STATE OF COLORADO
OIL & GAS
CONSERVATION COMMISSION

June 24, 2008

Certified Mail Return Receipt Requested # 7007 1490 0000 6634 5327

Ms. Jennifer Woodward
PO Box 632
Trinidad, CO 81082

RE: Complaint 200130491
Water Well Analysis
Well Permit 191959
SWSW 10 34S, 65W Las Animas County, Colorado

Dear Ms. Woodward:

In response to your concerns regarding possible impacts to water quality from coal bed methane (CBM) operations in the area near your home, the Colorado Oil and Gas Conservation Commission (COGCC) conducted a field visit to your property on April 30, 2008. Water samples were collected for general inorganic water quality testing as well as for analysis of dissolved methane and BART kit tests. A summary of the results of the chemical and bacterial analyses is presented below. The analytical results are also compared to published water quality standards and to results of prior testing of water from your well.

FIELD TESTING

I visited your property on April 30, 2008 and we walked to your domestic water well so that I could determine if methane was venting from your water well. I determined that there was methane venting from the casing of your water well before the pump was started. The concentration of methane present at the well head was 4% by volume. The pump had run previously that morning as water was used in the house. We started water flowing and ran 15 gallons before collecting samples. I did smell hydrogen sulfide in the water as it flowed and observed bubbled effervescing from the water while it flowed. The samples were shipped to Paragon Analytics in Fort Collins, CO and were received on May 1, 2008.

COMPARISON OF INORGANIC ANALYTICAL RESULTS TO CDPHE INORGANIC STANDARDS

The Water Quality Control Commission (WQCC) of the Colorado Department of Public Health and Environment (CDPHE) has established "Domestic Use-Quality" human health standards and drinking water standards. Analytical data for the samples from your water well was compared to these standards. This information is summarized in Table 1 which is located in Attachment 1 and discussed in narrative form below. Please keep in mind that these "Domestic Use-Quality Standards" were established for **municipal public** drinking water supplies and often people use and consume ground water from private wells that exceed these standards. The analytical results are included with this report as Attachment 2. Table 2 (Attachment 3) compares the analytical results from the March 2008 sampling with results obtained from samples collected in 2002.

- **Antimony (Sb):** The CDPHE human health standard for antimony is 0.006mg/l. Antimony is a contaminate metal.

  Antimony was detected in the sample collected from your water well at a concentration of 0.00074mg/l which is below the CDPHE human health standard.

- **Arsenic (As):** The CDPHE human health standard for arsenic is 0.05 mg/l. Arsenic is a highly poisonous metal.

  Arsenic was not detected in the sample collected from your water well.

- **Barium (Ba):** The CDPHE human health standard for barium is 2.0 mg/l. Barium is a contaminate metal.

  Barium was detected in the sample collected from your water well at a concentration of 0.82mg/l which is below the CDPHE human health standard.

- **Beryllium (Be):** The CDPHE human health standard for beryllium is0.004mg/l. Beryllium is a contaminate metal.

  Beryllium was not detected in the sample collected from your water well.

- **Cadmium (Cd):** The CDPHE human health standard for cadmium is 0.005 mg/l. Cadmium is a contaminate metal.

  Cadmium was not detected in the sample collected from your water well.

- **Chromium (Cr):** The CDPHE human health standard for chromium is 0.1 mg/l. Chromium is a contaminate metal.

  Chromium was not detected in the sample collected from your water well.

- **Lead (Pb):** The CDPHE human health standard for lead is 0.05 mg/l. Prolonged exposure to this metal can result in serious health effects.

  Lead was not detected in the sample collected from your water well.

- **Nickel (Ni):** The CDPHE human health standard for nickel is 0.1mg/l. Nickel is a contaminate metal.

  Nickel was not detected in the sample collected from your water well.

- **Selenium (Se):** The CDPHE human health standard for selenium is 0.05 mg/l. Selenium is a contaminate metal.

  Selenium was not detected in the sample collected from your water well.

