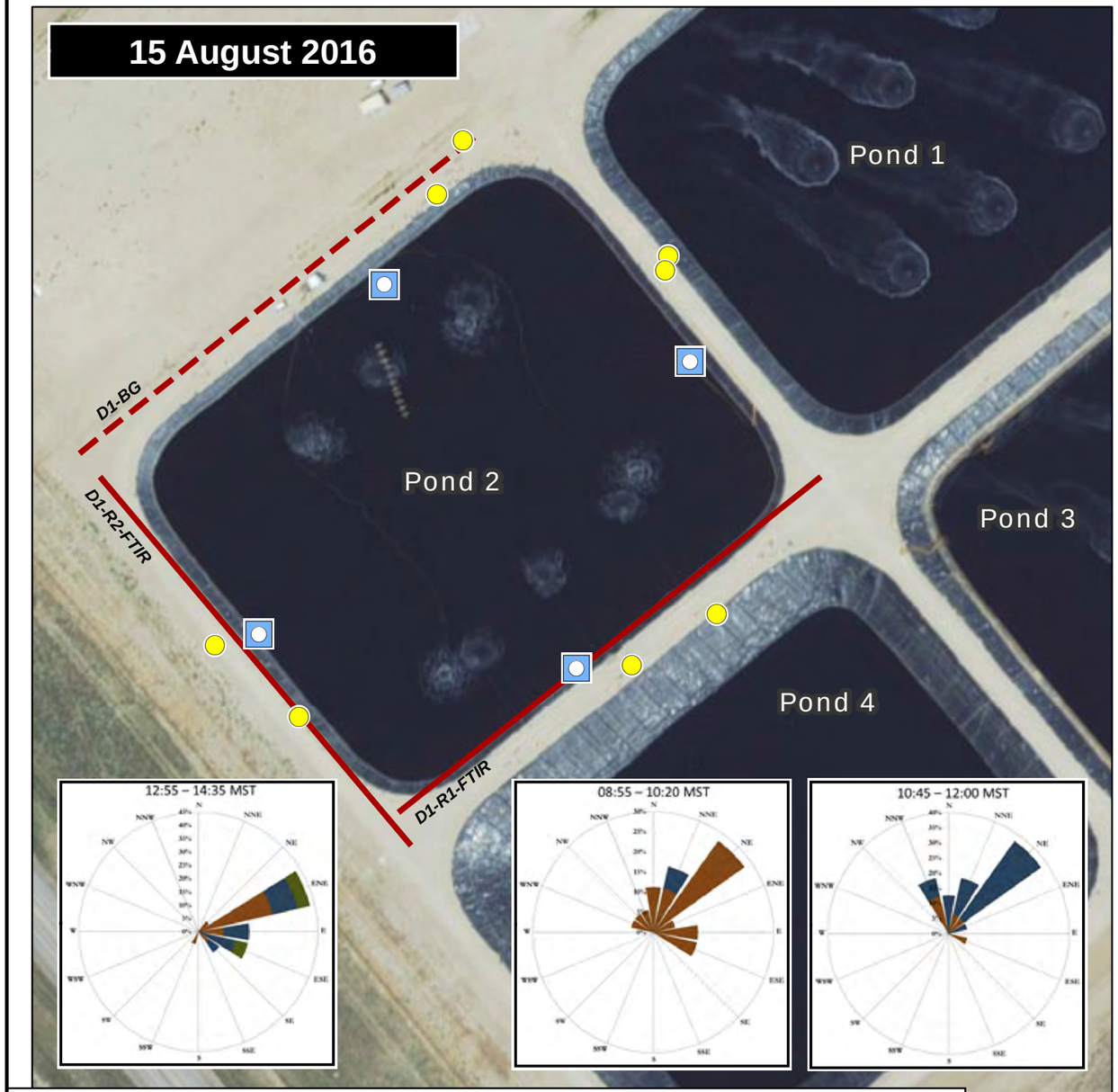
BP FACILITY SITE MAP

Disposal Pit Emission Study
Eastern Wyoming Site
Sweetwater County, Wyoming

