ATTACHMENT NOT INCLUDED

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Bristow, Creek County, Oklahoma
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LIST OF ACRYNOMS AND ABBREVATIONS

µg/L	Microgram(s) per liter
bgs	Below ground surface
DPT	Direct push technology
EA	EA Engineering, Science, and Technology, Inc.
EPA	U.S. Environmental Protection Agency
ETF	East Tank Farm
ft	Foot(feet)
ft/day	Foot(feet) per day
gal	Gallon(s)
GNSS	Global Navigation Satellite System
HHRA	Human Health Risk Assessment
LDA	Loading Dock Area
LNAPL	Light non-aqueous phase liquid
LPA	Lorraine Process Area
MCL	Maximum contaminant level(s)
mg/kg	Milligram(s) per kilogram
MNA	Monitored natural attenuation
NAPL	Non-aqueous phase liquid
NTF	North Tank Farm
ODEQ	Oklahoma Department of Environmental Quality
PAH	Polycyclic aromatic hydrocarbons
PVC	Polyvinyl chloride
RSL	Regional screening level(s)
Site	Wilcox Oil Company Superfund
SVOC	Semi volatile organic compounds
TAL	Target Analyte List
VOC	Volatile organic compounds

WPA Wilcox Process Area

1. INTRODUCTION

This Technical Memorandum presents the procedures, analyses, and results for the groundwater sampling, surface waste sampling, surveying, and aquifer testing conducted by EA Engineering, Science, and Technology, Inc. (EA) at the Wilcox Oil Company Superfund Site (site) (Figure 1) during the period of 10 August 2020 through 20 August 2020. This work was conducted for the U.S. Environmental Protection Agency (EPA) under Remedial Action Contract No. EP-W-06-004 (Task Order No. 0128-RICO-06GG).

1.1 PURPOSE

Groundwater sampling was conducted at existing wells and at new, temporary, locations to further delineate possible contaminant plumes at the Wilcox Process Area (WPA) and the Lorraine Process Area (LPA) (Figure 2). Surface waste samples were collected from known locations of contamination to determine toxicity and ecologic threat (Figure 2). Aquifer tests were performed at existing monitoring wells to determine site-specific hydraulic parameters necessary for developing groundwater models to evaluate remedial options for aquifer restoration. Groundwater levels in existing monitoring wells were gauged and a survey of Sand Creek was conducted to establish static water level and investigate possible communication between the groundwater and creek. This document will be used to supplement the Remedial Investigation and Feasibility Study reports.

1.2 PREPARATION ACTIVITIES

In preparation for and prior to conducting field activities, the necessary clearance of vegetation around existing monitoring wells and temporary groundwater sampling locations was performed.

1.3 CHRONOLOGY OF FIELD ACTIVITIES

The following field activities were conducted from 10 August 2020 through 20 August 2020:

Day	Date	Activities
Monday	10 August 2020	Mobilize to the site. Clear vegetation in order to access monitoring wells and hydro-punch sample locations.
Tuesday	11 August 2020	Hydro-Punch and sample WPA-GW-02. Sample MW-04 and MW-01.
Wednesday	12 August 2020	Perform survey of Sand Creek. Install all temporary wells. Sample MW-03 and MW-05.
Thursday	13 August 2020	Sample temporary wells. Sample MW-02 and MW-06.
Friday	14 August 2020	Sample temporary wells.
Monday	17 August 2020	Slug test MW-04 and MW-05.
Tuesday	18 August 2020	Sample GW-13-119. Slug test MW-01 and MW-06. Bail down test MW-03. Collect surface waste samples.

Wednesday	19 August 2020	Bail down/pump down test MW-02. Collect surface waste samples.
Thursday	20 August 2020	Sample GW-13-195. Collect surface waste samples. Demobilize.

2. FIELD ACTIVITIES

2.1 SAND CREEK SURVEY

Surface water elevations were recorded at five locations in Sand Creek along the southern edge of the LPA and the WPA (Figure 3). Surface elevations were recorded using a Global Navigation Satellite System (GNSS) receiver. The location and frequency of the points collected was limited due to poor satellite reception, as tree coverage impeded the devices ability to continuously record data. To investigate possible communication between the site groundwater and Sand Creek, groundwater elevations in the six existing monitoring wells (MW-01 through MW-06) were measured by electronic sounder prior to conducting groundwater sampling (Table 1).

