HAWTHORN PARK RECYCLING & DISPOSAL FACILITY
HARRIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-2185A

PERMIT AMENDMENT APPLICATION

PART III – FACILITY INVESTIGATION AND DESIGN
ATTACHMENT 4
GEOLOGY REPORT

Prepared for:

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GEOLOGY
2045
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2/9/2021

February 2021

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INTRODUCTION

The Hawthorn Park Recycling & Disposal Facility (referred to hereinafter as "Hawthorn Park RDF" or "facility") is an existing 171.6-acre Type IV municipal solid waste (MSW) facility owned and operated by USA Waste of Texas Landfills, Inc. (USA Waste) under TCEQ Permit No. MSW-2185. The facility is located at 10550 Tanner Road, approximately 500 feet east of Beltway 8 (Sam Houston Parkway) north of Tanner Road in Houston, Harris County, Texas.

By way of this application, USA Waste proposes to add approximately 38.6 acres to the permitted area of the facility, for a total permitted area of 210.2 acres under this permit amendment application (PAA) for Permit No. MSW-2185A.

This report summarizes the available data related to regional and local geology and aquifers in the area of the proposed facility expansion in accordance with 30 Texas Administrative Code (TAC) §330.63(e). Based on a review of this data, and on the results of recent and previous subsurface investigations conducted at the site, the proposed site is suitable for use as a MSW landfill facility.

1 REGIONAL GEOLOGIC/HYDROGEOLOGIC INFORMATION

30 TAC §§330.57(f)(2), 330.63(e)(1)

This geology and geotechnical report has been prepared by Elizabeth Floyd, P.G., a qualified groundwater scientist, for the Hawthorn Park RDF consistent with 30 TAC §§330.57(f)(2) and 330.63(e). Some of Section 1 has been adopted in whole or part from the previously approved geology report. The purpose of this report is to provide the geologic and hydrogeologic information required by applicable TCEQ rules and to provide the information and interpretations necessary to design a groundwater monitoring system.

1.1 Regional Physiography and Topography

The site is located on Quaternary sediments of the Gulf Coastal Plain. The Gulf Coastal Plain is a nearly smooth, featureless, depositional plain with adjacent low, rolling hills extending westward to the Balcones Fault Zone and to shallow bays, barrier islands, and beaches along the Gulf of Mexico. The plain rises gently inland to the west to an elevation of approximately 200 feet above sea level.

In the Harris County area, the land slopes approximately two feet per mile southeast toward the Gulf of Mexico. The generally flat relief of the Gulf Coastal Plain is broken by broad shallow valleys of smaller streams and narrow valleys of smaller streams that drain the region. Several salt domes form broad mounds on the surface with up to about 100 feet of relief. The local topography at the site is generally flat. The approximate elevation across the site is 100 feet above mean sea level (msl).

The nearest surface water bodies are an unnamed tributary of Cole Creek to the north and an unnamed tributary of Brickhouse Gully to the southeast.

1.2 Regional Geology and Lithology

The following section provides discussion of the regional geology in the area of the site, primarily the Texas Gulf Coastal Plain. Discussion of the regional geologic history, stratigraphy, and structure is presented in this section. Detailed site-specific information is presented in Section 4.3 – Site Stratigraphy and Structure.

1.2.1 Geologic History

Thousands of feet of clastic sediments underlie the Gulf Coastal Plain. These deposits represent continental (alluvial plain), transitional (delta, lagoon, and beach), and marine (continental shelf) deposition of sand, gravel, silt, and clay, with progressively finer-grained sediments occurring gulfward. The site is underlain by the Lissie Formation deltaic plain (Barnes, 1982). A regional geologic map for the area is presented in Appendix III-4A on Figures III-4A-1 and III-4A-2.

Deposition of Gulf Coastal Plain formations occurred in cycles from late Eocene to Quaternary. Each cycle began with a gradual tilting or uplift of the land. Subsequently, large volumes of clastic material from the land were then transported and deposited in the different environments. Subsidence of the depositional plains and periods of lesser sediment accumulation caused the landward migration of Gulf waters. The cycle would then begin again as gradual tilting or uplift of the land occurred. The resulting oscillating shoreline continued to move gulfward with each cycle to near its present position. During the Quaternary, sea level was much lower during glacial periods and fairly deep valleys were cut into older sediments. These valleys were subsequently filled with younger sediments (Baker, 1979).

