A Community-based Short-term Ambient Air Screening Study in Garfield County for Oil and Gas Related Activities

- Results and Discussion -

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1. 0 Background and Introduction

Garfield County, located in western Colorado, is one of the largest producers of natural gas in the state. The increased drilling in this area in recent years has raised the level of concern of citizens and local officials, specifically in the vicinity of the town of Parachute. The Parachute valley is home to approximately 1,000 individuals, 600 natural gas wells, and several oil and gas companies. A local community activist group, the Grand Valley Citizens Alliance (GVCA) has been expressing concerns over the potential for adverse health effects to residents to the Colorado Oil and Gas Conservation Commission for several years.

In 2000, the GVCA acquired air toxics sampling equipment consisting of a tedlar bag in a plastic bucket, also known as the "bucket brigade". This type of sampler has been used extensively by other citizens groups in California and elsewhere to measure, with some degree of reliability and accuracy, ambient air toxics levels around facilities. Using this equipment, the GVCA sampled around one well in Garfield County (the Giles well). It is believed that this sampling was done prior to the well being equipped with the combustor device. When the results came back the GVCA requested that the U.S. Environmental Protection Agency (EPA) and the State of Colorado Air Pollution Control Division (APCD) attend a public meeting to discuss the findings The APCD and the EPA agreed and suggested that other entities should be invited including the Colorado Oil and Gas Conservation Commission and Williams Production (the major gas producer in the county). At this meeting a commitment was made that all of the groups would continue to meet and evaluate options for collecting more information. The participants then formed a cooperative work group to pursue this commitment.

At a subsequent meeting of the work group, EPA announced that resources had been identified within the agency to conduct a short-term sampling study of both air toxics and criteria pollutants at oil and gas sites within the county, with the purpose of identifying whether any threats to human health or the environment exist due to the potential impact of gaseous chemicals emitting from natural gas wells. The work group then proceeded to develop a sampling design and make arrangements to meet with community officials and Williams Production to coordinate the sampling efforts. Based on a preliminary site reconnaissance visit and the subsequent development of a sampling and analysis plan (SAP) (PRI, 2002a) and a quality assurance project plan (QAPP) (PRI, 2002b), an EPA contractor conducted sampling in June 2002. The Giles well was included in the sampling plan as well as a nearby well with similar operating parameters but with out the combustor control technology. This EPA contractor report includes all the data collected under this collaborative process. This report assesses the potential for adverse human health effects.

2.0 Data Collection and Analysis

This section discusses the general approach used to conduct the air screening activities at this site. Further details of the sampling design and methods can be found in the SAP, QAPP and Final Report for the investigation (PRI, 2002a, 2002b, 2002c).

Based on the available sampling equipment and analysis costs, it was determined that a total of 20 air samples would be collected from seven locations, including one location selected as a background site (based on an absence of any nearby natural gas wells). The background sample was a single 24-hour sample collected from a location in the town of New Castle, located approximately 30 miles east of Parachute. The remaining sampling locations were located within the Parachute valley and included; two natural gas wells, a residential location, an active flare location, and locations in the valley near New Castle and near Parachute.

Samples were collected using 6-liter SUMMA canisters with flow regulators calibrated for either 24-hour or 8-hour collection periods. The two natural gas wells are referred to in this report as the Giles well and the Savage well. Both wells are located between Parachute and Rifle, Colorado. However, the Giles well is equipped with an emissions control device, allowing for a comparison of chemical concentrations observed both with and without emissions control devices. Operating parameters of both gas wells, as provided by Williams Production, are presented in Table 1. A total of six 8-hour samples were collected at each of the natural gas wells. Four were collected at a distance of approximately 50 feet in each cardinal direction (north, south, east, and west) from the fence line surrounding each respective well, and the remaining two were collected at approximately 300 feet North and South of each fence line. A single 24-hour sample was collected at the residential location, located approximately ½ mile from the Savage well. At the active flare location, a total of four 8-hour samples were collected at a distance of approximately 110 feet in each cardinal direction from the surrounding fence line. Lastly, 24-hour samples were collected at both up- and down-valley locations in the Parachute valley. The air samples collected using these SUMMA canisters were analyzed for volatile organic compounds (VOCs) by gas chromatography using EPA method TO-14A.

In addition to the collection of samples for VOC analysis, four continuous air monitors were placed at the active flare site (at the same locations as the SUMMA canisters) in order to evaluate ambient air concentrations of nitrogen oxides and sulfur dioxide.

Meteorological data were collected at the Savage well location using a portable monitoring station. Data were collected on wind speed, wind direction, temperature, and relative humidity for a 24-hour period.

3.0 Results

Data were collected for VOCs, sulfur dioxide and nitrogen oxides, and meteorological data. The complete analytical results are included in the Final Report submitted by the EPA contractor (PRI, 2002c), which has been attached as an Appendix to this report.

