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October 14, 2022

Mr. Matt Keating
Mudd, Bruchhaus, & Keating, LLC
422 E. College Street, Suite B
Lake Charles, LA 70605

Subject: **Most Feasible Plan for the Landowners**
Henning Management, LLC v Chevron USA, Inc et al;
Docket No. 73318; 31st JDC; Division "C", Jefferson Davis Parish, LA
Hayes Oil Field, Calcasieu and Jefferson Davis Parish, LA

Dear Mr. Keating,

ICON Environmental Services, Inc. (ICON) is pleased to present this Most Feasible Plan (MFP) to remediate contamination associated with the Chevron Limited Admission Areas:

- Area 2 associated with sn25340;
- Area 4 associated with sn26358, sn207055, sn210306, sn213760, sn970424, and sn970427;
- Area 5 associated with sn105169 and sn103174;
- Area 6 associated with sn128241; and
- Area 8 associated with sn31298.

The goal of this remediation plan is to address soil and groundwater contamination to regulatory standards of Statewide Order 29B, within the framework that the Henning Management, LLC does not consent to any exception to the provisions of Statewide Order 29B (as per Title 43.XIX.319.A).

For your convenience, please find attached to this letter:

Figure 1	Site Location Map
Figure 2	Topographic LIDAR Contours
Figure 3	USFWS Wetlands Map
Figure 4	Geologic Map
Figure 5	Locations of Borings and Monitoring Wells – Sitewide
Figure 6	Locations of Borings and Monitoring Wells – Limited Admission Areas
Figure 7	Cross Section A-A'
Figure 8	Cross Section B-B'
Figure 9	Cross Section C-C'
Figure 10	Isopach Map A Bed
Figure 11	Isopach Map B Bed

QUALIFICATIONS, AREAS OF EXPERTISE, AND COMPENSATION

Gregory Miller obtained a bachelor of science in geology from the University of Southwestern Louisiana in 1982, and has been employed as a professional geologist since 1983. He worked in the oil and gas industry as a core and log analyst from 1983 to 1986. Since that time, he has worked in the environmental industry in the northeast United States from 1986 to 1990, and in the Gulf Coast since 1990. Mr. Miller has been recognized in State and Federal courts as an expert in the fields of geology, hydrogeology, site assessment, implementation of the Louisiana RECAP protocol, and remediation. Mr. Miller is the president and an owner of ICON

Environmental Services, Inc. (ICON), and holds the State License Board of Contractor's License #35504 for ICON with specialization in hazardous materials site remediation. Mr. Miller holds License Number 939 from the Louisiana Board of Professional Geoscientists. ICON holds License #4001 from the Louisiana Professional Engineering and Land Surveying Board to provide professional engineering services in the State of Louisiana.

Mr. Wayne Prejean, P.E. obtained a bachelor of science in environmental engineering from Louisiana State University in 1999, and has worked as an environmental consultant since 1999. Mr. Prejean has been recognized in State courts as an expert in the fields of environmental engineering, environmental site assessment and remediation. Mr. Prejean is currently senior engineer at ICON Environmental Services, Inc. (ICON), and holds license #32502 to provide professional engineering services in Louisiana.

Mr. Jason Sills obtained a bachelor of science in environmental engineering from Louisiana State University in 2000, and has worked as an environmental consultant since 2000. Mr. Sills is currently senior engineer at ICON Environmental Services, Inc and holds certification as Engineering Intern with EI No. 20568. Mr. Sills has been recognized in State court as an expert in the fields of site assessment and remediation.

A copy of resumes and list of testimony experience is included in **Appendix H**.

PREVIOUS ASSESSMENT AND OBJECTIVES

ICON submitted and "Expert Report and Restoration Plan for the Landowners" dated September 30, 2021. Since that report was issued, ICON has participated in oversite activities of assessment at the subject property, including split sampling and evaluation of data gathered during the consultant's assessment on behalf of the defendants. These assessment activities included installation and sampling of soil borings and monitoring wells, and additional aquifer testing (slug testing). Below is a summary of the investigation activities ICON has performed at this site between October 2019 and August 2021:

- Soil and groundwater samples were collected using a hydraulic push rig from October 2019 through August 2021, and included the following tasks:
- Terrain conductivity survey was performed in October 2019 using a Geophex GEM-2 variable frequency conductivity meter. The instrument utilizes a transmitter coil and a receiver coil separated by about 5.5 feet, and contains a third "bucking coil" that removes the primary field from the receiver coil. The instrument utilizes a programmable variable frequency transmitter. In general, the instrument has a deeper effective depth of investigation at lower frequencies (1170 hz), and a relatively shallower depth of investigation at higher frequencies (13590 hz). The instrument was programmed to collect data at a time constant of approximately one second. The primary data are recorded as part per million (ppm) ratio of the secondary magnetic field to the primary magnetic field in phase and quadrature mode. Computer software is used to convert ppm data to apparent conductivity, based on the assumption that the earth below the sensor is

represented by a homogeneous and isotropic half-space. The resulting apparent conductivity data are in units of millisiemens/meter. The instrument concurrently logs coordinates obtained from a GPS receiver, and all data are stored into an on-board computer. Data were imported into a Surfer contouring program used to plot transects of the surveys (**Figure 15**), and contours for each frequency calculated using the kriging algorithm. Resulting maps were imported into an AutoCAD basemap of the site, and scaled to real dimensions and superimposed onto a scaled basemap included as **Figure 17** for the shallower higher frequency, and **Figure 16** for the deeper lower frequency. Distinct anomalies of high terrain conductivity were observed at Limited Admission Area 2 around the blowout sinkhole; at Area 4 around the former production pit and tank battery area; at Area 5 around the former production pit; and at Area 6 within and north of the former production pit.