2.2 AQUIFER TESTING

Single-well slug tests were conducted on two-inch monitoring wells MW-01, MW-04, MW-05 and MW-06. The "slug" utilized for these tests was a weighted polyvinyl chloride (PVC) rod with a volume of 0.22 gallons (gal). During each test, water-level rise during the "slug in" and water level recovery after the "slug out" was monitored using data-logging pressure transducers (automated) and, when possible, using a water level indicator (manually) as back up. The transducers were placed in each well prior to the start of each test, being set and securely supported near the bottom of the well. The transducers were capable of measuring water levels to within an accuracy of 0.01 foot (ft).

Bail down tests were conducted on wells MW-02 and MW-03 due to insufficient amount of water necessary to conduct a slug test. The wells were manually bailed dry and then allowed to recover with an automated data-logging transducer recording the resulting water level rise. The transducers were placed in each well prior to the start of each test, being set and securely supported near the bottom of the well. The transducers were capable of measuring water levels to within an accuracy of 0.01 ft.

The transducers were calibrated against the water level as measured from the top of casing with the electric sounder, and the data logger was set to record water level measurements at an interval appropriate for analysis. The slug was placed approximately three feet below the static water level and water levels were recorded manually and with the transducers. The slug was not pulled out of the well until the water level had recovered sufficiently (98% of the static water level or greater) from the "slug in" aspect of the test.

Data recorded during the tests included clock time, elapsed time since placement/removal of the slug, depth to water, and the maximum displacement that occurred during each test. As determined using transducer data, displacement was utilized in the 95% recovery determination during each test. Data was downloaded from the transducer at the end of both the placement and removal of the slugs using WinSitu® Software, version 5.6.25.0. Attachment 1 presents the slug test analyses and plots.

2.3 GROUNDWATER SAMPLING OF EXISTING WELLS

Groundwater samples were collected from six existing monitoring wells (MW-01 through MW-06) along with both the upper and lower screen intervals of GW-13 (119 and 195 ft below ground surface [bgs]) (Figure 2). Groundwater samples were collected via the low flow sampling technique. The wells were sampled post stabilization of water quality parameters for the analysis of volatile organic compounds (VOCs), semi volatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), total and dissolved target analyte list (TAL) metals (including mercury), and monitored natural attenuation (MNA) parameters.

Prior to purging and sampling, groundwater levels were measured with a water level indicator or interface probe (Table 1). In well MW-04, an interface probe was used to measure approximately 0.15 feet of light non-aqueous phase liquid (LNAPL). A hydrocarbon odor was noted at MW-02 and MW-03; however, no LNAPL was detected with an interface probe. Field documentation for parameter stabilization and sampling of well locations is presented in Attachment 2.

2.4 GROUNDWATER SAMPLING VIA HYDRO-PUNCH AND TEMPORARY WELLS

Initially, hydro-punch technology (using a four-foot stainless steel screen advanced by direct push technology [DPT] to sample groundwater) was to be used at all groundwater collection points outside of existing, cased wells. This method was used to sample groundwater at WPA-GW-02, taking approximately four hours to advance the screen and collect the sample. It was decided that this method of sample collection was inefficient and that temporary monitoring wells would be installed at the remaining pre-determined sample locations. Shallow refusal along with physical inaccessibility issues required the proposed well locations to be adjusted and ultimately prevented the installation of multiple planned sample locations; nine of eleven identified locations were able to have temporary wells successfully installed (Figure 2):

- LPA-GW-01, -02, and -03
- WPA-GW-01, -04, -05, -06, -07, and -09

Wells WPA-GW-03 and WPA-GW-08 were not installed due to refusal during drilling. Well WPA-GW-05 was located approximately 25 feet from well WPA-GW-08 resulting from efforts to establish a temporary well in an area that was continually met with refusal.

Temporary monitoring wells were installed via the DPT drilling method. As drilling advanced, soil core was continuously collected in clear PVC sleeves. The field geologist logged the soil core in accordance with the Unified Soil Classification System. Soil color was determined using a Munsell Color Chart. During logging, the field geologist made olfactory and visual observations, and recorded these data on boring log forms (Attachment 3). The temporary wells were constructed with one-inch diameter Schedule 40 PVC flush thread joint casing, and ten feet of Schedule 40 PVC 0.010-inch machine slotted screen. No filter pack or bentonite seal was placed in the annulus. A one-inch well cap was placed on top. Due to the low permeability of the aquifer, groundwater did not readily enter the well. As a result, the wells could not be developed, however groundwater samples were collected. After the wells were sampled, at the direction of EPA, the temporary wells were left in place.