3,1 Volatile Organic Compounds (VOCs)

Six VOCs out of a total of 42 VOCs analyzed, had detectable concentrations identified in one or more of the analyzed samples. The remaining 36 VOCs were below reported detection limits in all samples. Those chemicals with detectable concentrations were acetone, methyl ethyl ketone, benzene, toluene, m,p-xylene and o-xylene. Analytical results for these 6 chemicals are provided in Table 2. To summarize the table:

1. Acetone was detected in all twenty samples, with concentrations ranging from 14 to 31 micrograms per cubic meter (ug/m3). Acetone is a compound that is typically found in all VOC sampling and may be an artifact of reactions within the sampling canister or formed in the ambient air as a secondary product. It is also found in motor vehicle exhaust, tobacco smoke and wood burning, and is given off by plants.
2. Methyl ethyl ketone (MEK, or 2-butanone) was detected in 11of 20 samples, with concentrations ranging from 1.7 to 4.0 ug/m3. MEK is found in vehicle exhaust, solvents, resins, paints and tobacco smoke, and is also produced in forest fires and from biological degradation.
3. Benzene was detected in 6 of 20 samples, with concentrations ranging from 2.2 to 6.5 ug/m3. Benzene is found in motor vehicle exhaust, gasoline, petroleum products, tobacco smoke and solvents. It is also produced in forest fires and by plants.

4. Toluene was detected in 18 of 20 samples, with results ranging from 1.5 to 17.0 ug/m3. Toluene is primarily found in motor vehicle exhaust, gasoline, petroleum products and solvents,
5. m- and p-Xylenes were detected in 11 of 20 samples at concentrations between 2.4 - 13.0 ug/m3. Xylene is primarily found in motor vehicle exhaust, gasoline, petroleum products, solvents, paints and landfill gas.
6. o-Xylene was detected in one sample at a concentration of 2.1 ug/m3. Xylene is primarily found in motor vehicle exhaust, gasoline, petroleum products, solvents, paints and landfill gas.
7. The background sample from New Castle contained acetone (21 ug/m3), toluene (7.0 ug/m3), and m- and p-xylenes (2.4 ug/m3).

As discussed previously, air samples were collected at two natural gas wells, one of which (Giles well) has an emissions control device. From the results it appears that the benzene levels emitted from the two facilities are different, with the Savage Well (the non-emission controlled well) being higher (Figure 1). The levels of the other compounds, toluene and xylene, are similar. Participants are reviewing the data to explain why the emissions data for these other chemicals are not similarly reduced.

3,2 Sulfur Dioxide and Nitrogen Oxides

Continuous air monitoring data for sulfur dioxide, nitric oxide, and nitrogen dioxide at the flare location resulted in detection of sulfur dioxide at 0.2ppm at the eastern sample point. Sulfur dioxide levels were present from approximately 4:30PM to 6:36PM at this location. The remaining three monitors resulted in no detection during the sampling period.

3,3 Meteorological Data

Meteorological data collected during the sampling period show that the predominant wind direction was from the West/Southwest from 11:00AM to 8:00PM. The predominant wind direction was from the South/Southeast from 8:00PM to 10:00AM. Wind speed was highest during the period between 1:30PM and 8:00PM, averaging approximately 7mph (miles per hour) and ranging from 3.4 to 11.2mph. Relative humidity averaged 31%, with ranges from 14% to 59%, with the highest percentages of humidity occurring during late evening and early morning hours. No precipitation was accumulated during the sample period.

4.0 Analysis

In order to evaluate the potential for adverse health effects as a result of exposure to VOCs emitted from natural gas wells in Garfield County, Colorado, a screening approach was utilized. This approach compares the maximum detected concentration of a chemical from this study with a risk-based (RBC) concentration. The RBCs are conservative risk-based concentrations derived from equations combining residential exposure information assumptions with USEPA toxicity data. Under most circumstances, the presence of a chemical in air at concentrations below the corresponding RBC can be assumed to not pose a significant threat to human health. The presence of chemicals at concentrations above the RBCs does not necessarily indicate that a significant risk exists. However, it does generally indicate that further evaluation and investigation, but not necessarily cleanup, is warranted.

The toxic effects of a chemical generally depend not only upon the inherent toxicity of the compounds and the level of exposure (dose), but also on the route of exposure (oral, inhalation, dermal) and the duration of exposure (sub-chronic, chronic or lifetime). Thus, a full description of the toxic effects of a chemical includes a listing of what adverse health effects the chemical may

cause, and how the occurrence of these effects depend upon dose, route, and duration of exposure. The toxicity assessment process is usually divided into two parts: the first characterizes and quantifies the non-cancer effects of the chemical, while the second addresses the cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the time-course of action and the shape of the dose-response curve for cancer and non-cancer effects.