- **Silver (Ag):** The CDPHE human health standard for silver is 0.05 mg/l. Excess amounts of silver may cause a permanent gray discoloration of the skin.

  Silver was not detected in the sample collected from your water well.

- **Thallium (Tl):** The CDPHE human health standard for thallium is 0.002 mg/l. Thallium is a contaminate metal.

  Thallium was not detected in the sample collected from your water well.

- **Uranium (U):** The CDPHE human health standard for thallium is 0.03 mg/l. Uranium can be present due to erosion of natural deposits of this element.

  Uranium was detected in the sample collected from your water well at a concentration of 0.00016mg/l which is below the CDPHE human health standard.

- **Fluoride (F**): The CDPHE human health standard for fluoride is 4.0 mg/l. Where fluoride concentrations are in the range of 0.7 mg/l to 1.2 mg/l health benefits such as reduced dental decay have been observed. Consumption of fluoride at concentrations of greater than 2.0 mg/l can result in mottling of teeth. Consumption of fluoride at concentrations greater than 4.0 mg/l can increase the risk of skeletal fluorosis or other adverse health effects. Fluoride occurs naturally in the ground water in many areas in Colorado at concentrations that exceed the drinking water standard.

  Fluoride was detected in the sample collected from your water well at a concentration of 2.9mg/l which is below the CDPHE human health standard.

- **Nitrate (NO_3):** The CDPHE human health standard for nitrate is 10.0 mg/l. Nitrate can cause cyanosis in infants; a household water supply should not contain nitrate concentration in excess of 10 mg/l.

  Nitrate was not detected in the sample collected from your water well.

- **Nitrite (NO_2):** The CDPHE human health standard for nitrite is 1.0 mg/l. Nitrite concentrations exceeding 1.0 mg/l should not be used for feeding infants.

  Nitrite was not detected in the sample collected from your water well.

- **Copper (Cu):** The CDPHE secondary drinking water standard for copper is 1 mg/l.

  Copper was not detected in the sample collected from your water well.

- **Chloride (Cl):** The CDPHE secondary drinking water standard for chloride is 250mg/l. Chloride concentrations in excess of 250 mg/l usually produce a noticeable taste in drinking water.

  Chloride was detected in the sample collected from your water well at a concentration of 39mg/l which is below the CDPHE drinking water standard.

- **Iron (Fe):** The CDPHE secondary drinking water standard for iron is 0.3mg/l. Small amounts of iron are common in ground water. Iron produces a brownish-red color in laundered clothing, can leave reddish stains on fixtures, and impart a metallic taste to beverages and food made with it. After a period of time iron deposits can build up in pressure tanks, water heaters, and pipelines, reducing the effective flow rate and efficiency of the water supply.

  Iron was not detected in the sample collected from your water well.

- **Manganese (Mn):** The CDPHE secondary drinking water standard for manganese is 0.05mg/l. Manganese produces a brownish color in laundered clothing, may stain fixtures and affect the taste of coffee or tea.

  Manganese was not detected in the sample collected from your water well.

- **Sulfate (SO_4):** The CDPHE sulfate secondary standard for human drinking water is 250mg/l. Although CDPHE does not have an agricultural standard for sulfate, other agencies recommend a concentration below 1,500 mg/l for livestock watering. Waters containing high concentrations of sulfate, typically caused by the leaching of natural deposits of magnesium sulfate (Epsom salts) or sodium sulfate (Glauber's salt), may be undesirable because of their laxative effects.

  Sulfate was not detected in the sample collected from your water well.

- **pH:** pH is the measure of the hydrogen ion concentration in water. The pH of water in its natural state is generally from 5.5 to 9.0. The CDPHE standard for domestic and agricultural water is a range of 6.5 to 8.5. Seven (7) represents neutrality, while values less than 7 indicate increasing acidity and values greater than 7 indicate increasing alkalinity.

  pH was measured in the water sample from your well with a value of 8.36 which is within the CDPHE drinking water and agricultural standards.