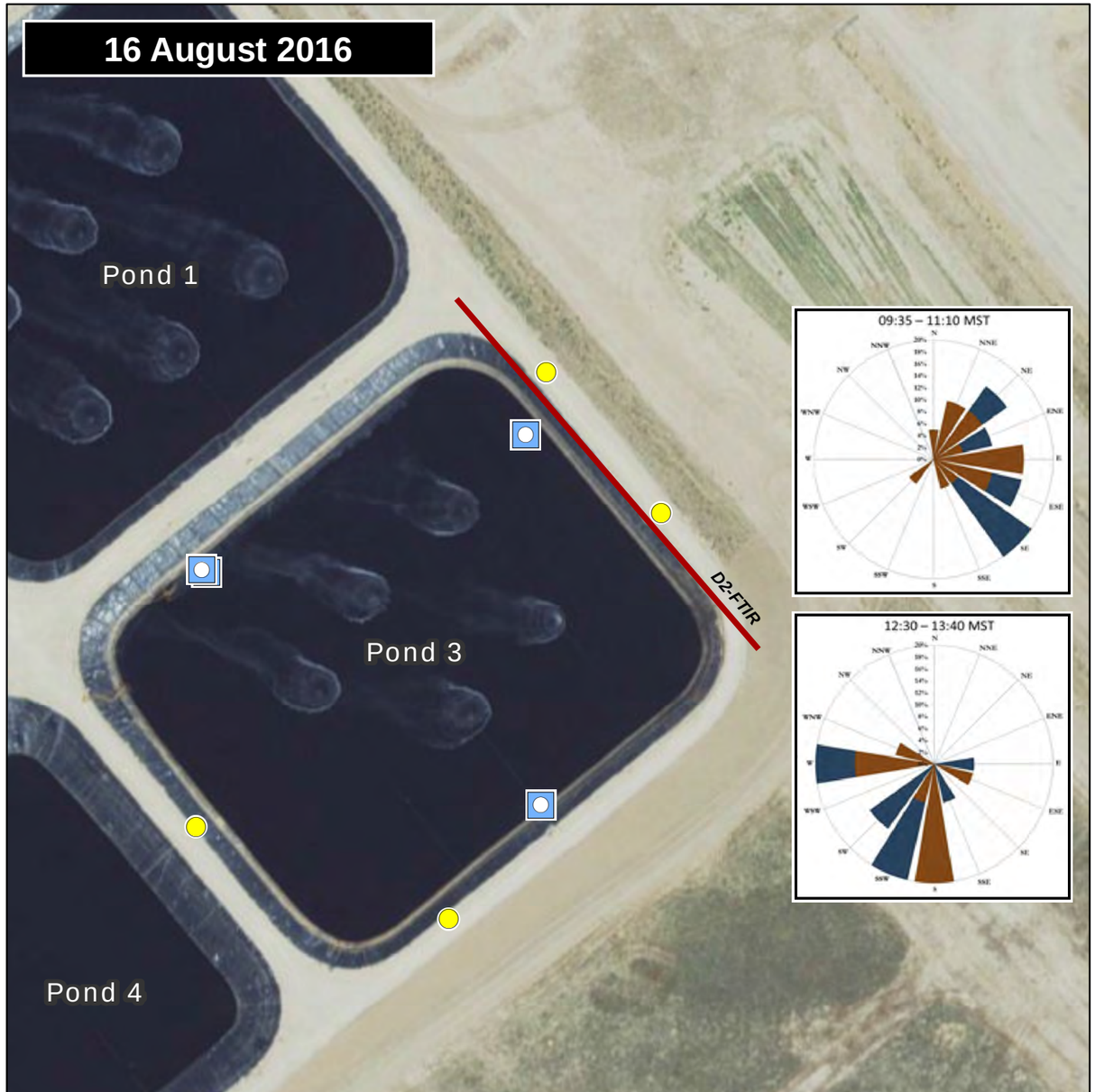
GSI Job No.	G-4194	Drawn By:	CDM
Issued:	10-Mar-2017	Chk'd By:	JAL
Map ID:	**006_01**	Appv'd By:	RLB

