Johnson 7-30A Investigation:

Gas Composition and Related Data Analysis

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Executive Summary

At the request of Kerr-McGee Oil & Gas Onshore LP (KMOG), I have been asked to review a 12/8/23 K.P. Kauffman Company, Inc. (KPK) letter report to the ECMC and to assist in determining if bradenhead gas present in the Johnson 32-30 bradenhead could have been derived from the production interval of the adjacent Johnson 7-30A well, 157 feet away.

Data presented in this report will demonstrate that gas samples from both bradenheads are analytically indistinguishable from one another and that they could not have been derived from underlying production gas intervals completed in commingled Niobrara, Codell, and J sand production zones. The conclusion is based on 34 gas sample data records for samples collected in all the neighboring commercial gas wells within a ¼ mile radius of the Johnson 32-30 well. On the basis of other published data, this report further demonstrates that gas composition in bradenhead gas samples from both wells is fully consistent with a Sussex Formation source.

Additional well construction data, structure contour data, pressure gradient data, and annular cement records are also presented. Those data demonstrate that stray gas could only have migrated from the highly pressurized open annular region around the Johnson 32-30 well into the open annulus of the adjacent Johnson 7-30A well and not the other way around.

Stable Isotopes - Johnson 32-30 bradenhead gas sample data vs. published data

To address the source of bradenhead gas samples, such as that collected by KPK from the Johnson 32-30 well, it is customary to compare analytical results with samples obtained from underlying produced gas samples in the same well, and samples collected from other bradenhead and production gas sources in wells from the surrounding area. Unfortunately, production gas samples from the Sussex interval in the Johnson 32-30 were never collected, and there are no other producing Sussex wells that can be sampled for comparison anywhere near section 30, T2N R66W. Therefore, this section of the report will first introduce concepts used to interpret analytical stable isotope data using relevant published Denver basin and related gas data (Sherwood et al., 2013; Dolan et al., 2007). Analytical results are then subsequently presented to demonstrate that bradenhead gas samples from the Johnson 32-30 bradenhead are most likely sourced from the Sussex Formation.

Because Sussex and Shannon formations (Exhibit 1) are the shallowest producing intervals in the stratigraphic column for this area of the Denver Basin (Nelson and Santus, 2011), their maximum burial temperatures will always be lower than that of any geologic formations below them. Oil, gas, and condensates derived from shallower buried organic matter in source rocks will have a lower thermal maturity signature than the deeper source rocks below them (earth temperatures increase with increasing depth). Stable isotopes analyses of carbon in hydrocarbon gases are among the most useful geochemical indicators of source rock maturity.

Exhibit 2A is a copy of Figure 6 published in the Sherwood 2013 report coauthored by Dr. Dolan, founder of Dolan Integration Group (DIG). DIG Laboratory uses this type of graph as part of their standard reporting format as presented in the KPK report on page 4. This type of graph, first published in 1988

(Chung et al., 1988) has since become a standard method for comparing stable carbon isotope ratios of multiple samples. Thin, semi transparent lines in the graph represent individual samples. Those lines are derived by connecting sample data points representing the stable isotope composition of carbon on the y axis and the inverse (reciprocal) of the carbon number of the gas constituent analyzed on the x axis (C1 = 1/1 or 1 for methane, C2 = ½ or 0.5 for ethane, C3 = $^{1}/_{3}$ or 0.33 for propane, and C4 = 1/4 for butane). Lines connecting data points with more negative stable isotope ratios represent gases derived from less thermally mature source rocks, whereas lines connecting data points with more positive stable isotope ratios represent gases derived from more thermally mature source rocks. The heavy colored lines represent average stable isotope data for samples derived from differing gas formations in the stratigraphic column. Note that the green line represents the average gas composition of Sussex gas samples which are the least thermally mature in the basin.

Exhibit 2B superimposes the line issued by DIG in their report to KPK for the Johnson 32-30 12/13/19 sample (page 4 of report) on those of Exhibit 2A. The Johnson 32-30 sample line is nearly directly superimposed on the line representing the average Sussex gas composition in the basin (dotted black line on deep green line). This result refutes the statement in the KPK report that "the characteristics of the gas on the Johnson 32-30 are more closely aligned to those of the NB-CD-J [Niobrara-Codell-J Sand] than SX-SH [Sussex-Shannon]" (end p.6). The average composition of gases from commingled Niobrara – Codell gas samples are higher up among the set of lines with more positive isotope ratios in the graph as represented with the heavy orange line.

As discussed, gas samples from the Sussex Formation will have the lowest thermal maturity index of any of the deeper commercially produced gas samples. This occurs because "production gases from the Codell through Sussex have been generated and accumulated *in situ*, with no apparent migration from distant source areas" (Sherwood and others, 2013). The article goes on to demonstrate that the range of stable isotope ratios derived from samples at any stratigraphic interval is also critically dependent on the location of the sample.

A second graphical method used to represent gas samples derived from source rocks of different thermal maturities is based on plotting stable isotope ratios for carbon in propane versus those in ethane (Dolan et al., 2007). Their maturity index combines both those stable isotope ratios to generate an isotope proxy (VREiso) of more traditional methods that quantify thermal maturity based on the microscopic examination of organic matter (vitrinite Ro) in shale and coal samples. Application of the method for Denver Basin gas samples is a significant contribution to the Sherwood 2013 article. Similar graphic displays of VREiso are included in every Dolan Integration Group report issued to clients with the analytical stable isotope results they provide. One of those is also included in the KPK report.

Stable isotope ratio data for two Sussex produced gas samples were selected for discussion in the KPK report. Those Sussex sample data come from two adjacent producing well locations that are 11.1 miles southeast (T1N67W Section 34) of the Johnson well 32-30 well (T2N R68W Section 30). No produced gas data were provided for Sussex samples in the immediate vicinity of the Johnson wells. Exhibit 3A shows that both gas samples are derived from source rocks having even lower thermal maturities than Sussex samples from the Denver basin illustrated by Sherwood and others. The KPK report appears use these data to suggest that bradenhead gas data from the Johnson well 32-30 cannot be derived from the Sussex Formation. However Exhibit 3B illustrates, on the basis of the DIG report on page 4 of the KPK report, that the relative location of Johnson 32-30 line falls exactly within the range of Sussex points on the plot presented in the Sherwood and others 2013 report (follow dashed green arrow between plots). Bradenhead gas samples from the Johnson 32-30 well do not fall within the higher maturity range of NB-CD-J gas as the KPK report claims.

Stable Isotopes - Johnson 32-30 bradenhead gas sample data vs. bradenhead and produced gas sample data from wells within a ¼ mile radius

Although no Sussex formation data are available for wells in this area of the basin, there are abundant gas data available for samples from all the producing gas formations within a ¼ mile radius of the Johnson 32-30 well (Table 1). The KPK letter report neither provides nor discusses stable isotope data of any produced gas samples from wells in the immediately adjacent to the Johnson wells. This section of the report will demonstrate that gas from producing horizons in this immediate area of the basin cannot be the source of stray thermogenic gas in bradenhead gas samples from either the Johnson 32-30 or Johnson 7-30A wells as suggested in the KPK report. Exhibit 4 illustrates the location of wells where either bradenhead or produced gases or both were sampled by KMOG and analyzed by Isotech Laboratory, Champaign IL.

