APPENDIX R

ADDITIONAL EXPERT ANALYIS BY FRAZIER AND WILSON

THIRTY-FIRST JUDICIAL DISTRICT COURT FOR THE PARISH OF JEFFERSON DAVIS

STATE OF LOUISIANA

CASTEX DEVELOPMENT, LLC.	
VERSUS	**DOCKET NO. C-502-20**
ANADARKO PETROLEUM CORP., ET Al.	

EXPERT REPORT OF JOHN R. FRAZIER, Ph.D., CHP
AND
CHARLES A. WILSON IV, Ph.D., CHP, CLSO, CSP

I. INTRODUCTION

We have been retained by counsel for Defendant BP America Production Company (BP) in the matter of Castex Development, LLC versus Anadarko Petroleum Corporation, et al. (31st JDC, Jefferson Davis, Docket No. C-502-20) to assess the radiological conditions of a certain property in the West Mermentau Oil Field in Jefferson Davis Parish, Louisiana. Specifically, we have been asked to review all available radiological data for the subject property and determine whether there is naturally occurring radioactive material (NORM) due to oil and gas operations in soil and groundwater. We have also been asked to review the October 18, 2024 report by Gregory W. Miller and Jason S. Sills and the November 4, 2024 report by Charles R. Norman. At the request of BP, Dr. Wilson visited the subject property on April 17, 2025, to perform radiation measurements and collect soil samples for laboratory analysis for concentrations of NORM radionuclides radium-226 (Ra-226) and radium-228 (Ra-228) in each sample. We have also been retained by Anadarko Petroleum Corporation and Anadarko US Offshore, LLC and have written a separate report regarding radiological conditions of the subject property for those defendants.

II. OPINIONS

We have reached the following conclusions with a reasonable degree of scientific certainty:

1. Radiation measurements were performed on the subject property by Plaintiff's representatives with ICON Environmental Services, Inc. (ICON) on June 8 and 9, 2022

identifying soil and equipment with above-background readings at contact. No one-meter readings were reported by ICON. Field notes taken by Hydro-Environmental Technologies (HET) on behalf of Defendants indicate the ICON radiation measurements were performed on June 9 and 10, 2022.

2. Eight (8) soil samples were collected by ICON from three (3) locations on the subject property. Nine (9) split soil samples, including one lab duplicate, were contemporaneosuly collected from those same locations by Environmental Resources Management Southwest, Inc. (ERM).

3. No portion of ICON's proposed soil excavation plan is proposed for the purpose of removing NORM-impacted soil.

4. There is NORM-impacted soil that exceeds the applicable Louisiana standards in one relatively small area on the subject property, in the vicinity of sample location R-3, of which the total volume is estimated to be less than 2.5 cubic yards (yd^3).

5. Analysis of groundwater samples from the subject property show no presence of oilfield NORM. Twenty-six (26) groundwater samples (and 32 split samples) were collected from 11 wells on the subject property. All of the ratios of concentrations of Ra-226 and Ra-228 in the water from the eleven (11) wells are consistent with natural ratios of Ra-226 and Ra-228 and do not indicate the presence of produced water from oilfield operations.

6. The November 4, 2024 report of Charles R. Norman does not include any radiological characterization data for the subject property. His opinions regarding the nature and extent of NORM on the property are based on the radiological characterization data produced by ICON. He does not include any site-specific assessment for radiological impacts due to NORM.

7. Based on our review of the radiological characterization data for the subject property, we have concluded that no one on or near the subject property can reasonably be expected to receive a radiation dose greater than the range of radiation doses from natural background radiation in Louisiana.

III. QUALIFICATIONS

Dr. Frazier's qualifications are detailed in Attachment A. His area of expertise is health physics – the scientific discipline of measuring radiation and protecting people from the harmful effects caused by high doses of radiation. His academic degrees include a B.A. in physics, M.S. in physics, and Ph.D. in physics (with emphasis in health physics and radiation protection). He has over forty-seven (47) years of professional experience in health physics, primarily in the areas of radiation detection and measurement, radiation dose assessments, external and internal radiation dosimetry, and radiation safety standards and practice. He has extensive experience performing radiological characterization surveys of property, assessing external and internal radiation doses from natural and man-made radiation sources, and reviewing/assessing operational data generated by facilities that are licensed to possess and use radioactive materials and other radiation sources. Over the past twenty-nine (29) years he has performed numerous radiological assessments of soil and groundwater on properties for oilfield NORM. He has also evaluated current and past radiation exposure conditions on properties impacted by oilfield NORM.

Dr. Wilson's qualifications are detailed in Attachment B. His area of expertise is also health physics. His academic degrees include a B.S. in physics, M.S. in medical and health physics (concentration in health physics), and Ph.D. in environmental sciences (concentration in environmental health physics). He has over seventeen (17) years of professional experience in health physics, primarily in the areas of radiation safety program design and implementation, radiation detection and measurement, and compliance with state and Federal radiation protection regulations. He has extensive experience performing radiological characterization surveys of facilities, assessing external and internal radiation doses, and reviewing/assessing operational data generated by facilities that are licensed to possess and use radioactive materials and other radiation sources.

