

**West Peetz Field - Quarterly Water
Well Sampling and Analysis
Summary
Logan County, Colorado
Q2, 2018**

Prepared for Ron Richards, East Cheyenne Gas
Storage, LLC

COGCC Remediation Project # 9425

August 15, 2018

VERSION 1.0





Summary and Principal Conclusions

- Due to similarities of the thermogenic hydrocarbon gas in the West Peetz storage field and the dissolved hydrocarbon gas found in the Nelson Water Well (NWW), East Cheyenne Gas Storage, LLC. carried out a sampling and analysis plan as outlined in the Colorado Oil and Gas Conservation Commission (COGCC) Form 27 to sample the NWW and groundwater wells within an approximate 1-mile radius of the NWW on a quarterly basis. The most recent field sampling campaign was conducted in June of 2018 to satisfy the Q2 2018 requirement and is summarized in this report.
- The sampling of the NWW occurred after the construction of an aeration type methane mitigation system on the NWW in early 2016. Samples were collected both upstream and downstream of an aeration type methane mitigation system to monitor the efficacy of the treatment system on a quarterly basis. Upstream and downstream samples were collected during this June 2018 sampling event and results indicate that the treatment system is removing more than 90% of the methane from the water.
- Of the nearby water wells sampled in June of 2018, the Michaels water well (MWW) and Wood water well (WWW) contained methane concentrations below laboratory detection limits. The Williams Shallow water well (WSWW) contained a very low methane concentration of 1.7 micrograms per liter (ug/l). No ethane or propane was detected in these samples either, demonstrating the absence of thermogenic gas in these wells. Comparison of these data with results from the previous quarterly sampling events indicate that the dissolved gas concentrations have remained relatively constant or have declined slightly with time in the water wells within a one-mile radius of the NWW.
- One additional water well that initially was not in the CO DWR water well database was sampled as well, the Williams Deep water well (WDWW), because it was also within the 1-mile radius. This well had also been sampled by ECGS multiple times for baseline purposes from 2010-2015 and throughout 2016 on a quarterly basis. The June 2018 results indicate that the dissolved gas concentration has remained relatively constant compared to previous sampling events. Previous stable carbon and hydrogen isotope composition analysis of the methane indicates the gas in the WDWW is predominantly of microbial origin.



- A Benzene, Toluene, EthylBenzene and Xylenes (BTEX) analysis was carried out on the sample collected from the NWW upstream of the dissolved gas treatment system. None of the target list compounds were present above the laboratory detection limits, which is consistent with results from previous quarterly sampling events.
- As requested, all analytical data from the June 2018 sampling campaign has been uploaded to the COGCC database through the COGCC's Electronic Data Deliverable (EDD) process.
- A review of the geochemical results of the June 2018 sampling event supports the conclusion that the nearby water wells in the area have not been impacted in the same manner as the NWW. The surrounding water wells continue to exhibit very low or undetectable levels of dissolved hydrocarbon gases and undetectable concentrations of BTEX compounds. Also, the pre- and post-treatment samples collected from the NWW indicate that the methane mitigation treatment system is operating effectively, reducing dissolved gas concentrations to low levels downstream of the system.
- The June 2018 dissolved gas results from the pre-treatment NWW samples represent the continuation of a general downward trend in the concentration of methane in the NWW, though the concentration did not change significantly from last quarter's sampling event. From March 2016 through June 2017, the methane concentrations in the NWW remained relatively stable and near the solubility limit for methane at standard conditions (app. 31.4 +/- 4 mg/l). The more recent four quarters of pre-treatment NWW samples exhibit significantly lower methane concentrations from September 2017 to June 2018: 22.0, 14.0, 22.0 and 23.0 mg/l, respectively. It is possible that this could be the result of remediation activities taken by ECGS on wellbores adjacent to the NWW.