- **Total Dissolved Solids (TDS):** CDPHE's TDS standard for human drinking water is 500 milligrams per liter (mg/l). Although CDPHE does not have an agricultural standard for TDS, other agencies recommend concentrations below 1500 mg/l for irrigation, and below 5,000 mg/l for most livestock watering. TDS occurs naturally in the ground water in many areas of Colorado at concentrations that exceed the drinking water standard.

  TDS was measured in the water sample collected from your well at a concentration of 1400mg/l which is above the drinking water standard.

- **Zinc (Zn):** CDPHE's Zn standard for human drinking water is 5 milligrams per liter (mg/l) and the agricultural standard is 2mg/l.

  Zinc was not detected in the sample collected from your water well.

The following parameters were also measured as part of the laboratory analysis although there are no CDPHE standards.

- **Sodium (Na):** People on salt restricted diets should be aware of the sodium concentration in the water they drink. A concentration of less than 20 mg/l is recommended by some for people on salt restricted diets or for people suffering from hypertension or heart disease. Sodium occurs naturally in the ground water in many areas of Colorado at concentrations that exceed this health advisory level.

  Sodium was detected in the water sample from your well at a concentration of 530mg/l which is above the recommended level.

- **Boron (B):**

  Boron was not detected in the sample collected from your water well.

- **Calcium (Ca):**

  The calcium concentration in the sample collected from your well was 1.9mg/l.

- **Magnesium (Mg):**

  Magnesium was not detected in the sample collected from your water well.

- **Potassium (K):**

  Potassium was detected in the water sample from your well at a concentration of 4.5mg/l.

- **Molybdenum (Mo):**

  Molybdenum was not detected in the sample collected from your water well.

- **Bicarbonate (HCO_3):**

  Bicarbonate alkalinity was measured in the sample collected from your well at a concentration of 1300mg/l.

- **Bromide (Br):**

  Bromide was not detected in the sample collected from your water well.

METHANE GAS ANALYSIS

Methane was detected in the sample collected from your well at a concentration of 23mg/l. The concentration of methane in the water produced from the well **is above** the threshold level of 1.1mg/l that could allow methane to accumulate in confined unventilated spaces and potentially be explosive. I believe you told me you do not have an outside vented cistern.

BACTERIAL ANALYSIS

The COGCC collected samples to analyze for the presence of iron, slime and sulfur bacteria in your water well. Samples from your water well were tested for the presence of iron-related (IRB), sulfate reducing (SRB) and slime forming (SLYM) bacteria using Biological Activity Reaction Test (BART) kits. In addition to detecting the presence of bacteria the BART Kits allow for an estimation of the size of the population and/or the rate at which they can metabolize and/or grow through an observable change or reaction. This reaction rate is referred to as the "aggressivity" of the bacterial population. The aggressivity levels of the bacteria are described as **Not Detected, Background, Moderately Aggressive, Very Aggressive, or Extremely Aggressive Levels**. The results of the tests are provided below and documented in Photographs 1 and 2. The progress of the bacterial growth on day zero is seen in Photograph 1. Photograph 2 shows the progress of the bacterial tests two days after the cultures were started. Photograph 3 shows the progress of the bacterial tests five days after the cultures were started.

- **Iron-Related Bacteria (IRB):** Although not harmful, iron-related bacteria can become a nuisance by plugging the well pump, causing red staining on plumbing fixtures and laundered clothing, building up red, slimy accumulations on any surface the water touches, and causing what appears to be a sheen on standing water. Signs that may indicate an iron bacteria problem include "yellowish, red or orange colored water, rusty deposits in toilet tanks and strange smells resembling fuel oil, cucumbers or sewage. Sometimes the odor will only be apparent in the morning or after other extended periods of non-use" (CDPHE, Laboratory Services Division).

  IRB bacteria were detected at Moderately Aggressive levels in the water sample collected at this well. The culture turns red with foam at the top to indicate the presence of IRB. The development of red color and foam can be seen in Photograph 3 after 5 days from initiation of the test.