1.2.2 Regional Stratigraphy and Structure

The regional geologic units in the area of the site are those that comprise the two defined aquifers underlying the site and the lower confining unit to the aquifers (Baker, 1979). These units include formations from the upper Miocene Series Fleming Formation to the Pleistocene Series Beaumont Clay Formation. The total thickness of these units beneath the site, from the surface to the base of the lower confining unit, is estimated to be about 1,800 feet (Figure III-4A-3). Stratigraphic positions of these geologic units, along with corresponding hydrogeologic units, are presented in Table III-4-1 (Baker, 1979).

The youngest of these formations, the Beaumont Clay, crops out approximately five miles southeast of the site (Figure III-4A-1). The site is on the outcrop of the Lissie Formation. Typically, the Lissie is characterized by deposits of clay, silt, sand, and minor amounts of gravel, locally calcareous with iron oxide and iron-manganese oxides (Barnes, 1982). Underlying the Lissie, the Willis Formation consists of clay, silt, sand (coarser-grained than younger units), and minor gravel including some petrified wood (Barnes, 1982). Lithologies of the Pliocene-age Goliad Sand, stratigraphically below the Willis, include sand, gravel, and calcite-cemented sandstone interbedded with clay and silt (Wood et al., 1963). The upper Miocene Fleming Formation, considered the lower confining unit to the overlying more permeable sediments, is predominantly massive clay and sandy clay interbedded with sand and sandstone (Wood et al., 1963). These formations are also addressed in the following sections on hydrogeology.

The Beaumont Formation generally consists of cohesive soils (i.e., clays), but it also consists of minor gravel, fine sand, clayey sand, sandy clay, and occasionally limey clay (Barnes, 1982). Clay and sand deposits of the Beaumont pinch out, coalesce, and grade into each other. The limited lateral occurrence of the deposits makes correlation of individual beds difficult, even over short lateral distances. The sand/clay ratio varies considerably vertically and horizontally in the Gulf Coastal Plain sediments. Baker (1979) reports that delineation of the Pleistocene units is “exceedingly difficult” due to lithologic similarities and the lack of a correlatable fossil record.

Underlying the Beaumont, the Montgomery, Bentley, and Willis Formations similarly comprise deposits of clay, silt, sand, and minor amounts of gravel (Barnes, 1982). The Montgomery and Bentley Formations form the upper and lower portions of the Lissie Formation. The underlying Pliocene Goliad Sand is characterized by a coarser distribution of clastic material including sand, gravel, and carbonate cemented sand interbedded with finer grained silt and clay than the overlying units.

The Upper Miocene Fleming Formation is considered to be the aquiclude to the overlying more permeable sediments. The Fleming Formation is primarily clay and sandy clay interbedded with lesser amounts of sand and sandstone (Wood et al., 1963). The lithologies of the Fleming Formation are part of the hydrogeologic unit designated the Burkeville Confining System.

Most stratigraphic units of the Gulf Coastal Plain thicken toward the Gulf of Mexico as a result of subsidence of the depositional basin. Locally, the thickness of some stratigraphic units has been increased by down-to-the-coast growth fault systems. Formation outcrops generally strike northeast to southwest nearly parallel with the coastline. Regional dip of Pleistocene formations in the area of the site is to the southeast at about 10 to 20 feet per mile.

Gulf Coastal Plain sediments are pierced in places across the region by diapiric salt domes. Oil and gas production activities and some mining activities are often associated with these salt domes.

Table III-4-1
Hawthorn Park Recycling & Disposal Facility
Stratigraphy of Part of the Coastal Plain of Texas (Modified from Baker, 1979)

System	Series	Stratigraphic Units	Hydrogeologic Units	Approximate Thickness in Site Vicinity (ft)	
Quaternary	Holocene	Alluvium	Chicot Aquifer	700	
	Pleistocene	Beaumont Clay			
		Lissie Formation ←			site
		Willis Sand			
Late Tertiary	Pliocene	Goliad Sand	Evangeline Aquifer	700	
	Upper Miocene	Fleming Formation	Burkeville Confining Unit	400±	
		Oakville Sandstone			

2 GEOLOGIC PROCESSES

30 TAC §§330.63(e)(2), 330.61(j)(2)

2.1 Fault Areas

Consistent with 30 TAC §330.61(j)(2) and 30 TAC §330.555, a fault evaluation was prepared by a professional geologist as part of this application to demonstrate that the Hawthorn Park RDF site meets the location restriction for fault areas.