IV. BASIS OF OPINIONS

During preparation of our opinions presented in this report, we reviewed documents pertaining to the subject property and natural radiological conditions in the vicinity of the subject property and throughout the State of Louisiana. Specific documents that we reviewed in preparation of this report are listed in Attachment C. In forming our opinions, we are relying on the radiological data acquired to date for the subject property by consultants for Plaintiff and Defendants. The following is a description of basic terminology and concepts of radiation and radioactive materials in the natural environment and associated with oil production.

A. Natural Background Radiation Levels in Louisiana

Every person is exposed to external radiation from natural background radiation sources every day of their lives. Natural background sources of external radiation include cosmic rays (and the external radiation from the interactions of cosmic rays with the atmosphere) and naturally occurring radioactive materials in and on the earth (soil, rocks, building materials, etc.). External radiation produces an external exposure rate that is often expressed in units of microroentgen per hour (μR/hr). The external exposure rate from natural background radiation sources varies with altitude, latitude, and the natural radionuclide content of soil, rocks, building materials, etc. In the United States, the external exposure rate from natural background radiation varies from less than approximately 3 μR/hr to well over 20 μR/hr (Myrick 1981; NCRP 2009). In Louisiana, the nominal external exposure rate from natural background radiation sources has a range from less than 5 μR/hr to over 14 μR/hr (Beck 1986).

B. Naturally Occurring Radionuclides in Native Louisiana Soil and Sediment

Naturally occurring radioactivity is present in essentially everything on, beneath, or above the earth's surface. These radioactive materials are present as primordial radioactivity (as they have been present since the earth was formed) or as naturally produced radioactivity (e.g., cosmogenic radioactivity) that continues to be formed from interactions of cosmic rays with the earth. The most abundant radionuclides on the earth are the primordial radionuclides in three natural decay series (thorium, uranium, and actinium) and the non-series primordial radionuclide, potassium-40. The concentrations and amounts of these natural radioactive materials that comprise the natural background radioactivity in substances on or in the earth have been described in detail in various reports. The NCRP, a council of 100 eminent independent scientists chartered by Congress, has published Report No. 160, "Ionizing Radiation Exposure of the Population of the United States" (NCRP 2009), that includes information on the sources and amounts of natural background radiation exposure being received by the U.S. public. NCRP Report No. 160 notes that concentrations of each of the primordial radionuclides vary with substance (rock, soil, sediment, etc.), location, and other factors. For surficial soil in the United States, each radionuclide in the uranium series and each radionuclide in the thorium series is present at a typical average concentration of one (1) picocurie per gram (pCi/g). The typical average concentration of potassium-40 in soil is in the range of approximately 10-25 pCi/g. However, the range of concentrations of these radionuclides in native soil varies with location, depending on the components of the soil (Myrick 1981; NCRP 2009).

Natural background concentrations of selected radionuclides, including Ra-226 and Ra-228, in soil and sediment in Louisiana are given in several publications (DeLaune 1986; Meriwether 1988; Meriwether 1991; Meriwether 1992). The range of concentrations of Ra-226 in native Louisiana soil is approximately 0.2 pCi/g to approximately 3 pCi/g, with an average concentration of approximately 1 pCi/g. The average and range of concentrations of Ra-228 in native Louisiana soil are approximately the same as the respective concentrations of Ra-226. In native soil, both Ra-226 and Ra-228 are continually being produced in the natural radioactive decay series uranium and thorium, respectively. The environmental behavior of radium is described in various publications, such as Technical Reports of the International Atomic Energy Agency (IAEA) (IAEA 1990; IAEA 2014).

C. Natural Background Radioactive Material in Louisiana Groundwater

Natural waters contain solids from contact with soils, rocks, and other natural materials. Some solids are suspended in the groundwater and some solids are dissolved (not removed by filtration) in the groundwater. The United States Geological Survey (USGS) has summarized the following points regarding dissolved solids in water:

> The dissolved solids concentration in water is the sum of all the substances, organic and inorganic, dissolved in water. This also is referred to as "total dissolved solids", or TDS. Calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, nitrate, and silica typically make up most of the dissolved solids in water. Combinations of these ions—sodium and chloride, for example—form salts, and salinity is another term commonly used to describe the dissolved solids content of water (USGS 2020).

