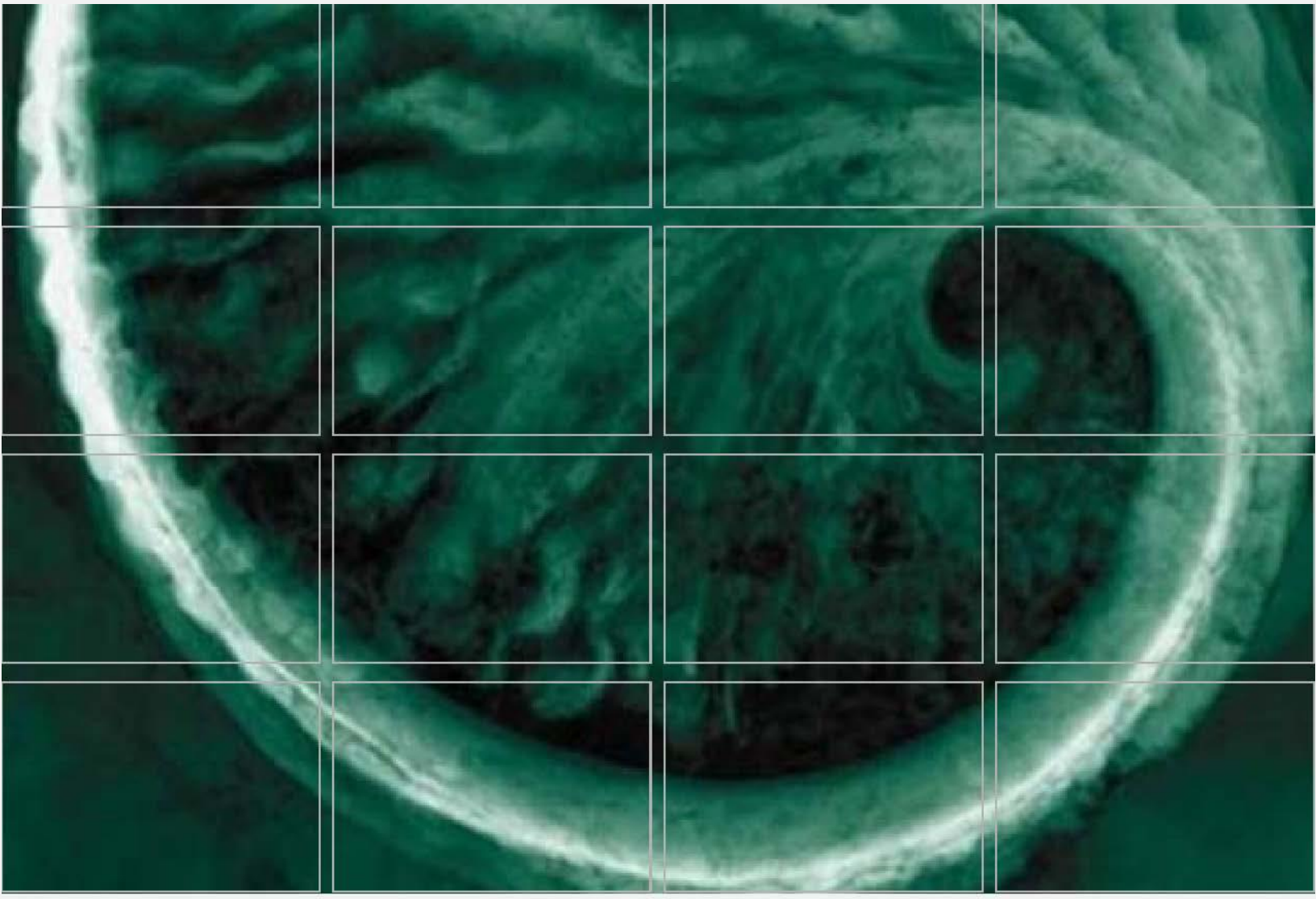

# Site Investigation Report and Remediation Work Plan – Chevron Limited Admission

Jeanerette Lumber & Shingle Co., LLC v.
ConocoPhillips Co., et al,
Docket No. 134307, Div “E”, 16th JDC
Bayou Pigeon Field
Iberia Parish, Louisiana

May 14, 2021

Project No.: 0519829

*The business of sustainability*

ERM

**Signature Page**

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Bayou Pigeon Field
Iberia Parish, Louisiana


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# 1. INTRODUCTION

Environmental Resources Management (ERM) is pleased to submit this Site Investigation Report and Remediation Work Plan – Chevron Limited Admission (Plan) for the former Chevron well, SN 70817. This Plan is submitted to the Louisiana Department of Natural Resources (LDNR) Office of Conservation in support of Chevron's April 28, 2021 limited admission to the court under La. R.S. 30:29.

The focus of this Plan is the former Chevron well location identified above on the property at issue in the lawsuit (Property), located in the Bayou Pigeon oil and gas field in Iberville Parish, Louisiana. The Property is the subject of a lawsuit, filed June 17, 2019, which alleges that ConocoPhillips Company (Conoco), Alta Mesa Holding. LP, Chevron U.S.A., Inc. (Chevron), Apache Corporation (Apache), and Texas Petroleum Investment Company (TPIC) caused soil, sediment, and groundwater contamination by historical oil and gas exploration and production (E&P) operations on the plaintiffs' property.

The plaintiffs' expert, ICON Environmental, Inc. (ICON), conducted investigations on the Property from May to September, 2020. ERM and Hydro-Environmental Technology, Inc. (HET), which is retained by another defendant in the case, conducted additional investigations in February and March 2021. The data collected by ICON, ERM, and HET during these investigations as well as the split sample data are provided and considered as part of this Plan.

## 1.1 Objective

The objective of this Plan is to present the results of the site investigation activities conducted to date in the vicinity of the former Chevron well location and provide a remediation plan.

# 2. SITE SETTING

The Plaintiffs' Property is located approximately 13 miles west-northwest of Pierre Part in Iberia Parish, Louisiana (Figure 1). The Property is accessible only by boat. The nearest boat launch is Pigeon Landing Boat Launch, approximately 9 miles from the former Chevron operational area via Little Bayou Pigeon and a network of canals (Figure 2). The Plaintiffs-identified parcels owned by Jeanerette Lumber & Shingle Co., LLC comprise approximately 3,825 acres (~6 square miles) located in Bayou Pigeon oil and gas field in all or parts of Section 1, 2, 9, 10, 11, 12, 13, 14, 15, 22, 23, 26 and 27 of Township 12S, Range 10E. Investigation activities on the Property have been focused in two areas, an area to the north designated as Area 1 and an area to the south designated as Area 2. Former Chevron operations occurred only in a small portion of Area 2. The Public Land Section lines, along with investigation Areas 1 and 2 on the Property, are shown on Figure 3.

## 2.1 Land Use and Ground Surface Topography

The Property is predominantly nontidal wetland and cypress swamp located east of Grand Lake and west of Little Bayou Pigeon (Figure 3). Land uses have included forestry, hunting, trapping, and fishing, and some portions have been used concurrently for oil and gas E&P operations beginning in the 1950s. Due to its remote location and unique site setting, future land uses are anticipated to be similar to current uses. Surrounding properties consist of largely undeveloped wetlands used for the same purposes including oil and gas E&P operations.

The USGS Topographic Map with Public Land Survey Sections is provided as Figure 3 and the Light Detection and Ranging (LiDAR) elevation model is provided as Figure 4. The Property is generally flat, the elevation of the majority of the Property ranges from +2 to +4 feet North American Vertical Datum of 1988 (NAVD88). The oil and gas operational areas are accessible only via manmade canals. Banks of the canals approach elevations of +4 to +8 NAVD88.

## 2.2 Wetland Classification

The entirety of the Property is identified as wetlands by the U.S. Fish and Wildlife Service (USFWS) (Figure 5). The following wetland categories are identified within Area 2:

- PFO1/2F: Palustrine system of forested nontidal wetlands, with broad-leaved deciduous trees or shrubs and needle-leaved deciduous trees (tamarack or bald cypress), and water regime (F), semipermanently flooded—surface water persists throughout the growing season in most years and the water table is usually at or near the land surface.
- PEM1Cs: Palustrine system of emergent nontidal wetlands dominated by trees, shrubs and herbaceous hydrophytes; and dominated by species that normally remain standing at least until the beginning of the next growing season. Water regime is seasonally flooded where water is present during the early portion of the growing season but is absent at the end of the growing season in most years. Special modifier(s) describes wetlands where deposition of spoil material forms the primary substrate type.
- PFO1Cs: Palustrine system of forested nontidal wetlands, with broad-leaved deciduous trees or shrubs that are 6 meters or taller (e.g., black ash). Water regime is seasonally flooded where water is present during the early portion of the growing season but is absent by the end of the growing season in most years. Special modifier (s) describes wetlands where deposition of spoil material forms the primary substrate.

- R2UBHx: Riverine system of wetlands and deepwater habitats contained within a channel. Water regime is permanently flooded. There is no tidal influence, and some water flows all year, except during years of extreme drought. The fauna is composed mostly of species that reach their maximum abundance in still water and true planktonic organisms are common. Special modifier (x) identifies channels that were excavated by humans.

The entirety of the Property is located within the Federal Emergency Management Agency (FEMA) 100-year flood zone (Figure 6), indicating that the Property is subject to flooding. In addition, the wetland classification for the majority of the Property (PFO1/2F) is described as semi-permanently flooded, with surface water present for an extended portion of the growing season, and with the water table typically at or near the surface. The remainder of the Property is described as seasonally flooded.

A submerged wetland is a:

- "wetland area which is normally inundated with water"

as defined by Title 43 of the Louisiana Administrative Code (LAC) – Natural Resources, Part XIX – Office of Conservation General Operations, Subpart 1 – Statewide Order No. 29-B (29-B), Chapter 3 – Pollution Control On-Site Storage, Treatment and Disposal of E&P Waste Generated from the Drilling and Production of Oil and Gas Wells (Oilfield Pit Regulations, LAC 43.XIX), §301 – Definitions.

The freshwater emergent and forested/shrub wetlands identified by the USFWS as listed above are submerged wetlands, normally inundated with water, as defined in the regulation cited above. The submerged wetland classification for sample locations on the Property was further confirmed by ERM and is discussed in Dr. Connelly's Ecological Risk Assessment (ERA) expert report, which is included in Appendix A.

## 2.3 Surface Water

The major surface water bodies near the Property consist of Grand Lake and Smith Bayou to the west, and Little Bayou Pigeon to the east (Figure 7). The Property is located within LDEQ Drainage Basin Subsegment #010501 Lower Atchafalaya Basin Floodway—From Whiskey Bay Pilot Channel at mile 54 to US-90 bridge in Morgan City and includes Grand Lake and Six-Mile Lake as shown on Figure 7. The LDEQ numerical chloride and total dissolved solids (TDS) criteria for Subsegment #010501 are 65 mg/L and 440 mg/L, respectively. The Designated Uses of this Subsegment are primary and secondary contact recreation, fish and wildlife propagation, and drinking water supply. Subsegment #010501 is reported to be impaired by color and mercury due to unknown sources and atmospheric deposition (LDEQ, 2019). Chloride concentrations in USGS surface water samples in the vicinity of the Property are shown on Figure 8.