During installation, hydrocarbon product staining was observed in the sample cores of WPA-GW-05, 06, 07, 09 and LPA-GW-01. Product observed was black to grey with a strong hydrocarbon odor accompanied by a visible sheen and free non-aqueous phase liquid (NAPL). Field boring logs are presented in Attachment 3. Table 2 summarizes all soil borings that have occurred at the site. Table 1 summarizes all monitoring and temporary wells installed at the site.

Groundwater samples were collected from temporary wells using a peristaltic pump and after a single preliminary reading of water quality parameters rather than after low-flow stabilization. This was due to the slow recharge rate and limited hydraulic production of the temporary wells along with the inability to measure the water level within the well due to the small diameter well casing (one-inch) used. Temporary wells WPA GW-01, 04, and 06 had notably slow recharge rates and were sampled over a 24-hour period in order to satisfy sample volume requirements. WPA-GW-05 and LPA-GW-03 were both advanced to refusal with screened casing installed but were insufficiently deep to allow groundwater incursion into the borehole. All samples collected from hydro-punch and temporary wells were submitted for analysis of VOCs, SVOCs, PAHs, total and dissolved TAL metals (including mercury), and MNA parameters. Field documentation for sampling of well locations is presented in Attachment 2.

2.4.1 Evaluation of Hydrocarbons in Temporary Wells

During installation of temporary monitoring wells, soil cores were collected and logged with depth and nature of any visible hydrocarbon contamination noted. The following temporary well locations displayed noticeable evidence of contamination:

> **WPA-GW-05:** Tar sand mixture at 6 to 8 ft bgs. Black product present from 11 to 16 ft bgs. This temporary well did not have groundwater incursion and was not sampled.
>
> **WPA-GW-06:** Tar and petcoke on the surface down to approximately 1 ft bgs. Product was present from 8 to 9 feet with fine stringers product present within the last 3-inches. When groundwater was sampled from this location, visual confirmation of light and heavy hydrocarbons was noted.

WPA-GW-07: Hydrocarbon product detected in clay at 13 to 17 ft bgs. LNAPL (black product) noted at 22 to 24 ft bgs. A very noticeable hydrocarbon odor was noticed during sampling.

WPA-GW-09: Hydrocarbon black product, sheen and odor detected from 9 to 15 ft bgs.

LPA-GW-01: Product observed at 7 to 9 ft bgs and again at 12 to 14 ft bgs.

Figure 4 displays the distribution of hydrocarbon sheen and product identified in these temporary monitoring well soil borings as well as from prior assessments of soil samples and monitoring wells in the WPA and the LPA. Table 2 describes the locations and description of NAPL/product present in each borehole installed at the site.

2.5 SURFICIAL WASTE VISUAL LOCATION AND SAMPLING

Surface waste samples were collected from previously noted areas of the WPA, LPA, East Tank Farm (ETF), North Tank Farm (NTF) and Loading Dock Area (LDA) where there was clear indication of surface staining or apparent solid waste (Figure 2). Samples were collected slightly below the surface to account for physical weathering and ultraviolet degradation that would impede accurate analysis of the material. Samples were analyzed for SVOCs, PAHs, and TAL metals (including mercury). Field forms are provided in Attachment 2 and laboratory analytical results are provided in Attachment 4. In addition to surface waste sample collection, both WPA and LPA were visually assessed for surface waste.

3. RESULTS

3.1 SAND CREEK SURVEY

Based on the survey data, the average surface water elevation along Sand Creek and south of the LPA and the WPA is approximately 767.0 feet above mean sea level (Figure 3). The surface water elevation decreases with the direction of flow, from north to south, at a gradient of approximately 0.002 foot per foot. Groundwater elevations measured in existing monitoring wells show site groundwater flow to be towards Sand Creek. There is an approximately 7 to 8-foot difference in elevation between the groundwater elevation and Sand Creek, and it appears groundwater is moving through soil perched on bedrock, where it discharges as seepage faces on the streambank. This flow is ephemeral in response to precipitation, infiltration, recharge, and groundwater movement. Much of the year the seeps are dry. The elevated iron in groundwater (as discussed in Sections 3.3 and 3.4) is oxidized by iron oxidizing bacteria at these seepage faces creating a visible iron red gelatinous slime. The rate of seepage does not appear to form a significant volumetric discharge of groundwater to surface.