Concentrations of dissolved solids in water can be so high that the water is unsuitable for drinking, irrigation, or other uses. Groundwater that contains natural solids (i.e., TDS) contains naturally occurring radioactive materials (NCRP 2009). Radium is a trace metal in groundwater that is usually present in the TDS as radium chloride (IAEA 1990). In general, greater concentrations of TDS and chlorides in groundwater correspond to greater concentrations of radium in that same water (Kraemer 1984; IAEA 1990; IAEA 2014). Elevated concentrations of chlorides in groundwater in contact with native soil, sediment, and rock can cause natural radium to pass from the soil, sediment, and rock into the groundwater as radium chloride (IAEA 1990; IAEA 2014). In Louisiana, groundwater sampling has shown that concentrations of Ra-228 are slightly greater than, or approximately equal to, the concentrations of Ra-226 in the groundwater (USGS 1988). This is a consequence of the approximate equal concentrations of natural background uranium and thorium in the soil, sediment, and rock that is in contact with groundwater (IAEA 1990; IAEA 2014).

D. Radiation Doses from Natural Background Radiation Sources

Radiation doses received by individuals from natural background radiation have been studied extensively for many decades. The term "dose" is used to represent the amount of radiation energy deposited in tissue per unit mass of tissue of a person exposed to ionizing radiation[1, 2]. External radiation doses are produced by penetrating radiation (e.g., gamma rays or x-rays) from radiation sources outside the human body. Internal radiation doses are produced by radiation emitted by radioactive material within the body following inhalation or ingestion of that radioactive material. Natural radiation and radioactivity in the environment provide the major

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[1] Ionizing radiation is radiation that can knock electrons from atoms or molecules. Ionizing radiation differs from non-ionizing radiation, such as visible light, microwaves, etc., that cannot ionize atoms or molecules.

[2] The standard unit of radiation dose equivalent is the "millirem."

source of external and internal radiation doses to humans. NCRP Report No. 160 describes the radiation doses received from natural background radiation sources in the U.S. (NCRP 2009).

The NCRP notes in Report No. 160 that the average radiation dose in the United States from cosmic radiation at ground level is approximately 33 millirem per year (NCRP 2009). The average external radiation dose from terrestrial radionuclides in the United States is approximately 21 millirem per year. As with soil and other terrestrial matter, the human body also contains naturally occurring radionuclides, the most abundant of which is the primordial radionuclide potassium-40. The average internal dose from radionuclides (excluding radon and radon progeny) in the body is approximately 29 millirem per year. Therefore, the NCRP concludes that the total natural background radiation dose (excluding radon and radon progeny) in the United States is approximately 83 millirem per year (NCRP 2009). In addition, the NCRP has determined that the average radiation dose from inhaled radon and radon progeny in the United States is approximately 228 millirem per year. Therefore, the total average radiation dose from natural background radiation sources in the United States is approximately 311 millirem per year (NCRP 2009). The total average annual radiation dose from natural background radiation sources in Louisiana is somewhat less than the average for the United States (NCRP 2009).