API	ATTRIB_3	SOURCE	OFFLINE_GC	SAMPLE_DATE	SAMPLE_NAM	LAB	FORMATION	C1	C2	C3	IC4	NC4	IC5	NC5	C6+	δ13C C1	δ2H C1	δ13C C2	δ13C C3	δ13C iC4	δ13C nC4	δ13C iC5	δ13C nC5
05-123-16238	32-30 JOHNSON	BHD	No	12/13/2019		***DIG***		78.8	8.38	5.549	0.773	1.517	0.262	0.22	0.653	-52.6		-33.5	-30.3	-32.3	-29.6		
05-123-16238	32-30 JOHNSON	BHD	No	12/5/2023		***DIG***										-56.5		-33.5	-30.4	-31.7	-29		
05-123-08550	A-2 WAGNER	PRDC	No	2/27/2015	Wagner A2	***DIG***	SX	63.6	11	11.8	2	4.8	1.4	1.16		-55.9	-242	-35.16	-31.68	-33.52	-30.12	-29.88	-30.06
05-123-08550	A-1 SELTZER	PRDC	No	2/27/2015	Seltzer 1A	***DIG***	SX	61.7	13.3	11.7	1.9	4.7	1.3	1.5	1.43	-56	-218	-35.4	-31.7	-33.6	-30.36	-29.9	-30.05
05-123-20767	7-30A JOHNSON	BHD	Yes	9/12/2019	SP_05_123_20767_BHD	ISOTECH	BHD	80.3	7.34	5.69	0.907	1.69	0.437	0.398	0.185	-54.82	-240.3	-33.89	-30.4	-31.84	-29.08	-28.33	-28.14
05-123-30119	10-30 BRYANT	BHD	Yes	9/12/2019	SP_05_123_30119_BHD	ISOTECH	BHD	43.8	0.28	0.06	0.021	0.014	0.023	0.007	0.0442	-67.62	-236.5	-36.7	0	0	0	0	0
05-123-30119	10-30 BRYANT	PRDC	Yes	9/12/2019	SP_05_123_30119_C	ISOTECH	NBCD	77.1	12.2	5.35	0.666	1.62	0.339	0.371	0.141	-48.85	-247.3	-33.1	-29.23	-31.55	-28.17	-28.28	-27.51
05-123-30121	24-30 BRYANT	BHD	Yes	9/12/2019	SP_05_123_30121_BHD	ISOTECH	BHD	82	7.85	4.73	0.556	1.23	0.271	0.258	0.127	-55.8	-244.4	-33.71	-30.17	-31.83	-28.85	-28.27	-27.9
05-123-30121	24-30 BRYANT	PRDC	Yes	9/12/2019	SP_05_123_30121_C	ISOTECH	NBCD	78.2	11.6	4.93	0.647	1.59	0.377	0.427	0.256	-48.29	-245.6	-32.74	-29.05	-31.43	-28.03	-28.32	-27.64
05-123-15062	2 SAWDEY UNIT	BHD	Yes	10/16/2019	SP_05_123_15062_BHD	ISOTECH	BHD	62.4	7.26	4.45	0.717	1.64	0.34	0.329	0.175	-55.03	-244.3	-32.55	-29.14	-31.35	-28	-28.22	-27.51
05-123-30118	8-30 BRYANT	BHD	No	8/11/2020	SP_05_123_30118_BHD	ISOTECH	BHD	79.3	8.97	6.19	0.879	1.94	0.461	0.459	0.279	-53.3	-243	-34.1	-30.3	-31.9	-29.5	-28.5	-28.2
05-123-30353	5-30 SAWDEY	BHD	No	8/26/2020	SP_05_123_30353_BHD	ISOTECH	BHD	85.6	4.71	4.1	0.868	1.04	0.333	0.217	0.23	-56	-236	-34.2	-31.7	-32.4	-31.1	-29.1	-30.1
05-123-30353	5-30 SAWDEY	PRDC	No	8/26/2020	SP_05_123_30353_C	ISOTECH	JNBCD	74	12.1	5.54	0.813	1.98	0.507	0.452	0.0928	-48.5	-246	-32.8	-29.2	-31.5	-28.1	-28.3	-27.5
05-123-30354	31-30 SAWDEY	BHD	No	11/25/2020	SP_05_123_30354_BHD	ISOTECH	BHD	70.8	5.31	4.47	0.779	1.33	0.419	0.419	0.112	-56.5	-233	-34.2	-31.1	-31.9	-29.4	-28.9	-28.8
05-123-30354	31-30 SAWDEY	PRDC	No	11/25/2020	SP_05_123_30354_C	ISOTECH	NBCD	76.8	12.3	5.65	0.749	1.75	0.34	0.347	0.0879	-49.8	-246	-32.8	-28.9	-31.3	-28.1	-28.6	-28.4
05-123-30356	32-30 SAWDEY	BHD	No	11/25/2020	SP_05_123_30356_BHD	ISOTECH	BHD	65.9	7.72	4.92	1.12	2.75	0.832	0.827	0.279	-52.1	-239	-33.1	-30.2	-31.7	-28.3	-28.6	-28.3
05-123-30356	32-30 SAWDEY	PRDC	No	11/25/2020	SP_05_123_30356_C	ISOTECH	NBCD	78	12.4	5.07	0.635	1.41	0.258	0.244	0.0727	-49.4	-243	-32.9	-29.2	-31.6	-27.9	-28.5	-28.1
05-123-23367	11-30 TEGELER	BHD	No	1/5/2021	BW_05_123_23367_BHD	ISOTECH	BHD	67	0.34	0.081	0.016	0.013	0.006	0.002	0.0028	-65.89	-275.6	-36.3	-25.7	0	0	0	0
05-123-20352	9-30A HSR-BRYANT	BHD	No	3/4/2021	SP_05_123_20352_BHD	ISOTECH	BHD	80.3	7.74	5.89	0.91	1.62	0.345	0.291	0.156	-54.8	-241	-33.7	-30.5	-31.9	-28.8	-28.3	-28
05-123-20352	9-30A HSR-BRYANT	PRDC	No	3/4/2021	SP_05_123_20352_C	ISOTECH	JNBCD	73.1	16.5	6.49	0.785	1.31	0.294	0.296	0.177	-48.1	-244	-32.7	-28.9	-31.5	-27.9	-28.6	-27.9
05-123-15062	2 SAWDEY UNIT	BHD	Yes	5/26/2021	SP_05_123_15062_BHD	ISOTECH	BHD	73.9	9.51	5.66	0.929	2.82	0.77	0.856	0.583	-55.71	-246.2	-32.54	-29.13	-31.47	-28.23	-28.36	-27.66
05-123-15062	2 SAWDEY UNIT	PRDC	Yes	5/26/2021	SP_05_123_15062_C	ISOTECH	DKJCD	58.4	6.75	4.1	0.692	1.72	0.392	0.386	0.284	-55.11	-240.1	-32.42	-29.02	-31.26	-27.95	-28.08	-27.32
05-123-30356	32-30 SAWDEY	BHD	No	12/6/2021	SP_05_123_30356_BHD	ISOTECH	BHD	83	6.29	4.12	0.862	1.13	0.375	0.368	0.447	-53.9	-228	-33.9	-31.5	-32.6	-30.5	-29	-28.7
05-123-30356	32-30 SAWDEY	PRDC	No	12/6/2021	SP_05_123_30356_C	ISOTECH	NBCD	77.1	12.2	5.19	0.748	1.82	0.418	0.427	0.14	-47.6	-239	-32.9	-29	-31.6	-28.3	-28.6	-27.9
05-123-30354	31-30 SAWDEY	BHD	No	2/2/2022	SP_05_123_30354_BHD	ISOTECH	BHD	78.7	6.24	4.57	0.768	1.38	0.417	0.482	0.422	-54.5	-231	-33.8	-31.3	-31.8	-29.2	-28.6	-28.2
05-123-30354	31-30 SAWDEY	PRDC	No	2/2/2022	SP_05_123_30354_C	ISOTECH	NBCD	78.2	11.7	4.98	0.619	1.41	0.266	0.267	0.0878	-48.3	-243	-32.6	-29	-31.2	-27.7	-28.2	-27.6
05-123-30118	8-30 BRYANT	BHD	Yes	2/9/2022	SP_05_123_30118_BHD	ISOTECH	BHD	80.3	8.81	5.83	0.749	1.43	0.27	0.246	0.162	-53.2	-236.9	-33.91	-30.35	-31.84	-28.95	-28.24	-27.95
05-123-30118	8-30 BRYANT	PRDC	Yes	2/9/2022	SP_05_123_30118_C	ISOTECH	JNBCD	7.26	1.25	1.17	0.178	0.378	0.084	0.07	0.0276	-53.17	-232.4	-32.59	-29.32	-31.6	-28.79	-28.6	-28.4
05-123-12476	1 GLADYS SAWDEY	BHD	No	5/9/2022	SP_05_123_12476_BHD	ISOTECH	BHD	84.7	3.83	2.95	0.52	0.55	0.171	0.123	0.142	-56.9	-233	-34.5	-31.2	-31.6	-29.1	-28.3	-27.6
05-123-12476	1 GLADYS SAWDEY	PRDC	No	5/9/2022	SP_05_123_12476_C	ISOTECH	JNBCDSXSH	83.7	6.54	4.49	0.756	1.27	0.371	0.344	0.236	-54	-231	-34.2	-31.4	-32	-29.8	-28.6	-28.7
05-123-30352	6-30 SAWDEY	BHD	No	5/9/2022	SP_05_123_30352_BHD	ISOTECH	BHD	82.8	5.77	3.51	0.863	1.11	0.374	0.273	0.19	-56.5	-240	-34	-30.7	-31.8	-29	-28.5	-27.8
05-123-30352	6-30 SAWDEY	PRDC	No	5/9/2022	SP_05_123_30352_C	ISOTECH	NBCD	76.1	11.3	5.33	0.833	2.27	0.73	0.892	0.788	-48.7	-244	-33.3	-29.3	-31.6	-28.2	-28.7	-27.8
05-123-23298	3-30 BALLANTINE	BHD	Yes	10/21/2019	SP_05_123_23298_BHD	ISOTECH	BHD	31.3	0.76	0.921	0.179	0.398	0.099	0.099	0.0417	-56.37	-272.10	-33.18	-29.37	-31.49	-28.07	-27.53	
05-123-23298	3-30 BALLANTINE	PRDC	Yes	10/21/2019	SP_05_123_23298_C	ISOTECH	NBCD	76	12.2	5.64	0.724	1.63	0.338	0.34	0.142	-47.83	-243.60	-32.49	-28.97	-31.43	-27.77	-28.24	-27.36
05-123-23298	3-30 BALLANTINE	BHD	Yes	8/11/2021	SP_05_123_23298_BHD	ISOTECH	BHD	4.24	0.32	0.52	0.163	0.526	0.229	0.256	0.153	-54.52	-254.80	-33.06	-29.75	-32.30	-28.20	-28.60	-27.50
05-123-23298	3-30 BALLANTINE	PRDC	Yes	8/11/2021	SP_05_123_23298_C	ISOTECH	NBCD	76.9	12	4.97	0.702	1.74	0.539	0.633	0.837	-48.20	-240.60	-32.64	-29.01	-31.60	-28.02	-28.56	-27.71