Photograph 1. BART Kits April 30, 2008

- **<u>Sulfate Reducing Bacteria (SRB)</u>**: Sulfate reducing bacteria are serious nuisance organisms in water since they can cause severe taste and odor problems. These bacteria reduce sulfate that occurs naturally in the water and generate hydrogen sulfide (H_2S) gas as they grow. In turn, the hydrogen sulfide (H_2S) gas is a nuisance because it smells like rotten eggs, initiates corrosion on metal surfaces and reacts with dissolved metals such as iron to generate black sulfide deposits.

  The test indicated that SRB were present at Very Aggressive levels in your well water. The culture turns black if SRB are present. A black precipitate formed in the black topped tube after 2 days as seen in Photograph 2.

Photograph 2. BART Kits May 2, 2008

- **Slime Forming Bacteria (SLYM)**: Although not usually harmful, Slime Forming Bacteria (SFB) can become a nuisance by plugging well pumps and causing slimy accumulations on plumbing fixtures and standing water. Slimes are often gelatinous in nature and may range in color from white, to red, or black. As slime bacteria mats grow they create an environment in which complex associations of other strains of bacteria can develop.

  SLYM bacteria were present at Very Aggressive levels in the water sample collected from this well. Photograph 2 shows development of cloudy culture media after two days in the green capped vial. The media would stay clear for the eight days of the test if bacteria were not present or only present at background levels.

Photograph 3. BART Kits May 5, 2008

Slime forming, sulfate reducing and iron related bacteria are present at **moderate to high levels** in your well. You may still want to consider treating the well and the distribution system with disinfecting solutions on a regular basis. Once bacterial colonies are established they are difficult to eliminate; therefore, you may need to establish a schedule for periodic disinfection of your well system to help control the bacteria present in it. The chlorination process is more easily accomplished if you have a frost-proof hydrant near the well head that you can use to remove the chlorinated water from the well. One technique that water well professionals use is to re-circulate the chlorine solution down the sides of the well shortly after adding the chlorine. This helps to kill bacteria on the sides of the well and on the pipes in the well.

Pamphlets published by the CDPHE that provide more information concerning the treatment of iron and sulfur bacteria and shock chlorination treatment of bacteria are included as Attachment 4. You may also want to contact a licensed water well contractor for additional information or for help in disinfecting your well and distribution system. Additional information and assistance can be provided through the State of Colorado Health Department. Contact information for the agency is provided below.

Colorado Department of Public Health and Environment
Colorado Drinking Water Program
4300 Cherry Creek Drive South
Denver, CO 80246-1530
Phone: 303-692-3500
Fax: 303-782-0390

CONCLUSIONS

Table 2 shows a comparison of results from a sample collected from your well in 2002 by a contractor for the COGCC. The overall chemistry of the water from your well has not changed greatly in the 6 years. The water is predominantly of a sodium-bicarbonate character. The general chemistry of many CBM wells in the Raton Basin is also a sodium-bicarbonate character. The chemistry of CBM produced water in some areas has more of a sodium-chloride-bicarbonate character. The concentration of total dissolved solids in water produced from your domestic well exceeds the groundwater and drinking water standards for TDS.

The inorganic chemistry of water from your well is similar to some coal bed methane (CBM) produced water in the Raton Basin. The general chemistry of the two closest CBM wells to your home is illustrated in Table 3. The general chemistry of one nearby water well is also shown in Table 3. The locations of your well, the nearby water well and the two nearby CBM wells is shown in Figure 5. The general character of the produced water from the two closest CBM wells is of a sodium-chloride-bicarbonate nature. The chemistry of water from your well and a nearby domestic well is of a sodium-bicarbonate character.

The area of your home is underlain by the Raton Formation and your well is probably completed in the Raton Formation. The Raton Formation contains coals, sandstones and shales. The Agate 11-11 and BGR 14-2 are reported as producing gas from the Vermejo Formation which lies under the Raton Formation. Both CBM wells produce gas from depths as shallow as 378 feet below land surface. The records indicate your water well is 275 feet deep and that water was being produced from a zone approximately 175 feet below ground surface.

Table 3. Comparison of nearby water well and CBM well chemistry.