- Soil samples were collected using a Geoprobe hydraulic direct-push rig, advancing a Geoprobe Dual-Tube Core Sampling system with dedicated liner. The dual tube system simultaneously advances an outer casing and an inner core barrel with an acetate liner for soil sample recovery in four-foot lengths. Once the base of the cored interval is reached, the core barrel with sample and liner are withdrawn while leaving the outer casing in place. A new liner is inserted in the core barrel and lowered to the base of the outer casing, and both strings are advanced another four feet. Thus, the coring process proceeds through a cased hole, allowing soil sampling through perched groundwater or unconsolidated zones, and prevents downward cross-contamination from previously sampled intervals. Selected soil samples were submitted for laboratory analysis and the data is summarized in **Table 1**. Boring Logs are included in **Appendix A**.
- Soil conductivity logs were obtained from 24 borings using a Geoprobe® Soil Conductivity probe in October and November 2019, and March, April and August of 2021. A SC5000 Wenner Array conductivity probe was advanced using a Geoprobe hydraulic direct push rig, and conductivity readings were logged into a field computer. The log that is generated depicts bulk conductivity in units of mS/m. The probe is calibrated at the factory to several concentrations of fluid conductivity. The probe has a vertical resolution of 0.05 ft, and a sampling rate of 20 samples per second. Prior to use, the probe calibration and continuity/isolation of the contact array was checked using a calibration block. The field computer completes the calibration check automatically, and will not allow use of a contact that does not meet minimum criteria for calibration, continuity or isolation. In native materials, clays have a relatively high electrical conductivity (generally 200 to 450 mS/m), silts have an intermediate conductivity, and sand/gravel has a low conductivity (less than 50 mS/m). In soils impacted by salt water, the conductivity exceeds values obtained in unimpacted sediments. Thus, the conductivity log is an excellent indicator of brine impact. The conductivity data are obtained at a frequency of one reading per 0.05 foot, and the depth is concurrently measured using a potentiometer (string pot) and concurrently logged onto a field computer. Conductivity logs are plotted and imported onto a soil boring log where log response can be evaluated along with lithological descriptions and laboratory data. Boring logs are presented in **Appendix A**.

- Soil hydraulic profiling logs were obtained from borings H9, H10, H14, H15 and H19 in November 2019, H20 in March 2021, and H22, H23, H24 and H25 in April 2021, using a Geoprobe® Direct Image® Hydraulic Profiling Tool (HPT). The HPT probe was advanced using a Geoprobe hydraulic direct push rig, and readings were logged into a field computer. This instrument was developed by Geoprobe® to evaluate hydraulic conditions of the subsurface soils. The tool is advanced at a constant rate while water is injected through the probe. A pressure sensor in the probe measures the pressure response of the soil to the water injection. The pressure response indicates the ability of the soil to transmit water. The pressure and flow rate of water injected into the subsurface along with the electrical conductivity is logged versus depth. The log can be used to determine formation permeability and map salt contaminant plumes in the subsurface. The detailed logs are included on the soil boring logs presented in **Appendix A**.
- Groundwater samples were collected from ¾-inch diameter PVC wells with a 5-foot or 10-foot long screen, installed in October and November 2019, and March, April and August 2021 by pushing the well within a barrel with an expendable tip to the desired interval and withdrawing the barrel while keeping the well in place, or by installing in the open borehole resulting from soil sampling if the hole depth was similar to the desired well depth. Wells installed using the tracked Geoprobe rig were completed with surface completions and were surveyed to determine groundwater flow direction. A clean commercial filter sock was placed over the screened portion of the well. Filter sand was poured into the annular space adjacent and slightly above the screened interval. A bentonite seal was placed in the top portion of the annulus using ¼-inch diameter bentonite pellets. Grout consisting of Portland cement with 4% bentonite powder is typically pumped through tremie pipe above the bentonite seal to ground surface to complete the installation.
- Groundwater samples were collected using a peristaltic pump with dedicated polyethylene tubing. Wells were purged prior to sampling and the same dedicated tubing was used for purging and sampling. Field parameters were measured while purging (specific conductance, temperature, pH, dissolved oxygen, oxidation-reduction potential and turbidity). Once field parameters stabilized, the well was immediately sampled by pumping with the peristaltic pump at a low flow rate. Groundwater samples were collected in laboratory-supplied containers with appropriate preservative, and were chilled in an ice chest during storage and shipment to Element Materials Technology (LELAP accredited for all constituents), Lafayette, LA; and Pace Laboratories, Greensburg, Pennsylvania for radionuclide analysis. Groundwater analytical data is summarized in **Table 3**.