Table 1. Produced and bradenhead gas sample data available from gas wells within a ¼ mile radius of the Johnson wells.

KMOG gas composition data are available for 18 bradenhead gas samples and 14 produced gas samples from wells within a 1¼ mile radius of the Johnson wells. Nine samples come from commingled NBCD intervals, 3 samples come from commingled JNBCD, 1 sample comes from commingled DKJCD intervals, and 1 sample comes from commingled JNBCDSXSH intervals (codes illustrated in Exhibit 1). Fourteen of the samples were analyzed using Isotech's offline method (very high precision) whereas the remaining samples were analyzed using their online method that has approximately the same analytical precision as data from DIG laboratory. Only bradenhead gas sample data are available for both adjacent Johnson 32-30 and 7-30A wells in the center of the sampled wells within section 30.

Exhibit 5 illustrates the data from produced and bradenhead gas samples for all wells within a ¼ mile radius of the Johnson wells on another propane vs. ethane stable isotope cross plot. For reference, a portion of the VREiso index line near a VREiso of 0.8, is included on the plot (refer to Exhibit 3). Sample data for both Sussex Seltzer 1 and Wagner 1 well samples presented in the KPK report are also included for reference on this exhibit.

The cross plot demonstrates that produced gas sample data from wells within a ¼ mile radius of the Johnson 32-30 well are clustered within a compositional region that does not correspond to that of bradenhead samples from either of the Johnson wells. Furthermore, all of the Johnson well bradenhead gas samples have stable carbon isotope ratios that are distinctly more negative than those of the produced gas samples. This is consistent with the expected lower source rock maturity signature of Sussex gases at any given location. The gas sample data from the 1 Gladys Sawdey well, the only well with commingled Sussex and Shannon production gases, falls in a region where the stable carbon isotopic composition is also more negative than that of deeper producing intervals.

Stable isotope ratios of carbon in ethane and propane from both Johnson 32-30 samples, collected on 12/13/19 and on 4/16/20, have almost exactly the same values. Those corresponding values are analytically indistinguishable from Johnson 7-30A well gas sample. Therefore, gas in the bradenheads of both wells sampled at the time likely had the same low thermal maturity stray thermogenic gas source.

Other relevant geologic and engineering data

The KPK report makes a number of unsupported claims to propose that stray gas in the Johnson 32-30 well was derived from the Johnson 7-30A well. Additional data presented in this section demonstrate that the exact opposite it far more likely.

The KPK report attributes groundwater aquifer flow direction in this area to suggest that produced gas from the Johnson 7-30A well was the source of gas in the Johnson 32-30 bradenhead. Such an argument may be true if dealing with migration of a dissolved hydrocarbon phase, but does not apply to migration of a free gas phase through a porous, water saturated matrix at elevated pressures. Free gas in the saturated subsurface is buoyant and will always find a way to migrate either directly vertically or in a generally updip direction.