Surface water bodies on and near the Property are shallow. Depths measured in Bayou Pigeon were up to 13 feet, and depths in the dredged canals in and around Area 2 were up to approximately 10 feet. Survey data, including water depth measurements, are included in Appendix B. Other surface water bodies in the area are also shallow. For example, bottom elevations of Grand Lake ranged from -0.56 to +0.33 feet above mean sea level in 1988 (Hale et al, 1999), or approximately 6 feet deep on average.

## 2.4 Surface Soils

The surface soils underlying the Property are predominantly clayey throughout and comprise level soils mainly in swamps in the Atchafalaya Basin Floodway of the alluvial plain based on the United States Department of Agriculture (USDA) soils map provided as Figure 9. A description of the soils is provided below (USDA, 1978 & USDA Web Soil Survey accessed 2021):

- FE – Fausse soils, 0 to 1 percent slopes, frequently flooded. This map unit is composed of 75 percent Fausse and similar soils and 25 percent minor components. The Fausse soils occur on flood plains with a parent material of clayey alluvium. The typical soil profile comprises 0 to 1 inch of mucky clay (A1), 1 to 11 inches of clay (A2), 11 to 47 inches of clay (Bg), and 47 to 79 inches of clay (BCg). The soils are very poorly drained and the capacity of the most limiting layer to transmit water is defined as 0.03 to 0.11 in/hr. Flooding and ponding of water is frequent, and salinity is nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm). Minor components of the soils include Schriever (15 percent) and Barbary (10 percent).

The Soil Survey of Iberia Parish states the soils are flooded much of the time by freshwater. From December through June the soil unit is continuously under 2 to 8 feet of water. The soils receive annual deposits of clayey sediment from the Atchafalaya River. The water table fluctuates within a depth of 1.5 feet at all times. The soil is high in content of organic matter and high in available phosphorous, potassium, and calcium. Woodland is mostly bald cypress and water tupelo. The acreage comprising the map unit is used for woodland, recreation, and wildlife habitat. The soil is the main source of natural habitat for deep-water crawfish. Unless the soil map unit is protected from flooding, it is not suited for crops or pasture (USDA, 1978).

## 2.5 Geology

The surface geology underlying the Property as determined by the Louisiana Geological Survey (LGS) is presented on Figure 10 and consists of backswamp deposits of the Mississippi and Atchafalaya rivers. Deposits consist of fine-grained, usually clayey and often organically rich sediments that underlie flood basins between meander-belts.

Shallow geology underlying the Property was evaluated using geological information obtained from the soil borings advanced by ERM and ICON. ERM visually logged soil borings and developed boring logs, which are provided in Appendix C. ERM also prepared two geologic cross sections based on the boring logs. The locations of geologic cross-sections A to A' and B to B' are shown on Figure 11, and the corresponding cross-sections are shown on Figures 12 and 13, respectively. The cross sections document that the subsurface soils down to a depth of approximately 56 feet below the ground surface (bgs) consist primarily of clay, silty clay, and peat. Two shallow water-bearing zones, "30-foot Zone" and "50-foot Zone", were identified during the investigation of the Property. Where present, the laterally variable and discontinuous water bearing zones consist primarily of silt, clayey silt, and sandy silt, with some silty sand in the 50-foot Zone. The shallow soils underlying the Property are part of the primarily clay confining unit overlying the Atchafalaya Aquifer.

## 2.6 Hydrogeology and Groundwater

Based on a search of LDNR's SONRIS database, no registered water wells were identified within a one-mile radius of the Property. The nearest registered water wells are approximately 3 miles northwest of the Property (approximately 6.5 miles from the former Chevron operational area) and are 180 to 195 feet deep and reportedly screened in the Atchafalaya aquifer (Figure 14). Water well files obtained from the LDNR are provided in Appendix D. Based on water well driller logs from these wells, the sandy Atchafalaya aquifer is first encountered from 107 to 150 feet below ground surface (bgs) and is overlain by clay. The Property is located over an area that has no potential to recharge the Atchafalaya Aquifer based on the Louisiana Geological Survey (LGS) map (LGS, 2000) as shown on Figure 15.

Shallow groundwater is encountered underlying the Property in two distinct zones (the 30-foot Zone and the 50-foot Zone) that are discontinuous and laterally variable in grain size and thickness (Figures 12 and 13). Where present, the 30-foot Zone is encountered from approximately 25 feet to 34 feet bgs, with a

maximum thickness of approximately nine feet. The 30-foot Zone is separated from the 50-foot Zone by approximately 8 to 10 feet of low permeability clay. Where present, the 50-foot Zone is encountered from approximately 43 to 56 feet bgs, with a maximum encountered thickness of at least 12 feet. Both shallow water bearing zones consist primarily of silt, clayey silt, and sandy silt, with some silty sand in the 50-foot Zone.

ERM collected a soil sample at a depth of 42 to 44 feet bgs from soil boring JLS-2 in order to evaluate the vertical permeability of the clay confining layer between the 30-foot and 50-foot Zones. The sample was sent for geotechnical analysis to Ardaman and Associates, Inc., a Louisiana Environmental Laboratory Accreditation Program (LELAP) accredited laboratory. The geotechnical report indicated the clay confining layer has vertical permeability of $8.3 \times 10^{-8}$ cm/sec, which meets the Statewide Order 29-B definition of a "Natural liner – having a hydraulic conductivity no greater than $1 \times 10^{-7}$ cm/sec", and limits vertical migration.

The shallow water-bearing zones (30-foot and 50-foot Zones) have never been used as a water source on the Property and do not represent a viable future source of potable or irrigation water due to their low yield, discontinuous nature, and naturally poor water quality. In both groundwater zones, naturally occurring arsenic, iron, and manganese concentrations are elevated. There are no registered water wells within a one-mile radius of the Property that are reported to be screened in the shallow water-bearing zones (Figure 14). According to the USGS, the primary source of fresh groundwater (i.e., chloride concentration less than or equal to 250 mg/L) in eastern Iberia Parish is the Atchafalaya aquifer, and iron and manganese concentrations generally exceeded the EPA SMCLs (USGS Fact Sheet 2016-3100, February 2017).

### 2.6.1 Groundwater Classification

ERM analyzed aquifer tests performed during site investigation activities, including slug tests performed by ERM on three monitoring wells in the 30-foot Zone (MW-1, MW-2, and MW-3), and a low-flow steady-state pumping test performed by ICON at one well in the 30-foot Zone (JLS-11). ICON was not able to achieve steady-state pumping during their test at JLS-11 due to the well repeatedly pumping dry. ERM analyzed the recovery data collected during this test as a rising-head slug test. The slug test results are summarized in Table 1, and the individual slug test evaluation reports are provided in Appendix E. The aquifer test results indicate that the shallow 30-foot Zone is not able to sustain a yield of greater than 800 gallons per day, the threshold between RECAP Class 2 and 3 groundwater. Therefore, the 30-foot Zone is RECAP Class 3A groundwater, and is not a viable future groundwater resource.

The 50-foot Zone is also RECAP Class 3A groundwater based upon ICON's low-flow pumping test on one well, JLS-14, with a reported well yield of 249 gallons per day (GPD). ICON's result is reasonable and generally consistent with the expected yield for the laterally variable 50-foot Zone demonstrating the 50-foot Zone is not a viable future groundwater resource.

### 2.6.2 Groundwater Flow

Groundwater level measurements were collected on February 9, 2021, from ERM's three monitoring wells (MW-1, MW-2, and MW-3) screened in the 30-foot Zone. The well survey results, water elevations, and calculated Equivalent Fresh Water Heads (EFWH) are provided on Table 2. The potentiometric surface map for the 30-foot Zone (EFWH) is provided as Figure 16. The groundwater flow direction in the 30-foot Zone is to the north-northwest. Based on the potentiometric map, the 30-foot Zone has an average gradient of approximately 0.003 and a flow velocity of less than two feet per year. The groundwater flow direction in the 50-foot Zone was not determined.

## 2.7 Arsenic in Soils and Groundwater

Arsenic is a naturally occurring element that is present in soils and minerals throughout the world (ATSDR, 2007). Arsenic is naturally present in the soils and shallow groundwater underlying the Property and surrounding area and in soils as well as the waters that come into contact with these soils throughout Louisiana (Ori, et al., 1993). Ori, et al. (1993) has reported arsenic concentrations ranging from near zero to 73 milligrams per kilogram (mg/kg) with a mean concentration of 23.2 mg/kg in over 450 alluvial and other soil samples from across Louisiana. In general, finer grained soils (i.e. clays and silts) and groundwater in contact with finer grained soils tend to exhibit higher arsenic concentrations than coarser grained soils (i.e. sands) and associated groundwater.

Because arsenic occurs naturally in soils at much higher concentrations (i.e., mg/kg or part per million) than in groundwater (i.e., µg/L or parts per billion), elevated arsenic concentrations detected in groundwater cannot always be attributed to some type of contamination. According to Smedley and Kinniburgh (2002), strongly reducing aquifers often derived from alluvium tend to exhibit elevated arsenic concentrations. These aquifers also tend to contain geologically young sediments and are located in flat, low-lying areas where groundwater flow is sluggish. Smedley and Kinniburgh (2002) further state the following:

> "A characteristic feature of high groundwater arsenic areas is the large degree of spatial variability in arsenic concentrations in the groundwater. This means that it may be difficult, or impossible, to predict reliably the likely concentration of arsenic in a particular well from the results of neighboring wells, and means that there is little alternative but to analyze each well."

Yang, et al. (2014) reports that:

> "Aquifers with elevated groundwater As (arsenic) concentrations commonly consist of Holocene riverine and deltaic sediments that are under reducing conditions, poorly drained, and associated with high levels of organic matter content."

As shown on Figure 17, the shallow water-bearing zones underlying the Property and surrounding area are susceptible to contamination from arsenic containing minerals in the alluvial soils as documented by Yang, et al. (2014).

The shallow water-bearing zones beneath the Property contain geologically young sediments and exhibit reducing conditions and naturally elevated arsenic concentrations consistent with both the Smedley and Kinniburgh (2002) and Yang, et al. (2014) references.

In 2010, the LDNR issued a Memorandum and a Louisiana alluvial aquifer water quality summary to Louisiana Licensed Water Well Contractors that stated the following regarding the presence of arsenic in alluvial aquifers:

> "Louisiana alluvial aquifer groundwater quality is reported by the USGS to be primarily limited to use for industrial and agricultural purposes due to excessive concentrations of dissolved solids, hardness, iron, or localized salinity. The natural groundwater quality of these aquifer systems is generally considered not suitable for drinking water supply purposes without first undergoing appropriate water treatment. Furthermore, it is reported that other dissolved metals such as arsenic have been, and are expected to be, detected in groundwater in localized areas of these aquifers."

# 3. HISTORICAL OPERATIONS

Based on available data from LDNR's SONRIS database, 38 registered oil and gas wells have been drilled on the Property and are shown on Figure 18. Chevron or its predecessors had a working interest in only one well on the property, SN 70817. Table 3 provides the oil and gas operator well history for the Chevron well. LDNR oil and gas well files are provided in Appendix F.