This information combined with sediment and surface water results collected during the Remedial Investigation further confirm the conclusions of the Human Health Risk Assessment (HHRA). Sediment and surface water samples collected during the RI indicate that there has not

been appreciable impact to Sand Creek downstream of the WPA (EA 2020). The HHRA (EA 2020) concluded that there are no potential human health concerns for exposure to surface water and sediment within Sand Creek. Chemicals in sediment and surface water may pose a risk to aquatic and benthic organisms in Sandy Creek (total PAHs and manganese) (EA 2020).

A discussion of hydraulic conductivity, movement of groundwater, and potential discharge to Sand Creek is provided below.

3.2 SLUG TEST RESULTS

Data from the slug tests were analyzed using the software program AQTESOLV. Table 3 summarizes the slug test results. The Bouwer-Rice (1976) method was used for the analysis. The Bouwer-Rice method is applied to the recovery period of a well after the rapid removal of a slug of water, making it the appropriate method for the tests performed in the shallow unconfined aquifer conditions present. Note that only "slug out" data was analyzed, as the rapid removal of a slug and the subsequent recovery of the well is more appropriate for analyses in wells screened in shallow aquifers.

MW-01, displayed a hydraulic conductivity of 0.24 feet per day (ft/day) along with a transmissivity of 21.6 gal per ft/day. MW-01 has a 10-foot screen section installed from 7 to 17 ft bgs, in sandy clay above the site's predominant sandstone unit. The hydraulic conductivity and transmissivity of this well are as expected considering the height of the water column and lithology of the well.

MW-02, did not have a sufficient volume of water to perform an accurate slug test.

MW-03, did not have a sufficient volume of water to perform an accurate slug test.

MW-04, displayed a hydraulic conductivity of 0.07 ft/day along with a transmissivity of 15.1 gal per ft/day. MW-04 has a 20-foot screen section installed from 18 to 38 ft bgs, in clay and sandy clay. The hydraulic conductivity and transmissivity of this well are as expected considering the height of the water column and lithology of the well.

MW-05, displayed a hydraulic conductivity of 0.64 ft/day along with a transmissivity of 134.1 gal per ft/day. MW-05 has a 20-foot screen section installed from 17 to 37 ft bgs, in sandy clay. The hydraulic conductivity and transmissivity of this well are higher than expected when compared to MW-04, which is characteristically similar in lithology and water column height.

MW-06, displayed a hydraulic conductivity of 0.29 ft/day along with a transmissivity of 43.7 gal per ft/day. MW-06 has a 20-foot screen section installed from 30 to 50 ft bgs, in sandy clay. The hydraulic conductivity and transmissivity of this well are as expected considering the height of the water column and the lithology of the well.

The geometric hydraulic conductivity using MW-01, MW-05 and MW-06, which are considered representative of zones that transmit groundwater at the site, is 0.35 ft/day. For the measured hydraulic gradient of 0.002 ft/ft, and an assumed effective porosity of 0.2, the calculated seepage

velocity is 0.0035 ft/day, or 1.3 feet per year. If a retardation factor for benzene of 2 to 3 is assumed, benzene seepage velocity is 0.4 to 0.7 feet per year.

This minimal flux of groundwater at the site is supported by anoxic conditions which are observed in the MNA parameters, including elevated manganese and iron in groundwater which are in turn oxidized at the point of discharge on the stream banks. The Darcy velocity is only 0.007 ft/day, 0.26 ft/year. For an assumed aquifer thickness of 10 feet, the discharge at sand creek would be 260 cubic feet per year per 100 linear feet of stream bank, or 0.0037 gallons per minute (0.01 L/min). This low discharge is what is observed in seeps, and accounts for the lack of significant impacts to sediment and surface water. Petroleum constituents and metals would be oxidized at these seepage faces.

3.3 GROUNDWATER CONTAMINATION

Groundwater analytical results for VOCs, SVOCS, PAHs, and TAL metals at all sampled wells are presented in Table 4. Concentrations are shown in comparison to the EPA National Primary Drinking Water Regulation Maximum Contaminant Levels (MCLs) and Resident Tapwater Regional Screening Levels (RSLs). Figure 5 displays the analytes exceeding their respective MCL and Figure 6 displays the analytes exceeding their respective Tapwater RSL. Laboratory analytical reports are located in Attachment 4.

Benzene is the predominant VOC exceeding its MCL, with a partially defined benzene plume containing wells MW-04, WPA-GW-02, and WPA-GW-07 (Figure 5). In comparison to the MCL of 5 micrograms per liter (µg/L), the benzene concentrations for MW-04, WPA-GW-02, and WPA-GW-07 are 2,800, 1,500, and 140 µg/L, respectively. The benzene plume is not a defined upgradient of well MW-04. Other VOCs exceeding their MCLs include 1,1,2-trichloroethane, 1,2-dibromo-3-chloropropane, ethylbenzene, tetrachloroethene, and toluene; exceedances of each analyte occurred only once. Exceedances of the Tapwater RSLs occur for an additional four VOC analytes (Figure 6).