The structure contour map presented in Exhibit 6 shows that, in this area, the Fox Hills Marker dips to the SE. Therefore, the preferred free gas migration pathway will always be towards the NW, away from the Johnson 32-30 and towards the Johnson 7-30A, not the other way around. Furthermore, this report has already demonstrated that gas composition in the Johnson 32-30 bradenhead is analytically indistinguishable from that in the Johnson 7-30A bradenhead. Neither of those bradenhead gases could have been derived from underling production intervals deeper than the Sussex Formation.

Exhibit 7 illustrates several additional features relevant to addressing the source of gas in both Johnson wells. The most remarkable feature evident from the diagram, and not discussed in the KPK report, is that there was only 10 feet of cement placed in the annular space above the top of the perforated Sussex interval in the Johnson 32-30 well. It is hard to imagine that such a thin layer of cement would be sufficient to prevent gas from invading the annulus at some time. For example, all water wells in County are required to have a minimum 20 feet of grout across the annulus of surface conductor casing just to prevent surface water from infiltrating a well. The Johnson 7-30A well, in contrast, had 658 feet of cement covering the annular space above the top of the Sussex Formation in the Johnson 7-30A well. That makes it highly unlikely as the source of gas in the Johnson 32-30 well.

Historic bradenhead gas pressure data also make it unlikely that the stray gas would migrate from the Johnson 7-30 well to the Johnson 32-30 well. When the first bradenhead gas sample was collected from the Johnson 7-30 well on 9/12/19, prior to plugging and abandoning the well on 10/14/2019, the bradenhead pressure was recorded as 171 psi. Earlier, on 3/14/18, ECMC records show that the pressure on the Johnson 7-30 bradenhead was reported to be 115 psi, but no samples were collected at that time. However, when the first bradenhead gas sample was collected from the Johnson 32-30 well on 12/13/19, the pressure on the bradenhead was 460 psi. or 2.7 times higher than the highest bradenhead pressure recorded in the adjacent 7-30 well.

The KPK report also states that elevated bradenhead pressures could not have been derived from the completed interval in the Sussex well because the production gas pressure at the Sussex interval was only 25 psi. at the time. However, such a statement ignores the distinct possibility that a casing leak in the open, uncemented annular space would have charged the shallow subsurface with gas. For example, 460 psi equates to an equivalent gas column height of 460 psi/0.433 psi/ft or, 1062 feet. That depth is within the 650 foot to 2700 foot interval estimated to correspond to the casing leak depth at the Johnson 32-30 well. Such a depth is also deeper than the depth to the surface casing shoe in the Johnson 7-30A well. High pressure gas charging, originating from the pressurized open annular space of the Johnson 32-30 well, is consistent with gas migration into the uncemented annular space of the Johnson 7-30A well.

Gas pressures ranging from of 115 psi to 171 psi in the Johnson 7-30A well correspond to an equivalent gas column height in a water saturated matrix of between 267 to 398 feet. That is one third to one half the distance of the surface casing depth in the well of 748 feet. This begs the question as to whether or not gas pressures recorded in the Johnson 7-30A well prior to abandonment represented residual pressures remaining in response to high pressure gas injection from the open annulus at the neighboring Johnson 30-32 well. An effective gas column height would have to be taller than 748 feet or greater than 321 psi, to displace a column of water and penetrate the base of the surface casing shoe at the Johnson 7-30A well. Based on pressure considerations alone, therefore, it is not likely that gas at lower pressures in the Johnson 7-30 well could have invaded the open annular space of the Johnson 32-30 well.

Conclusion

Geochemical gas data presented in this report make it evident that bradenhead gases in both Johnson 7-30A and Johnson 32-30 wells are analytically identical in stable isotope composition. Neither of the bradenhead gases can be derived from underlying producing gas intervals deeper than the Sussex Formation in this area of the basin. Furthermore, well construction, historic gas pressure, and structural geologic constraints are inconsistent with the idea that the Johnson 7-31A well could have been the source of gas in the Johnson 32-30 bradenhead. If anything, the reverse is true. Gas from the Sussex Formation completed in the Johnson 32-30 well was ultimately the most likely source of gas in the Johnson 7-30A well.

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Exhibits

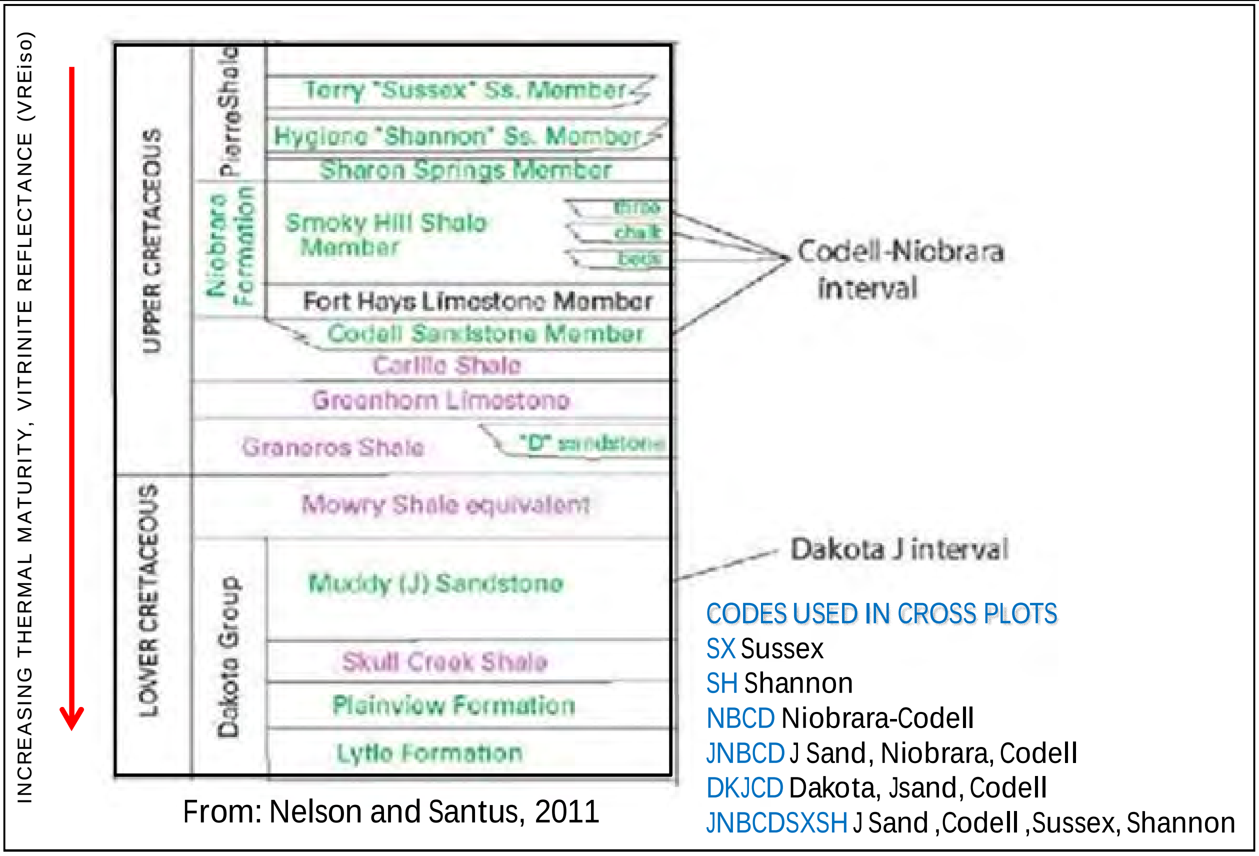

Exhibit 1: Stratigraphic column (adapted from Neslons and Santus 2011), generalized thermal maturity with depth (red arrow), and stratigraphic codes used in this report.