Historical aerial photographs from 1940 through 2019 showing the historical development of oil and gas operations on the Property and the current use of former E&P operational areas are provided as Figures 19 through 40. Based on the aerial photography, in 1940 the Property was undeveloped wetlands with no evidence of E&P operations. Canals related to oil and gas E&P operations on the Property are first visible in the 1951 aerial photo. The canal network is further developed through at least the 1980s. Oilfield operations, including a well slip, well head, and associated equipment, are first visible in the former Chevron operational area beginning in the 1967 aerial photo. SN 70817 was plugged and abandoned (P&A'd) in February, 1978, and the wellhead and associated equipment are no longer visible in the 1978 aerial photo. Beginning in 1983, a well slip immediately to the south of the former SN 70817 well slip is visible, apparently associated with Apache Corporation's SN 187214 well. The general configuration and extent of canals in Area 2 is consistent from 1983 through the present day. The area outside of the canals in Area 2 currently is (and has historically been) a thriving wetland ecosystem.

# 4. REGULATORY FRAMEWORK

The oil and gas E&P operations that have been conducted on the Property are regulated by LDNR's Office of Conservation (OC). LDNR rules for environmental protection are presented in Louisiana Administrative Code, Title 43, Part XIX (LAC 43: XIX), Subpart I, commonly referred to as Statewide Order 29-B.

Statewide Order 29-B has evolved over time, with major revisions in the mid-1980s requiring the registration of existing pits and the ultimate upgrading or phase out/closure of existing pits. Prior to the January 20, 1986 amendments to Statewide Order 29-B, there were no specific or numeric LDNR standards for registration or closure of pits. Many of the former wells and other operational features on the Property, including the former Chevron well (SN 70817), were plugged and abandoned and/or closed well before Statewide Order 29-B was amended.

## 4.1 Soil

The applicable or relevant and appropriate standards for soils are Statewide Order 29-B Chapter 3 pit closure criteria and LDEQ RECAP standards. The Statewide Order 29-B pit closure regulations establish standards for metals, salts and hydrocarbons (oil & grease) in soils at E&P sites. RECAP was developed by LDEQ based on EPA guidance to provide a framework for evaluating risks to human health and the environment from chemical constituents in impacted media (e.g., soil and groundwater).

The soil data gathered from the Property have been compared to the following Statewide Order 29-B criteria (adopted in 1986) and to RECAP standards (adopted in 2003) where appropriate:

- Range of pH: 6-9
- Total metals (mg/kg wet weight, unless noted):
  - Arsenic: 10
  - Cadmium: 10
  - Chromium: 500
  - Lead: 500
  - Mercury: 10
  - Selenium: 10
  - Silver: 200
  - Zinc: 500
  - True Total Barium: 20,000 (Wetland) (dry weight)
- Oil and Grease: <1 percent (dry weight)

Based on a root zone study performed by Dr. Luther Holloway and Mr. Patrick Ritchie on the Property (included as Appendix G), baldcypress exhibited effective root zones (ERZs) between 12 and 14 inches bgs. ERZs for tupelo gum ranged from 11 to 24 inches bgs. Statewide Order 29-B salt parameters in soil are agronomic standards established to promote the growth of crops and other vegetation; therefore it is appropriate to apply them only to soils within the effective root zone. Furthermore, there are no 29-B standards for salt parameters in submerged wetland settings. Based on the ERA, the wetlands and adjacent areas on the Property are characterized as submerged wetlands and are discussed in Dr.

Connelly and Dr. Rogers's ERA expert report (included as Appendix A). Therefore, soil samples were compared to Statewide Order 29-B standards for land treatment in submerged wetlands.

In addition to the promulgated LDNR salt standards, LDEQ established guidelines for salt parameters in a 2012 document entitled, "How should a release of brine (sodium chloride) be addressed under RECAP?" [Commonly referred to as the RECAP Frequently-asked-questions (FAQ) on salt]. The RECAP FAQ adopts the Statewide Order 29-B standards for salt parameters for soils within the effective root zone as a screening tool and utilizes a synthetic precipitation leaching procedure (SPLP) approach for determining salt concentrations in deeper soils that are protective of groundwater. To assess salt parameters in soils below the effective root zone, RECAP utilizes a comparison of soil SPLP leachate results to standards for chloride appropriate to the specific groundwater classification.

Based on LDEQ guidance for evaluating whether soil concentrations are protective of groundwater provided in RECAP Appendix H (2003), ERM utilized SPLP analyses to determine if soil concentrations above the shallow water-bearing zone were protective of groundwater quality for barium. ERM compared the SPLP results to the appropriate RECAP standards.

RECAP does not address radioactive materials. However, LDEQ regulations for oilfield Naturally Occurring Radioactive Material (NORM) in soil are contained in LAC 33: Part XV Chapter 14 and the NORM data have been evaluated in accordance with LDEQ's NORM regulations.

## 4.2 Groundwater

There are no direct comparative groundwater standards provided in Statewide Order 29-B; therefore, the groundwater data have been evaluated in accordance with LDEQ's RECAP regulation. EPA's Maximum Contaminant Levels (MCLs) and Secondary Maximum Contaminant Levels (SMCLs) are used in RECAP to evaluate groundwater zones that are classified as a drinking water resource. MCLs are enforceable standards established by EPA to protect the public against consumption of drinking water contaminants that present a risk to human health. An MCL is the maximum allowable concentration of a contaminant in drinking water supply, which can be delivered to the consumer. SMCLs are non-enforceable standards that are used as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. MCLs and SMCLs do not apply to RECAP Class 3 groundwater.

LAC 43.XIX.303.C identifies that "Contamination of a groundwater aquifer or a USDW with E&P Waste is strictly prohibited." However, a February 25, 2011 Memorandum of Understanding (MOU) between LDNR and LDEQ establishes a mechanism for the use of RECAP procedures for the evaluation or remediation of groundwater at E&P sites. This interagency agreement recognizes that RECAP contains groundwater evaluation and remediation standards and protocols that are applicable and appropriate for E&P sites.

Groundwater within the shallow water-bearing zones (30-foot and 50-foot Zones) is RECAP Class 3A based on slug and pump test results and is naturally poor quality based on laboratory analytical results. The shallow groundwater is not currently being used, has never been used, and is not a viable drinking water or irrigation source due to its naturally poor water quality and low yield.

### *4.2.1 Radionuclides Rule*

The Radionuclides Rule (65 FR 76707), promulgated on December 7, 2000, specifies a MCL of 5 pCi/L for Combined radium-226/-228 in Community Water Systems (CWS) [See relevant regulations provided in Appendix H]. The Radionuclides Rule applies to all CWSs; however, the regulations do not apply to non-community water systems (US EPA, 2002, page I-4). A CWS is defined as:

> "A public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents."

The Radionuclides Rule is not applicable to the following two types of Non-Community Water Systems (NCWS) as defined in 40 CFR Part 141 – National Primary Drinking Water Regulations (Appendix H):

> "Non-transient non-community water system or NTNCWS means a public water system that is not a community water system and that regularly serves at least 25 of the same persons over 6 months per year."

> "Transient non-community water system or TWS means a non-community water system that does not regularly serve at least 25 of the same persons over six months per year."

Due to naturally poor water quality and very low yield, the shallow water-bearing zones are not a suitable source for a CWS or NCWS. Consequently, the Radionuclides Rule regulations (i.e., 5 pCi/L MCL for Combined radium-226/-228) are not applicable to the reasonably anticipated future use of the groundwater in the shallow water-bearing zones underlying the Property.

### *4.2.2 LAC Title 56 Regulations*

In addition to the natural limitations on use of the shallow groundwater due to low yield and quality, any attempted use of groundwater in the shallow water-bearing zones for potential potable supply use could/would result in non-compliance with the Louisiana Administrative Code (LAC) Title 56 Part I Section 319.

Section 319 regulations pertinent to small diameter (<4-inches) water wells located in coastal areas prone to flooding as a result of direct impact of storm surge events shall be constructed with:

- "5. grouting down to a depth of at least 50 feet below ground surface."

The top of the 30-foot shallow groundwater-bearing zone is as shallow as 24 feet below the ground surface on the Property. Potable water could not be obtained from this zone based upon the LAC Title 56 regulations cited above.

# 5. REVIEW OF AGENCY RECORDS

## 5.1 LDNR Records

ERM reviewed pit records and inspection reports, Lease Facility Inspection Reports (LFIR), and Compliance Orders (CO) and Notices obtained from LDNR, but did not identify any such documents associated with the one Chevron well, Jeanerette #001 (SN 70817). The nearest water well driller logs and historic oil and gas well files were obtained from the LDNR SONRIS database and are included in Appendices D and F, respectively.

## 5.2 LDEQ Records

A search for LDEQ Agency Interest (AI) locations in the vicinity of the Property indicated that only one AI is located within the Property boundary (Figure 41). Little Bayou Pigeon Production Facility #1 (AI#32120) is located on the north side of the Property, approximately 1.5 miles from the former Chevron operational area. Available documents for AI#32120 and other nearby AIs were reviewed in LDEQ's Electronic Document Management System (EDMS). Documents pertaining to the former Chevron operational area were not identified.

# 6. INVESTIGATION ACTIVITIES AND RESULTS

The following sections provide a discussion of the results of the November 2019 through March 2021 investigations conducted on the Property. The soil analytical data from ICON's, Hydro-Environmental Technology, Inc. (HET)'s and ERM's investigations, including split samples, are summarized in Table 4. Soil geotechnical data are summarized in Table 5. The groundwater analytical data for samples collected in July and August 2020 and in February 2021 are summarized in Table 6. The field parameters recorded during the groundwater sampling events are provided on Table 7. Surface water analytical data are summarized on Table 8.

Field investigations were conducted in two main sampling areas on the Property, which ERM identifies as Area 1 and Area 2. The sampling areas and sample locations are shown on Figures 42 and 43. ERM's analysis is focused on the former Chevron operational area within Area 2 (Figure 43). However, all sample results from the Property are presented in the analytical data tables.

Soil boring logs and monitoring well construction diagrams are provided in Appendix C. Field notes recorded by ERM during site investigation activities are provided in Appendix I. Photographs recorded during the site investigation activities and photo logs are provided in Appendix J. Laboratory reports are provided in Appendix K. LDNR well registration documents for the monitoring wells installed by ERM are included in Appendix L. A summary of work performed and materials relied upon by ERM is included in Appendix M.

## 6.1 Soil

ICON performed a terrain conductivity survey in November 2019 using a Geophex GEM-2 variable frequency conductivity meter. The GEM-2 conductivity meter is a screening tool used by ICON that does not provide analytical data for remedial decisions. Based in part on the results of the terrain conductivity surveys, ICON selected locations for soil and groundwater sampling.

In May 2020, ICON collected subaqueous sediment samples using a Russian Peat coring tool at sample locations JLS-1 through JLS-3 in Area 2 and JLS-4 through JLS-9 in Area 1. HET and ERM collected split samples at select locations.

In July and August 2020, ICON collected soil samples using a Geoprobe hydraulic direct push drill rig mounted on a Marsh Master (JLS-10 through JLS-17 in Area 2). ERM was present for split sample collection from JLS-10 and JLS-11; however, split samples of soil were not provided at JLS-11 due to low sample recovery volume. HET collected split samples from the remaining sample locations.

In August 2020, ICON collected soil and subaqueous sediment samples using a hand auger and/or a Russian Peat coring tool (JLS-18, 19, & 20 in Area 1). HET collected split samples.

In September 2020, ICON collected subaqueous sediment samples using a Russian Peat coring tool and hand auger (JLS-21, 22, & 23 in Area 2). HET collected split samples from JLS-21, and ERM collected split samples from JLS-22 and 23.