CONCEPTUAL SITE MODEL AND ELEMENTS OF RESTORATION PLAN

1. Historical exploration and production activities at Limited Admission Area 2 included the Gulf Refining Company (Gulf) 1942 completion of the Hayes gas field discovery well, the Calcasieu National Bank #1 (CNB #1, sn25340) in the southeast quarter of

Section 18 on the subject property after several wildcats had been drilled in the area beginning about 1936. In March 1941, 9-5/8" casing was set to 9200 feet and cemented, and after drilling to 10,534 feet the 7" casing was set and extended upward into the 9-5/8" casing a distance of 1593 feet. On July 16, 1941, the bottom of the 7" casing was perforated for a cement squeeze and the well immediately pressured up and Halliburton was hired to lubricate the well (pump a heavy mud column). On July 20, 1941 the well blew out at the well head connection and continued as an uncontrollable blowout until August 13, 1941 when it bridged over and killed itself. Throughout this 23 day period, the well continuously erupted large volumes of salt water and sand mixed with distillate and other substances several hundred feet in the air. For half of this period the well was on fire. As described in the case history for Watkins v Gulf Refining Co. (*20 So. 2d 273 La. 1944*):

> "*The atmosphere was made to appear foggy by the spray from the well and the wind and air currents spread this moisture over an area of about six miles from the well and it settled like dew on the farm, buildings, and equipment in that section. After drying this salt and other mineral substances thus precipitated left a brownish gray sediment, which killed the rice and cotton crops as well as other vegetation and trees and corroded and rusted the metal equipment, roofing, fencing, guttering, screen wire, etc. upon which it had fallen. The heat from the burning gas and distillate erupting from the well dried the crops within a large area. The plaintiffs were successful rice farmers whose farm lands were located from two and a half to four miles from the well. A great deal of the salt and other mineral substances covered their fields, buildings and equipment in quantitie, varying according to the direction of the wind and its velocity. It is clear that this substance seriously damaged the plaintiffs' crops consisting of Early Prolific and Blue Rose rice and water melons, and substantially damaged the pasture lands, the metal equipment, barbwire fencing, roofing, guttering, screen wire, etc on their farm*"

Historical aerial imagery shows the blowout crater and a broad area of salt scarring extending 500 feet from the CNB#1; the scarring extends further to the north and south in the drainage ditch located west of the crater. A series of pits are visible south of the crater outside of the limited admission area. The crater remains open and flooded to this day. Assessment data associated with Borings H11 and H12 shows contamination associated with this blowout represents a "bottom up" contamination profile (a deep source with contamination migrating upward towards land surface), where the highest measured residual produced water salt concentrations occur from 45 to 65 feet below land surface (bls), within the lower "B-Bed" of the Shallow Aquifer (**Figure 7**).

2. Historical exploration and production activities at Limited Admission Area 4 included:
    - The CNB #2 (sn26358) completed in 1941 and P&A'd in 1984.
    - The Hayes SWD #1 (sn970424) completed in 1957 and P&A'd in 1983.
    - The Hayes U1 SWD #2 (sn970427) completed in 1977 and P&A'd in 1984.
    - The Walker Properties #1 (sn213760) completed in 1990 and currently shut-in.
    - The Walker Properties #2 (sn207055) drilled in 1987 and P&A'd as a dry hole.

Historical imagery shows a central production facility located east of the CNB #2 well. The 1971 aerial image (**Figure 14**) shows two pits at the SWD well site, a tank battery east of the #2 well and a production pit south of the tank battery. By 1981, historical imagery shows the pit north of the SWD and south of the CNB #2 tank battery are no longer visible. Assessment data in this area shows typical "top-down" contamination profile (a source at the land surface migrating vertically downward), with the highest residual produced salt water concentrations at Boring H16 at depths of 5 to 45 feet bls (Figure 7).

3. Historical exploration and production activities at Limited Admission Area 5 included the dual completion of the Hayes U1 #6 (sn103174) and #6d (sn105169), completed in 1964 and P&A'd in 1980. Historical imagery shows a two-celled pit feature north of the well, and a pit feature (likely a flare pit) west of the well (**Figure 14**). By 1981, the production pit north of the well is no longer visible on historical imagery. Assessment data in this area shows typical "top-down" contamination profile, with the highest residual produced salt water concentrations at Borings H18 and H19 at the former production pit at depths of 7 to 18 feet bls (**Figure 8**).
4. Historical exploration and production activities at Limited Admission Area 6 included the completion of the Hayes U1 #7 (sn1128241) in 1969 and P&A'd in 1983. Historical imagery shows production equipment (separators) and a production pit southeast of the well pad (**Figure 14**). The pit is visible with solids extending above the fluid level on 1981 aerial imagery, and the pit appears flooded with no solids on 1983 aerial imagery. The pit is no longer visible on 1994 aerial imagery.
5. Historical exploration and production activities at Limited Admission Area 8 included the CNB #1 (sn31298) drilled and P&A'd in 1946-47 as a dry hole.
6. Surface topography as shown on LIDAR contours in **Figure 2** ranges from +5 feet NGVD in Section 18 and the northern portion of Section 19 (forming a very gently east-west ridge), to +1 NGVD in the eastern half of Section 18 (along a drainage feature draining areas north of the ridge) and the southeast quarter of Section 20 (along a drainage feature draining areas south of the ridge). Both drainage features flow to Bayou Lacassine that has been designated by the Louisiana Department of Environmental Quality (LDEQ) as subsegment 050601 with designated uses as (A) primary contact recreation, (B) secondary contact recreation, (C) propagation of fish and wildlife and (F) agriculture. Numerical criteria include 90 mg/L for chlorides and 400 mg/L for total dissolved solids (TDS). The United States Geological Survey (USGS) has monitored water quality in Bayou Lacassine since 1989 at the bridge where LA Hwy 14 crosses the bayou approximately 2500 feet southeast of the property. Chloride concentrations resulting from laboratory analysis of 68 samples collected between 1998 and 2004 averaged less than 50 mg/L, with only five samples exceeding 100 mg/L (and only two exceeding 500 mg/L) in the entire period. This data indicates that the watershed at this location is characterized as a fresh water habitat.
7. The property has historically been used for agriculture (primarily rice with some vegetable truck crops), some residential use, and some inactive oilfield equipment and wells remain. The U.S. Fish and Wildlife Service (USFWS) wetlands map indicates that