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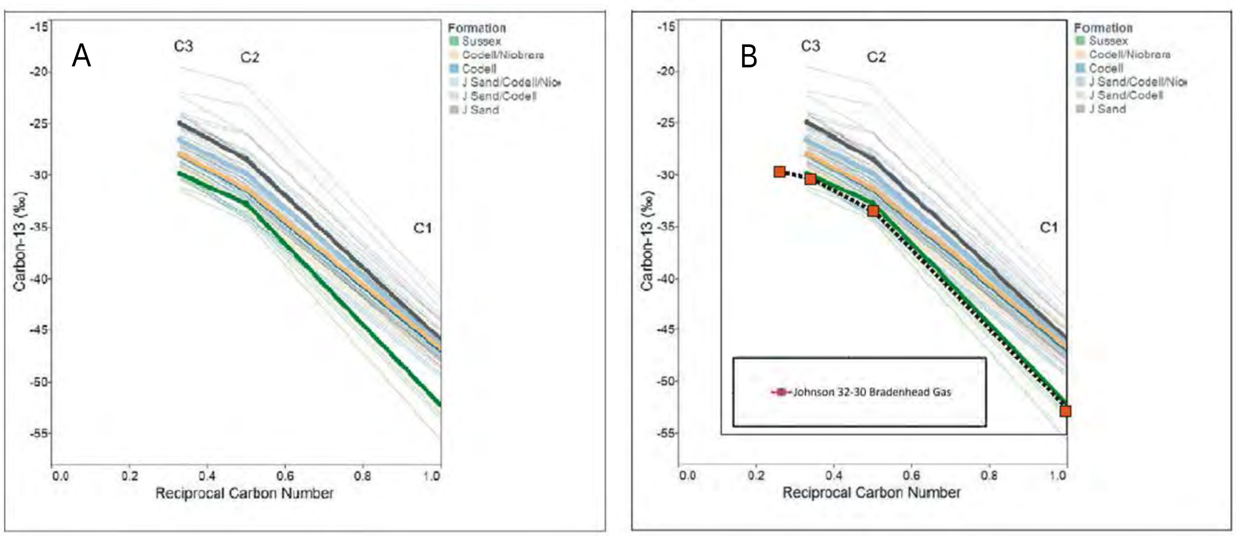

Exhibit 2. Chung plot of stable carbon isotope data published in Sherwood et. al, 2013 (A) and that presented in DIG laboratory report to KPK for the Johnson 32-30 bradenhead gas sample collected on 12/13/19 (B).

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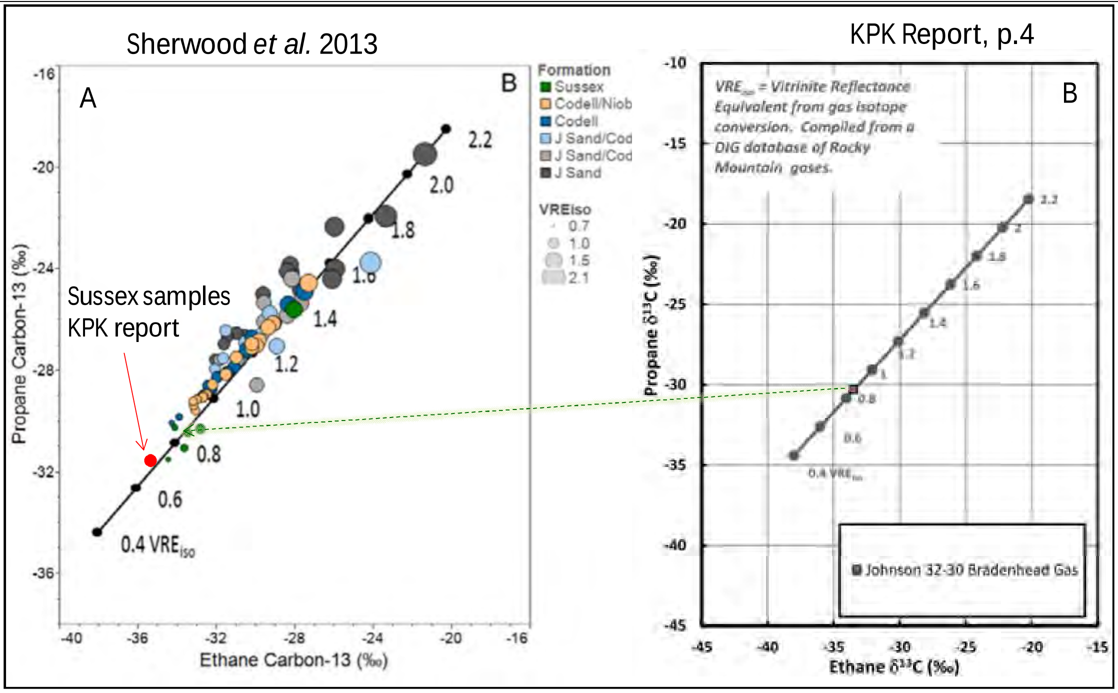

Exhibit 3.Stable isotope ratios carbon in ethane and propane from the Johnson 32-30 well fall exactly within the thermal maturity range reported for Sussex gas samples in the Denver Basin.

-

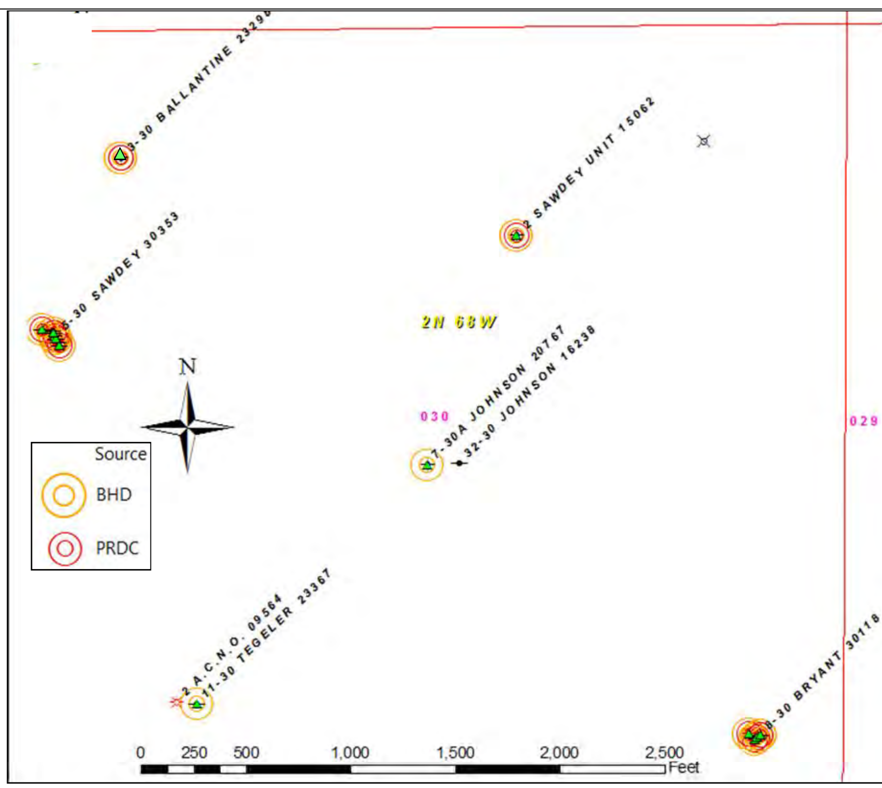

Exhibit 4. There are numerous produced and bradenhead gas sample data available from commercial gas wells within a ¼ mile radius of the Johnson wells (BHD = bradenhead sample, PRDC = produced gas sample).