In January 2021, HET collected soil samples using a Russian Peat coring tool and hand auger or using a Geoprobe hydraulic direct push drill rig mounted on a barge at several locations in Area 1 (JLS-6R & 9R) and Area 2 (JLS-1R, 12R, 14R, & 15R; SB-1, 2, & 3).

On February 2, 2021, ERM collected soil samples using a Russian Peat coring tool and hand auger at JLS-23 in Area 2.

On February 3, 2021, HET collected additional soil samples at JLS-15R.

On February 3 and 4, 2021, ERM advanced a soil boring at JLS-2 in Area 2 to a total depth of 56 feet below the mud line (bml) using a Geoprobe hydraulic direct push drill rig mounted on a barge. Soil samples were collected in the 42-44' interval for geotechnical parameter analyses and at 44' for electrical conductivity. On February 8, 2021, ERM returned to JLS-2 to collected sediment samples using a Russian Peat coring tool and hand auger (0-2', 2-4', 4-6', and 6-8').

From February 4 through 5, 2021, ERM advanced three soil borings for the installation of three monitoring wells in Area 2 (MW-1, MW-2, and MW-3), and collected soil samples from these locations at 0-2', 2-4', and 24-26'.

On February 25, 2021, ERM collected sediment samples using a Vibracore at JLS-2. The vibracore tube was advanced to a depth of 11 feet below the mud line, and samples were collected from 0 to 5 feet and 5 to 11 feet bml.

Sampling activities performed were limited based on the ability to access locations via boat with sampling equipment, and were generally limited to areas within and adjacent to existing canals. The sediments/soils were not readily recovered by the multiple types of sampling equipment used due to their soft nature, specifically at the JLS-2 location. The sample intervals were dictated, in some cases, by the material the sampling equipment was able to recover.

On March 1, 2021, HET collected soil samples using a Geoprobe hydraulic direct push drill rig mounted on a Marsh Master at SB-4 in Area 2.

Walker Hill Environmental (WHE), a Louisiana-licensed water well driller, performed the drilling during ERM's investigation. The soil samples were logged in the field by an ERM scientist, including field screening with a Photo Ionization Detector (PID), and handheld electrical conductivity (EC) pen. Soil samples were collected for laboratory analysis in new laboratory-provided containers and placed on ice. Soil samples were sent to Element in Lafayette, Louisiana and Pace Analytical in Baton Rouge Louisiana for analysis. Geotechnical samples were sent to Ardaman & Associates, Inc. These three laboratories are Louisiana Environmental Laboratory Accreditation Program (LELAP) accredited laboratories. ICON was present during ERM and HET's investigations and collected splits of soil samples.

During ICON, ERM, and HET's investigations, a total of over 200 soil samples from 32 locations on the Property were submitted for laboratory analysis. A discussion of the sampling results is included in Section 7.

Dr. Luther Holloway and Mr. Patrick Ritchie performed a root study on the Property concurrently with ERM's investigation. Based on their results, baldcypress exhibited ERZs between 12 and 14 inches bgs. ERZs for tupelo gum ranged from 11 to 24 inches bgs. The results of the ERZ investigation are presented in a separate expert report, which is included in Appendix G.

## 6.2 Groundwater

In July and August 2020, ICON collected groundwater samples from temporary ¾-inch diameter polyvinyl chloride (PVC) wells incorporating 5 or 10-foot long screens. A filter sock was placed over the screened portion of each well and attached with electrical tape. The monitoring wells were installed using a Geoprobe drill rig mounted on a Marsh Master. Each of ICON's temporary monitoring wells was plugged and abandoned upon completion of groundwater sampling.

ICON collected groundwater samples using a peristaltic pump with dedicated polyethylene tubing. Wells were purged prior to sampling. Field parameters were measured while purging, including specific conductance (SC), temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity. After stabilization of field parameters, each well was sampled by pumping with the peristaltic

pump at a low flow rate. Split samples were collected by either ERM or HET at each ICON groundwater sample location. ERM's samples were placed on ice immediately following collection and submitted under proper chain-of-custody to Pace Analytical and Eberline Analytical, LELAP accredited laboratories, for analysis.

From February 4 through 5, 2021, ERM installed three monitoring wells using a Geoprobe drill rig mounted on a barge. Upon completion of each soil boring, a 1-inch diameter Schedule 40 PVC monitoring well equipped with a 5-foot prepacked screen (0.01-inch slot) was installed in the borehole. The wells were installed to a depth of 28 feet bml, and screened from 23 to 28 feet bml. A 20/40 grain size silica sand pack was placed in the annular space and extended to approximately 2-feet above the top of the screen. An approximate 2-foot bentonite pellet plug was placed on top of the sand pack. The remainder of each borehole was tremie-grouted to the ground surface using a Portland/powdered bentonite grout mixture consistent with LDEQ/Louisiana Department of Transportation and Development (LDOTD) specifications. The monitoring wells were completed above grade. The locations of the monitoring wells (MWs-1, 2 and 3) are presented on Figure 43.

On February 9, 2021, ERM used a peristaltic pump and dedicated polyethylene tubing to develop, purge and sample each well. Each monitoring well was developed to remove fine-grained sediment and prepare the well for the collection of water samples representative of the actual groundwater quality at each location. Groundwater was purged at EPA-recommended rates of 0.1 to 0.5 liters/minute. Field geochemical parameters including pH, temperature, SC, DO, turbidity and ORP were measured during the well purging process. After stabilization of field parameters, each groundwater sample was directly discharged to the laboratory supplied sample bottles. Each sample bottle was labeled with a unique sample number, the date and time of collection, and the sampler's initials. Samples were placed on ice immediately following collection and submitted under proper chain-of-custody to Pace Analytical. ICON collected splits of each groundwater sample.

T. Baker Smith, a Louisiana-licensed professional land surveyor based in Houma, Louisiana surveyed the location, top of casing (TOC), and adjacent bottom elevation (mud line) of ERM's wells on February 9, 2021. The survey data are included in Appendix B. ERM conducted water level measurements in the surveyed monitoring wells on February 9, 2021. Water levels were measured in each well using an electronic tape, which was slowly lowered down the center of the casing and the water level was recorded to the nearest hundredth of a foot. The survey data and groundwater elevation measurements from ERM's investigation are presented in Table 2. The potentiometric surface map is provided on Figure 16.

A discussion of the groundwater results is included in Section 7 of this report.

## 6.3 Surface Water

On February 25, 2021, ERM collected five grab surface water samples at a depth of four feet below the water surface (approximate mid-depth of the water column). The selected locations included three locations from Little Bayou Pigeon (upstream, site entrance & downstream), one location within the well slip in the former Chevron operational area, and one location in the canal providing access to the former Chevron operational area. The water samples were sent to Pace Analytical laboratory and analyzed for SC and chloride. ICON collected a split sample from each location but did not submit their samples for laboratory analysis. A discussion of the surface water results is included in Section 7 of this report.

On February 1, 2021, T. Baker Smith, a Louisiana-licensed professional land surveyor based in Houma, Louisiana surveyed the water depth at numerous locations within the waterways that connect Pigeon Landing Boat Launch to the former Chevron operational area. Two transects of the canal bathymetry were also surveyed in the vicinity of the former Chevron operational area. Four additional elevation

transects were surveyed on March 4, 2021 on the canal edges throughout Area 2. The survey data are presented in Appendix B.

## 6.4 Hydrogeology

An ERM scientist visually logged soil borings during the soil and groundwater investigation activities and boring logs are provided in Appendix C. Cross-sections A-A' and B-B' depicting the subsurface lithology are shown on Figures 12 and 13, respectively. A description of the shallow geology and hydrogeology in Area 2 based on ERM's boring logs is included in Sections 2.5 and 2.6 of this report.

On February 3, 2021, ERM collected two soil samples for geotechnical analysis at JLS-2 from a depth of 42 to 44 feet below the mud line to evaluate the clay-confining layer between the 30-foot Zone and the 50-foot Zone. ERM collected a soil sample from 43' to 44' for grain size/soil classification (ASTM D422), and 42' to 44' for vertical permeability (ASTM D5084) and soil classification. The samples were sent to Ardaman & Associates, Inc., a LELAP-accredited laboratory for analysis. The laboratory test results are provided on Table 5 and the laboratory report is provided in Appendix K. The location of the vertical permeability sample is shown on Cross-section B-B' (Figure 13). These samples were classified by the laboratory as gray clay and gray fat clay. The 8- to 10-foot thick clay confining layer between the 30-foot and 50-foot zones has vertical permeability of $8.3 \times 10^{-8}$ cm/sec, which meets the Statewide Order 29-B definition of a "Natural liner – having a hydraulic conductivity no greater than $1 \times 10^{-7}$ cm/sec", and limits vertical migration.

On July 31, 2020, ICON attempted to conduct a low-flow steady state pumping test at JLS-11 in the 30-foot Zone. ICON was not able to achieve steady-state pumping during their test at JLS-11 due to the well repeatedly pumping dry, even at low flow rates (ranging from approximately 195 to 429 mL/min). Water levels were measured during this test with a pressure transducer, and the recovery data between tests behaved as a rising-head slug test. ERM analyzed the recovery data collected during this test as a rising-head slug test using the methodology described below.

On February 10, 2021, ERM performed slug tests on the three monitoring wells previously installed by ERM (MW-1, MW-2, and MW-3), which were screened in the 30-foot Zone. The slug tests were performed with a solid stainless steel slug. Water levels in the wells were continuously recorded using an In-Situ Level Troll 700. ERM analyzed the data from the slug tests by uploading the water level data into AQTESOLV Version 4.5, a commercially available and widely used software program. The water level displacement data collected during the tests were plotted electronically on a logarithmic scale vs. elapsed time on a linear scale. As specified in RECAP Appendix F, the Hvorslev (1951) curve-matching method for confined aquifers was used to calculate the hydraulic conductivity. The well yield for each well was calculated based upon LDEQ's RECAP Appendix F equation for a confined aquifer. The overall yield of each water-bearing zone was calculated as specified by RECAP by taking the geometric mean of all wells screened in each water-bearing zone. The overall yield of the discontinuous shallow water-bearing 30-foot Zone is 211 GPD and falls within the range specified by LDEQ as a Class 3 aquifer (less than 800 GPD). Furthermore, monitoring wells JLS-10 and JLS-11 went dry during low-flow pumping (JLS-10 during groundwater sampling and JLS-11 during the low-flow pumping test), further demonstrating the low yield of the 30-foot Zone (Figure 44). The slug test results are summarized in Table 1, and the individual slug test evaluation reports are provided in Appendix E.

The 50-foot Zone is also RECAP Class 3A groundwater based upon ICON's low-flow pumping test on one well, JLS-14, with a reported well yield of 249 GPD. ICON's result is reasonable and generally consistent with the expected yield for the laterally variable 50-foot Zone demonstrating the 50-foot Zone is not a viable future groundwater resource.

# 7. EVALUATION OF SAMPLING RESULTS

An evaluation of the soil, groundwater, and surface water sampling results from the Property is provided in this section. ERM's evaluation is focused on the sample locations in the vicinity of the former Chevron operational area located within Area 2, as depicted on Figure 43.

## 7.1 Evaluation of Soil and Sediment Analytical Data

ERM compared soil and sediment analytical data from samples collected from the former Chevron operational area to the Statewide Order 29-B pit-closure criteria provided in Section 4.1. Where appropriate, ERM compared soil and sediment results to the LDEQ RECAP screening standards for discussion purposes (see RECAP Table 1). A full RECAP evaluation was conducted by Ms. Angela Levert and is presented in Section 8 of this report.

