Ground Survey in Weld County for Methane Anomalies

June 28, 2016

Prepared by:

S. E. McLaren
Apogee Scientific, Inc.
2895 W. Oxford Ave., Suite 1
Englewood, CO 80110-4397

Prepared for:

Colorado Oil and Gas Conservation Commission
1120 Lincoln St. Room 801
Denver, CO 80203

Contract # PO PHAA 2016*7965

Introduction

Weld County is a major oil and gas production and agricultural area within the State of Colorado. In 2015, Weld County produced 81 million barrels of oil and over one half trillion cubic feet of natural gas, and 75 percent of the county land is devoted to farming and raising livestock. In the spring of 2016, the Colorado Oil and Gas Conservation Commission (COGCC) contracted Apogee Scientific, Inc (ASI) to conduct a natural gas seep survey of Township 3 North, 66 West in Weld County, CO. The purpose of the survey was to look for sources of natural gas escaping from the ground not associated with emissions from oil and gas production infrastructure or agricultural operations. Geologic natural gas seeps are known to exist in the Raton and San Juan Basins of Colorado as well as other areas, but have not been previously documented in Weld County. ASI has conducted similar methane seep surveys within the Raton Basin for the COGCC in 2000, 2007 and 2015.

This survey was conducted using a 4-wheel drive vehicle, similar to the one pictured in Figure 1, that was equipped with an infrared-based gas detector developed by ASI. This type of gas detector was designed to find leaks in natural gas pipelines, and is referred to as the Apogee Leak Detection System (LDS). The LDS is a three-channel instrument capable of measuring methane (CH_4), total hydrocarbons (HC), and carbon dioxide (CO_2) at sub part per million (PPM) concentrations at a speed of 10 samples per second. The vehicle was also equipped with a high accuracy GPS and wind sensor that was used to mark the locations of seeps.

Figure 1. LDS-equipped ground survey vehicle.

The survey took place between April 25, 2016 and June 1, 2016. A total of 30 hours were spent driving in the survey area, of which 18 hours was used and the remaining 12 hours of data discarded due to sustained wind speeds over 20 mph. During this time, a total of 245 miles of roads were surveyed.

Procedures

Equipment

The LDS consists of a high-speed gas analyzer that can detect methane, total hydrocarbons, and carbon dioxide in gas plumes at sub part per million concentrations. The LDS is coupled to a GPS receiver to determine vehicle location, and has a computer-based data acquisition system for data logging and display.

A comparison of the relative concentrations of the three gases helps determine the probable source of the emission being detected. For example, a plume with above background concentrations of methane and carbon dioxide will be likely coming from biological sources, such as cattle, rather than from a methane seep. In addition, the presence of elevated total hydrocarbons, carbon dioxide, and methane is an indication that exhaust from a combustion source, such as an automobile, is being sampled.

The LDS was mounted in the rear of the survey vehicle. Ambient air was collected at the front of the vehicle at a height of approximately 18 inches above the ground, passed through a filter to remove particles and other debris from the air stream, and was carried to the LDS through 2-inch diameter pipe. The delay time between gas entering the entrance of the collection system and being detected by the LDS was approximately 1 second.

The navigation system consisted of a Garmin GPS 18x GPS receiver. Output from the GPS receiver, in the form of NEMA 183B data sentences, was captured by the LDS data acquisition system which displayed the current vehicle location in real time on a map containing the path the vehicle had previously taken and all previously discovered seeps overlaid on a street map.

Wind speed and direction were measured using an Airmar PB200 ultrasonic wind sensor. The sensor was mounted at a height of 18 inches above the roof of the survey vehicle. The true wind direction was obtained by adding the apparent wind direction as measured by the wind sensor to the direction the vehicle was facing, which was obtained from the GPS. Wind speed and direction data was recorded manually with the vehicle stationary.

Data Collection

The survey vehicle was driven on public and lease roads within the survey area, as shown in Figure 2. An attempt was made to drive all of the lease roads in the area, but this was not possible due to several factors. Access to several lease roads was prevented due to locked gates, largely in the Southwest part of the survey area. In addition, access to several of the smaller lease roads that passed through farmed fields was not possible due to muddy road conditions and crops having been planted on the road. Also, it was sometime difficult to locate the infrequently used lease roads leading to well heads due to farming activities.