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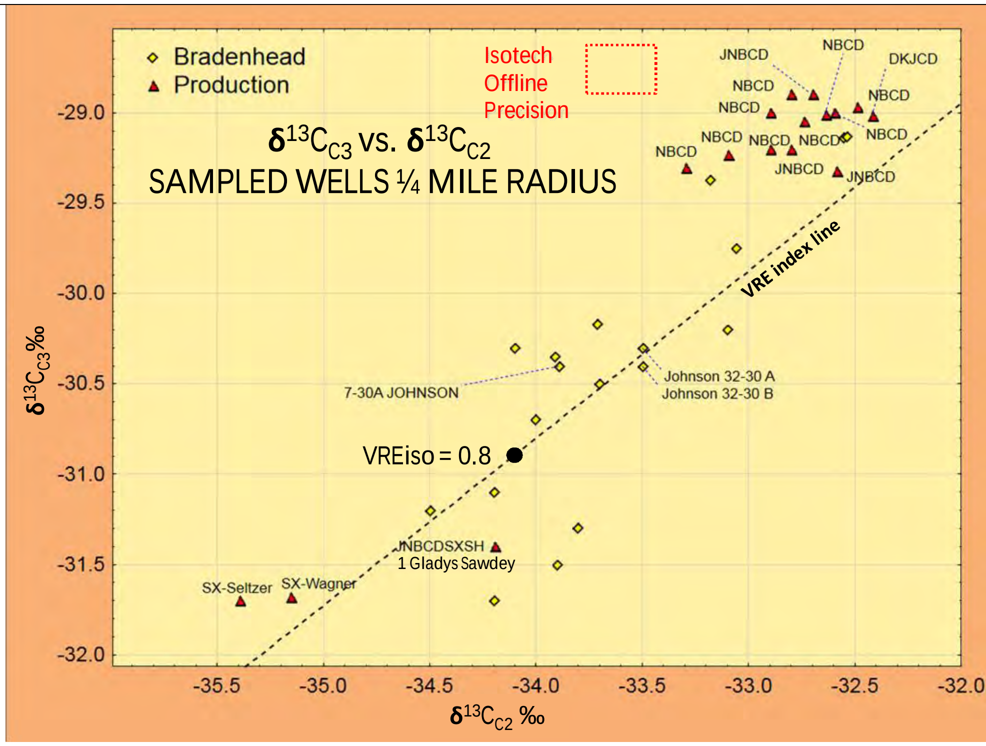

Exhibit 5. Bradenhead gas samples from the Johnson 32-30 and Johnson 7-30A wells cannot be derived from underlying gas production intervals in this area of the basin.

-

Exhibit 6. Depth to the Fox Hills Marker (FHM), feet above mean sea level. Contour interval = 20 feet.

-

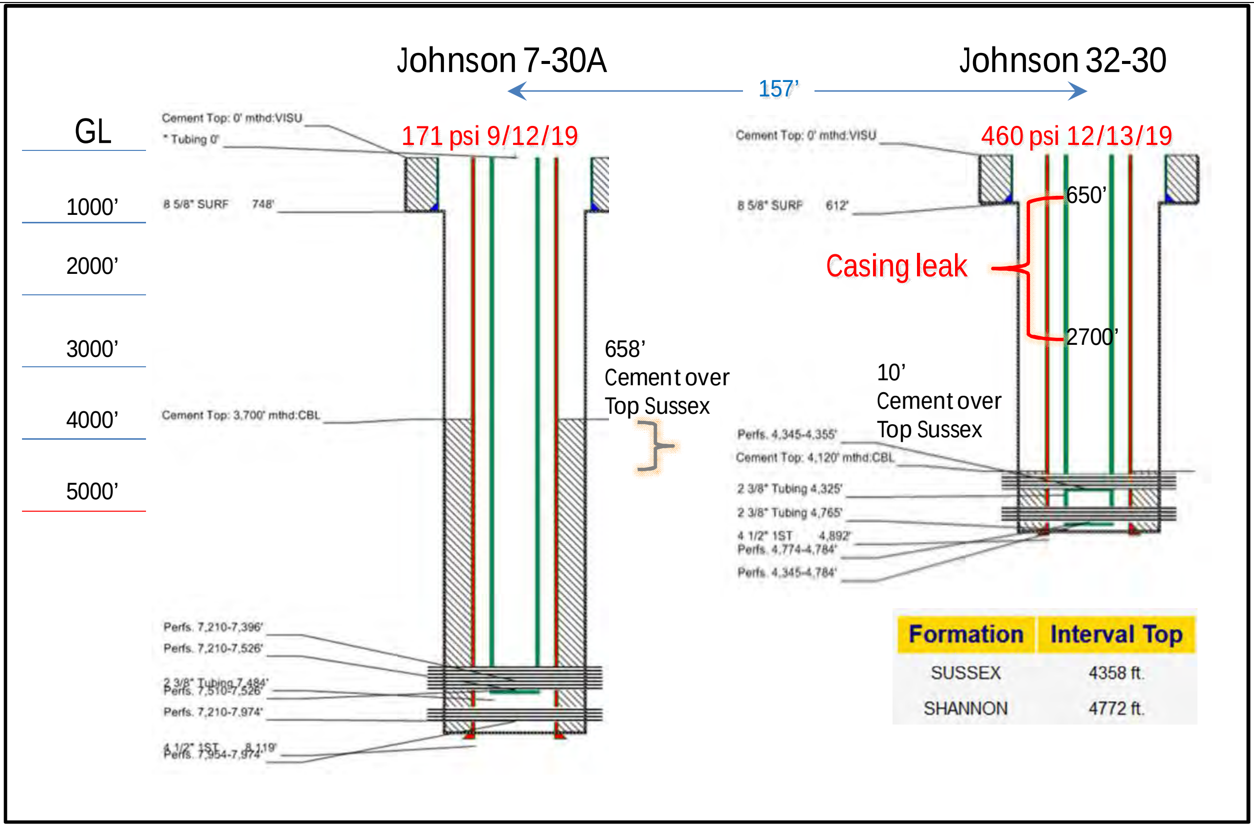

Exhibit 7. Summary ECMC well bore diagrams with relevant features discussed in this and the KPK report.