the majority of the property in the subject assessment area is non-wetlands (**Figure 3**). The only wetlands within the subject assessment area of the property are located in Limited Admission Area 2 near the blowout crater in Section 18, mapped by the USFWS as PEM1A: Palustrine (nontidal wetlands), classified as emergent with erect, rooted herbaceous hydrophytes that are present for most of the growing season and normally remain standing at least until the beginning of the next growing season, and a water regime where surface water is present for brief periods (a few days to a few weeks) during the growing season, but the water table usually lies beneath ground surface for most of the season. The NRCS maps soils in the limited admission areas as prime farmland, with salinity ranging from nonsaline to slightly saline (0 to 4 mmhos/cm) with a maximum SAR of 4.

8. The Louisiana Geological Survey (LGS) maps the surface geology of the subject property and surrounding areas as “Ppbe”, the Beaumont Alloformation, the Pleistocene stratigraphic sequence underlying the oldest and topographically highest of the Prairie surfaces west of the Mississippi alluvial valley. It exhibits the relict channels of the Red River (**Figure 4**). The principal potable aquifer in this area is the Chicot Aquifer (200 and 500-foot sands). Shallow geology was determined from lithological descriptions of core samples, driller’s logs of water wells, soil conductivity logs, HPT (hydraulic profiling tool), and geophysical logs of some of the oil wells. Shallow lithology is depicted on an East-West Cross Section diagram (**Figure 8**). The locations of the cross section transects are shown on **Figure 7**. The general shallow geology is as follows:
   - 0-20 to 30 feet bls: Clay and Silty Clay, gray with red and orange staining, stiff to med soft, with a layer of shell fragments at approximately 10 feet bls. Low pressure on HPT logging indicates this strata is permeable to water.
   - ~20 to 50 feet bls: SILT, Clayey SILT, and Silty SAND, herein termed the **Shallow Aquifer System**. Near Bayou Lacassine, the saturated permeable strata are comprised of almost 30 feet of saturated silt with sand at the base that thins laterally to the west away from the bayou. At distances of approximately one mile from the bayou, the saturated permeable strata occur as two stacked sinuous channel fill deposits at general depths of 30 to 40 feet and 45 to 50 feet, herein termed the “**A-Bed**” and “**B-Bed**”. Core data and HPT logs of both beds can be laterally correlated to enable construction of isopach maps included herein as **Figures 10** (A-Bed) and **Figure 11** (B-Bed). Both channel fill deposits along the axis of deposition exceed 8 feet in thickness. Similarity of static hydraulic head and contaminant concentration distributions indicate that both deposits are in hydraulic communication and function as a single hydrostratigraphic unit. Core sampling in Limited Admission Area 4 did not occur at a sufficient depth to penetrate the B-Bed of the Shallow Aquifer.
   - ~40 feet thick in the east to 80 feet thick in the west: stiff CLAY that comprises the confining unit for the Chicot Aquifer. Thin zones of low pressure on HPT logging in this stratum indicates the presence of permeable lenses of silt. The conductivity log for Boring H1 in Limited Admission Area 5 was the deepest

penetration of the assessment, and indicates another permeable zone at 63 to 68 feet bls within the confining unit.

- ~100 to ~130 feet bls: Sand and Gravel of the CHICOT AQUIFER. Static groundwater in the Chicot occurs at depths of 40 to 46 feet bls.
- 1190': Base of the Underground Source of Drinking Water (USDW), as found in the well file for the Hayes SWD #1, sn970423 in Section 19 T11S R5W.

9. Groundwater flow was determined by measuring depth to static groundwater level relative to the surveyed top of well casing elevation. The Langlinais & Associates survey can be found in **Appendix I**. Because of the presence of elevated concentrations of contamination by produced water in some wells, potentiometric data were corrected for density effects to properly evaluate groundwater flow. Hydraulic head is the measured depth to water in a well, and is a function of elevation head and pressure head. The pressure head of the water level in a well is a function of the density of the water and the gravitational constant. In lay terms, in an instance of two wells with the same potentiometric surface, the measured depth to water in a well with highly saline water will be greater as compared to the depth to fresh water in the other well. In order to properly evaluate groundwater flow potential, a groundwater flow regimen of variable density can be normalized using a reference density typically called the fresh water head (the imaginary equivalent column of water of equal density for all wells). Corrections were based on methods included in the publication *"Using Hydraulic Head Measurements in Variable-Density Ground Water Flow Analyses, Post, Kooi and Simmons, GROUND WATER, Vol 45, No.6, Nov-Dec 2007, Pp 664-671"*, and corrected head is presented in units of equivalent fresh water head – EFWH). Potentiometric measurements on May 21, 2021 in the monitoring wells (**Figure 12**) show overall groundwater flow to the north. The highest potentiometric elevations (over +4 feet NAVD88) were in Limited Admission Area 5 in areas of highest land surface elevation (+5 feet NAVD88), and the lowest (-1.62 feet NAVD88 in H10) was located in Limited Admission Area 4. Potentiometric measurements on May 21, 2021 in the monitoring wells (**Figure 13**) show similar groundwater flow patterns with the highest potentiometric elevations in Limited Admission Area 5 and the lowest (-4.62 feet NAVD88) in monitoring well H10.
10. ICON performed aquifer tests (slug tests) in Monitoring Wells H3, H9, H18, H20 and H27. Data were analyzed using the Hvorslev and Bouwer and Rice Methods yielding a range in hydraulic conductivity of 0.055 to 8.7 feet/day. Data are summarized on **Table 6**. ERM performed slug testing on all of the monitoring wells that they installed (MW1 through MW11). A summary of their slug test results is also included on **Table 4**. Considering the aquifer thickness, hydraulic conductivity and confining head, an estimated well yield can be calculated using the Cooper and Jacob Approximation to the Theis Non-Equilibrium Equation for confined aquifers. The version of this equation most commonly used in environmental assessments in Louisiana limits the drawdown to 75% of the confining head (hc), which results in a much more conservative yield than a well's maximum capable yield. The data on Table 6 indicates that the A-Bed of the Shallow