Introduction

Ron Richards from East Cheyenne Gas Storage, LLC requested that the Dolan Integration Group (DIG) provide a summary of the sampling and analytical results obtained from water wells sampled near the West Peetz gas storage field in Logan County, Colorado in June of 2018. This sampling and analytical program was implemented as part of the plan of action outlined in the COGCC Form 27 and is in reference to COGCC Remediation Project Number 9425 – Peetz West Field (Ron Nelson Water Well). Specifically, the COGCC recommended the following actions:



1. Perform quarterly monitoring of the Nelson Water Well for the duration of the source area investigation. Collect water well samples prior to the treatment system for the following laboratory analyses:
 - a. 8260 VOCs full list, 8270 SVOC full list, pH, specific conductance, total dissolved solids, dissolved (methane, ethane, propane, butane, iso-butane, pentane, iso-pentane, hexane), total bicarbonate as CaCO₃, carbonate as CaCO₃, bromide, fluoride, sulfate, nitrate and nitrite as N, phosphorus, calcium, iron, magnesium, manganese, potassium, sodium, barium, boron, selenium, strontium and iron related bacteria. If the full list VOC constituents are not detected during the initial sampling event, only BTEX analysis shall be required during subsequent monitoring events. SVOC analysis shall not be required beyond the initial sampling event if the results are below the detection limits.
2. If access can be obtained, collect groundwater samples from surrounding water wells within an approximate 1-mile radius of the Nelson (Langness) water well and analyze for the same constituents requested for 1.a. Follow up sampling of the water wells will be determined based on the analytical results.
 - a. Specific water wells include Hugh Williams Permit No. 82501; Kevin & Peggy Michaels Permit No. 235877; U.S. Air Force Permit No. 11499-A. If the US Air Force well is not available to sample, the David Davis Permit No. 15889-A should be pursued as an alternate.
3. Upload all groundwater sample results via the EDD process into the COGCC database.
4. Collect pre- and post methane treatment system water samples from the Ron Nelson Water Well for dissolved methane analysis in order to confirm the effectiveness of the treatment system. Collect the samples upon completion of the methane treatment system installation, and again within 5 days of the system startup. After the two initial sampling events, continue the post system sampling and analysis during the ongoing quarterly monitoring events.
5. If not already completed, offer to provide a methane monitoring and alarm system to the residence and/or the ground water treatment system building.

As requested by the COGCC, samples were collected from the water wells listed in Table 1. Though permission to sample the Air Force Permit No. 11499A well was requested, permission was not obtained and the David Davis Permit No. 158889A well was subsequently sampled as an alternate. The Colorado Department of Water Resources (DWR) information has not been updated to reflect the present ownership of the David Davis Permit No. 158889A well; that property is currently owned by Mr. Frank Wood and will henceforth be referred to as the Wood Water Well (WWW). Also of note, the Williams Deep Water Well (WDWW) was sampled while field personnel were in the area and submitted for analyses, though it was not requested by the COGCC in the list of nearby water wells. This may be due to the fact that the Williams Deep water well was not in the Colorado DWR permit database. A map of the area in Figure 1 shows the WDWW is located inside the 1 mile radius from the Nelson Water Well that was specified.



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Samples from the water wells listed in Table 1 were collected by Tasman Geosciences and submitted for the analyses listed in Table 2, per COGCC guidance. These sample sites are also shown in Figure 1, a base map of the water wells and other features in the area. Care was taken to strictly follow the COGCC Model Sampling and Analysis Plan as dictated in COGCC Rule 609 – Statewide Groundwater Baseline Sampling and Monitoring. Results from the analyses were uploaded via the EDD process into the COGCC database under the respective COGCC facility ID’s listed in Table 2.



Table 1: Nearby water wells sampled as part of the June 2018 West Peetz Field study.

Well ID	CO DWR Receipt #	CO DWR Permit #	Field Sample ID	Lat	Long	Sec.	TwN	Rng.	Well Depth (ft)
Nelson Water Well (NWW)	3638023B	280327A	18852	40.961583	-103.212912	6	11N	52W	1020
Williams Shallow Water Well (WSWW)	9045346	82501	17956-N	40.962312	-103.230001	1	11N	53W	500
Williams Deep Water Well (WDWW)			17956-S	40.961580	-103.230420	1	11N	53W	1160
Michaels Water Well (MWW)	480219	235877	18250	40.976627	-103.224838	31	12N	52W	435
Wood Water Well (WWW)	0319388B	158889A	19973	40.965008	-103.194840	32	12N	52W	300

Table 2: COGCC facility ID's, sample dates, analytical parameters and results for the water wells sampled during the Q2 2018 sampling campaign.