E. Oilfield NORM

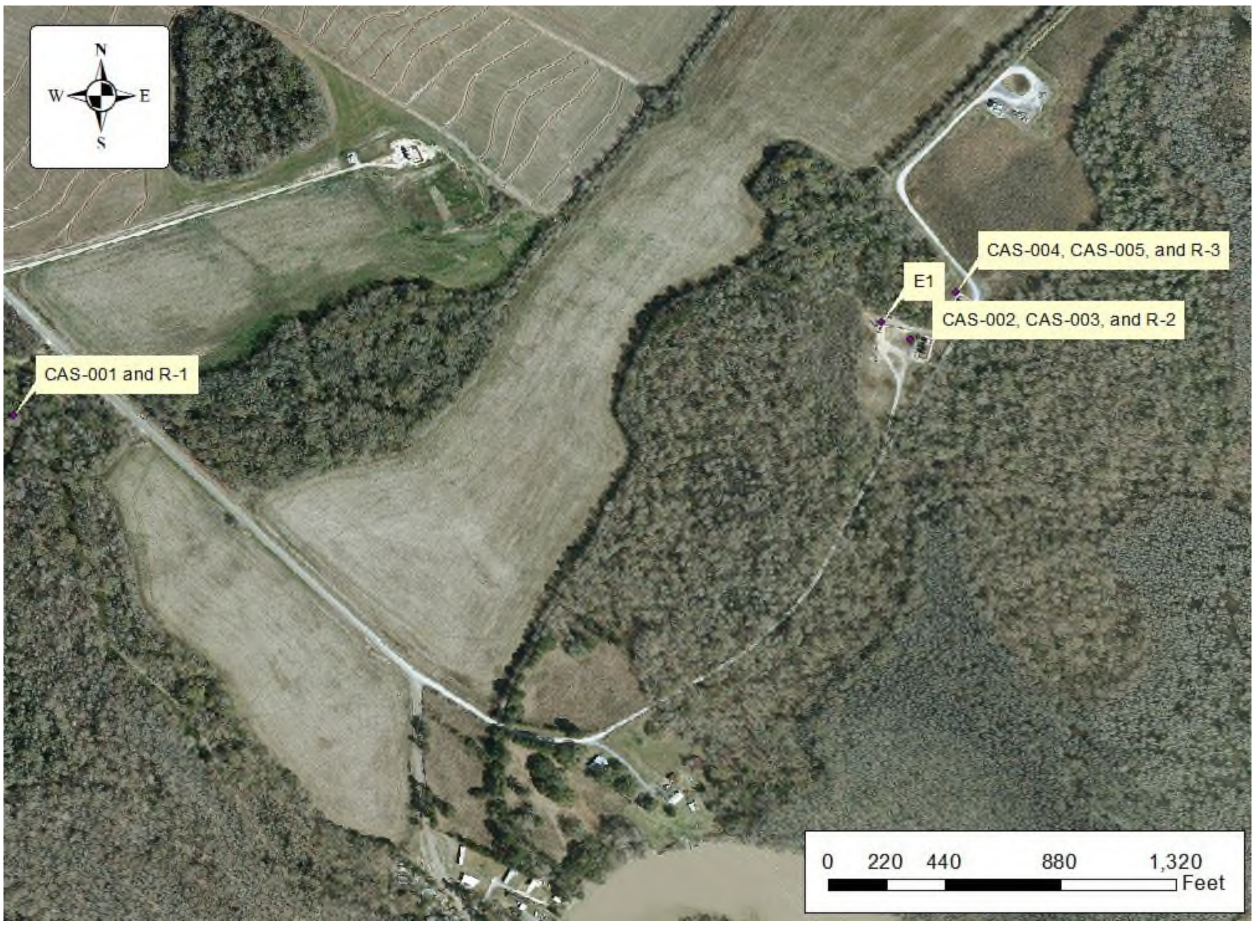
During production of oil from underground geological formations, water that is co-mingled with the oil is transported to the ground surface. This water is generally referred to as “produced water”. There are concentrations of NORM in some oil-bearing geologic formations that exceed the natural background concentrations of the same radionuclides in native soil. The chemical compounds that are present in produced water include trace amounts of the natural element radium. Because radium is radioactive, produced water that contains radium compounds contains NORM. The principal radionuclides in affected produced water are Ra-226 and Ra-228 (NRC 1999). During oil production, some radium compounds in the produced water convert to sulfates or carbonates and are precipitated, or are otherwise deposited, onto surfaces as scale and sludge in tubulars, pipe, and other production equipment. The scale is primarily barium sulfate with trace amounts (by mass) of radium in the same mineral matrix (Smith 1996; NRC 1999). The chemical forms of scale that have been shown to contain oilfield NORM are highly insoluble and NORM radionuclides (i.e., Ra-226 and Ra-228) in the scale are not readily leached or transported from impacted pipe, other production equipment or soil by surface water or groundwater (IAEA 1990).

The presence (or absence) of oilfield NORM in groundwater is determined by collection of representative samples of groundwater from locations in the vicinity of potential sources and analysis of the water samples for the concentrations of Ra-226, Ra-228, and TDS in the water.

F. Description of the Subject Property

The property that is the subject of this radiological assessment is a subset of the 1,130 acres in West Mermentau Oil Field in Jefferson Davis Parish (Miller 2024). The site is accessed via LA Highway 1126 and portions of it are currently used to grow rice (Miller 2024) and may be used for crawfish farming. Additional descriptions of the location of the subject property are given in Plaintiff's Petition for Damages (Castex 2020) and in the October 17, 2024 report by Gregory W. Miller and Jason S. Sills (Miller 2024).

Figure 1. Overview of sample locations and equipment.



G. Gamma Radiation Measurements on the Subject Property

Gamma radiation measurements were performed on the subject property on June 8 and 9, 2022, by ICON personnel on behalf of Plaintiff (Miller 2024 at Appendix D). Personnel from Hydro-Environmental Technology (HET) and ERM representing Defendants observed ICON personnel during the onsite work in 2022 (HET 2022a,b). During the ICON surveys, gamma radiation readings in contact with soil and oil production equipment were made by ICON personnel on the property as indicated in the ICON field notes (Miller 2024 at Appendix E).

ICON did not appear to record all readings collected according to field notes taken during the June 2022 survey. They do not indicate any exposure readings in the immediate vicinity of areas associated with BP that exceeded the natural range of background (which they appear to use twice background 20 μR/hr as the threshold of interest) except what they labeled as R-2, R-3, and E-1. The ICON field notes state that: the R-2 location is in the vicinity of the R R Bruce et al. # 001 (SN 200722) and CIB H VUA; R R Bruce #003 well not associated with BP; the R-3 location includes scale from inside a tank associated with the aforementioned wells; and the E-1 location related to an active flowline used by then-current operators on the property.