The procedure followed while performing this survey was to drive the survey vehicle along the road being surveyed. The LDS display and audio output would be continually checked for indications of an elevated methane concentration. When a methane plume was detected, the operator would look upwind for potential sources of the plume. Normally there would be a well head, storage tank, cow pasture, or some other obvious source for the methane plume. If no

obvious source for the methane plume was found, the spot would be marked as a possible seep location.

The survey vehicle was stopped at approximately 15-minute intervals to allow collection of wind speed and wind direction data. These measurements were made in flat, open areas where possible.

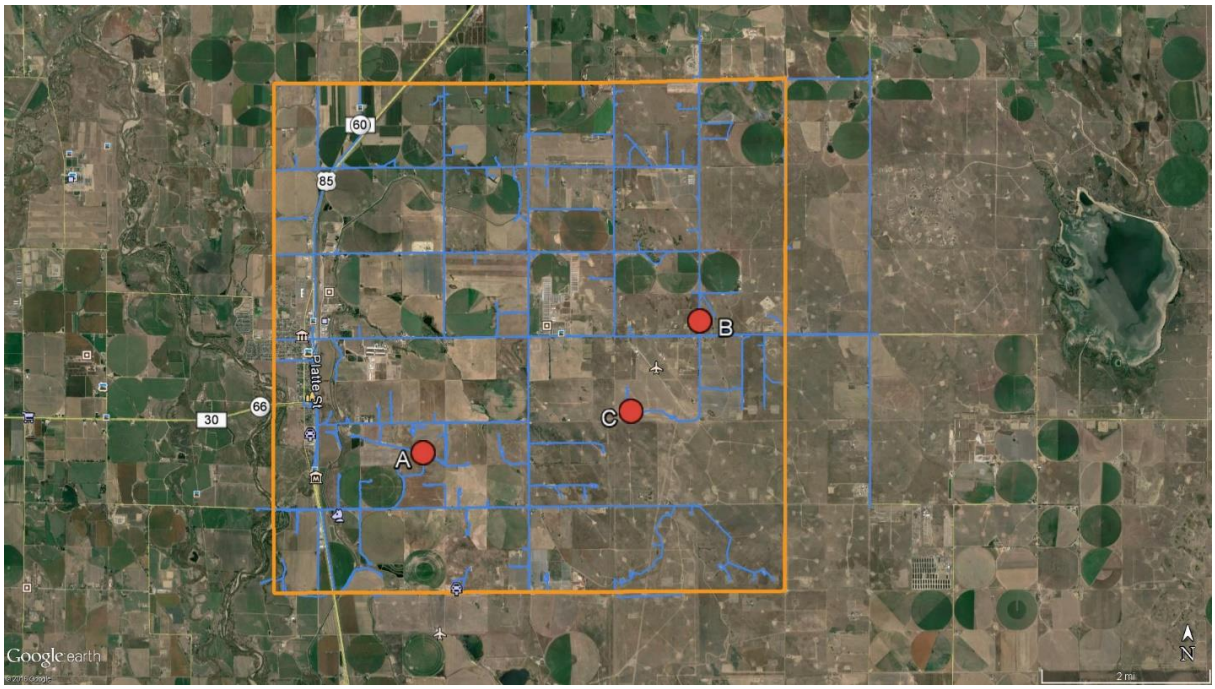

Figure 2. Map showing the survey vehicle track (blue line) and location of the three potential seeps (red dots). The orange line represents the boundary of the 36 square mile survey area.

Results

Over 100 methane plumes were encountered during the survey. The vast majority were the result of emissions from oil and gas production infrastructure. Other sources included agricultural activities and cattle. Approximately 5% of the methane plumes were attributed to non-oil and gas production operations. An example of the system response when driven downwind of a pad containing storage tanks and other natural gas processing equipment is shown in Figure 3. In this Figure, there are two distinct peaks due to two emission sources at the well pad. The methane to hydrocarbon ratio of the two peaks is slightly different, indicating two distinct emission sources. As expected for this type of emission source, there are no corresponding carbon dioxide peaks.