Non-cancer risks are described in terms of the ratio of the dose at the site divided by a dose that is believed to be safe. This ratio is referred to as the Hazard Quotient (HQ). If the HQ is equal to or less than a value of 1, it is believed that there is no appreciable risk that non-cancer health effects will occur. If an HQ exceeds 1, there is some possibility that non-cancer effects may occur, although an HQ above 1 does not indicate an effect will definitely occur. However, the larger the HQ value, the more likely it is that an adverse health effect may occur. If more than one chemical affects the same target tissue or organ system (e.g., the liver), then the total risk of adverse effects in that tissue is referred to as the Hazard Index (HI), and is estimated by summing the HQ values for all chemicals that act on that tissue. According to EPA policy, action is generally not warranted unless non-carcinogenic risks exceed a hazard index of 1.0 (USEPA, 1991a).

Benzene was the only chemical detected at this site listed by EPA as an inhalation carcinogen. Risk of cancer from exposure to benzene is described in terms of the probability that an exposed individual will develop cancer because of that exposure by age 70. The level of cancer risk that is of concern is a matter of individual, community and regulatory judgment. However, the USEPA typically considers risks below 1 in a million (1E-06) to be so small as to be negligible, and risks above 100 per million (1E-04, also expressed as 1 in 10,000) to be sufficiently large that some sort of action or intervention is usually needed (USEPA, 1991a).

A site-specific risk assessment is an evaluation of the risk posed by exposure to site contaminants in various media. At this stage in the investigation, a forward-going risk assessment was not conducted. Rather a screening level approach was applied to evaluate which, if any, chemicals posed a potential health threat to residents of Garfield County. To calculate RBCs, the exposure equations and pathway models are run in reverse to back calculate an “acceptable level” of a contaminant in air. Toxicity criteria were used to define an acceptable level of contamination in air, based on a range (one-in-a-million (1E-06) to 100 per million (1E-04)) of individual excess cancer risk for carcinogens and a hazard quotient (HQ) of 1 for non-carcinogens. The exposure values were based on “standard” residential exposure scenarios, which assume that exposure to gaseous emissions via inhalation will occur over a period of 350 days/year for 30 years. The values used as RBCs for this investigation were ambient air concentrations from the USEPA Region 9 PRG table (EPA, 2002), which were developed using the approach described above.

The maximum detected concentrations for the VOCs were then compared to these residential RBC values to determine if measured concentrations at the site were above or below these “safe” levels. This comparison is shown in Table 3.

As seen, all of the maximum reported concentrations for non-carcinogenic VOCs are below their corresponding RBC values, based on a non-cancer hazard index of 1.0. This indicates that concentrations measured within the Parachute valley do not pose significant health risks to area residents. Only one carcinogen, benzene, was measured in air at detectable levels during this investigation. Comparison of the maximum detected concentration of benzene (6.5 ug/m^3) to the risk-based range (0.23 to 23 ug/m^3), shows that the measured maximum concentration lies between the lower end of the range (0.23 ug/m^3), based on a cancer risk of one per million, and the higher end of the range (23 ug/m^3), based on a cancer risk of one-hundred per million.

In addition to evaluating the concentrations of chemicals detected in this investigation for human health risks, a side exercise was conducted to compare the concentrations observed in Garfield

County with measured concentrations in Grand Junction and Denver. Results of this comparison are shown in Table 4 and Figure 2 (benzene only).

In looking at Table 4 it is important to note the different sampling methodologies used in the collection of the data presented. The GVCA sampling was performed by taking a grab sample, or a short time period sample. The sample was collected over just a few minutes by pulling air into a Tedlar bag. In comparison, all of the other sampling followed EPA methods TO-14 and TO-15 guidelines using Summa-polished stainless steel canisters, with the air being drawn in at a continuous rate over a long time period. The advantage of a grab sample is that it is quick and easy. The advantage of a long sample is that it provides a more realistic idea of what people may be exposed to. With the equipment, the advantage of a Tedlar bag is that it is cheap and easy. The advantage of a Summa canister is that it is less prone to gas diffusion and organic reactions on the walls.

In Denver and Grand Junction, the data reported in this report and the sampling were done at established monitoring stations that had been previously selected to meet EPA air monitoring criteria for urbanized areas In Denver and Grand Junction, the sampling is done at established monitoring stations that had been previously selected to meet EPA air monitoring criteria for urbanized areas. The monitoring in Denver was performed as part of EPA's Urban Air Toxics Monitoring Project to examine concentrations of air toxics in large urban areas. Sampling was conducted every sixth day for over a year at a site in Denver that is heavily influenced by motor vehicles and commercial activity. Sampling in Grand Junction was performed as part of EPA's Urban Air Toxics Pilot Project to look at a wide range of air toxics, including small cities and more rural areas. Sampling was conducted every sixth day at two locations, one that was primarily influenced by motor vehicles and one that was primarily influenced by industrial activities. For both studies, sampling for VOCs was performed using Summa canisters that collected an air sample over 24 hours, and analysis following EPA method TO-15 guidelines

5.0 Discussion

The collaborative process used in this study no doubt enhanced the credibility of study design used to collect appropriate samples. Through the coordination amongst the parties, better information was incorporated in the sample design and an effort was made to pinpoint potential sources of release and capture these events in the sampling process.