E-1 was described as one (1) piece of equipment and R-2 and R-3 are each ground areas which were identified as having readings above 20 μR/hr. The ground areas were the subject of the soil samples described below. E-1 was described as 85 feet of active flowline between separators (Miller 2024 at Appendix E). Active equipment does not need to be remediated until the cessation of onsite production activities to achieve release for unrestricted use of the property (LADEQ 2023). The highest exposure reading taken on contact with E-1 was 200 μR/hr.

The above radiation exposure rates do not present an external radiation hazard nor exceed any applicable standards for exposure.

Dr. Wilson visited the property on April 17, 2025, to perform gamma radiation surveys on and immediately around the areas identified by ICON as being NORM-impacted. Details of the survey methods and the instruments we used to make radiation measurements are given in Attachment G. Copies of our field notes and survey-related forms are given in Attachment G Appendix A. During our survey approximately 6,100 readings of gamma radiation levels at the ground surface were obtained and each reading was recorded electronically with the corresponding location coordinates. The data acquired during our GPS-based survey are given in Attachment G Appendix B.

Gamma radiation measurements made during our survey showed that most of the areas surveyed had radiation readings within the range of natural background radiation levels for Louisiana (Beck 1986) and do not indicate any presence of oilfield NORM in those areas.

Gamma radiation measurements were also taken at a height of one meter (approximately three feet) above the ground surface at several locations on the subject property (see Attachment G). Those measurements are used to assess potential external radiation exposure rates at the measurement locations. The gamma radiation readings at the two locations having the highest readings at the ground surface (R-2 and R-3) showed the external radiation exposure rates within a few square feet at those locations to be greater than the natural background exposure rates for

Louisiana (Beck 1986). Ordinarily, natural background readings at a height of one meter above the ground surface are approximately the same as the natural background radiation readings in contact with the ground surface. Gamma radiation readings that indicated greater than natural background exposure rates were found at a height of one meter only in a few square feet (ft^2) near ICON's locations "R-1" and additional readings at "R-3" (locations named according to Miller 2024 at Appendix E). The readings are summarized in Table 1.

Plaintiff's representatives with ICON performed gamma radiation measurements in contact with pipe and other production equipment and identified specific pipe and equipment having external gamma radiation levels exceeding natural background radiation levels. Results of the ICON survey of pipe and equipment are given in the October 18, 2024 report (Miller 2024 at Appendix E).

Dr. Wilson went to the pipe and equipment location identified by ICON as having gamma radiation readings exceeding natural background radiation levels and performed gamma radiation measurements at those locations. The readings are also included in Table 1.

Table 1. Summary of One-Meter Gamma Readings

Name	Maximum Contact Reading	Maximum One-meter Reading	ICON High Reading (Contact)
	(μR/hr)	(μR/hr)	(μR/hr)
Background Reference Area R-1	10	10	10
Gravel near R-2 and E-1	NA	5	NA
Soil near R-2 and E-1	NA	10	NA
R-2	20	10	23
E-1	150	<20	200
R-3	30	20	43

Accessible pipe and equipment that have gamma radiation readings exceeding the LADEQ standard of 50 μR/hr above background will need to be removed from the property following cessation of onsite production activities to achieve release for unrestricted use of the property (LADEQ 2023).

H. Collection and Analysis of Soil Samples from the Subject Property

Soil samples were collected on June 9, 2022, by ICON personnel representing Plaintiff from three (3) locations on the subject property. The soil sampling locations are given in Appendix E of the October 17, 2024 report by ICON (Miller 2024) and shown on Figure 1. Samples were collected from two (2) depths at two locations and from four (4) depths at the background location, with a total of eight (8) soil samples collected for laboratory analysis of NORM radionuclides (Ra-226 and Ra-228) (Miller 2024).

Each sample was sealed in a sample container, marked with a unique sample identification code, and shipped under chain of custody to an offsite, commercial laboratory (Pace Analytical Services, LLC [Pace] in Greensburg, Pennsylvania). The samples were analyzed by Pace to determine concentrations of Ra-226 and Ra-228 in each sample. Results of analysis of those samples are given in one report of analysis (Pace 2022c) and are summarized in Table 1.

Split samples of each of the eight (8) soil samples from the subject property were provided to Defendant's representatives with ERM on June 10, 2022 (HET 2022b). The split samples were shipped under chain of custody to another offsite commercial laboratory (Eberline Analytical Services in Oak Ridge, Tennessee [Eberline]) for measurement of NORM concentrations in each sample. Results of analysis of the split samples are given in one report of analysis from Eberline (Eberline 2022c) and are included in Attachment D3. Concentrations of Ra-226 and Ra-228 measured by Eberline for the split soil samples are also summarized in Table 2.