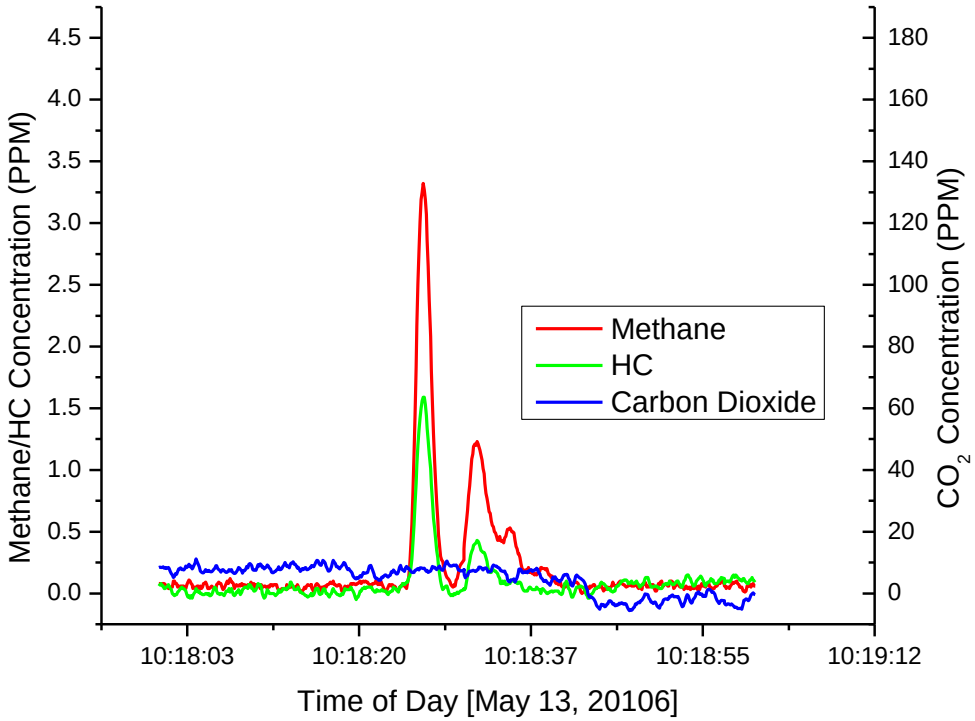

Figure 3. LDS response when driving through a plume caused by emissions from natural gas processing equipment. The two peaks are caused by two distinct emission sources.

There were three methane plumes that were encountered during the survey for which a source could not be found, and which have been labeled Potential Seep A, B and C and are described below. These are denoted to as potential seeps because the source of the methane plume could not be located, not because actual seeps have been located. It is possible, and even likely, that these methane plumes were coming from oil and gas production infrastructure but the exact source could not be located.

Potential Seep A

This potential seep was first detected on May 11, 2016 at 2:47 PM at 40.198005° north latitude and -104.796533° west longitude. The wind speed at the time of detection was 12 mph and the wind direction was 340 degrees. This potential seep was detected while driving along an approximately east-west oriented lease road as shown in Figure 4. Elevated concentrations of methane and hydrocarbons were detected along a 3600-foot-long section of the lease road indicated by the yellow line in Figure 4. The peak methane concentration measured was 4.1 ppm. A graph of the measured methane and HC concentrations while driving along the 3600-foot segment of lease road is shown in Figure 5. There is an oil and gas production facility approximately 1000 feet upwind of the seep location but detailed inspection of that equipment did not reveal any emissions that were large enough to account for the observed methane plume.

Immediately after finding the potential seep, County Road 30, which runs parallel to the lease road and approximately 1600 feet upwind was surveyed and no methane plumes detected. This indicated that the methane source was located between County Road 30 to the north and the lease road to the south. There are several pipelines located in this area that might have been leaking and causing the observed methane plume.

Figure 4. Map of Potential Seep A. The blue line is the track of the survey vehicle and the yellow line is the area where an elevated methane concentration was observed.