Based on an evaluation of the data collected during this investigation, none of the non-carcinogenic VOCs detected were at concentrations that would pose a significant health risk to area residents. The maximum detected concentration of benzene, a carcinogenic chemical, was found to be within a range of risk generally considered acceptable by both EPA and the State. However, as discussed previously, the level of acceptable risk is generally a matter of individual, community and regulatory judgment. Because benzene was detected at a concentration above that equivalent to a 1 per million risk (1E-06), this chemical may warrant further review pertaining to exposure scenario assumptions and typical exposure concentrations.

It is important to consider that when evaluating human health risks associated with chemical exposures, there are a number of considerations. It is important to consider not only the concentrations of chemical(s), but also the sampling locations being representative in terms of realistic human exposure scenarios. If human receptors (residential, occupational, recreational, or otherwise) do not come in contact with the chemical(s), then the exposure cannot be considered complete. In the case of an incomplete exposure pathway, the risk of adverse health effects cannot be evaluated." The values collected in this report were screened using an assumption that area residents would be in contact with maximum concentrations of these chemicals for a period of 350 days/year over 30 years. Based on the location of several of these samples, this is considered to be an overly conservative assumption. In terms of the results

presented in the Final Report (PRI, 2002c), a comparison of benzene concentration and distance from natural gas wells indicates, not surprisingly, that the highest concentrations of benzene were detected at the sampling sites located nearest the gas wells (50 feet). In fact, benzene was below detectable levels at sampling sites located 300 feet from the gas wells. In other words, risks are predicted to decrease as distance from a source increases. However, even at maximum concentrations, the risks were found to be within a range generally deemed acceptable by EPA and the State.

However, it is important to note that benzene also was detected at the sampling site near the VFW building parking lot in the town of Parachute. Although lower than the benzene levels reported from the urban areas of Denver and Grand Junction, some type of further investigation down-valley in the town of Parachute and perhaps rural locations elsewhere, would be important to better characterize the nature and extent of areas being impacted by natural gas well emissions and their fate and transport in the environment. This may be a difficult and complex task as benzene and other VOCs are emitted from many other sources such as motor vehicles and refueling operations. (See Table 4 and Figure 3 below.)

Based on the results reported, benzene levels are lower at the well where control equipment is in place. However, levels measured are much lower than the GVCA sample conducted earlier. It is unclear why benzene is the only compound that showed a reduction over the well where emissions are not controlled. Perhaps, this may be a function of the design of the combustion chamber and the combustion temperatures

6.0 Conclusions

The main objectives of the study were achieved. The sampling was sufficient to conduct a risk screening analyses. Two methodologies were used by the CDPHE and EPA and the conclusions were the same.

The cooperative nature of this project has been positive and the development of supplemental analyses and other comparisons have added depth to the findings in the report

There should be some follow up information developed on nearby benzene emission sources near the Parachute – VFW monitoring site. Certainly, the presence of mobile and area source emissions need to be evaluated.

7.0 References

Project Resources Inc. (PRI), 2002a, Sampling and Analysis Plan for the Site Screening Activities, Garfield County, Colorado; May 21, 2002.

Project Resources Inc. (PRI), 2002b, Quality Assurance Project Plan for the Site Screening Activities, Garfield County, Colorado; May 21, 2002.

Project Resources Inc. (PRI), 2002c, Final Report for the Site Screening Activities, Garfield County, Colorado; July 31, 2002.

U.S. Environmental Protection Agency (EPA) 2002. Region 9 PRGs Table 2002 Update. October 2002. http://www.epa.gov/region09/waste/sfund/prg/index.htm

U.S. Environmental Protection Agency (EPA) 1991a, Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER Directive 9355.0-30. Office of Solid Waste and Emergency Response, Washington, DC 20460. April 1991.

U.S. Environmental Protection Agency (EPA) 1991b, Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals. OSWER Directive 9285.7-01B. Office of Solid Waste and Emergency Response, Washington, DC 20460. December 1991.