Parameter	Report limit	Units	18852-PRE Nelson Water Well (NWW) Pre-treatment	18852-POST Nelson Water Well (NWW) Post-treatment	17956-S Williams Deep Water Well (WDWW)	17956-N Williams Shallow Water Well (WSWW)	18250 Michaels Water Well (MWW)	19973 Wood Water Well (WWW)
COGCC Facility ID			707193	707193	754160	754159	754716	754715
Sample Date			6/4/2018	6/4/2018	6/4/2018	6/4/2018	6/4/2018	6/4/2018
Bicarbonate as CaCO ₃	20	mg/l	420		420	300	150	180
Carbonate as CaCO ₃	20	mg/l	ND		ND	ND	ND	ND
Total Alkalinity as CaCO ₃	20	mg/l	420		420	300	150	180
Iron Related Bacteria	1	cfu/ml	9000		9000	9000	9000	9000
Dissolved Methane	1	µg/l	23000	1700	1800	1.7	ND	ND
Dissolved Ethane	2	µg/l	720	80	4.7	ND	ND	ND
Dissolved Propane	1	µg/l	ND	2.5	ND	ND	ND	ND
Benzene	1	µg/l	ND		ND	ND	ND	ND
Toluene	1	µg/l	ND		ND	ND	ND	ND
Ethylbenzene	1	µg/l	ND		ND	ND	ND	ND
M+P-Xylene	1	µg/l	ND		ND	ND	ND	ND
O-Xylene	1	µg/l	ND		ND	ND	ND	ND
Total Xylenes	1	µg/l	ND		ND	ND	ND	ND
Bromide	0.2	mg/l	0.67		0.47	0.68	0.32	ND
Chloride	0.4	mg/l	49		33	140	40	14
Fluoride	0.1	mg/l	0.95		2.2	0.5	1	0.69
Nitrate as N	0.2	mg/l	ND		ND	0.79	6	11
Nitrite as N	0.1	mg/l	0.22		0.37	ND	0.16	0.57
Sulfate	1	mg/l	160		38	35	37	31
Dissolved Barium	0.001	mg/l	0.031		0.031	0.24	0.075	0.095
Dissolved Boron	0.05	mg/l	1.7		1.8	0.4	0.12	0.11
Dissolved Calcium	1	mg/l	13		4.5	110	39	50
Dissolved Iron	0.1	mg/l	ND		ND	ND	0.17	ND
Dissolved Magnesium	0.1	mg/l	4		1.3	35	12	14
Dissolved Manganese	0.002	mg/l	0.018		0.0062	0.51	ND	ND
Dissolved Potassium	1	mg/l	9.3		5.6	13	8.7	8.4
Dissolved Selenium	0.001	mg/l	ND		ND	ND	0.0055	0.0024
Dissolved Sodium	1	mg/l	260		220	44	43	31
Dissolved Strontium	0.001	mg/l	0.46		0.18	1.5	0.54	0.58
pH	0.1	pH	7.79		8.27	7.19	7.46	7.32
Specific Conductivity	1	µmhos/cm	1322		1044	1149	582	576
Total Dissolved Solids	20	mg/l	780		560	630	360	360
Total Phosphorous	0.05	mg/l	ND		0.088	ND	ND	ND