ERM converted soil and sediment results reported by ICON in dry weight concentrations to wet weight concentrations in accordance with LDNR or LDEQ guidance and to provide uniformity of units. Soil sampling results, along with the regulatory standards used for comparison, are presented on Table 4. Exceedances of the regulatory standards in soil are highlighted in Table 4 and are summarized on Figure 45. In order to further demonstrate extent and delineation of constituents, Barium, TPH Fraction, and PAH concentrations in soil and sediment are presented in Figures 46, 47, and 48, respectively. Exceedances of soil standards in the vicinity of the former Chevron operational area were observed at JLS-2, JLS-11, and JLS-23.

JLS-23 contained total petroleum hydrocarbons (TPH)-diesel range organics (DRO) in the 0-2' and 2-4' intervals at concentrations slightly above the RECAP $Soil_{SSGW}$ standard. ERM's split samples in each of these intervals were analyzed for RECAP-specified TPH fractions, which did not exceed RECAP screening standards.

Soil samples collected at JLS-2 included concentrations reported above RECAP screening standards (and therefore warranting further evaluation) for barium, TPH-DRO, Aliphatic >C8-C10, and Aromatic >C8-C10 fractions at various depths in the upper 11 feet (see Table 4 and Figure 45). Barium was reported above screening standards in the 0-2', 2-4', 4-6', 6-8', and 5-11' intervals. The exceedances in the upper six feet were not confirmed in split samples (three splits in the 0-2' interval, two splits in the 2-4' interval, and two splits in the 4-6' interval were all below the screening standard). The maximum detected barium concentration was in the 6-8' interval (2,050 mg/kg); however the ICON split sample result was considerably lower (797 mg/kg). The barium concentration in the 5-11' interval was 749 mg/kg, indicating decreasing concentration with depth. Additionally, the 0-2', 2-4', 4-6', and 6-8' intervals were analyzed for SPLP barium. The SPLP barium results were below the RECAP screening standard for leachate, indicating that the detected concentrations are protective of groundwater. TPH-DRO was reported above the screening standard in the 0-2', 2-4', 0-5', 4-6', 6-8', and 5-11' intervals. ERM and HET split samples were analyzed for TPH fractions, which did not exhibit exceedances in the 0-2', 2-4', 0-5', or 5-11' intervals, as well as two of the three split samples from the 4-6' interval. In one split sample from the 4-6' interval, and one in the 6-8' interval, concentrations were reported above the RECAP screening standard for Aliphatic >C8-C10 and Aromatic >C8-C10. TPH fraction results were either non-detect or below the screening standard in the 5-11' interval, demonstrating vertical delineation for hydrocarbons. ERM's result for arsenic in the 6-8' interval (10.5 mg/kg) was slightly above the 29-B arsenic standard (10 mg/kg). ICON's split sample result (4.4 mg/kg) did not confirm the exceedance.

Elevated EC concentrations were reported in soils samples from JLS-11 to the bottom of the boring (32' bgs). Field EC results from the adjacent boring JLS-2 (approximately 70 feet to the north) decrease rapidly with depth at approximately 24' bml. Field EC readings are posted on the boring logs shown in

Appendix C. The ground surface elevation of JLS-11 is approximately 9 feet above the mudline elevation at JLS-2; therefore, the reduction in EC concentrations in JLS-2 roughly corresponds to the bottom of the JLS-11 boring (see Figure 13). The low field EC with depth at JLS-2 is confirmed by a laboratory EC sample collected at 44' bml (2.27 mmhos/cm). Furthermore, the vertical permeability measurement in JLS-2 of 8.3 x $10^{-8}$ cm/s in the 8-10 foot clay confining layer below the 30-Foot Zone limits vertical migration. Based upon the regional geologic information, the total thickness of the confining unit is estimated to be over 100 feet and would protect the underlying groundwater in the Atchafalaya Aquifer. The lateral extent of salt impacts to soil is delineated by the low field and laboratory EC values in the MW-1, MW-2, and MW-3 borings.

## 7.2 Evaluation of Groundwater Quality

To visually depict the groundwater quality beneath the Property, ERM prepared both Piper and Stiff diagrams using the concentrations of cations (sodium, potassium, calcium, and magnesium) and anions (chloride, bicarbonate, and sulfate) present in groundwater. The Piper and Stiff diagrams display variations in water chemistry in the 30- and 50-foot Zones, based on the concentrations of cations and anions present in groundwater, and compare the groundwater samples to a produced water sample from SN 972653, a salt water disposal well on the north side of the Property.

Piper diagrams help to distinguish between individual water types by examining different groupings of samples within the diagram. Samples that plot in the same general location on a Piper diagram indicate similar water quality. Groundwater samples collected from the 30- and 50-foot Zones on the Property and a produced water sample from SN 972653 are shown on the piper diagram on Figure 49.

JLS-11 plots near the produced water sample on the Piper diagram, indicating that JLS-11 likely has been impacted by produced water. Samples MW-1 and MW-3 plot separately from other samples primarily due to slightly elevated chloride concentrations. The remainder of the samples in the 30-foot and 50-foot Zones plot in a cluster that appears to be representative of natural groundwater quality in these zones. The arsenic concentrations reported in some of these samples demonstrate that the presence of arsenic in the shallow groundwater is natural, highly variable, and results range up to over 0.4 mg/L (over eight times higher than the RECAP $GW_{3DW}$ standard of 0.05 mg/L).

The Stiff diagrams shown on Figure 50 demonstrate the limited nature of impacts to groundwater. JLS-11 shows a produced water signature. The surrounding wells (MW-1, MW-2, and MW-3) show a rapid improvement in groundwater quality with relatively short distance from the former Chevron operational area. Stiff diagrams in the 50-foot Zone (JLS-14 and JLS-17) do not show indications of impacts to groundwater quality.

## 7.3 Evaluation of Groundwater Analytical Data

ERM compared the analytical results from groundwater samples collected to RECAP MO-1 $GW_{3DW}$ standards (from LDEQ RECAP Table 3) and EPA SMCLs. These standards are presented for discussion purposes. A full RECAP evaluation was conducted by Ms. Angela Levert and is presented as Section 8 of this report. Groundwater sampling results, along with the regulatory standards used for comparison, are presented on Table 5. Groundwater concentrations of arsenic, barium, chloride, and radium are presented on Figures 51 through 54.

Arsenic concentrations in groundwater exceed the RECAP screening standard in all samples collected. The arsenic concentrations in both the 30-foot and 50-foot Zones are variable and do not correlate with chloride concentrations, indicating a natural source (i.e., if arsenic were the result of E&P activities, the highest arsenic concentrations should be found in the same samples with the highest chloride

concentrations). Naturally elevated arsenic is expected in the geologic conditions present beneath the Property, as discussed in Section 2.7 of this report.

The maximum detected chloride concentration was encountered at JLS-11, near the former SN 70817 well location (42,700 mg/L). Concentrations drop dramatically with distance from JLS-11, with slightly elevated chloride in wells in the down-gradient direction (1,190 mg/L in MW-1, approximately 330 feet northwest of JLS-11, and 831 mg/L in MW-3, approximately 190 feet north-northeast of JLS-11). A similar trend is seen in the barium and combined radium-226/-228 results. The groundwater results in the 30-foot Zone demonstrate that impacts to groundwater are limited to a small area within the former Chevron operational area, and that little lateral movement has occurred in the over 40 years since SN 70817 was plugged and abandoned.

Groundwater samples from the 50-foot Zone were not collected in the vicinity of the former Chevron operational area. However, field and lab EC readings and the vertical permeability sample collected at JLS-2 demonstrate that salt impacts have not migrated from the 30-foot Zone to the 50-foot Zone. Furthermore, groundwater samples collected in the 50-foot Zone at JLS-14 and JLS-17 (outside of the former Chevron operational area, but within Area 2) appear to be generally consistent with natural groundwater quality.

Iron and manganese concentrations exceeded the EPA SMCLs of 0.3 mg/L and 0.05 mg/L, respectively. However, the 30-foot and 50-foot Zones are RECAP Class 3A groundwater and the SMCLs are not applicable. The naturally elevated concentrations of arsenic, iron, and manganese demonstrate that the shallow groundwater beneath the Property is not a viable source of potable water.

## 7.4 Evaluation of Surface Water Analytical Data

ERM compared the chloride analytical results for surface water samples collected on and around the Property to the LDEQ numerical surface water criteria for Drainage Basin Subsegment #010501 of 65 mg/L. The analytical results, presented on Table 8 and Figure 55, indicate that all results are well below the numerical criteria and consistent with nearby USGS results. Surface water chloride concentrations ranged from 26.3 mg/L to 27.2 mg/L, and SC ranged from 259 µmhos/cm to 271 µmhos/cm. The chloride concentrations are very similar in all five samples, including both upstream and downstream of the former Chevron operational area. The surface water sample results demonstrate that E&P operations in the former Chevron operational area are not affecting surface water, and that there is no connection between surface water and the shallow water bearing zones beneath the Property.

# 8. RECAP EVALUATION

The results of the soil/sediment, and groundwater investigations conducted in Area 2 of the JLS property were evaluated in accordance with RECAP, which provides LDEQ-recommended methods for identifying standards protective of human health and the environment. The Conceptual Site Model is provided in Section 8.1 to identify the exposure pathways and scenarios that warrant risk evaluation. Section 8.2 provides a description of the analytical data from Area 2 available for risk assessment. Quantitative RECAP assessment is then provided for contact with soil and sediment (Section 8.3.1), groundwater (Section 8.3.2), and soil/sediment-to-groundwater protection (Section 8.3.3) in a step-wise process, using a screening step to first identify potential constituents of concern, followed by site-specific risk assessment.

## 8.1 Exposure Assessment and Conceptual Site Model

A Conceptual Site Model (CSM) was developed based on the results of site investigations and a site-specific exposure pathway analysis. Site-specific information used in the exposure assessment includes land use and exposure setting (Section 8.1.1) and groundwater use and classification (Section 8.1.2). The CSM describes the potential exposures and the default scenarios used to evaluate Area 2 of the JLS property under RECAP. The CSM (Figure 56) confirms that screening and Management Option (MO) RECAP standards (including their default exposure pathways/scenarios) applied to the site are appropriate or conservative (i.e., protective) for the actual exposure conditions.

### *8.1.1 Land Use and Exposure Setting*

Area 2 of the Property is a wetland location only accessible by boat. The nearest public dock is Pigeon Landing Boat Launch approximately nine miles from the former Chevron operational area via Little Bayou Pigeon and a network of canals (Figure 2).The area was used historically for both E&P (commercial/industrial) activities and recreation such as boating, fishing, and hunting. E&P activities in the Chevron operational area were discontinued following the well P&A in 1978. The E&P activities conducted by other operators in Area 2 were discontinued by 1989. There are no public parks or other public amenities within Area 2 or the broader Property. There are no permanent dwellings. A recreational camp on pontoons was docked in Area 2 at the time of site investigations. Based on the remote location and wetland setting of the study area, and historical and ongoing use, future use can be expected to remain the same, providing opportunities for recreational or commercial boating, fishing, trapping and hunting. The default industrial scenario of RECAP provides a conservative (i.e., protective) assessment of potential risk for commercial boating, fishing, trapping and hunting activities and is likely to overestimate exposure frequency given the seasonal nature of these activities.