Table 1. Comparison of gas well parameters		
Location	**Giles well**	**Savage well**
Condensate and water throughput	0.55 BPD avg. condensate 9.25 BPD water	0.43 BPD avg. condensate 1 BPD water
Flashing Frequency	Several times per day (combustor operates continuously)	Several times per day (no combustor present)
Gas dehydration	Diethyl glycol and supplemental combustion	Diethyl glycol and **no** supplemental combustion
Compression	None at wellhead site	None at wellhead site
Gas production	307,000 SCF/D	188,000 SCF/D

BPD = Barrels per day
SCF/D = Standard cubic feet per day

Table 2. Garfield County Monitoring Results

Site	Acetone ug/m3	MEK ug/m3	Benzene ug/m3	Toluene ug/m3	m/p-Xylene ug/m3	o-Xylene ug/m3	Duration/Period
New Castle (Background site)	21	ND	ND	7.0	2.4	ND	5/29-30/02 24:05 hrs
Residential (out-of-town)	24	2.4	ND	3.5	ND	ND	5/29-30/02 24:03 hrs
Parachute (VFW Building)	25	2.4	2.2	6.9	3.4	ND	5/29-30/02 23:55 hrs
Unocal ManCamp (Parachute Creek)	23	2.2	ND	4.1	2.8	ND	5/29-30/02 24:00 hrs
Completion Flare - North	18	2.1	ND	ND	ND	ND	5/29/02 8:13 hrs
Completion Flare - East	14	ND	ND	3.0	ND	ND	/29/02 8:14 hrs
Completion Flare - South	15	1.7	ND	1.5	ND	ND	5/29/02 8:05 hrs
Completion Flare - West	21	4.0	ND	4.5	4.0	ND	5/29/02 8:15 hrs
Giles Well - EC - N - 50'	19	ND	4.4	17.0	17.0	ND	5/29/02 7:59 hrs
Giles Well - EC - E - 50'	13	ND	ND	2.1	ND	ND	5/29/02 7:59 hrs
Giles Well - EC - S - 50'	22	ND	ND	2.5	ND	ND	5/29/02 8:16 hrs
Giles Well - EC - W - 50'	26	2.3	ND	4.1	2.9	ND	5/29/02 8:13 hrs
Giles Well - EC - N - 300'	25	2.6	ND	3.3	2.4	ND	5/29/02 8:00 hrs
Giles Well - EC - S - 300'	19	ND	ND	ND	ND	2.1	5/29/02 8:00 hrs
Savage Well - NEC - N - 50'	17	ND	6.5	16.0	13.0	ND	5/29-30/02 7:50 hrs
Savage Well - NEC - E - 50'	19	2.9	2.2	4.7	2.7	ND	5/29-30/02 7:55 hrs
Savage Well - NEC - S - 50'	22	2.9	3.7	9.1	6.4	ND	5/29-30/02 7:57 hrs
Savage Well - NEC - W - 50'	31	2.4	2.2	4.4	2.5	ND	5/29-30/02 7:50 hrs
Savage Well - NEC - N - 300'	12	ND	ND	1.9	ND	ND	5/29-30/02 7:52 hrs
Savage Well - NEC - S - 300'	14	ND	ND	2.9	ND	ND	5/29-30/02 7:51 hrs
Trip/Method Blank	ND	ND	ND	ND	ND	ND	05/30/02
Lab reporting limit	1 - 2	1 - 2	1 - 2	1 - 2	1 - 2	1 - 2	---
GVCA - Giles proximal - NEC	34.0	3.5	16.0	60.0	22.0	2.7	5/22/00 (grab @ 12:30)
GVCA - Giles @ 150' - NEC	22.0	4.3	1.7	12.0	4.6	1.0	5/22/00 (grab @ 12:54)
Lab reporting limit	1	1	1	1	1	1	---

NOTES:

Throughput:

Gas well - Emissions Controls (EC): Giles Well = 292,900 SCF/D for May 29, 2002 and 315,400 SCF/D for May 30, 2002

Gas well - No Emissions Controls (NEC): Savage Well = 200,600 SCF/D for May 29, 2002 and 185,100 SCF/D for May 30, 2002

Sites:

New Castle (Background site) = Congregational Church of Christ, 131 6th St., New Castle

Residential (out of town) = 4510 CR 320

Parachute (VFW yard) = VFW Post 5485, Parachute

Unocal ManCamp - Williams Production (Parachute Creek) = CR 215

GVCA = Grand Valley Citizens Alliance = previous grab-sample study

Table 3. Comparison of Garfield Air Monitoring Concentrations to Risk Based Screening Levels

Chemical	Maximum Detected Concentration ug/m^3■	Risk Based Ambient Air Concentration ug/m^3✋	Basis	Does Maximum Detected Concentration Exceed Risk Based Concentration?
ACETONE	31	365	N	NO
METHYL ETHYL KETONE (2-BUTANONE)	4	1043	N	NO
BENZENE	6.5	0.23 – 23.1	C	WITHIN RANGE
TOLUENE	17	402	N	NO
m,p-XYLENES	13	106	N	NO
O-XYLENE	2.1	106	N	NO