FIGURE 2

15 August 2016



16 August 2016



LEGEND

- Flux-Chamber and Water Sample location
- Summa Canister location
- OP-FTIR Beam Path
- Background OP-FTIR Beam Path

Wind Roses

- 4 - 6 m/s
- 2 - 4 m/s
- 0 - 2 m/s

Notes:

1. OP-FTIR = Open-Path Fourier Transform Infrared Spectrometry, BG = Background, D = Day, R = Reading.
2. Locations from the Summer 2016 sampling event.
3. Multiple measurement periods were performed on Day 1, indicated by the "R" (e.g. Reading 1) in the Sample ID.
4. Background Imagery: USGS Orthoimagery: Esri, National Map, USGS, and the GIS User Community.

GSI ENVIRONMENTAL

Scale (ft): 0 60 120

Projected Coordinate System
Datum: NAD 1983
UTM: Zone 13N

GSI Job No.	4194-115	Drawn By:	CDM
Issued:	10-Mar-2017	Chk'd By:	JAL
Map ID:	**007_01**	Appv'd By:	RLB

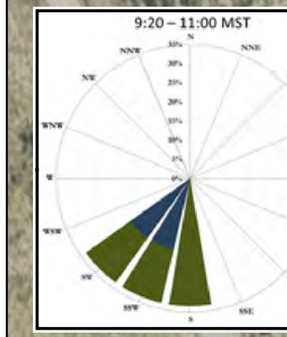
FIGURE 3

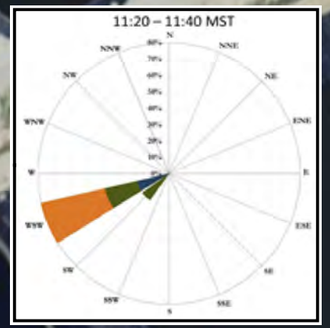
SUMMER SAMPLE LOCATIONS: GRASSLANDS FACILITY

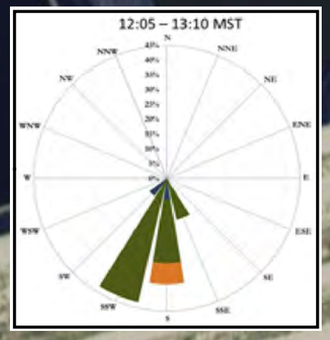
Disposal Pit Emission Study

Eastern Wyoming Site
Converse County, Wyoming

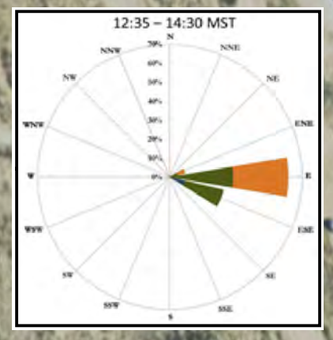
17 August 2016







18 August 2016



LEGEND

- Flux-Chamber and Water Sample location
- Summa Canister location
- OP-FTIR Beam Path
- Background OP-FTIR Beam Path

Wind Roses

- 6 - 8 m/s
- 4 - 6 m/s
- 2 - 4 m/s
- 0 - 2 m/s

Notes:

1. OP-FTIR = Open-Path Fourier Transform Infrared Spectrometry, BG = Background, D = Day, R = Reading.
2. Locations from the Summer 2016 sampling event.
3. Multiple measurement periods were performed on Day 1, indicated by the "R" (e.g. Reading 1) in the Sample ID.
4. Background Imagery: USGS Orthoimagery: Esri, National Map, USGS, and the GIS User Community.

GSI ENVIRONMENTAL

Scale (ft)
0 60 120

Projected Coordinate System
Datum: NAD 1983
UTM: Zone 13N

GSI Job No.	4194-115	Drawn By:	CDM
Issued:	10-Mar-2017	Chk'd By:	JAL
Map ID:	**007_02**	Appv'd By:	RLB

FIGURE 4

SUMMER SAMPLE LOCATIONS: BP FACILITY - WAMSUTTER

Disposal Pit Emission Study

Eastern Wyoming Site
Converse County, Wyoming