Exposure to sediment sampled at the base of canals may occur during fishing or other recreational activities, primarily as incidental contact. Sediment samples were collected under water with depths of approximately 2 feet to 10 feet in canals. While there are no beaches or maintained swimming areas, contact may occur in shallower canal locations when boating, fishing or hunting. For sediment in deeper canal locations, incidental contact may occur when pulling nets, traps, and fishing gear. As a conservative and comprehensive evaluation, all soil and sediment sample locations were considered available for routine contact in the risk assessment provided herein. A site-specific assessment is required under Management Option 3 (MO-3) of RECAP to evaluate sediment and recreational exposure. The following RECAP assessment therefore includes development of MO-3 standards for the recreational assessment and MO-1 standards for the industrial/commercial assessment. Additionally, although not applicable to the site setting and use, the default non-industrial scenario of RECAP was also used to identify health-protective standards as a sensitivity analysis.

### 8.1.2 Groundwater Use and Classification

For the purposes of risk evaluation under RECAP, LDEQ recognizes three classifications of groundwater (GW 1, GW 2, and GW 3) based on the current and potential use of the groundwater as indicated by sustainable yield and indicators of natural quality (i.e., Total Dissolved Solids or TDS). As discussed in Section 6.4, based on the analysis of slug tests and low-flow pumping tests completed in monitoring wells in the shallow zone, a sustainable yield of 211 gallons per day (gpd) was estimated for the 30-foot zone, which is identified as Class 3A in accordance with RECAP (i.e., yield <800 gpd). Class 3A is also identified for the 50-foot zone based on ICON's pumping test yield and the lithology logged by ERM. The groundwater classification of the zones is supported by ERM's well purging and sampling records.

RECAP requires that a water well survey be conducted to determine current water usage within one mile of an area of investigation to support groundwater classification. There are no registered water supply wells on the Property and no record of wells completed for any purpose on the property historically. A survey of the LDNR water well database identified no registered water supply wells within one mile of the Property (Figure 14). Registered water wells are located over 5 miles from Area 2 and are screened in the Atchafalaya aquifer at depths of 180 feet bgs and greater.

The water well survey results are consistent with site data that show natural conditions and quality in the shallow zones investigated in Area 2 would result in limited sustainable yield and objectionable aesthetic characteristics (e.g., taste, color) for drinking water in both zones. The available water well registry information supports Class 3 for the 30-foot and 50-foot water-bearing zones investigated beneath the Property.

Because there are no drinking water wells or wells used for any purpose completed in the groundwater zones investigated in Area 2, there is no exposure and no risk of potential health effects associated with direct exposure to constituents in the groundwater zones. The 30-foot and 50-foot zones do not provide a viable drinking water supply due to low yield and naturally poor quality, and they are not regulated by LDEQ RECAP as a water supply source.

In accordance with RECAP requirements, Class 3 groundwater is considered a potential source medium for surface water that could potentially receive discharge from the groundwater zone. Canals in and around Area 2 were surveyed to identify surface water depths or canal bottom elevations. The surface water bodies, with maximum depths of approximately 10 feet, do not intersect and receive discharge from either the 30-foot or 50-foot groundwater zone in Area 2. Groundwater flows generally to the north-northwest in Area 2 based on water level measurements in the 30-foot zone, and the network of canals on the Property potentially downgradient do not intersect and receive discharge from the 30-foot zone. Additionally, review of public records indicates the larger surface water bodies in the vicinity of the Property such as Grand Lake are also shallow and would not intersect the 30-foot zone (if present). Based on the site-specific hydrogeology and shallow surface water depths, the groundwater to surface water discharge pathway is incomplete and no risk of adverse effects to surface water (or surface water users) is identified.

### 8.1.3 Summary of Exposure Pathway Analysis and Exposure Scenarios

Consistent with RECAP guidance, the land and groundwater use as presented above was considered in the evaluation of risk to human health. Based on the analysis of potential exposure pathways for the site, the human exposure scenarios that are quantitatively evaluated in this risk assessment for current and potential future conditions include:

- Direct contact exposure to soil / sediment, including commercial/industrial, recreational, and for demonstration purposes default non-industrial: exposure pathways include ingestion, dermal contact, and inhalation.
- Class 3 groundwater (GW3DW): incomplete pathway, but for purposes of demonstration, an example MO-1 calculation of GW 3 standards is provided, considering a hypothetical discharge from the 30-foot zone to surface water in Subsegment 010501, with designated surface water uses assumed to include recreation, fish and wildlife propagation, and drinking water supply.
- Soil / sediment-to-groundwater protection ($Soil_{GW3DW}$): for purposes of demonstration, transfer of constituents from soil and sediment to the 30-foot zone is evaluated, considering subsequent migration and hypothetical discharge of constituents to surface water.

The CSM summarizing the exposure pathways for the site is provided as Figure 56. The following sections provide a description of analytical data available for quantitative risk assessment, and an evaluation of human health risk in accordance with RECAP based on the available data and the exposure pathways identified above.

## 8.2 Data Available for RECAP Evaluation

### *8.2.1 Soil and Sediment*

Chemical analytical results for over 100 soil and sediment samples, including split samples, provide data used in the evaluation of human health risk. The soil or sediment samples were collected from borings completed by ICON, ERM, and HET, and in most boring locations, at least two discrete samples were collected. Constituents useful for human health risk assessment were analyzed in samples to a maximum depth of 26 feet below ground surface (bgs). The chemical analytical data relevant to RECAP assessment for the soil and sediment samples are summarized in Tables N-1 and N-2 (in wet and dry weight units, respectively). The following parameters useful for human health risk evaluation were analyzed: metals, hydrocarbons, and/or semivolatile organic constituents including polycyclic aromatic hydrocarbons (PAHs). Sampling locations selected by ERM were chosen to provide further delineation of constituent concentrations and to gather the following RECAP-specific data: hydrocarbon fractions, hydrocarbon indicator constituents (PAHs), and Synthetic Precipitation Leaching Procedure (SPLP) metals. Analyses were performed using EPA and LDEQ-recommended methods and were reported with supporting Quality Assurance/Quality Control (QA/QC) data by the laboratories.

For the samples analyzed for total petroleum hydrocarbons by ICON, the analysis was performed using the "mixtures" method (Method 8015), with the results expressed as total petroleum hydrocarbons in the diesel, and oil ranges (TPH-DRO, and TPH-ORO). This analytical method provides a measure of total extractable organics. To evaluate the potential presence of petroleum hydrocarbons, the ERM samples were analyzed using the more specific hydrocarbon fractioning method, which provides more accurate information for risk assessment than mixture data. Louisiana and federal regulators recommend using TPH fractionation data instead of mixture data for risk evaluation (LDEQ, 2003; TPHCWG 1997 and 1998; EPA, 2009). The site-specific evaluation of potential health risks and site management decisions are based upon fractionation data in accordance with Appendix D of the RECAP regulation, therefore hydrocarbon fractionation data were used in this risk analysis.

### *8.2.2 Groundwater*

Seven monitoring wells were installed in Area 2 and sampled by ICON and ERM, with split samples collected by HET at some wells. Five monitoring wells were completed in the 30 foot zone that was identified at approximately 25 to 34 feet bgs. Where encountered, the zone had a maximum thickness of approximately 9 feet with an average thickness of approximately 4 to 4.5 feet. A low permeability clay

separates the 30-foot and 50-foot zones. Two monitoring wells were completed in the 50-foot zone identified at approximately 43 to 56 feet bgs. In total, 14 groundwater samples (including splits) were collected and submitted for laboratory analysis. The groundwater data collected by all investigators in Area 2 were considered in the risk evaluation.

The groundwater samples were analyzed for the following parameters useful for human health risk evaluation: total metals, dissolved metals, hydrocarbons, the volatile organic constituents BTEX, chlorides and other water quality indicators. The chemical analytical data are summarized in Table N-3. EPA and LDEQ-recommended laboratory methods were used with supporting QA/QC. Based on the turbidity of some unfiltered samples collected by ICON from their wells, analysis of filtered samples was performed by both parties for those samples as recommended by EPA and LDEQ guidance on obtaining representative samples (LDEQ, 2003; EPA, 2002a; Saar, 1997). Both the filtered and unfiltered sample results for metals are shown in the RECAP evaluation tables for complete information. Similar to the soil analyses, ICON provided groundwater analyses of hydrocarbon mixtures (TPH-GRO, TPH-DRO, and TPH-ORO by SW-846 Method 8015), and ERM or HET provided fraction analyses for all groundwater sample locations. In accordance with RECAP Appendix D, the fraction analyses are used in the quantitative risk assessment.

## 8.3 Development and Comparison to RECAP Standards

RECAP provides a tiered framework consisting of a Screening Option (SO) and three Management Options (MO-1, MO-2, and MO-3) to evaluate risk to human health and the environment posed by releases of chemical constituents to environmental media. The higher tiers of assessment offer the flexibility to derive standards more reflective of site-specific conditions.

The SO, for which generic criteria are provided by LDEQ, was used to identify preliminary constituents of concern (COCs) in soil/sediment and groundwater. Further evaluation of the site-specific COCs was performed under higher Management Options for each exposure pathway.

### *8.3.1 Soil / Sediment Direct Contact Evaluation*

To evaluate potential risk associated with sediment and recreational exposure, RECAP and supporting guidance require a site-specific evaluation under MO-3. EPA and LDEQ guidance recommend the use of the soil risk assessment algorithms for sediment in combination with exposure assumptions that are appropriate to the site use. As an initial assessment and to support a focus on the constituents of potential concern in a site-specific evaluation, comparison to default non-industrial (residential) screening standards was performed for soil and sediment (Tables 9 and 10). The residential standards (which assume adult and child direct contact 350 days per year) are not applicable to the site use or to sediment in canal bottoms, but provide conservative benchmarks for screening constituents and concentrations from further human health evaluation. As the first step in the RECAP risk evaluation, soil and sediment concentrations were compared to nonindustrial (residential) screening standards to identify constituents warranting further site-specific evaluation.

Direct contact was evaluated for the surface interval of 0 to 3 feet given the limited potential for intrusive soil and sediment activities in the wetland setting (note that samples collected from 2 to 4 feet bgs were included in this interval). Additionally, the 0 to 15 feet bgs interval was evaluated for complete information based on the RECAP definition for "surface soil", which indicates soil (e.g., in an upland residential or industrial setting) from the ground surface to a depth of 15 feet bgs is considered potentially available for direct human contact including dermal contact, soil ingestion, and inhalation. As a practical matter, repeated contact is limited to surface material, and evaluation of samples collected deeper than the

upper-most sample interval represents a hypothetical scenario which, to be relevant, requires that soil be excavated, spread, and left at the surface permanently.

Table 9 (3 feet bgs interval) and Table 10 (15 feet bgs interval) provide the comparison of maximum reported concentrations in soil or sediment to the non-industrial (residential) screening standards. Barium and hydrocarbon fractions were reported above the screening standards in a single boring location, JLS-2. These constituents are below screening standards in all other borings and are therefore further evaluated as the JLS-2 Area of Investigation (AOI). The constituent concentration distribution in soil and sediment is identified for barium in Figure 46 and for hydrocarbon constituents in Figures 47 and 48. The JLS-2 sample location and the resulting AOI are canal sediment, where reported water depths ranged from 6.2 to 8.9 feet during the multiple sampling events. The sediment AOI is further evaluated to provide a more relevant, site-specific risk assessment.