C = Cancer (Risk Range = 1E-06 to 1E-04)
N = Non-cancer (HQ = 1.0)

■ This column lists the maximum detected concentration identified in this study
✋ Risk Based Ambient Air Concentrations were obtained from EPA, 2002 and are based on inhalation for 350 days/yr for 30 years

Table 4. Garfield County – Comparison of Towns / Non-Well

Site	Acetone ug/m3	MEK ug/m3	Benzene ug/m3	Toluene ug/m3	m/p-Xylene ug/m3	o-Xylene ug/m3	Duration/Period
New Castle (Background site)	21	ND	ND	7.0	2.4	ND	05/29-30/2002 24:05 hours
Residential (out-of-town)	24	2.4	ND	3.5	ND	ND	05/29-30/2002 24:03 hours
Parachute (VFW Building)	25	2.4	2.2	6.9	3.4	ND	05/29-30/2002 23:55 hours
Unocal ManCamp (Parachute Creek)	23	2.2	ND	4.1	2.8	ND	05/29-30/2002 24:00 hours
Grand Jct - MCHD - avg	10.29	2.30	2.87	13.95	12.08	3.67	05/2001 - 04/2002 average
Grand Jct - MCHD - max	23.99	14.63	8.70	125.35	147.54	42.08	05/2001 - 04/2002 24-hr. Max.
Grand Jct - MCTS - avg	8.18	2.81	2.12	10.03	10.17	4.12	05/2001 - 04/2002 average
Grand Jct - MCTS - max	44.30	9.23	6.76	35.38	62.16	17.97	05/2001 - 04/2002 24-hr. Max.
Denver - CAMP - avg	8.15	3.52	3.38	9.05	4.48	2.07	09/2000 - 12/2001 average
Denver - CAMP - max	21.96	11.78	9.12	26.03	13.24	5.87	09/2000 - 12/2001 24-hr. Max.

NOTES:

New Castle (Background site) = Congregational Church of Christ, 131 6th St., New Castle
Residential (out of town) = 4510 CR 320
Parachute (VFW yard) = VFW Post 5485, Parachute
Unocal ManCamp - Williams Production (Parachute Creek) = CR 215
Grand Jct - MCHD = Mesa County Health Dept., 515 Patterson Rd., Grand Junction (vehicle/residential influence)
Grand Jct - MCTS = Mesa County Traffic Services = 925 4th Ave., Grand Junction (industrial influence)
Denver - CAMP = 2105 Broadway, Denver (vehicle/commercial influence)