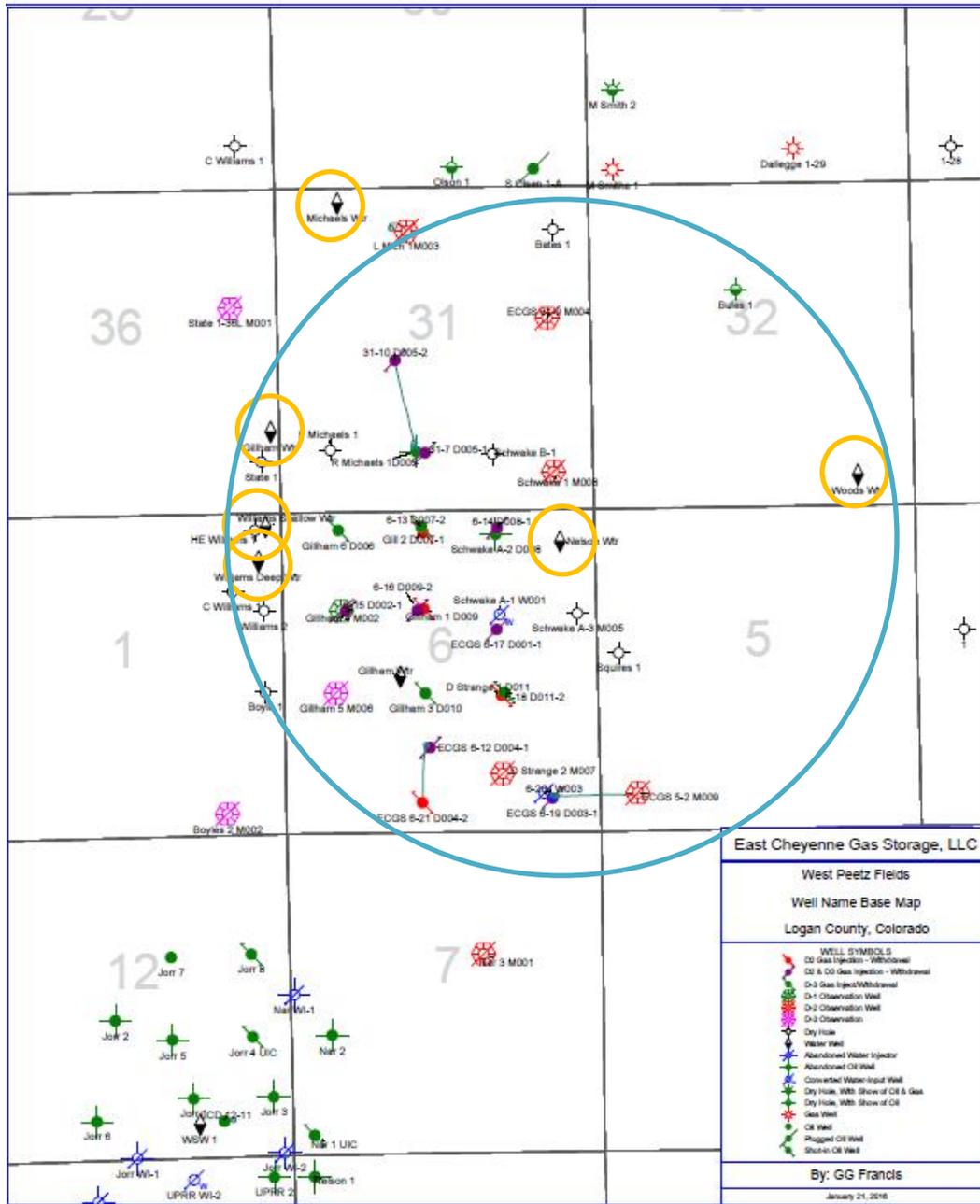


Figure 1: Well name base map for West Peetz field portion of the East Cheyenne Gas Storage project from Greg Francis. Orange circles indicate water well locations that were sampled in June of 2018 to satisfy the Q2 requirement. Blue circle indicates a 1 mile radius from the NWW specified by the COGCC when selecting nearby wells.



Analytical Results and Discussion

As no compounds from the EPA 8260 full list of VOCs' had been detected during previous sampling events, all samples were only required to be analyzed for BTEX concentrations. None of the samples collected contained detectable levels of BTEX compounds.