Aquifer has lower potential yield as compared to the B-Bed with summary statistics as follows:

- A-Bed, hydraulic conductivity (k-geomean): 0.345 ft/day.
- A-Bed, yield at 0.75(hc): 129 gpd (geomean), 421gpd (average), 228 gpd (median).
- B-Bed, hydraulic conductivity (k-geomean): 2.13 ft/day.
- B-Bed, yield at 0.75(hc): 948 gpd (geomean), 1893 gpd (average), 1846 gpd (median).

Both the A-Bed and B-Bed comprise permeable portions of the shallow aquifer, and total estimated yield to a 4-inch diameter well fully penetrating the aquifer would be represented by the sum of the yield of both beds, for a yield of 1077 gpd (sum of the geomeans). This estimated yield is considered conservative and low because the Hvorslev estimate of hydraulic conductivity for the setting of a fully penetrating well in a confined, infinite, homogeneous and isotropic aquifer is accurate only to within an order of magnitude (*A Critique of the Hvorslev method for Slug Test Analysis: The Fully Penetrating Well, Chirlin, Spring 1989, GWMR*). Additionally, both the Hvorslev and Bouwer & Rice methods underestimate hydraulic conductivity (as determined by large-scale aquifer testing) by a factor of about 4 (*In Situ Slug Test Analysis, A Comparison of Three Popular Methods for Unconfined Aquifers, Brother, Christians, Eckenfelder Inc*.). Estimates for recovery of contaminated groundwater in this plan were based on the geometric mean of hydraulic conductivity of 0.345 ft/day for the A-Bed and 2.13 ft/day for the B-Bed, with the assumption that separate recovery well systems will be required for the A-Bed and B-Bed to prevent preferential flow that would otherwise be expected from a single recovery well penetrating both beds.

11. The plaintiff's MFP is utilizing a background groundwater remedial standard consistent with Statewide Order 29B, without exceptions. ICON installed a series of monitoring wells (H3, H32, H33, H34) to collect groundwater quality data at distances far away and to the east of historical onsite production activities to represent un-impacted conditions. Data from the wells suggest that some degree of impact is apparent. This is likely due to: 1) effects of the 1941 blowout that affected the entire property and 2) two of the well locations are next to an apparent pit feature located just offsite to the east in Section 21 that is visible in 1998 aerial imagery. Because of the extensive historical impacts to the entire property during the blowout, a true onsite "background" monitoring well can be difficult to locate and install. Nonetheless, data from monitoring wells H3, H32A, H32B, H33 and H34 were used to calculate a conservative baseline groundwater remedial goal that will address the bulk of the contamination, and will rely of future precipitation/dilution to address residual contamination. The comparative standard was calculated as the mean plus one standard deviation. Background data are included on **Table 3.** A background chloride value of 428 mg/L resulted from this conservative analysis. ICON believes that true background groundwater chloride concentrations are significantly lower that this value. Ten monitoring wells in the limited admission area had chloride concentrations below this value, five of these wells had chlorides less than the EPA SMCL of 250 mg/L, and two upgradient wells had chlorides less than 65 mg/L.

Provisions to install additional background monitoring wells are included in the Additional Assessment section of this plan.