ANTHONY W. GORODY, Ph.D., P.G.

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PROFILE: Dr. Gorody is a geoscientist with more than 30 years of diverse international and domestic oil and gas industry experience. His technical specialty relates to state-of-the-art forensic geochemical fingerprinting and hydrogeologic characterization techniques useful for evaluating natural gas resources, groundwater and surface water resources, produced water, and hydrocarbon pollution in the near-surface hydrogeologic environment. An industry leader in baseline environmental measurement and monitoring programs, Dr. Gorody provides both consulting and training services. These include the following:

- Collecting and interpreting forensic data related to the drilling and completion of natural gas reservoirs and surrounding water resources;
- Assembling and managing multi-disciplinary teams to design and implement groundwater assessment and monitoring projects.
- Developing standard practices for water resource sampling, analysis, and reporting;
- Designing and implementing environmental risk mitigation options in gas field development projects.

These services have been successfully applied to support and advise oil and gas producers, state and federal regulators, and community development groups.

Dr. Gorody's work experience is based on domestic projects in the Appalachian, Piceance, Denver, Sandwash, Washakie, Wind River, Powder River, Green River, San Juan, Raton, Fort Worth, East Texas Salt, Black Warrior, Gulf Coast Tertiary, Rio Grande, and Uinta Basins, and international projects in the North Sea, Baltic, Telkwa (BC); Comox (BC); and Hat Creek (BC), and Alberta (AB) Basins. He is experienced with all aspects of litigation.

HONORS

2014 Nominee for the ENI Enrico Mattei prize "Protection of the Environment"
2012 AAPG Division of Environmental Geosciences Public Outreach Award: "In recognition of efforts and accomplishments in the promotion and presentation of environmental concerns and subjects to the general public".

PROFESSIONAL EXPERIENCE:

P.G. Licenses: Texas # 10498, Wyoming # 3674, Pennsylvania # PG004977
1994 - Present President: Universal Geoscience Consulting, Inc.
1994 - 1997 Executive Vice President: Alliance Gas Marketing, Inc., Chicago, IL
1990 - 1994 Principal Scientist and Technology Manager: Gas Research Institute - Natural Gas Reserve Growth
1986 - 1990 Senior Scientist: Gas Research Institute - Natural Gas Supply
1983 - 1986 Sr. Staff Advisor: Texas Eastern Transmission Corp - Business Development
1980 - 1983 Research Advisor: Texas Eastern Transmission Corp - Business Development

CLIENT LIST:

Regulatory agencies: Alberta Environment**;** British Columbia Ministry of Energy, Mines, and Petroleum Resources (MEMPR); Colorado Oil & Gas Conservation Commission; Pennsylvania Department of Environmental Protection-- Bureau of Oil & Gas Management

Oil and Gas operators (alphabetical order):

Amoco Production Co.; Anadarko Petroleum Co. (Denver); Antero Resources; Apollo Energy; Bill Barrett Corp.; BP America; Chesapeake Energy Corp.; ConocoPhillips, Inc.; Dolphin Energy Corp.; Emerald Gas Production Co.; EnCana Corporation (Canada); EnCana Oil & Gas (USA) Inc.; Energen Resources Corp.; EnerVest San Juan

Operating LLC; ExxonMobil Production Co.; IKAV Energy; GeoMet Operating Co.; Luca Technologies; Inc.; Neosho Oil & Gas Company; Noble Energy; Nonsuch Natural Gas Co.; Norse Energy Corp.; Occidental Oil and Gas; Quicksilver Resources, Inc.; Oso Energy Resources; Patina Oil and Gas Corp.; Pennaco Natural Gas; LLC.; PetroBras; PetroCanada; Petrohunter Energy; Pioneer Natural Resources USA; Range Resources; Redstone Resources; Shell Exploration and Production Co.; Talisman Energy USA; Tenneco Oil & Gas Company; Texaco E&P Technology; Ticora Geosciences; Inc.; Union Pacific Resources; Corp.; Wolverine Oil and Gas Corp.

Environmental Research Firms:

Alberta Innovates-Technology Futures (AITF); Alberta Research Council; AMEC Earth & Environmental Division; Argonne National Laboratory; Ernest Orlando Lawrence Berkeley National Laboratory; Gas Research Institute; GSI Environmental, Inc., Southwest Research Institute; Worley Parsons Komex.

Mining Companies: Amax Coal Company; RAG Coal West Inc.; Hanna Mining Company;

Law Firms: Lewis, Bess, Williams, and Weese, P.C.; Wilmer Cutler Pickering Hale and Dorr, LLP; Houston Harbaugh; Beatty and Wozniak, P. C.; Burns, Figa & Will, P. C.; Clements, Pierce, Pickens, and O'Neil, Attorneys at Law; Davis, Graham, and Stubbs, LLP; Gardere and Wynn, LLC; Holland & Hart; Holmes, Owens, and Roberts, LLP; Hughes and Luce Attorneys at Law; K&L Gates, P. C.; Lightfoot, Franklin, and White, LLC; McNerney, Page, Vanderlin & Hall; Lonabaugh and Riggs, LLC; Patton and Boggs, LLC.; Temkin, Wielga, and Hardt, LLP; Yonkee and Toner, LLC

International Projects: Swedish Power Board (Vattenfall); Norwegian Continental Shelf Institute (IKU); Danish Geological Survey, Belgian-German Underground Coal Gasification Project (IDGS).

EDUCATION:

Ph. D., 1980, Rice University - Weiss Fellow
M.S., 1980, Rice University - Weiss Fellow; AAPG Grants-in-Aid Scholarship
B.A., 1971, Rutgers University - Maxim Moroz Memorial Scholarship in Geology

MEMBERSHIPS:

National Groundwater Association, American Water Resources Association, American Association Petroleum Geologists, Society Petroleum Engineers, American Geophysical Union, American Chemical Society, American Association for the Advancement of Science, Rocky Mountain Association of Geologists.

PUBLICATIONS AND ABSTRACTS

Molofsky, L. J., S. D. Richardson, A. W. Gorody, F. Baldassare, J. A. Connor, T. E. McHugh, A. P. Smith, A. S. Wylie, and T. Wagner, 2018, Purging and other sampling variables affecting dissolved methane concentration in water supply wells: Science of The Total Environment, v. 618, p. 998–1007, doi: 10.1016/j.scitotenv.2017.09.077.

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Gorody, A. W., 1993, Reservoir characterization R&D; Unlocking the natural gas potential of the Rocky Mountain Region, Invited Keynote Address, Annual Meeting of the Am. Assn. Pet. Geol., Rocky Mountain Section, Salt Lake City, UT, Abstracts.

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Castaño, J. R. and Gorody, A., 1992, The Siljan ring structure as a target for hydrocarbon exploration; implications from the Gravberg 1 well, Sweden, Annual Meeting of the Am. Assn. Pet. Geol., Calgary (Abstract); p. 17.

Lutz, S., Nielson, D. L., Thorn, D., and Gorody, A. W., 1992, Scientific drilling in the Cretaceous Ferron sandstone, Utah, 1992 SEPM meeting: Mesozoic of the Western Interior, p. 17 – 19.