Analyte	**Woodward Water Well**	**C Water Well**	**Agate 11-11**	**BGR 14-2**
TDS	1400	932	3870	3330
pH	8.36	8.1	8.0	7.8
Cl	39	16	1720	1520
SO_4	<2	3.3	<5	<5
HCO_3	1300	1047	1170	1180

The water produced from your water well contains methane at concentrations that could result in buildup of methane in an enclosed space to levels that might ignite. Installation of a vented outdoor cistern where water is temporarily stored before being brought into your home might lessen the potential for methane to build up to potentially hazardous levels. You may want to purchase and install methane detectors inside your home. Such detectors can alert you if methane before methane builds up to potentially explosive levels.

You inquired about possible methane seeps on your property. One symptom of such seeps is patches of stressed vegetation. I did not see evidence of stressed vegetation on your property during my visit or on aerial photographs (2005) of the area around your home. As I explained, the 2007 driving survey conducted under contract for the COGCC to locate methane seeps in the Raton Basin did not drive through your subdivision as they did in a previous survey. Your subdivision maintains private gated roads and the survey

crew did not gain access to those roads last year. Photograph 4 below shows a seep in Las Animas County and illustrates stressed vegetation so that you might better recognize the possible impacts of methane seepage on vegetation. If you are aware of any unusual patches of stressed vegetation or areas that will not support vegetation on your property please contact me.

Photograph 4. Stressed vegetation near a methane seep in Las Animas County.

I did not find any impacts to water quality in your domestic well. The chemistry is essentially unchanged from the previous sampling event in 2002. The 2007 ground survey could not access your subdivisions roads as they are gated and indicate no access other than for owners. Access to perform that survey could have helped to better determine if there are methane seeps on or near your property. There are shallow coals in the vicinity of your home. Methane seeps can and do occur in areas with coals near the surface. There is anecdotal evidence that the methane seeps near the Madrid Canyon bridge across the Purgatoire River have been in existence for as long as 50 years or more.

If you have any questions or would like to discuss these matters further, please contact me at 719-846-3091 or by email at peter.gintautas@state.co.us .

Sincerely,
Colorado Oil and Gas Conservation Commission

Peter Gintautas
Environmental Protection Specialist

Attachments:
Attachment 1 - Table 1 - Analytical Summary
Attachment 2 - Paragon Analytics Data Report
Attachment 3 - Table 2 - Comparison of 2002 and 2008 Analytical Results
Attachment 4 - CDPHE water well pamphlets
Attachment 5 - Location of CBM and Water Wells

cc: David Neslin, Acting COGCC Director w/o attachments
Debbie Baldwin, COGCC Environmental Protection Manager w/o attachments
Margaret Ash, COGCC Environmental Protection Specialist w/o attachments