Figure 1. Comparison of Benzene levels measured at the two wells

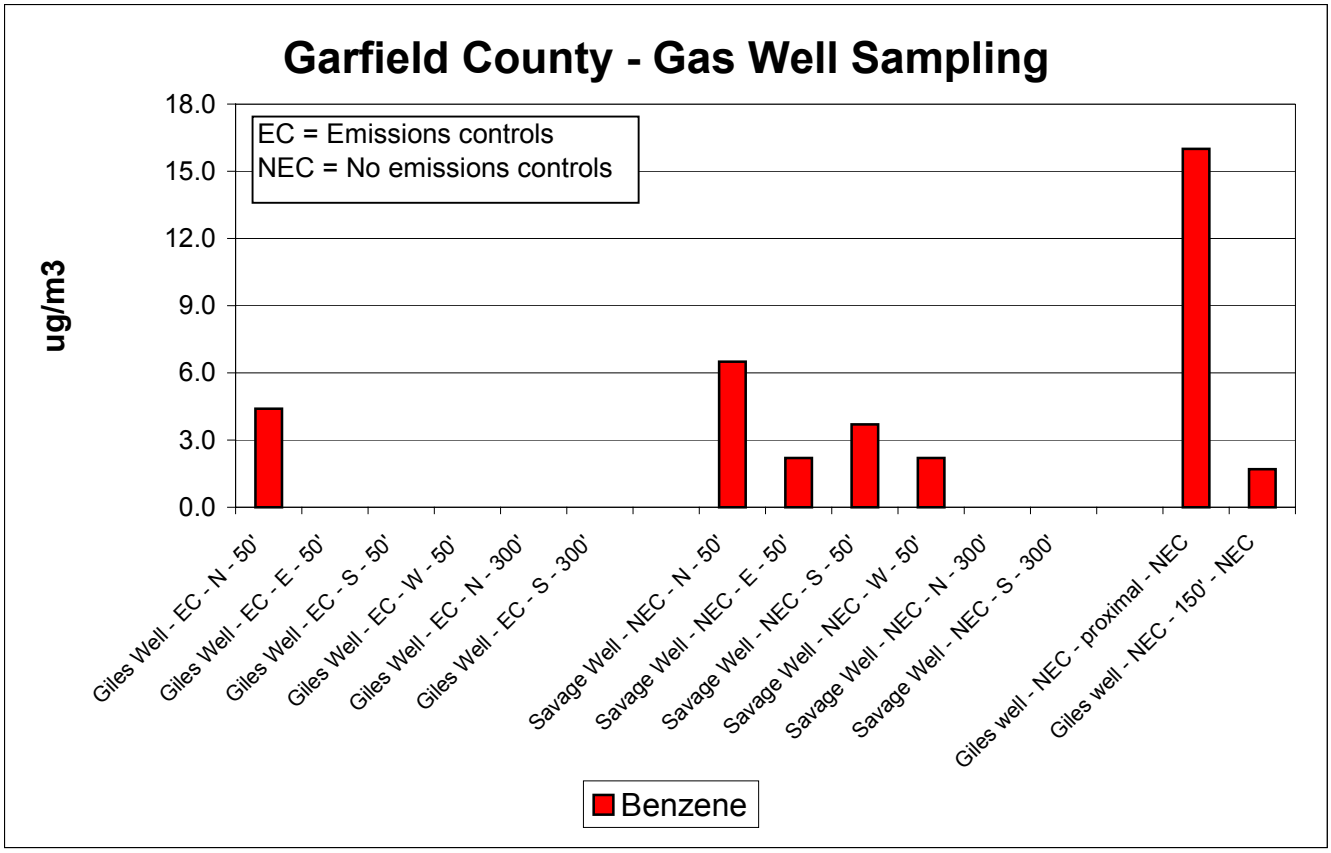

Figure 2. Comparison of Parachute, background and urban average and max. levels