The site-specific risk assessment performed for sediment under MO-3 includes identification of reasonable maximum exposure (RME) for sediment at the base of a canal. For an adult and child recreator, visitation was assumed to occur twice weekly (or daily for 3 months of the year) for the RECAP default duration of 30 years, with sediment ingestion, dermal contact, and inhalation (as applicable) on each visit. This is a highly conservative assumption (i.e., likely an overestimate) of exposure frequency for the sediment AOI in Area 2 given the water depth. These RME assumptions also address a hypothetical scenario in which canal bottom sediments are dredged and placed on spoil banks and become more accessible for recreational contact. To address potential sediment contact during commercial fishing or trapping (NAICS codes 1141 and 1142), the default industrial scenario was also used to develop RECAP standards. The default industrial scenario assumes direct contact with the sediment occurs 250 days per year for 25 years, and likely overestimates exposure frequency given the seasonal nature of these activities. Table 11 provides a comparison of maximum reported sediment concentrations to the MO-3 recreational and MO-1 industrial standards, and demonstrates that soil and sediment samples collected in Area 2 are less than risk-based standards and protective of human health for routine recreational or commercial/industrial activity.

The concentrations at the JLS-2 AOI were also compared to default non-industrial MO-1 soil standards provided in RECAP as a sensitivity analysis and to demonstrate the margin of protection. The assessment of non-industrial exposure represents the most conservative approach to assessing health risks in accordance with RECAP because it assumes the greatest amount of exposure: direct soil contact is assumed to occur for an adult and child 350 days per year for 30 years, with ingestion of the soil, dermal contact, and inhalation each day. Maximum concentrations of the constituents that warranted evaluation beyond screening are below the MO-1 default non-industrial RECAP standards and protective of unrestricted land use.[1]

Arsenic concentrations are below the LDEQ-identified state-specific soil background level (the residential screening standard) on a point-by-point basis in all soil and sediment samples. In lieu of developing a background level specific to sediment, to further demonstrate protection of human health for sediment, the carcinogenic risk associated with recreational or commercial/industrial exposure to the maximum reported arsenic concentration in sediment was calculated. The estimated risks for recreational ($5x10^{-6}$) and commercial/industrial ($4x10^{-6}$) sediment contact comply with the target risk range ($10^{-6}$ to $10^{-4}$)

[1] Sensitivity Analysis for non-industrial (residential) exposure scenario:

| Constituent | MO-1 Soilni (mg/kg) | Additiv. | JLS-2 AOIC for 0-3' | JLS-2 AOIC for 0-15' |
|---|---|---|---|---|
| Barium | 5500 | 1 | 953 | 2040 |
| Ali >C8-C10 | 1200 | 1 | <60.8 | 313 |
| Aro >C8-C10 | 650 | 1 | <56 | 216 |

identified in RECAP and, for reference, are less than the risk associated with routine exposure to background arsenic concentrations in Louisiana soil.[2]

The foregoing evaluation of current and potential future exposure to soil and sediment in Area 2 provides the conclusion of the RECAP evaluation using concentrations expressed in wet weight (i.e., at field conditions) in accordance with RECAP definition of exposure concentrations and risk-based RECAP standards. An additional sensitivity analysis is provided in Appendix N (Tables N-4 to N-6) considering the concentrations expressed in dry weight units (mg/kg-dry). The additional analysis confirms the foregoing conclusion that potential exposure concentrations in soil and sediment are protective of human health. The complete RECAP assessment for soil and sediment samples collected from the former Chevron operational area indicates that residual constituent concentrations do not and will not adversely affect the uses of the Property.

### *8.3.2 Groundwater Evaluation*

Reported groundwater constituent concentrations were evaluated in a stepwise approach, with comparison to screening standards in Table 12 followed by evaluation for the site-specific groundwater classification, GW 3. The screening standards include MCLs if available, and risk-based levels protective of a residential drinking scenario. RECAP identifies that SMCLs may be considered for groundwater assessment on a site-specific basis. SMCLs are non-enforceable standards that are used as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. The SMCLs for chlorides, TDS, iron, and manganese are compared to the groundwater concentrations solely for reference in the screening assessment, as drinking water standards are not applicable to Class 3 groundwater.

The E&P indicator constituents barium and chlorides were reported above screening standards in the 30-foot zone, with maximum concentrations at location JLS-11. Figures 52 (barium) and 53 (chlorides) show the concentration distributions in groundwater. Barium concentrations decline to below the screening standard at surrounding wells MW-1 through MW-3, and chlorides concentrations decline more than an order of magnitude. Concentrations of these indicator constituents were below screening standards in samples collected from the 50-foot zone in Area 2.

Concentrations of iron and manganese are recognized as naturally elevated above the SMCL in the Atchafalaya aquifer and confining unit in Iberia Parish, and these constituents exceed the SMCL in the groundwater samples from Area 2 (USGS, 2017). Natural occurrence of arsenic above the MCL is also recognized in alluvial aquifers in the vicinity of the site, and the maximum concentrations of arsenic reported in groundwater in Area 2 occur in the 50-foot zone where the E&P indicators are below screening standards (Figure 51 shows the arsenic concentration distribution). Geochemical analysis provided in Section 7.2 indicates groundwater samples collected in the 50-foot Zone appear to be generally consistent with natural groundwater quality (at JLS-14 and JLS-17 outside of the former Chevron operational area, but within Area 2). The sampling results demonstrate there has been no impact above RECAP standards to the 50-foot zone sample locations from E&P activities.

Based on the site-specific hydrogeology and shallow surface water depths, the groundwater to surface water discharge pathway is incomplete and no risk of adverse effects to surface water (or surface water users) is identified. The results of surface water sampling and analysis for chlorides performed in Area 2 confirm that reported chlorides concentrations in monitor wells immediately adjacent to canals (e.g., JLS-11, MW-1) have not resulted in surface water concentrations above the ambient water quality standard or the SMCL, which are relevant to the designated uses of the surface water subsegment (Table 8).

[2] The risk associated with the state-specific background level of 12 mg/kg for the default non-industrial scenario is $3x10^{-5}$.

For purposes of demonstration, an example MO-1 calculation of GW 3 standards is provided in Table 13, considering a hypothetical discharge from the 30-foot zone at the maximum distance included in the RECAP default MO-1 model. Assuming a hypothetical discharge point at 2,000 feet within Subsegment 010501, the MO-1 GW3DW standards are identified for protection of the LDEQ-designated uses of recreation, fish and wildlife propagation, and drinking water supply (uses identified in the Louisiana Surface Water Quality Regulations, LAC 33:IX.1123) (Figure 7). Based on comparison of the maximum reported concentrations in the 30-foot zone in Area 2 to the example MO-1 standards, the reported concentrations of constituents in Area 2 are protective of hypothetical receiving water bodies and people who may use them. Further, the step-out samples at MW-1, MW-2, and MW-3 demonstrate order of magnitude attenuation within approximately 300 feet of JLS-11 for the most elevated and mobile constituent, chlorides. The groundwater sampling results provide reasonable lateral delineation of E&P-related constituents of concern (COCs) in groundwater (barium, strontium, chlorides) for site-specific risk assessment (note that potential additional delineation is described in Section 9).

The vertical distribution of constituents beneath the 30-foot zone in the former Chevron operational area was evaluated based on field evidence (PID, olfactory, visual, EC) and lab EC readings. No odor or hydrocarbon staining of soil/sediment was identified below approximately 8 feet depth in the impacted soil location JLS-2. Field EC results from the deepest boring in the Chevron operational area (JLS-2) showed notable decline beginning at approximately 24 feet deep, with EC remaining low through the full 56 foot depth of the boring. The low field EC below the 30-foot zone and above the 50-foot zone was confirmed in the laboratory-reported soil sample result of 2.27 mmhos/cm collected at 44 feet deep at JLS-2. The limited vertical migration observed beneath the 30-foot groundwater zone is supported by the geotechnical laboratory measurement of the vertical permeability in the 8 to 10 foot clay confining layer below the 30-foot zone in JLS-2. The low permeability ($8.3 \times 10^{-8}$ cm/s) of the clay layer supports the conclusion that salt (and other) impacts from E&P activities have not migrated from the 30-foot zone to the 50-foot zone. As described previously, groundwater samples from the 50-foot zone at JLS-14 and JLS-17 demonstrate no impact above RECAP standards to the second zone west of the Former Chevron operational area from E&P activities.

### *8.3.3 Soil / Sediment to Groundwater Evaluation*

An evaluation of potential transfer of detected metals, hydrocarbons, and PAHs from soil and sediment to groundwater was performed using the data collected for RECAP parameters in Area 2 and the LDEQ methods provided in RECAP (Table 14). For metals, LDEQ recommends site-specific leachate testing to evaluate constituent partitioning, and SPLP was therefore used to evaluate one metal (barium) with concentrations above the default screening level in one boring location (JLS-2). The samples/intervals with maximum concentrations above the Soilssgw, or splits of those samples, were analyzed by SPLP and the barium results (see maximum value in Table 14) were less than RECAP screening standards for leachate and for groundwater, protective of all classes of groundwater. Additional metals (arsenic, cadmium, zinc) were analyzed by SPLP in 0-2 and 2-4 feet bgs samples at JLS-2 and/or JLS-23, and the reported leachate concentrations were below RECAP screening standards for leachate and for groundwater and below surface water quality criteria for human health protection.

Reported concentrations of all other constituents in soil and sediment were compared to the default RECAP screening standards (Table 14).[3] A single fraction exceeded the groundwater protection screening standard in one boring location (JLS-2) and warrants evaluation beyond screening. Although the pathway of groundwater to surface water discharge was identified as incomplete, for purposes of

[3] For high moisture content solids such as sediment, RECAP recommends assessment of the groundwater protection pathway in dry weight concentration units. The assessment of this pathway is therefore provided separately from the direct contact pathway assessment (Section 8.3.1) because the AOI concentrations are expressed in different concentration units.

demonstration, an example MO-1 calculation of standards for soil-to-groundwater protection is provided in Table 15 considering a hypothetical discharge to surface water occurs. The maximum reported fraction concentration is less than the MO-1 standard for protection of the LDEQ-designated surface water uses, including recreation and drinking water supply. The results of this comparison, and site-specific leachate testing in accordance with RECAP, indicate that concentrations of constituents in soil and sediment do not represent a residual source of contamination to groundwater or surface water above health-based standards.

### *8.3.4 Evaluation of Salt in Soil / Sediment*

The reported chlorides concentrations in site soil and sediment are not a concern for adverse effects to human health. A primary consideration for chloride-impacted soil is health of vegetation, which is addressed in the root zone study performed by Dr. Luther Holloway and Mr. Patrick Ritchie (Appendix G), and the ERA expert report prepared by Dr. Helen Connelly and Dr. John Rogers (Appendix A). LDEQ has provided guidance for evaluation of the soil-to-groundwater pathway for chlorides. LDEQ recommends the comparison of SPLP leachate results from salt-affected soil to a standard developed for the appropriate classification of underlying groundwater. The uppermost water-bearing zone is Class 3 (GW3DW), and SPLP results (and all other leachate method results) for chlorides are below the MO-1 GW3DW standard that incorporates the default MO-1 DAF assuming (hypothetically) discharge were to occur from 30-foot zone groundwater to surface water (GW3DW x DF3 = 65 or 250 mg/L x 440). The results of site-specific leachate testing (see Table N-2) indicate that concentrations of salt in soil and sediment in Area 2 are protective of water bodies that hypothetically may receive discharge from the 30-foot groundwater zone. The surface water sampling in Area 2 (Table 8) demonstrates that residual salt concentrations in the shallow subsurface do not represent a residual source of contamination to surface water above applicable standards in Area 2.