12. Groundwater data from onsite monitoring wells exceeded the calculated baseline standards for salts (TDS, sodium and chlorides), heavy metals (barium, cadmium, iron, manganese, strontium, and zinc), petroleum hydrocarbons (TPH-Diesel, TPH-Oil, TPH-Gasoline, benzene), and radium 226-228 (shading on **Table 4**). Contaminant distribution maps were prepared for barium, benzene, cadmium, chloride, strontium, petroleum hydrocarbons, and radium 226-228 (**Figures 18** through **24**). The groundwater contaminant plume maps suggest the following sources and transport mechanisms:
    - Limited Admission Area 2 has high levels of groundwater contamination around the blowout crater by salt constituents (chlorides, TDS, sodium); heavy metals (barium, iron, manganese, and strontium); light-end petroleum hydrocarbons (TPH-Gasoline and benzene); and Radium 226-228.
    - Limited Admission Area 4 had high concentrations of salts (TDS, chlorides, sodium), petroleum hydrocarbons TPH-Diesel and TPH-Oil; Radium 226-228; and heavy metals (cadmium, strontium) with the highest concentrations at monitoring well H16 at the former central facility and tank battery.
    - Limited Admission Area 5 had high concentrations of salts (TDS, chlorides, sodium); Radium 226-228; and heavy metals (cadmium, strontium) with the highest concentrations at monitoring well H18 at the former production pit.
    - Monitoring well H24 at Limited Admission Area 6 had groundwater exceedances of chlorides, strontium and radium 226-228.
    - The distribution of these contaminants forms a commingled plume that encompasses Limited Admission Areas 2, 4, 5, and 6.
13. Soil samples were analyzed in accordance with the 2011 version of the Laboratory Procedures for Analysis of Exploration and Production Waste as per requirements of Title 43.XIX.611.C, including the use of the 29B Leachate Chloride standard to represent the salt concentration in soil that represents a potential source for continued leaching to groundwater. This test has been demonstrated to result in an accurate prediction of leaching potential in an actual retroactive field study that allowed evaluation of the potential error rate. That field study involved an 8.5 acre stockpile of treated E&P waste with a maximum soil EC of 7.5 mmhos/cm and a maximum Leachate Chloride result of 311 mg/L. Groundwater chlorides at the stockpile area averaged ~25 mg/L in four years of quarterly monitoring before the stockpile was constructed. After construction, quarterly data began to show increasing chloride concentrations in groundwater. The chlorides peaked at 550 mg/L in 2008, approximately 10 years after construction of the stockpile, then leveled off at ~ 325 mg/L. The accuracy of the 29B Leachate Chloride test in this case is remarkable, predicting a concentration of 311 mg/L that would leach to groundwater containing 25 mg/L chlorides (predicting 335 mg/L to be measured in groundwater), compared to ~325 mg/L final chloride concentration in groundwater. In contrast, the application of the SPLP test for conservative non-reactive constituents like chlorides as has been implemented by defendants is inaccurate, lacks scientific and mathematical basis, and has a 100% error rate and should not be used to predict

leachability of salts. The 29B Leachate Chloride test was run on selected samples that were also measured for saturated paste EC. A crossplot of soil EC vs 29B Leachate Chlorides had an excellent linear regression correlation coefficient (R2) that indicated that the 29B Leachability Standard of 500 mg/L corresponds to a soil EC of 10.84 mmhos/cm (Figure 27). Areas of subsurface soil exceeding the leachability standard are included on the cross section diagrams in **Figure 7** (A-A') and **Figure 9** (C-C').

14. Soil data from onsite borings exceeded the 29B Standards for salts (EC, SAR, and ESP) (shading on **Table 1**). Soil excavation and amendment areas on shown on **Figures 28** and **29**. Likely sources of soil contamination include the use of the former pits, tank batteries, surface releases at the former production areas, and blowout well (CNB #1, sn25340).

REMEDIATION GOALS

15. A study of remedial alternatives was performed within the framework of Title 43.XIX.Chapter 6. Criteria for a plan acceptable to the Office of Conservation include:
    - (LAC 43.XIX.611.F.) "Any plan submitted by any party, or approved or structured by the commissioner, shall comply with the standards set forth in Statewide Order 29B. Any party that seeks an exception under the provisions of §319 of Statewide Order 29B shall submit:
        - A plan that complies with all the provisions of Statewide Order 29B, exclusive of §319; and
        - A separate plan that includes sufficient proof that there is good cause to grant an exception or exceptions sought under §319, sufficient proof showing that the exception or exceptions sought under §319 do not endanger USDWs, and a specific citation to the Louisiana rules regulations or statutes sought to be applied in lieu of Statewide Order 29B."
16. Therefore a plan must meet 29B criteria or appropriate criteria of another Louisiana Agency, must be in compliance with specific relevant and applicable standards, and is reasonable. Title 43.XIX does not define "reasonable". The EPA guidance for conducting remedial investigations and feasibility studies suggests a plan that meets remedial action objectives be evaluated for effectiveness (how proven and reliable the process is); implementability (ability to perform the option including permitting); and cost. The sections below details the remediation options chosen to address the contamination at the subject property.

SOIL REMEDIATION

17. Two options for soil remediation were chosen and estimated costs to implement were developed. The two options are described below.
    - [*A plan that complies with all the provisions of Statewide Order 29B*] Removal of all soil to total depth (maximum to 32 feet bls) of any 29B Upland or Wetland

(depending on location of sample) Standard exceedance. This option is to comply with all provisions of Statewide Order 29B, since there are no depth limitations contained within the regulations.

- [*Separate plan that includes an exception or exceptions under §319*] Removal of all soil to a total depth of 12 feet bls that exceeds any 29B Upland or Wetland Standards (depending on location of sample), and remove soil that exceeds an EC of 10.84 mmhos/cm to a total depth of 18 feet bls. Onsite data indicates that a soil EC above 10.84 mmhos/cm would exceed the 29B Leachate Chloride standard of 500 mg/L, the concentration that is protective of groundwater resources. The remaining soil that exceeds an EC of 10.84 mmhos/cm below 18 feet bls will be remediated using soil flushing. The excavated area around boring H16 will not be backfilled to allow for ponding to flush soils below the excavation in the unsaturated zone. Clean effluent from the groundwater treatment system will be pumped to the soil treatment area and used for flushing to remediate salt-impacted soil around H16. Infiltrating water passing through the impacted soil will be recovered using the groundwater recovery wells and pumped to the RO system for treatment.