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Gevirtz, J. L., Curtis, J. B., Gorody, A. W., Brown, S. W., 1988, Sampling and variation: application to surface geochemical surveying (Abstract); 1988 AAPG Annual Mtg.

Fish, F., and Gorody, A. W., 1987, Siljan drilling experiment: Participation of the Gas Research Institute, in: Bodén, A., and Eriksson, K. G.,(eds.); Deep Drilling in Crystalline Bedrock, Volume I: The Deep Gas Drilling in the Siljan Impact Structure, Sweden, and Astroblemes, p. 3-9.

Gorody, A. W., 1984, TEDSI develops horizontal drilling technology, Oil and Gas Journal, Oct., p. 118-126.

Gorody, A. W., 1980, Dolomitization and paleohydrologic history of the Lower Ordovician Mascot Formation, Upper Knox Group in Central Tennessee, 1980 Geol. Soc. Am. Annual Mtg, (Abstract).

TRAINING & WORKSHOPS

Gorody, A. W., 2010, Baseline groundwater sampling and monitoring best practices – AMEC Earth and Environmental Div., All day training seminar presented to AMEC staff and their clients in Marcellus Shale play.

Gorody, A. W., 2009, Factors affecting forensic analysis and interpretation of impacts from stray gas well hydrocarbons: pressure, mixing, oxidation, and dilution: USGS Stray Gas Workshop, Eastern Region Water Science Center, Pittsburgh PA, Nov. 4-6, 2009.

Gorody, A. W., 2009, Baseline groundwater sampling and monitoring best practices: Lessons learned from two decades of baseline groundwater sampling and monitoring in Colorado unconventional gas resource plays, 2009 Independent Oil and Gas Assn. N.Y. Ann. Mtg. Workshop.

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SPONSORED COMMUNITY PRESENTATIONS

2007, The hydrologic and geologic environment in the Pavillion Area, Nov. 12, Pavillion, Wyoming. Sponsor: EnCana Oil and Gas (USA) Inc., Northern Rockies Development Unit.

2007, Water wells and water use in the Barnett Shale resource development area, North Central Texas, Barnett Shale Energy Expo May 16th 2007. Sponsor: Fort Worth Chamber of Commerce.

2006, Recommendations for establishing a baseline groundwater sampling and analysis program in the Telkwa-Smithers coal basin: Oct. 17 to Telkwa , B. C. Sponsor: BC Ministry of Energy, Mines, and Petroleum Resources.

2006, Baseline environmental monitoring results from the Piceance Basin and their relevance to oil and gas operations in Garfield County, Colorado: Oct,26, Rifle, Colorado. Sponsor: Garfield County Energy Advisory Board

2005, What's in your water well?, January 20 – 22, Rifle and Parachute Colorado. Sponsor: Colorado Mountain College. DVD of entire televised presentation available through CMC Rifle Campus, c/o Ms. Pam Arsenault.

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2004, Final results of a COGCC-sponsored baseline environmental study related to coalbed methane development in the Raton Basin, Colorado, Presented Feb. 17 – 18 to Las Animas and Huerfano County Commissioners. Sponsor: Colorado Oil and Gas Conservation Commission. Slides available on COGCC web site.

2004, Interpreted results of hydrochemical data from the West Divide Creek seep investigation, Public testimony on behalf of EnCana USA, before the COGCC, Glenwood Springs, CO, August, 2004.

LEGAL CASES AND HEARINGS

Consulting expert for following cases and hearings:

2007 on behalf of MacTec Inc. (Piceance Basin hydraulic fracturing);: Denver County District Court 06 CV 6335.

2005 on behalf of BP (San Juan Basin infill drilling);: Before the COGCC – Cause No. 112, Docket 0509-AW-16, La Plata County, CO

2004 on behalf of EnCana (Piceance Basin);: Before the COGCC-Cause No. 1V, Docket No. 0408-OV-27, Garfield County, CO

2002 on behalf of ConocoPhillips (Conventional gas property, Laredo, TX);
Ophelia M. Guerra vs. ConocoPhillips**:**

1999- 2000 on behalf of BP-Amoco Production Co. (Conventional oil and gas property);
Merijildo Martinez vs. BP-Amoco Production Co.
U. S. District Court for the District of New Mexico, Civil Action No. CIV 99-617-LCS:

1998-1999 on behalf of Energen Resources (Coalbed gas property);
David L. Hayes and Betty L. Hayes, et al. vs. Amoco Production Company, Inc., et al.;
Circuit Court of Jefferson County, Alabama, Civil Action N0. CV 95-2678:

Various plaintiffs referred to as: Avery et al. vs. USX Corp., Taurus Exploration Inc., Jim Walter Resources, Inc., Teco Coalbed Methane, Inc., Black Warrior Methane, Inc., U. S. Mining Co., Inc. and Drummond Co. Inc.;
Circuit Courts of Jefferson and Tuscaloosa Counties, Alabama:

1997 on behalf of Mitchell Energy Corporation (Conventional gas property);
Carol R. Bailey, et al, vs. Mitchell Energy Corp.
District Court of Wise County, TX, Consolidated Case No. 95 08 422:

1994 - 1997 on behalf of Amoco Production Co. (Coalbed gas properties);
George E. Zollinger vs. Amoco Production Co.
U. S. District Court for the District of Colorado, Class Action No. 94 C 1656:

D. Matthew Runnels, Plaintiff, vs. Amoco Production Co., and Meridian Oil Production Inc.
U. S. District Court for the District of New Mexico, Class Action 93-1091-CIV-JP-WWD:

David E. Field, et al., vs. Amoco Production Co.
U. S. District Court for the District of Colorado, Case No. 94 C 105:

Testifying expert and expert testifying witness for following cases and hearings:

2003, Affidavit: Hickman V. Groves 2003 Wy 76 71 P.3d 256 Case Number: 02-173 Decided: 06/17/2003

2003, Affidavit: McGee V. Caballo Coal Company 2003 Wy 68 69 P.3d 908 Case Number: 02-109 Decided: 05/29/2003

1994 - 1997 on behalf of Amoco Production Co. (Coalbed and conventional gas properties);
Franklin "Hank" Dippery and Mescal Dippery, John Friend & Mary Friend, Lora Mae Clark & Freddie A. Clark, Linda Truett Compton & Cassidy Compton, Jewel Waggoner, Brandon Lee Waggoner, & Talon Lauren Waggoner, and Craig Ward & Patricia Ward Vs. Amoco Production Co., & Burlington Resources Oil & Gas Co.
U. S. District Court for the District of New Mexico, Consolidated Civil Action Nos. CIV 93 1091, 95-908, 94-1432, 95-1493, 96-33, and 96-333:

1994 - 1997 on behalf of Amoco Production Co. (Coalbed and conventional gas properties);
Rosemary Tedesco & Michael Tedesco vs. Amoco Production Co.
U. S. District Court for the District of New Mexico, Civil Action No. CIV 95-906:

1987 - 1988 on behalf of Amax Coal Company (Coal mining property);
W. Douglas Miller, et. al., vs. Amax Coal Company,
U. S. District Court for the District of Wyoming, Civil Action C 87-0300-J:

ANTHONY W. GORODY, Ph.D., P.G.

REFERENCES

Provided on Request