Table 2. Summary of Laboratory Measurements of Soil Samples Collected on February 9, 2022

	Eberline Lab				**Pace Lab**			
	Ra-226		**Ra-228**		**Ra-226**		**Ra-228**	
Sample ID	**Result (pCi/g)**	**CSU* (pCi/g)**	**Result (pCi/g)**	**CSU (pCi/g)**	**Result (pCi/g)**	**CSU (pCi/g)**	**Result (pCi/g)**	**CSU (pCi/g)**
R-1 (0-6") Dup	1.29	0.321	1.25	0.478	NLD**	NLD	NLD	NLD
R-1 (0-6")	1.36	0.279	1.52	0.398	3.64	1.639	1.429	0.348
R-1 (6-12")	1.17	0.181	1.53	0.239	2.00	1.206	1.60	0.368
R-1 (12-18")	1.36	0.38	1.54	0.532	4.44	2.113	1.531	0.366
R-1 (18-24")	1.15	0.324	1.81	0.412	NP	NP	NP	NP
R-2 (0-6")	10.70	0.894	1.34	0.398	18.89	4.565	1.935	0.50
R-2 (6-12")	1.82	0.242	1.22	0.29	4.84	2.155	1.177	0.429
R-3 (0-6")	26.40	2.13	2.46	0.832	36.23	8.682	3.033	0.855
R-3 (6-12")	3.52	0.377	1.32	0.284	2.05	1.921	1.75	0.369
R-3 (12-18")	1.11	0.209	0.925	0.202	6.06	2.064	1.764	0.422

NP – Not provided

*CSU - Combined Standard Uncertainty (one sigma)

**NLD - no lab duplicate

Following our gamma radiation survey of the property on April 17, 2025, we collected 11 soil samples from five locations (boreholes) on the subject property. The locations were selected from areas having the highest surface gamma radiation reading near a location chosen by ICON in their June 2022 sampling as well as nearby distance where the readings approached the average background. We selected this in order to delineate any potentially NORM-impacted soil. We collected the samples in accordance with accepted procedures and practices as indicated in references listed in Attachment C.

Each of the soil samples was mixed in a stainless-steel pan and separated into two parts to provide a split sample for Plaintiff's representatives. Decontamination of sampling tools was performed after collection of each sample. The samples were doubly sealed in plastic bags and each bag was marked with a unique sample ID, date and time of sample collection, and the name of the person collecting the sample. Eleven split samples were provided to Plaintiff's representatives. The remaining samples were shipped under chain of custody to Eberline for measurement of NORM (Ra-226 and Ra-228) concentrations in each sample. Results of laboratory analysis of the samples are given in one Eberline Report of Analysis (Eberline 2025) and are included in Attachment D9. The analytical results for soil samples collected on April 17, 2025, are summarized in Table 3. At the time of writing this report, we have not received the analytical results for the split soil samples provided to ICON on April 17, 2025.

Gamma radiation measurements were also made throughout the depth of each of the boreholes installed by ICON (Miller 2024 at Appendix E) and the boreholes we installed (Attachment F). The gamma measurements within the boreholes, in combination with the results of analysis of the soil samples from that location, indicate the NORM-impacted soil to be present within approximately six inches below the surface.

Table 3. Summary of Laboratory Measurements of Soil Samples Collected on April 17, 2024

	Eberline Lab				**Pace Lab**			
	Ra-226		**Ra-228**		**Ra-226**		**Ra-228**	
Sample	**Result**	**CSU***	**Result**	**CSU**	**Result**	**CSU**	**Result**	**CSU**
ID	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**
CAS 001-0-6 DUP	1.12	0.25	1.39	0.32	Not yet provided at the time of writing this report.			
CAS 001-0-6	1.09	0.26	1.21	0.32				
CAS 001-6-12	1.53	0.22	1.24	0.24				
CAS 002-0-6	10.65	1.18	1.39	0.56				
CAS 002-6-12	1.61	0.27	1.2	0.3				
CAS 003-0-6	1.15	0.21	1.11	0.25				
CAS 003-6-12	1.18	0.26	1.41	0.38				
CAS 004-0-6	35.24	3.43	2.11	0.69				
CAS 004-6-12	8.35	0.8	1.01	0.33				

CAS 004-12-18	2.55	0.39	1.58	0.46	
CAS 005-0-6	1.70	0.35	1.09	0.38	
CAS 005-6-12	1.24	0.24	1.41	0.29	

*CSU - Combined Standard Uncertainty (one sigma)

I. Discussion of Results for Soil Samples

Two locations, R-2 and R-3 included soil samples with Ra-226 concentrations that exceeded regulatory standards. Location R-2 is described as a 2-feet by 1-foot area (Miller 2024 at Appendix E) and soil samples support a NORM-impacted depth of approximately six (6) inches. Applicable regulations require averaging concentrations over a 100 square meter area which, according to the GPS readings, would remove R-2 need for remediation. Location R-3 was described as a 14-feet by 10-feet area (Miller 2024 at Appendix E) and soil samples support a NORM-impacted depth of approximately six (6) inches. After visiting this location, it was visually confirmed to be an above-ground pile of soil that appeared to include scale (consistent with ICON's description [Miller 2024]).[3]

Following cessation of onsite production activities, and prior to release of the site for unrestricted use, excavation and removal/transportation of NORM-impacted soil from the R-3 to an approved NORM disposal facility should be performed in accordance with applicable regulations of the Louisiana Department of Environmental Quality (LADEQ 2023). Based on the radiation measurements at the ground surface, radiation measurements within sample boreholes, and results of analysis of soil samples we estimate that less than approximately 2.5 cubic yards (yd^3) of NORM-impacted soil should be removed from the property following cessation of onsite production activities to achieve release of the property for unrestricted use.