The site was visited again two days later on May 12. No methane plume from the potential seep was detected. The wind direction on this date was out of the north north-east compared to being out of the north north-west when the plume was originally detected. Based on these wind directions, we would expect that if the potential seep was still emitting methane during the second visit, it would have been detected.

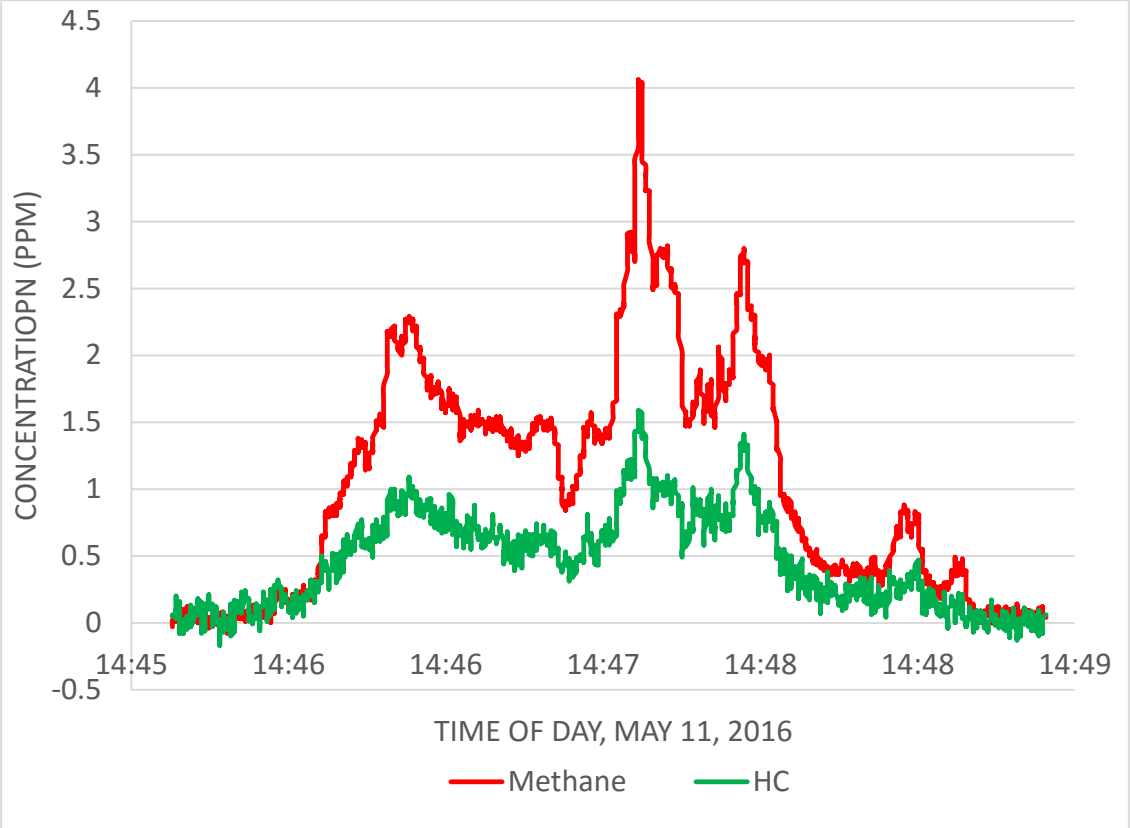

Figure 5. Graph of methane and HC concentrations while driving through the plume from Potential Seep A.

Potential Seep B

Potential Seep B was located while driving south on County Road 35 between County Road 32 and County Road 34 on May 13, 2016 at 10:33 AM. The potential seep is located at 40.220453° north latitude and -104.734773° west longitude as shown in Figure 6. The wind speed at the time of detection was 17 mph and the wind direction was 42 degrees. Multiple passes were made through the plume and the maximum methane concentration measured while traversing the plume was 0.3 ppm. The peak HC measurement was below the 0.2 ppm detection limit.