Benzo[a]pyrene exceeds its MCL in well WPA-GW-02, with a benzo[a]pyrene concentration of 0.62 µg/L in comparison to the MCL of 0.2 µg/L. No other SVOCs or PAHs exceed their MCLs. In comparison to the Tapwater RSLs, exceedances of naphthalene are prevalent (Figure 6).

For metals, total arsenic and lead concentrations commonly exceed their MCLs. Two lead plumes can be partially defined, with one containing wells LPA-GW-01 and LPA-GW-02 and the other containing wells WPA-GW-02, WPA-GW-06, WPA-GW-07, WPA-GW-09, and GW-13 (Figure 5). The greatest lead concentration of 147 µg/L was identified in well WPA-GW-06 (MCL=15 µg/L). Arsenic above the MCL is widespread and is not defined (Figure 5). An additional six metals, including iron and manganese, exceed the Tapwater RSLs (Figure 6).

3.4 GROUNDWATER MNA

To assess if NA is occurring at the site, groundwater parameters (i.e., dissolved oxygen, oxidation reduction potential) and the following groundwater analytes were analyzed: ferrous iron, total iron, total manganese, nitrate, sulfate, carbon dioxide, and methane, tables 4 and 5 present these data. Additionally, Figure 7 displays these data and Figures 8 through 12 display contoured concentrations of dissolved oxygen, total iron, total manganese, nitrate, and sulfate, respectively. It should be noted that field parameter readings from the temporary wells were collected from the first purge due to slow recharge, which was found to be turbid. Groundwater samples were field filtered only for the dissolved metals analysis. As a result, the temporary wells were not used to assess MNA.

In order to implement MNA at the site, the Oklahoma Department of Environmental Quality (ODEQ) in its MNA Guidance (ODEQ 2019) requires *"Full delineation of the contaminant plume, including sentinel wells that are below the maximum contaminant level (MCL), is needed. It must be demonstrated that conditions conductive to natural attenuation exist and attenuation is occurring. A steady or decreasing plume front must be established."* It is further recommended that *"An approved monitoring well network would normally be sampled quarterly for at least two years to establish baseline trends."* Based on this guidance, additional plume delineation, establishment of a permanent monitoring network, and additional groundwater monitoring are required.

Based on the low dissolved oxygen, low oxidation reduction potential, and the elevated manganese and iron concentrations present, particularly in wells MW-01, MW-04, and MW-05, anoxic or anerobic conditions are present within the aquifer. At MW-04, sulfate has been totally depleted indicating virtually no assimilative capacity for continued sulfate reduction; however, the presence of methane indicates that methanogenesis is ongoing. Conditions at the site are highly reducing. The carbon dioxide observed may be from methane oxidation taking place at the phreatic surface via soil gas transfer and limited infiltration of oxygenated rainfall. It is not thought that significant aerobic degradation of fuel hydrocarbons is ongoing.

To determine whether NA of benzene in groundwater is occurring at sufficient rates, additional monitoring will be required to 1) verify plume stability, 2) continue to evaluate MNA parameters and possible destruction pathways, and 3) evaluate first order decay rate of benzene. Because MW-4 contains NAPL, the decay rate may prove insufficient to result in cleanup in a timely manner. Moreover, per ODEQ MNA Guidance (ODEQ 2019), *"DEQ rarely approves MNA as a sole remedy. Source identification and removal, including free-product removal, should be parts of an overall remedy and may accelerate natural attenuation."*

Hot spot treatment of NAPL and residual NAPL (e.g., source removal) with oxidant in the MW-4 area may be required to eliminate persistent source. Then, MNA may proceed at sufficient rate to achieve to remedial action objectives for groundwater. The use of oxidant would prevent continued mobilization of reduced metals, including arsenic.

Furthermore, the groundwater results show sulfate and nitrate concentrations have been reduced which indicates overall groundwater condition is slightly reducing to moderately reducing. The reducing condition may cause metals to become dissolved and as a result, both iron and manganese have elevated concentrations.

3.5 SURFICIAL WASTE CONTAMINATION

The WPA and the LPA were assessed visually for waste present on the surface. One narrow area of surface waste was identified on the eastern side of the LPA and two areas of waste were identified within the central area of the WPA. Figure 13 shows the locations of the observed waste.