In addition to the analysis of the recent water well samples collected in June of 2018, results of the dissolved gas analyses were compiled from samples collected since March of 2016 as part of the same Form 27 actions. These geochemical data are incorporated in this report to distinguish potential temporal changes. In Figure 2, the dissolved methane concentration in micrograms per liter is plotted against sample date for samples collected both pre- and post-treatment from the NWW, as well as from the WWW, MWW, WSWW and WDW. The pre- and post-treatment NWW samples show the effectiveness of the methane treatment system installed; most recent results indicate this system is reducing the methane concentration in the water from 23 mg/l to 1.7 mg/l. The WWW, MWW and WSWW all contain either very low dissolved methane concentration or undetectable levels and the WDW contains a small amount of methane (1.8 mg/l). Previously collected stable carbon and hydrogen isotope data have shown the WDW methane signature to be microbial in origin.

Figure 2 demonstrates the consistent nature of these results from the surrounding water wells with time. The lack of any significant temporal changes in the dissolved gas concentrations suggests that the surrounding wells have not been impacted in a similar manner to the NWW. As noted in the principal conclusions, the NWW pre-treatment samples continue to show a general decrease in methane concentration, particularly after the sampling event that took place in June of 2017. This may be the result of recent well remediation operations adjacent to the NWW.

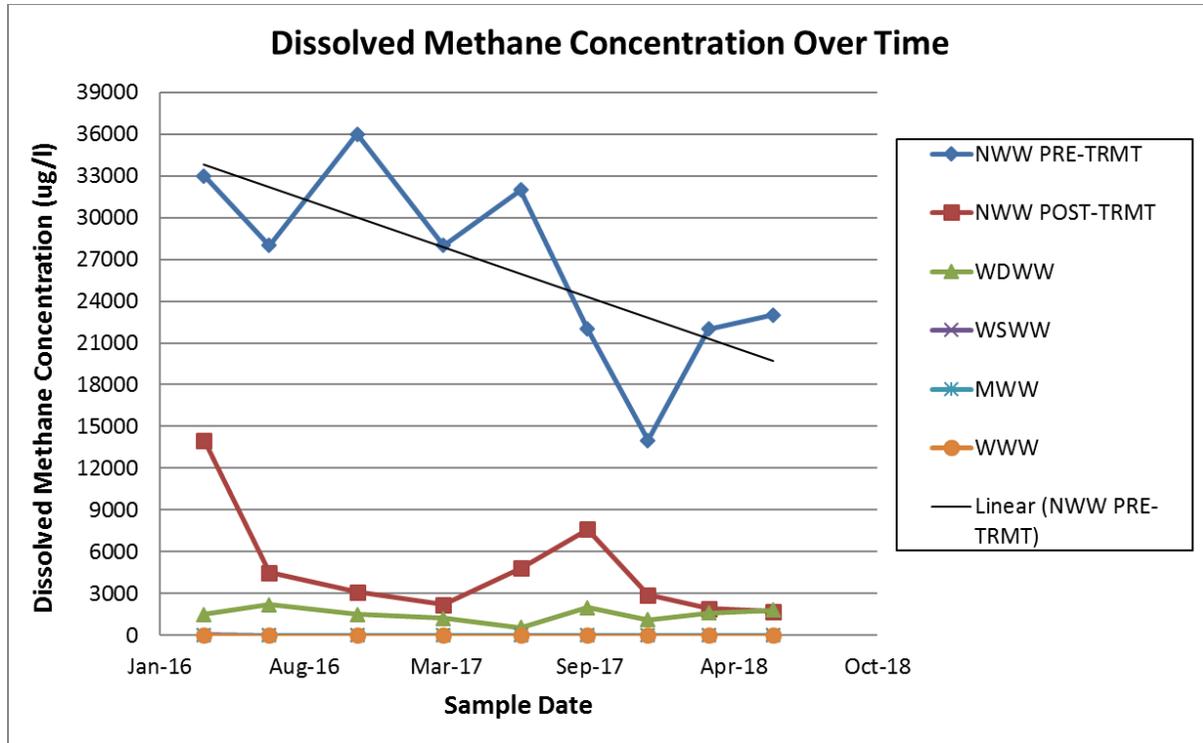


Figure 2: Dissolved methane concentration data over time from the NWW and nearby water wells.

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