18. The volume of impacted soil was calculated using soil sample laboratory data and areas were calculated using an engineering design computer program (AutoCadd). Soil remediation includes the following elements:
    - Excavate any clean (compliant) overburden to stockpile. Excavate contaminated soil into trucks for offsite disposal. If water accumulates in the excavation, dewatering will occur by digging a sump that is 2 feet deeper than the maximum planned excavation depth and pumping accumulated water into a holding tank for treatment and volume reduction.
    - Collection of confirmation samples.
    - Backfilling of excavated areas to land surface using stockpiled clean soils and/or clean soil from an offsite location.
    - Chemical amendment of soil with salts (SAR and ESP) above the calculated background standard using liquid gypsum. Affected soils will be excavated and the amendment will be applied and mixed according to the manufacturer's specifications (Global; Aqua Science, LLC – Soil Logic). Treated soils will then be backfilled in one-foot lifts into the excavation.
19. Soil disposal costs were estimated based on the waste being classified as Exploration and Production Waste (E&P Waste) and considering offsite disposal at a licensed commercial E&P disposal facility (Chemical Waste Management (CWM) in Sulphur, LA). A soil disposal cost of $40 per ton provided by CWM for a similar project was used for the estimate. Costs for excavation, earthwork, site preparation, transportation and backfilling under this option were calculated from unit price data included in *Heavy Construction Costs with RSMeans Data, 31st Edition (2017)*, and include material, equipment and labor. The RS Means publication includes comprehensive construction cost data and is listed in the Louisiana Department of Natural Resources (LDNR) document, *Permitting Requirements and Procedures Guidance Document for Commercial Exploration and*

Production Waste Facilities and Transfer Stations (March 2010) as the preferred reference for estimating closure and post-closure costs for E&P facilities. Individual unit prices (including overhead and profit) for each task were obtained from categorized tables in the RS Means publication and summarized to provide a unit rate for this estimate. Costs are itemized on tables in **Appendix E**.

GROUNDWATER REMEDIATION

20. Only one option for groundwater remediation is presented to remediate constituents to background standards to comply with DNR policy with Statewide Order 29B.
21. Costs for groundwater restoration were developed for groundwater plume areas associated with Zone "A" through Zone "K" as shown on **Figure 25**. The plume areas were designated based on similarity of COC concentration and similarity of aquifer properties. The restoration plan for contaminated groundwater in the A Bed and B Bed at this site includes pumping contaminated water to the target remedial standards (background), and treatment of recovered contaminated groundwater by volume reduction, using a treatment train that includes air stripping, physical filtration, chemical dosing, anti-scaling, pH adjustment, and reverse-osmosis (RO) to remove chlorides, TDS, metals and hydrocarbons and to concentrate the volume (the estimate for the RO treatment systems were prepared using specifications provided by Pure Aqua, Inc., for a similar project.). Due to the presence of highly elevated chloride and TDS, remediation of Zone "A" and Zone "F" will be performed using a seawater RO system. The remaining groundwater remediation areas will utilize two brackish water RO systems. Design specifications of the RO systems are as follows:
    - The seawater RO system is designed to operate at 40% recovery; approximately 40% of the recovered groundwater volume will be discharged onsite. Super-concentrated wastewater, or retentate, (approximately 60% of the original feed volume) from RO treatment will be stored in tanks onsite, pending disposal.
    - The brackish water RO system is designed to operate at 50% recovery; approximately 50% of the recovered groundwater volume will be discharged onsite. Super-concentrated wastewater, or retentate, (approximately 50% of the original feed volume) from RO treatment will be stored in tanks onsite, pending disposal.

    Alternative disposal costs were developed considering both offsite disposal at a commercial facility, and onsite injection of retentate into two saltwater disposal wells (SWD's). Costs to remediate groundwater were evaluated as follows:
    - The average contaminant concentration in groundwater was used as the initial concentration for modeling.
    - The yield, radius of influence and drainage area for recovery wells was calculated to arrive at an optimum well spacing, recovery rate and number of recovery wells applicable to the geometry of the aquifer and site. The Theis non-equilibrium equation was used to predict yield and radius of influence from a 4-inch diameter recovery well using:

    - The average aquifer thickness within each plume,
    - The site-wide average hydraulic conductivity, based on the geometric mean of slug test data.
    - A storativity of 0.1.
    - The average available drawdown within each plume

  The radius of influence was read from the Theis sheets at the approximate 0.5 ft drawdown distance. The resulting calculations are included on the summary sheets in **Appendix F.**

  - A sensitivity analysis was performed to calculate the number of aquifer pore volume flushes required to achieve remedial goals, based on the volume of the plume, the groundwater recovery rate, and starting and ending contaminant concentrations. Pore volume flushing calculations were based on algorithms presented in EPA's *"Design Guidelines for Conventional Pump-and-Treat Systems, EPA/540/S-97/504, September 1997"*. The time required to achieve target remedial goals at the site was then derived based on the number of pore volumes required to achieve remedial goals and the groundwater recovery rate. This is a conservative approach, as some studies suggest that four (4) pore volume flushes are required based on the ideal advective-dispersive equation, and as many as 10 pore volume flushes may be needed in non-ideal aquifers due to the tailing effect, as interstitial clays desorb contaminants to the groundwater (*Evaluation of Simple Methods for Estimating Contaminant Removal by Flushing, Brusseau, Ground Water, Vol 34, No. 1, Jan-Feb 1996*).

22. Estimated costs associated with groundwater remediation include recovery well installation, pump test, groundwater modeling, system engineering and optimization, capital costs and operation and maintenance of the RO systems, installation of two saltwater disposal wells (SWD's), and operation and maintenance of the SWD's. Unit costs are based on vendor estimates provided for similar estimates, and from unit price data included in *Heavy Construction Costs with RSMeans Data, 36th Edition (2022).* Costs are itemized on tables in **Appendix F**.
23. Groundwater remediation will be implemented in phases according to the following schedule:
    - Phase 1
        - Groundwater recovery and monitoring well installation.
        - Data collection/ groundwater modeling/engineering design.
        - Pilot Testing/Treatment system optimization.
    - Phase 2
        - Full-scale groundwater remediation and groundwater monitoring.