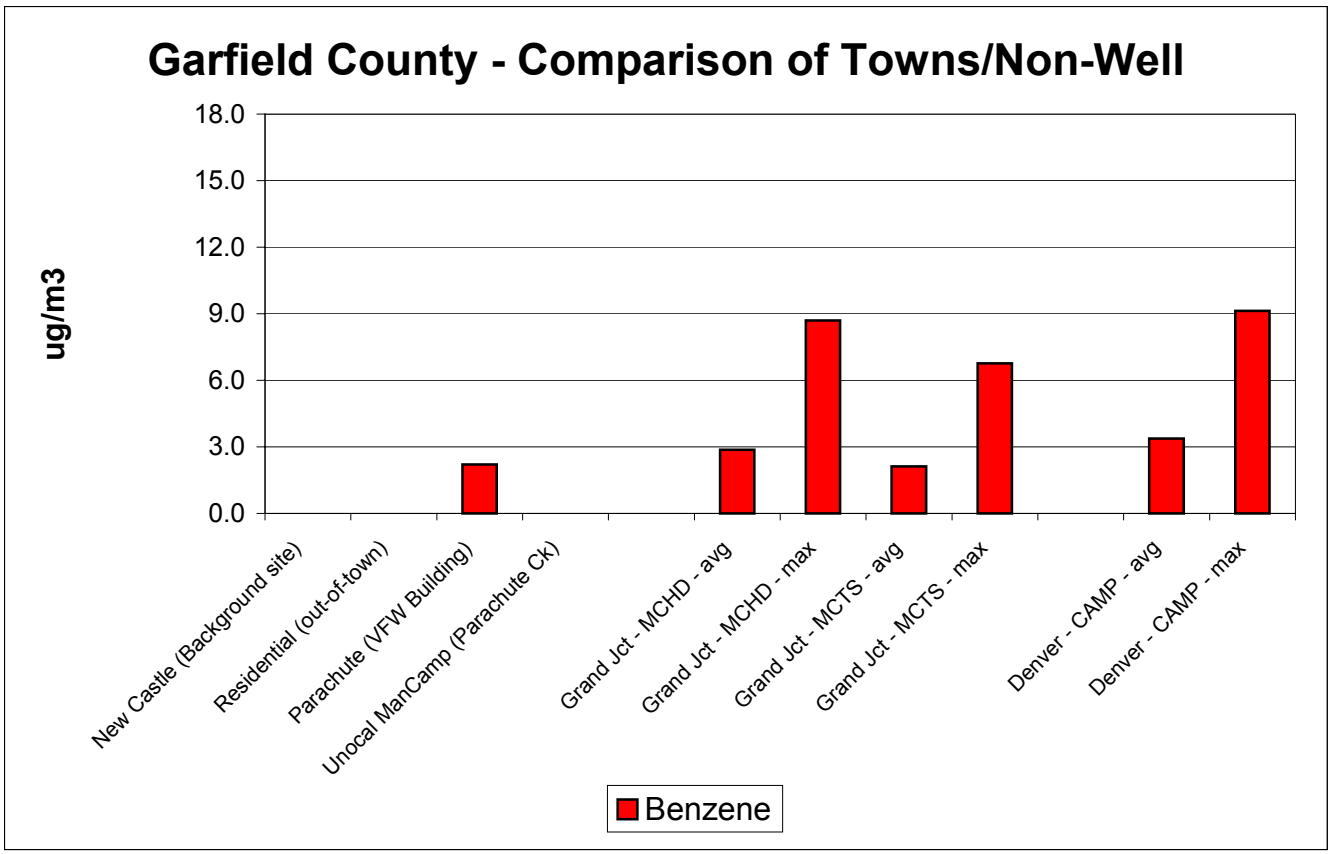

Figure 3. Maps of Garfield County monitoring locations

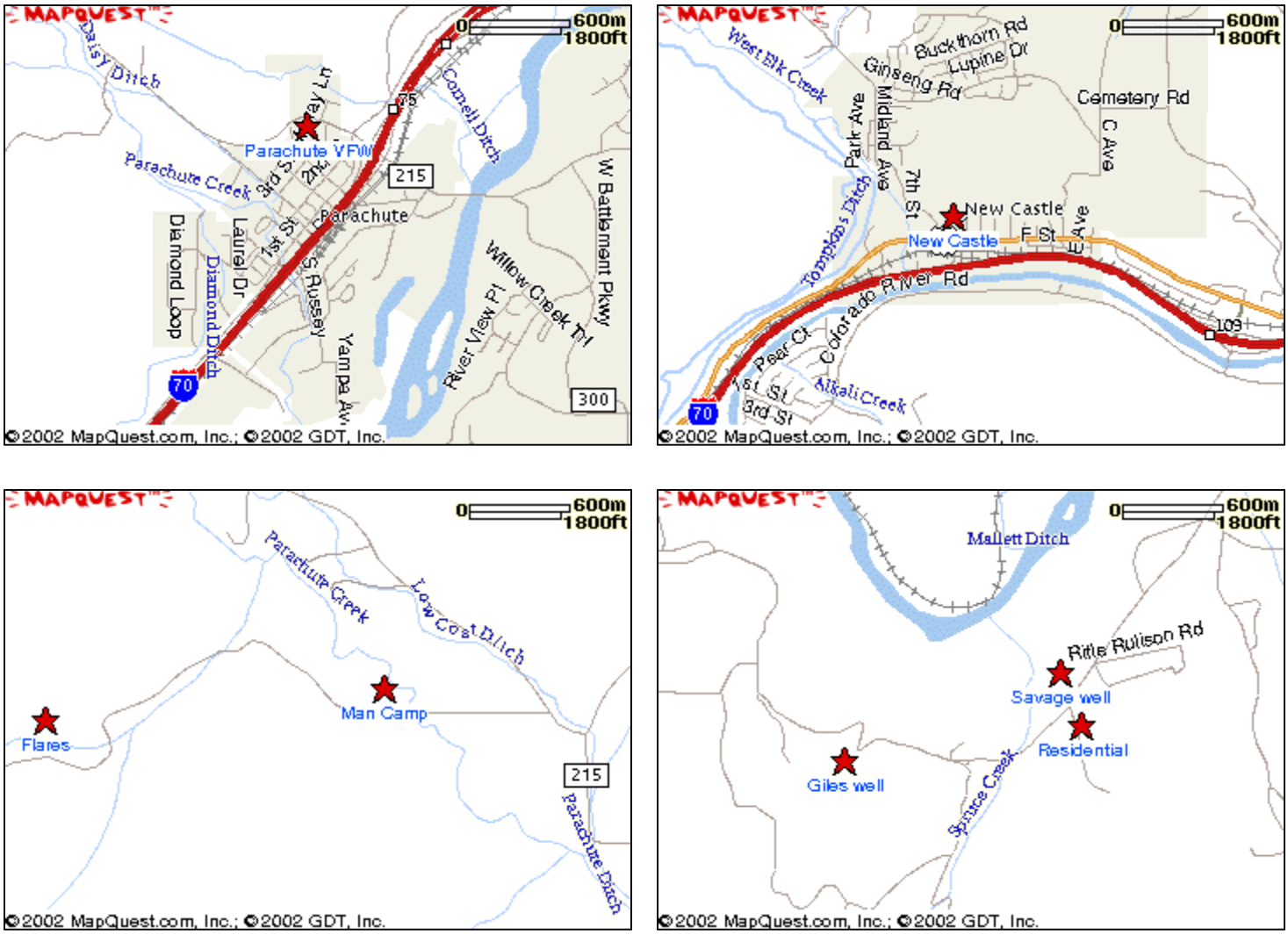

Figure 4. Maps of other CDPHE-APCD monitoring locations