J. Collection and Analysis of Groundwater Samples from the Subject Property

Twenty-six (26) groundwater samples were collected by ICON personnel from 11 wells on the subject property from March 2022 to July 2024. The locations of those wells are described in the October 17, 2024 report by ICON (Miller 2024). Each sample was sealed in a sample container, marked with a unique sample identification code, and shipped under chain of custody to an offsite, commercial laboratory (Pace). The samples were analyzed by Pace to determine concentrations of Ra-226, Ra-228, and TDS in each sample. Results of analysis of those samples are given in six (6) reports of analysis (Pace 2022a,b,d,e; Pace 2024a,b) and are summarized in Table 3.

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[3] According to the Pace soil lab report (Pace 2022c), soil analysis was performed 13 days after receiving the sample which is insufficient time to allow the ingrowth of Ra-226 progeny usually required for accurate concentration measurements, however this error did not impact our analysis.

Splits of the 26 groundwater samples collected by ICON were collected by ERM as well as six (6) lab duplicates. Each split sample was sealed in a sample container, marked with a unique sample identification code, and shipped under chain of custody to Eberline for analysis of concentrations of Ra-226, Ra-228, and TDS in each sample. Results of the analyses by Eberline of the split samples are given in seven (7) reports of analysis (Eberline 2022a,b,d,e; Eberline 2024a,b). A copy of those reports of analysis are included as Attachments D1, D2, D4, D5, D6, D7 and D8. Results of the analyses of groundwater samples by Eberline are also summarized in Table 4.

Table 4. Summary of Laboratory Measurements of Groundwater Samples Collected February 27, 2023 to February 22, 2024

	Eberline Lab					Pace Lab				
	Ra-226		Ra-228			Ra-226		Ra-228		
Sample ID	Result (pCi/L)	CSU* (pCi/L)	Result (pCi/L)	CSU* (pCi/L)	TDS** (mg/L)	Result (pCi/L)	CSU (pCi/L)	Result (pCi/L)	CSU (pCi/L)	TDS (mg/L)
CD-4A	0.385	0.181	0.628	0.480	1230	0.338	0.578	0.640	0.527	1080
CD-4B	1.130	0.370	1.290	0.621	2120	2.120	3.230	2.700	4.880	2020
CD-5A	0.501	0.227	0.935	0.570	714	0.394	0.507	1.040	0.531	835
CD-5A DUP	1.050	0.390	0.656	0.544	714	NLD	NLD	NLD	NLD	NLD
CD-5B	4.700	1.670	23.000	5.470	19000	21.600	6.570	27.200	9.120	21300
CD-5C	0.194	0.198	1.338	0.554	704	2.400	0.801	3.170	0.795	855
CD-5D	0.203	0.178	0.273	0.500	49	0.445	0.281	0.447	0.475	327
CD-6A	0.386	0.210	0.815	0.480	899	0.662	0.394	0.507	0.331	845
CD-6B	0.177	0.201	-0.583	0.546	415	0.170	0.369	0.197	0.295	436
CD-8A	0.412	0.231	0.601	0.409	10396	0.628	0.417	0.231	0.294	432
CD-9A	0.368	0.222	0.328	0.458	516	0.270	0.462	0.522	0.353	534
CD-9B	0.281	0.234	1.089	0.512	379	0.193	0.401	0.471	0.319	387
CD-9B DUP	0.303	0.235	0.401	0.617	379	NLD	NLD	NLD	NLD	NLD
CD-10A	0.229	0.177	0.598	0.565	289	0.331	0.344	0.436	0.325	309
CD-12A	0.051	0.088	1.317	0.589	117	0.210	0.307	0.669	0.368	242
CD-12B	0.144	0.129	0.602	0.476	265	-0.109	0.214	-0.700	0.225	351
CD-12B DUP	0.244	0.167	0.101	0.399	265	NLD	NLD	NLD	NLD	NLD
CD-13A	0.855	0.379	0.715	0.499	611	0.313	0.345	0.674	0.373	675
CD-13B	0.482	0.215	2.149	0.723	723	0.388	0.257	0.386	0.328	790
CD-13C	0.237	0.140	0.783	0.460	44	1.230	0.859	3.630	1.440	562
CD-17A2	1.357	0.628	2.304	1.392	1417	-0.115	0.320	0.603	0.414	835
CD-17A2 DUP	0.666	0.317	0.800	0.669	1417	NLD	NLD	NLD	NLD	NLD
CD-17B	2.131	1.008	2.550	1.312	1102	1.340	0.864	1.080	0.499	621
CD-18A	0.280	0.264	1.722	1.121	1292	0.054	0.408	0.576	0.352	436