## 8.4 RECAP Evaluation Conclusions

The RECAP evaluation for direct contact with soil and sediment in Area 2 included comparison to screening standards followed by MO-3 (and default MO-1 industrial) evaluation. The constituents reported in soil and sediment above the limiting screening standards included barium and hydrocarbon fractions. Further evaluation under the Management Options of RECAP demonstrates that AOICs are less than the RECAP standards protective of human health for the current and future land use of the Property in Area 2 (i.e., commercial/industrial and recreational). Based on a sensitivity analysis, the AOICs are below the MO-1 default non-industrial RECAP standards and are protective of unrestricted land use.

Site-specific assessment completed by ERM indicates that the groundwater discharge pathway is incomplete based on the depth to the groundwater zones and the shallow depth of surface water features on site and in the vicinity. The evaluation for groundwater included a comparison to screening standards for the 30-foot and 50-foot groundwater zones, followed by an example MO-1 evaluation for the 30-foot zone. Maximum concentrations (Compliance Concentrations) in the 30-foot zone are below the example MO-1 RECAP standards protective of hypothetical receiving surface water bodies used for recreation, fish and wildlife propagation, and drinking water supply. No risk of adverse effects to surface water (or surface water users) is identified. The results of surface water sampling and analysis for chlorides performed in Area 2 confirm that elevated chlorides concentrations in monitor wells adjacent to canals have not resulted in surface water concentrations above the relevant water quality standards. Groundwater conditions are protective of human health, the environment, and the beneficial use of the Property. Constituent concentrations in groundwater samples from the 50-foot zone outside of the former Chevron operational area demonstrate no impact above RECAP standards to the second zone sample locations from E&P activities. No corrective action for groundwater is warranted for human health protection.

Although the pathway of groundwater to surface water discharge was identified as incomplete, for purposes of demonstration, an example MO-1 calculation of standards for soil-to-groundwater protection was provided considering a hypothetical discharge to surface water occurs. The results of this comparison, and site-specific leachate testing in accordance with RECAP, indicate that concentrations of constituents in soil and sediment, including chlorides, do not represent a residual source of contamination to groundwater or surface water above health-based or other applicable standards.

# 9. ERM PROPOSED REMEDIATION PLAN

The remediation plan proposed in this section relies upon Statewide Order 29-B and RECAP, which is the State's risk-based protocol for environmental evaluation and remediation. A remediation plan that fully complies with Statewide Order 29-B without exceptions (referred to as a "Hypothetical 29-B Plan" hereafter), along with a detailed discussion on why such a plan is unreasonable and unnecessary, is included in Appendix O.

Due to the unique site setting, numerous natural environmental conditions may impede the implementability or practicality of sampling and remediation activities beyond the footprint of the existing canals. The former Chevron operational area can only be accessed by boat (approximately 9 miles from Pigeon Landing Boat launch), and all equipment must be transported by barge or boat. Sampling locations in the swamp may be inaccessible by the desired equipment, and the heavily wooded/vegetated swamp environment presents significant safety concerns when working with heavy equipment over water or offloading equipment from a barge to limited dry land. Furthermore, a thriving wetland ecosystem is present in and around the former Chevron operational area, and accessing sampling locations outside of the canals could potentially impact these areas. The safety risks and impacts to the swamp environment may exceed any technical value provided by additional delineation sampling.

The need for and extent of remediation will be dependent upon LDNR review of the site investigation data. Based on the investigation results presented herein, the ERA performed by Dr. Connelly and Dr. Rodgers, and the ERZ study performed by Dr. Holloway and Mr. Ritchie, no active remediation of soil, sediment, or groundwater is necessary in the former Chevron operational area. However, if LDNR ultimately determines that sediment in the former Chevron operational area should be addressed, the contingent remedy discussed in Sections 9.3 and 9.4 is proposed.

## 9.1 Delineation Sampling

ERM believes that sufficient data has been collected in the former Chevron operational area for remedial decision making. ERM believes that, based upon the unique site setting and the currently available analytical data, additional sampling data is not likely to change the proposed remedy. However, ERM anticipates that LNDR may ultimately request additional sampling solely for delineation purposes. If LDNR believes further delineation is needed before a remedial decision can be made, ERM proposes the delineation sampling outlined below. The proposed sampling locations are shown on Figure 57. The delineation sampling plan assumes that ERM and their subcontractors will have the ability to access the proposed locations with the appropriate drilling equipment (barge-mounted direct push drill rig for MW-1, MW-2, MW-3, DMW-1, and B-1, and marsh master-mounted direct push rig for MW-4 and MW-5), as well as the ability to drill to the proposed depths, if access is possible. Furthermore, based upon the poor soil core recovery observed during prior sampling events using multiple sampling methods, completion of the entire sampling program outlined below may not be achievable. Actual sample locations, depths, and sampling methods may need to be adjusted based on observations made during a preliminary site visit with the subcontractor and/or during sampling activities. The estimated cost to implement the delineation sampling is included in Table 16.

### *9.1.1 Sediment and Soil Delineation Sampling*

An evaluation of the soil and sediment data in the former Chevron operational area is included in Sections 7 and 8 of this report. Based on the evaluation, soil and sediment are generally well delineated around the samples where COC concentrations are highest (JLS-2 and JLS-11). However, if LDNR requests additional delineation sampling in soil and sediment, ERM proposes the following in order to supplement

existing delineation samples, and to provide further delineation of soil and sediment to the east, and vertical delineation in soil, if practical:

- Resample sediment/soil adjacent to wells MW-1, MW-2, and MW-3 to supplement existing field EC data
  - At each location, analyze the sample with the highest field EC reading and the soil/groundwater interface for EC, percent moisture, and SPLP chloride;
- Install a sediment boring (B-1) east of JLS-2 within the canal for horizontal delineation of sediment
  - Analyze each two-foot interval up to approximately 12' bml for EC, 29-B metals, percent moisture, and TPH fractions
  - If elevated field EC is present at 12' bml, additional deeper samples will be collected
  - Analyze the samples with the highest field EC and laboratory EC readings for SPLP chloride
  - If TPH fractions are present, analyze the sample with the highest aromatic TPH fraction concentrations for PAHs
- Install a soil boring (MW-4) east of JLS-11 for horizontal delineation of soil
  - Analyze soil at the highest field EC reading for EC, percent moisture, and SPLP chloride
  - Analyze soil at 24-28' bgs for EC and percent moisture
  - Analyze soil below the 30-foot Zone for EC, percent moisture, and SPLP chloride
- Install a soil boring (DMW-1) adjacent to the former JLS-11 location for vertical delineation of soil, with final depth guided by field measurements
  - Analyze soil below the 30-foot Zone for EC, percent moisture, and SPLP chloride

### *9.1.2 Groundwater Delineation Sampling*

An evaluation of the groundwater data in the former Chevron operational area is included in Sections 7 and 8 of this report. Based on the evaluation, groundwater in the 30-foot Zone is reasonably delineated laterally around JLS-11, where COC concentrations are highest. Samples collected in the 50-foot Zone at JLS-14 and JLS-17 (within Area 2, but outside the former Chevron operational area) appear to be generally consistent with natural background groundwater quality, and are also generally consistent with JLS-10 and MW-2 in the 30-foot Zone (see Stiff diagrams on Figure 50). These samples indicate a background chloride concentration of approximately 170 to 280 mg/L. The 30-foot Zone was not encountered in borings west of JLS-10, or south of MW-2, further supporting delineation to the west and south. If LDNR requests additional delineation sampling in groundwater, ERM proposes the following to further delineate groundwater north of MW-1 and MW-3, where chloride was slightly elevated, east of JLS-11 where no sampling has been conducted, and below the 30-foot Zone, if practical:

- Install a monitoring well (MW-4) in the 30-foot Zone, if encountered, east of JLS-11 for horizontal delineation of groundwater
  - Collect groundwater sample and analyze for chloride, alkalinity, TDS, cations, anions, sulfate, total and dissolved metals, TPH fractions, BTEX, and radium 226/228.
- Install a monitoring well (MW-5) in the 30-foot Zone, if encountered, north of MW-1 and MW-3 for further delineation of groundwater in the down-gradient direction
  - Collect groundwater sample and analyze for chloride, alkalinity, TDS, cations, anions, sulfate, total and dissolved metals, TPH fractions, BTEX, and radium 226/228.

- Install a well (DMW-1) in the 50-foot Zone adjacent to the former JLS-11 location for vertical delineation of groundwater
    - Collect groundwater sample and analyze for chloride, alkalinity, TDS, cations, anions, sulfate, total and dissolved metals, TPH fractions, BTEX, and radium 226/228.

The proposed delineation sample locations are shown on Figure 57. The estimated cost to implement soil, sediment, and groundwater delineation sampling is approximately $123,000 (Table 16).

## 9.2 Groundwater Monitoring Plan

In order to evaluate the stability of groundwater conditions over time, ERM proposes the following groundwater monitoring plan:

- Conduct quarterly groundwater monitoring for up to three years at the three existing ERM monitoring wells in the 30-foot Zone (MW-1, MW-2, and MW-3)
    - Collect and analyze groundwater samples for arsenic, barium, chloride, and radium 226/228
    - Measure depth to water in each monitoring well

The proposed groundwater monitoring network is shown on Figure 57. The estimated cost to implement up to three years of groundwater monitoring is approximately $160,000 (Table 17).

## 9.3 Contingent Sediment Remediation Plan – Alternative 1

ERM proposes as a contingent remedy the placement of a synthetic cap over sediment within the former Chevron operational area near the JLS-2 sample location. ERM proposes the following activities:

- Obtain Coastal Use Permit and develop Work Plan;
- Place geotextile fabric barrier; and,
- Place approximate 4-inch AquaBlok cap over remediation area (vertical swelling will increase final cap thickness to approximately 5 to 6 inches).

The methodology of the contingent remediation plan is based on the Interstate Technology Regulatory Council's (ITRC) guidance document, *Contaminated Sediments Remediation* (August 2014). The contingent remediation area based on currently available data is presented in Figure 58. The estimated cost to implement Alternative 1 is approximately $350,000 and is summarized in Table 18. The supporting documentation is provided in Appendix P.

## 9.4 Contingent Sediment Remediation Plan – Alternative 2

Alternative 1 is the least intrusive and disruptive to the environment and most cost-effective remedy. Dredging and offsite disposal of sediment from the JLS-2 area is excessive and would cause more harm to the environment than Alternative 1. However, if LDNR ultimately determines that sediment in the JLS-2 area should be removed and disposed offsite, ERM proposes the following activities:

- Obtain Coastal Use Permit and develop Work Plan;
- Dredge impacted sediment to a depth of up to 3 feet for offsite disposal; and,
- Using unimpacted sediment from nearby canals; replace the dredged sediment with up to 3 feet of imported sediment in the removal area.

The contingent remediation area based on currently available data is presented in Figure 58. The estimated cost to implement Alternative 2 is approximately $670,000 and is summarized in Table 19. The supporting documentation is provided in Appendix P.

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# APPENDIX P SUBCONTRACTOR COST ESTIMATES

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