There were no obvious sources for the methane plume visible upwind of the potential seep location as shown in Figure 7. There is a gas well located approximately 1000 feet upwind of the seep location that was visited on May 11. At that time, there were no significant emissions from the well that could account for the potential seep plume observed on May 13. This site was resurveyed on June 1 and the plume from the potential seep could not be found at that time.

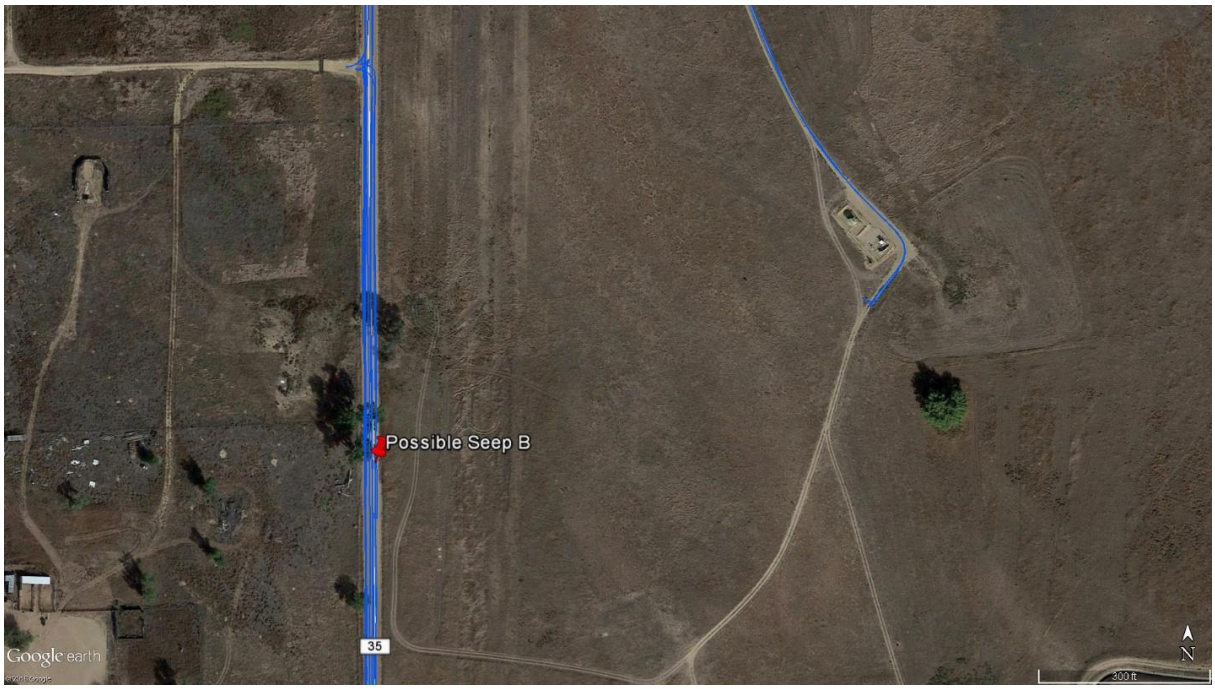

Figure 6. Map of Potential Seep B. The blue line is the track of the survey vehicle and the red dot where an elevated methane concentration was observed.

Figure 7. Photograph looking upwind (north-east) from Potential Seep B.

Potential Seep C

Potential Seep C was located while driving an east-west oriented lease road on May 13, 2016 at 11:05 AM. The potential seep is located at 40.205093° north latitude and -104.750105° west longitude as shown in Figure 8. The wind speed at the time of detection was 13 mph and the wind direction was 30 degrees. Multiple passes were made through the plume and the maximum methane concentration measured while traversing the plume was 0.6 ppm. The peak HC measurement was below the 0.2 ppm detection limit.

There were no obvious sources for the methane plume visible upwind of the potential seep location as shown in Figure 9. There is a gas well located approximately 750 feed upwind of the seep location that was not visited and could possibly be the source of the methane plume.