CD-18B	0.986	0.572	1.097	0.973	2251	0.360	0.687	0.337	0.359	828
CD-18B DUP	0.470	0.271	0.605	0.721	2251	NLD	NLD	NLD	NLD	NLD
CD-18C	0.968	0.517	3.524	1.686	1468	0.596	0.747	0.575	0.450	547
CD-18D	0.096	0.126	3.129	1.309	1180	0.479	0.748	0.336	0.323	470
CD-19B	1.158	0.545	3.536	1.697	4542	1.100	0.771	0.965	0.435	1470
CD-19C	1.627	0.750	5.704	3.212	1697	1.150	0.586	0.589	0.347	557
CD-19D	1.666	0.849	8.683	2.327	408	1.560	0.766	1.720	0.545	347
CD-19D DUP	1.300	0.625	7.052	1.982	408	NLD	NLD	NLD	NLD	NLD

NLD – No lab duplicate
*CSU – Combined Standard Uncertainty (one sigma)
**TDS – Total Dissolved Solids, Pace TDS values are provided in Element Reports (Element 2022a-d, 2024a-c)

K. Discussion of Results for Groundwater Samples

Ratios of concentrations of radium isotopes in the water from all wells are consistent with native solids in groundwater and do not indicate the presence of NORM from oilfield operations, according to both the Pace and Eberline analyses of samples collected by ICON and ERM. This is evident as the ratios of Ra-226 to Ra-228 remain near one or less when considering the measurement uncertainties.

Fifty-nine (59) of the 116 analytical results reported by Eberline and Pace (more than half) show that the radium concentrations to be so low that they qualify as "non-detects." This occurs when the "result" for a sample is less than the minimum detectable concentration (MDC) or Minimum detectable activity (MDA) for the sample.

The sum of the reported concentrations of Ra-226 and Ra-228 in water is sometimes compared with the Maximum Contaminant Level (MCL) of 5 pCi/L for radium in Community Water Systems (USEPA 2000b). This comparison is inappropriate for groundwater that is not used as drinking water at the tap (USEPA 2000b. The national secondary standard for TDS in drinking water is 500 milligrams per liter (mg/L) and, while samples of groundwater from the subject property exhibit a wide range of TDS concentrations, the average and majority of the samples analyzed contained TDS concentrations greater than 500 mg/L. Water treatment methods that reduce TDS concentrations below 500 mg/L will reduce concentrations of Ra-226 and Ra-228 below 5 pCi/L (IAEA 2014; USGS 2020).]

L. Review of the October 17, 2024 Report by Gregory W. Miller and Jason S. Sills

We have reviewed the October 17, 2024 report by Gregory W. Miller and Jason S. Sills of ICON (Miller 2024) in this matter and have the following observations regarding those reports: The ICON report includes a description of the methods and locations for their collection of soil and groundwater samples from the subject property and the results of laboratory measurements of

NORM (Ra-226 and Ra-228) in soil and groundwater samples (listed above). Appendix E of the October 17, 2024 report presents the methods and results of their gamma radiation survey of the property (Miller 2024). [Field notes taken by HET indicate the radiation measurements were taken on June 9, 2022 and measurements and soil samples were taken June 10, 2022.]

M. Review of the November 4, 2024 Report by Charles R. Norman

We have reviewed the November 4, 2024 report by Charles R. Norman (Norman 2024) in this matter and find his report does not include any radiological characterization data that he obtained and only refers generally to findings by ICON (Miller 2024). He does not include any site-specific assessment for radiological impacts due to NORM.

V. CLOSING REMARKS

The observations, conclusions, and opinions noted in this report are based on our personal knowledge and experience and are consistent with accepted practice in the field of health physics. We reserve the right to amend this report should additional data or other information become available to us in the future.

VI. RATES OF COMPENSATION

Dr. Frazier is being compensated at a rate of $300 per hour for his time to work on this project, including sworn testimony at deposition and trial.

Dr. Wilson's fully-burdened compensation rate is $220 per hour for his time to work on this project, including sworn testimony at deposition and trial.

VII. PRIOR TESTIMONY

A list of cases in which Dr. Frazier has given sworn testimony at deposition or at trial during the past four years is included in Attachment E.

A list of cases in which Dr. Charles A. Wilson IV has given sworn testimony at deposition during the past four years is listed in Attachment F.

Prepared and submitted by:

John R. Frazier, Ph.D., CHP	Charles A. Wilson IV, Ph.D., CHP, CLSO, CSP
Date: June 9, 2025	Date: June 9, 2025