TABLE 1
ANALYTICAL SUMMARY
Complaint 200130491
Woodward Water Well

Parameter	Sample Date		CDPHE Standards		
	30-Apr-08				
	Result	Unit	Domestic	Agriculture	Units
Antimony	0.00074	mg/l	0.006	NS	mg/l
Boron	ND	mg/l	NS	0.75	mg/l
Copper	ND	mg/l	1	0.2	mg/l
Arsenic	ND	mg/l	0.05	0.1	mg/l
Barium	0.82	mg/l	2.0	NS	mg/l
Berylium	ND	mg/l	0.004	0.1	mg/l
Cadmium	ND	mg/l	0.005	0.01	mg/l
Calcium	1.9	mg/l	NS	NS	
Chromium	ND	mg/l	0.1	0.1	mg/l
Cobalt	ND	mg/l			
Iron	ND	mg/l	0.3	5	mg/l
Lead	ND	mg/l	0.05	0.1	mg/l
Lithium	0.17	mg/l	NS	NS	
Magnesium	ND	mg/l	NS	NS	
Manganese	ND	mg/l	0.05	0.2	mg/l
Molybdenum	ND	mg/l	0.035	NS	mg/l
Nickel	ND	mg/l	0.1	0.2	mg/l
Potassium	4.5	mg/l	NS	NS	
Selenium	ND	mg/l	0.05	0.02	mg/l
Silver	ND	mg/l	0.05	NS	mg/l
Strontium	0.43	mg/l	NS	NS	
Sodium	530	mg/l	NS	NS	
Thallium	ND	mg/l	0.002	NS	mg/l
Uranium	0.00016	mg/l	0.03	NS	mg/l
Zinc	ND	mg/l	5	2	mg/l
Chloride	39	mg/l	250	NS	mg/l
Nitrite	ND	mg/l	1.0	10	mg/l
Nitrate	ND	mg/l	10.0	100	mg/l
Total Nitrite/Nitrate	ND	mg/l	10.0	100	mg/l
Fluoride	2.9	mg/l	4.0	NS	mg/l
Total Dissolved Solids	1400	mg/l	400	*1500	mg/l
pH	8.36	No units	6.5 - 8.5	6.5 - 8.5	No units
Sulfate	ND	mg/l	250	NS	mg/l
Bromide	ND	mg/l	NS	NS	
Total Alkalinity	1300	mg/l	NS	NS	
Bicarbonate	1300	mg/l	NS	NS	
Carbonate	ND	mg/l	NS	NS	
Conductivity	2390	umhos/cm	NS	NS	
Total Organic Carbon	1.1	mg/l	NS	NS	
sulfide	ND	mg/l			
methane	23	mg/l	NS	NS	

Notes

CDPHE	Colorado Department of Public Health and the Environment.
Domestic	Water Quality Control Commission 5 CCR 1002-41, Regulation No. 41 - The Basic Standards For Groundwater.
Agriculture	* Standards for agriculture complied from CDPHE and other of sources.
mg/l	milligrams per liter (ppm or parts per million).
µmhos/cm	micromhos per centimeter
NA	Not analyzed.
ND	Not detected.
NS	No Standard.
**	Health Advisory.
	Human health standard.
	Secondardy standard.

TABLE 2
COMPARISON 2002 TO 2008 RESULTS
Complaint 200130491
Woodward Water Well

Parameter	Sample Date	Sample Date	
	08-Jan-02	30-Apr-08	
	Result	Result	Unit
Antimony	NA	0.00074	mg/l
Boron	NA	ND	mg/l
Copper	ND	ND	mg/l
Arsenic	ND	ND	mg/l
Barium	0.924	0.82	mg/l
Berylium	NA	ND	mg/l
Cadmium	ND	ND	mg/l
Calcium	2.1	1.9	mg/l
Chromium	ND	ND	mg/l
Cobalt	NA	ND	mg/l
Iron	ND	ND	mg/l
Lead	ND	ND	mg/l
Lithium	ND	0.17	mg/l
Magnesium	0.7	ND(<1)	mg/l
Manganese	ND	ND	mg/l
Molybdenum	NA	ND	mg/l
Nickel	NA	ND	mg/l
Potassium	2.1	4.5	mg/l
Selenium	ND	ND	mg/l
Silver	ND	ND	mg/l
Strontium	NA	0.43	mg/l
Sodium	615	530	mg/l
Thallium	NA	ND	mg/l
Uranium	NA	0.00016	mg/l
Zinc	NA	ND	mg/l
Chloride	53	39	mg/l
Nitrite	ND	ND	mg/l
Nitrate	ND	ND	mg/l
Total Nitrite/Nitrate	ND	ND	mg/l
Fluoride	3.4	2.9	mg/l
Total Dissolved Solids	1358	1400	mg/l
pH	8.1	8.36	No units
Sulfate	ND	ND	mg/l
Bromide	ND	ND	mg/l
Total Alkalinity	1560	1300	mg/l
Bicarbonate	1543	1300	mg/l
Carbonate	19.6	ND	mg/l
Conductivity	1195	2390	umhos/cm
Total Organic Carbon	NA	1.1	mg/l
sulfide	NA	ND	mg/l
methane	12.2	23	mg/l

Woodward Water Well Location

SCALE 1 : 7,212

500 0 500 1,000 1,500

FEET

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