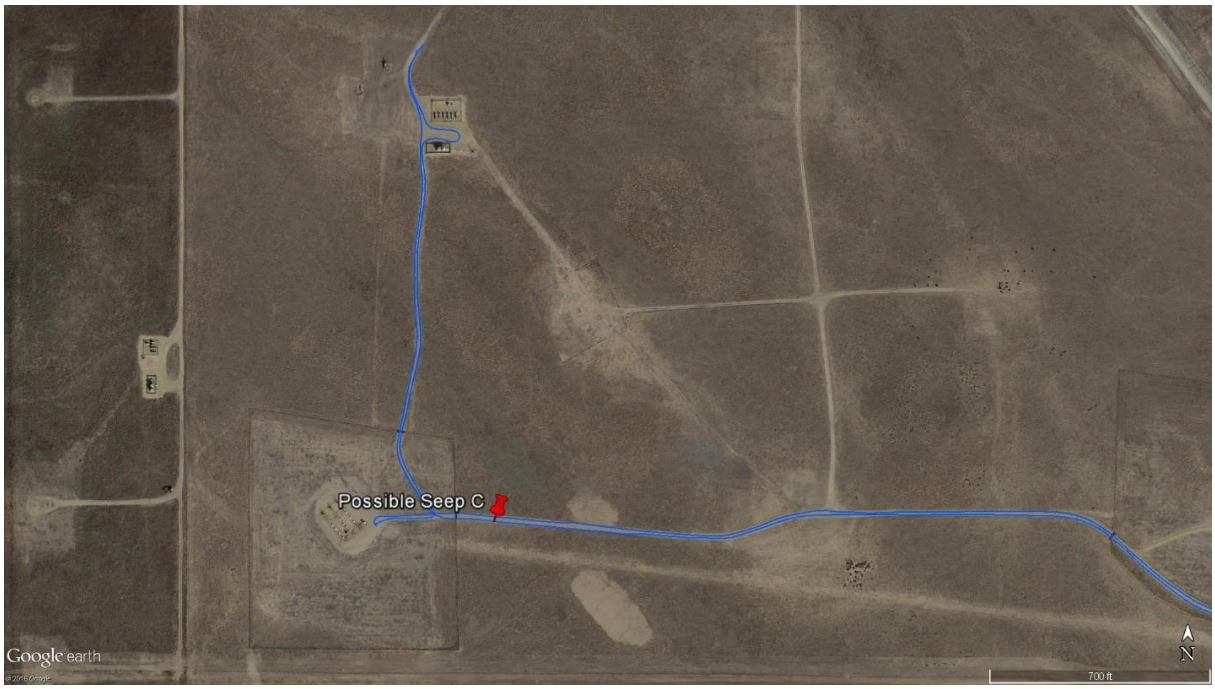

Figure 8. Map of Potential Seep C. The blue line is the track of the survey vehicle and the red dot where an elevated methane concentration was observed.

Figure 9. Photograph looking upwind (north-east) from Potential Seep C.

A companion compact disk (CD) to this report has been prepared which contains all of the data collected during this project. The contents of this CD are documented in Table I.

Table I. Contents of Supplemental Data CD

Filename	Description
Seeps.ZIP	A ZIP file containing an ESRI shapefile of the potential methane seep locations.
Seeps.xls	An EXCEL spreadsheet containing information about the potential seeps.
WindData.ZIP	A ZIP file containing an ESRI shapefile of the wind speed and direction data.
WindData.xls	An EXCEL spreadsheet containing wind speed and direction data.
Track.ZIP	A ZIP file containing an ESRI shapefile of the path driven by the survey vehicle.

Note: All shapefiles use the WGS84 geographic coordinate system with units of degrees [European Petroleum Survey Group (espg) code: 4326]

Conclusions

In the 36 square mile survey area, only three potential seeps were found. It is questionable if these three potential seeps are actual seeps or just artifacts due to emissions from the extensive oil and gas infrastructure in the area. We were not able to verify the presence of the methane plume from any of the potential seeps on later visits to Potential Seeps A and B.

It is possible that there are additional small methane seeps in the survey area that were not detected. The large fluctuations in background methane concentration due to both oil and gas infrastructure and agricultural operations in the area make detection of small seeps difficult using the type of analytical equipment used in this study.