    Pore volume flushing and groundwater recovery modeling herein upon which groundwater remediation costs are based suggest the following time frames will be required to achieve background target concentrations:

    - A-Bed
        - Zone A: 0.5 years;
        - Zone E: 0.7 years;

  - Zone F: 6.2 years;
  - Zone G: 2.4 years;
  - Zone H: 0.3 years;
  - Zone I: 0.5 years; and
  - Zone J: 0.8 years.
- B-Bed
  - Zone A, B, C, D: 11.8 years;
  - Zone E, H, J: 12.1 years; and
  - Zone K: 1.2 years.

ADDITIONAL ASSESSMENT

24. The lateral extent of constituents of concern in the A-Bed and B-Bed have not been delineated in the northwest corner of Limited Admission Area 2. Additional assessment would include nested wells (A-Bed and B-Bed wells) in the northwest corner of Area 2. One deep monitoring well (approximately 150’ bls) will be installed near CNB #1 (sn25340) blowout crater to investigate potential impacts to the Chicot Aquifer. The wells located in Limited Admission Area 4 did not penetrate the B-Bed. ICON is proposing to install B-Bed wells at all previous locations in Area 4 (H2, H10, H16, H22, MW6, and MW7). The wells are designated to determine the horizontal and vertical extent of groundwater contamination in the B-Bed in Area 4. Five nested wells (A-Bed and B-Bed wells) will be installed outside of historical E&P operations to confirm background concentrations. Costs for these wells are based on industry-standard common unit rates. Estimated costs for additional assessment of the Shallow Aquifer total **$122,493**, and are itemized in **Appendix G**.

ADDITIONAL EVALUATION OF BARIUM

25. Since Barium does not have a soil standards under Statewide Order 29B, further ecological evaluation is needed to determine a comparative standard to protect wildlife on the property. ICON has included the Texas Commission on Environmental Quality (TCEQ) Ecological Protective Concentration Level (PCL) Database in **Appendix J** to demonstrate that Barium exceeds some of the calculated protective standards for species that could live on the property in the Limited Admission Areas. Base on the TCEQ PCL table, if Barium concentration were remediated to be protective of Mallards (832 mg/kg), the cost for the additional soil remediation would be approximately **$5,000,000**.

COST ESTIMATE SUMMARY

REMEDIATION OF SOIL TO 29B (TOTAL DEPTH 32' BLS) AND GROUNDWATER REMEDIATION TO BACKGROUND

	Offsite Disposal of Retentate from RO	Onsite Injection of Retentate From RO
Soil Remediation	$2,304,710	$2,304,710
GW Remediation Zone A Bed A	$554,096	$469,530
GW Remediation Zone E Bed A	$3,455,689	$2,666,351
GW Remediation Zone F Bed A	$1,737,501	$478,538
GW Remediation Zone G Bed A	$1,020,107	$415,959
GW Remediation Zone H Bed A	$562,039	$490,504
GW Remediation Zone I Bed A	$3,272,199	$2,839,158
GW Remediation Zone J Bed A	$667,534	$504,131
GW Remediation Zone A, B, C, D Bed B	$3,389,920	$404,488
GW Remediation Zone E, H, J Bed B	$1,423,705	$359,057
GW Remediation Zone K Bed B	$96,933	$79,556
RO Unit Capital and O&M costs (Seawater)	$311,224	$311,224
RO Unit Capital and O&M costs (Brackish)	$454,879	$454,879
SWD Capital and O&M costs	-	$7,457,378
Additional Assessment Cost	$122,493	$122,493
TOTAL	**$19,373,029**	**$19,357,956**

REMEDIATION OF SOIL TO 29B (TOTAL DEPTH 18' BLS) WITH SOIL FLUSHING IN UNSATURATED ZONE AND GROUNDWATER REMEDIATION TO BACKGROUND

	Offsite Disposal of Retentate from RO	Onsite Injection of Retentate From RO
Soil Remediation	$1,033,956	$1,033,956
GW Remediation Zone A Bed A	$554,096	$469,530
GW Remediation Zone E Bed A	$3,455,689	$2,666,351
GW Remediation Zone F Bed A	$1,737,501	$478,538
GW Remediation Zone G Bed A	$1,020,107	$415,959
GW Remediation Zone H Bed A	$562,039	$490,504
GW Remediation Zone I Bed A	$3,272,199	$2,839,158
GW Remediation Zone J Bed A	$667,534	$504,131
GW Remediation Zone A, B, C, D Bed B	$3,389,920	$404,488
GW Remediation Zone E, H, J Bed B	$1,423,705	$359,057
GW Remediation Zone K Bed B	$96,933	$79,556
RO Unit Capital and O&M costs (Seawater)	$311,224	$311,224
RO Unit Capital and O&M costs (Brackish)	$454,879	$454,879
SWD Capital and O&M costs	-	$7,457,378
Additional Assessment Cost	$122,493	$122,493
TOTAL	**$18,102,275**	**$18,187,202**

The opinions and interpretations listed herein are based on the referenced sources and are subject to change upon receipt of additional data. If you have any questions concerning this report, please feel free to contact me at (225) 344-8490.

Sincerely,
ICON Environmental Services, Inc.

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