Surface waste analytical results for SVOCs, PAHs, and TAL metals at all sampled locations are presented in Table 6. Concentrations are shown in comparison to the EPA RSLs for the Resident Soil and Industrial Soil scenarios, as well as an ecological soil screening level defined as the lower value from either the Risk Assessment Information System database or the EPA Ecological Soil Screening Level. Figure 14 displays the analytes exceeding their respective Resident Soil RSL. Laboratory analytical reports are located in Attachment 4. Table 7 summarizes field observations and laboratory results from the surface waste samples collected during this event, along with test pit and waste characterization activities from prior events.

Benzo[a]pyrene exceeds its Residential Soil RSL of 0.11 milligrams per kilogram (mg/kg) in all four samples collected from the WPA, as well as one sample from the LPA and one sample from the ETF (Figure 14). The sample from WPA-SA-04 has the greatest benzo[a]pyrene concentration (390 mg/kg) and the adjacent sample WPA-SA-03 has the second greatest concentration (40 mg/kg). In the samples where the benzo[a]pyrene Residential Soil RSL is exceeded, additional PAHs (including: benzo[a]anthracene, benzo[b]fluoranthene, benzo [k]fluoranthene, chrysene, dibenz[a,h]anthracene, dibenzofuran, fluoranthene, indeno[1,2,3-c,d]pyrene, naphthalene, and pyrene) may also exceed their respective Residential Soil RSLs. No SVOCs exceed their respective Residential Soil RSLs.

Arsenic exceeds its Residential Soil RSL of 0.68 mg/kg at every sample location (Figure 14). The greatest arsenic concentration identified was 22.3 mg/kg at sample location ETF-SA-08. Lead exceeds its Residential Soil RSL of 400 mg/kg at sample location WPA-SA-04 with a concentration of 945 mg/kg.

4. SUMMARY

The following summarizes the activities and results of the August 2020 field events:

- The Sand Creek survey indicates that Sand Creek is 7 to 8 feet below the groundwater elevation, with the groundwater flow direction toward Sand Creek. Groundwater is moving through soil perched on bedrock and discharging as seepage faces on the streambank.

- The slug tests indicate that the hydraulic conductivity in the wells tested ranges from 0.07 ft/day to 0.64 ft/day and the transmissivity ranges from 15.1 gal/ft/day to 134.1 gal/ft/day.

- Benzene contamination is present in groundwater above the MCL in wells MW-04, WPA-GW-02, and WPA-GW-07. The benzene plume is not a defined upgradient.

- Arsenic is present in all wells sampled and is above the MCL, except for MW-02, MW-03, GW-13, WPA-GW-02, WPA-GW-04, WPA-GW-09. The arsenic groundwater plume is not defined.

- Lead contamination in groundwater above the MCL is present in two wells at LPA and five wells at WPA and is not defined.

- To determine whether NA is occurring in groundwater additional data is required to 1) verify plume stability, 2) continue to evaluate MNA parameters and possible destruction pathways, and 3) evaluate first order decay rate of benzene.

- Based on visual observation, there is one area of waste present at the LPA and two areas of waste at the WPA. This is in addition to the areas of waste identified during the Remedial Investigation.

- Benzo[a]pyrene is present above the Residential Soil RSL in all four surface waste samples collected from the WPA, one surface waste sample collected from the LPA, and one surface waste sample collected from the ETF. Additional PAHs are present above their Residential Soil RSLs at these locations.

- Arsenic is present above the Residential Soil RSL in all surface waste samples and lead is present above the Residential Soil RSL at WPA-SA-04.

5. REFERENCES

Bouwer, H. and R.C. Rice. 1976. *A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells*. Water Resources Research. 12(3): 423-428.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2020. *Remedial Investigation Report Wilcox Oil Company Superfund Site, Bristow, Creek County, Oklahoma*. October.

Oklahoma Department of Environmental Quality (ODEQ). 2019. *Monitored Natural Attenuation. https://www.deq.ok.gov/wp-content/uploads/deqmainresources/ MonitoredGroundWater_11-2019.pdf.* November 20.

TABLES

FIGURES

ATTACHMENT 1

SLUG TEST ANALYSES AND PLOTS

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FIELD NOTES

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TEMPORARY WELL LOGS

ATTACHMENT 4

ANALYTICAL LABORATORY REPORTS

ATTACHMENT 5

TRANSDUCER DATA (on SharePoint separately)