The property on which the Hawthorn Park RDF site is located was examined for the presence of faulting according to 30 TAC §330.555 criteria. A fault study was conducted that included the review of the McBride – Ratcliff and Associates, Inc. Fault Study completed in 1993 (See Appendix III-4H), reviewing aerial photographs for the site, reviewing available geologic literature and maps of the area, conducting site reconnaissance, and examining the subsurface boring data from the site.

The site and the immediate area were investigated for:

- Structural damage to constructed facilities (roadways, railways, and buildings).
- Scarps in natural ground.
- Presence of surface depressions (sag ponds and ponded water).
- Presence of lineations on aerial maps and topographic sheets. The following historical imagery (aerial photographs) were reviewed:

2/2019	4/2016	10/2013	1/2008	9/2002
10/2017	3/2016	8/2013	4/2006	1/1995
9/2017 (2)	7/2015	10/2012	1/2006	12/1989
8/2017 (2)	5/2015 (2)	3/2011	10/2005	12/1978
2/2017	3/2015	2/2010	5/2005	12/1953
1/2017	4/2014	1/2010	2/2004	12/1944
5/2016	2/2014	1/2009	12/2002	

In addition, a site walkover and an investigation by driving streets and roads in the landfill vicinity was conducted by an experienced geologist familiar with faulting and solid waste disposal facilities to identify possible physical evidence caused by faulting. The facility was examined for indications of faulting in accordance with 30 TAC §330.555(b)(1-12). No unusual scarps or topographic breaks were interpreted within 200 feet of the site. No evidence of faulting was found by examination of area roadways. No evidence of faulting was found by inspection of open excavations on the site. No unusual relief or topographic features, such as sag ponds, and no vegetation changes were observed on the site. No evidence of structural damage to buildings on the property was identified.

The streets within a half-mile of the site were driven to look for evidence of repairs, sags, or abrupt changes of grade that could indicate subsidence faulting in the site vicinity. The streets were asphalt-paved and were in good condition. No evidence of subsidence faulting was observed. In addition, facades of buildings and houses in the same area were viewed for structural damage that could have resulted from subsidence faulting. None was observed.

In summary, based on the review of regional data, surface observations (no evidence of subsidence of streets, no unusual relief or topographic features, etc.), aerial photographs, and subsurface geologic structure maps, there are no geologic faults with Holocene-age displacements within 200 feet of the landfill boundaries and there is no faulting activity or differential subsidence that could adversely affect the landfill. There is no active faulting within 200 feet of the site; therefore, the site complies with 30 TAC §330.555.

2.2 Previous Fault Study

A geological fault assessment was conducted for the site by McBride - Ratcliff Associates in 1993. The complete report of the fault assessment is presented in Appendix III-4H. A summary of the scope of work, findings and conclusions is discussed below.

The fault assessment was conducted in two phases. The Phase I evaluation consisted of assessments of structural damage to constructed facilities, scarps on natural ground, the presence of surface depressions, lineation's noted on aerial maps and topographic sheets, structural control of natural streams, vegetation changes, oil and natural gas accumulations and the extraction of sulphur, and the extraction of significant amounts of groundwater. Further, the sideslopes of the excavation were evaluated for stratigraphic offsets indicative of fault movement.

No evidence of surface faulting was identified within the boundaries of the property. There was evidence of active surface faulting within 0.5 mile of the facility. The surface trace of the Brittmoore fault is approximately 1,850 ft northwest of the northwest corner of the proposed facility. Because of the presence of this fault in the vicinity, a Phase 2 evaluation was undertaken to identify if there were unknown faults that may potentially impact the landfill.

The Phase 2 evaluation consisted of the correlation of the subsurface strata to check for stratigraphic offsets. This correlation was based on the drilling of thirty-two test holes to a depth of 300 ft along the perimeter of the proposed facility. Each test hole was logged for electrical spontaneous potential, single point resistance, and natural gamma radiation logs. Each log was then correlated and evaluated to identify the stratigraphy beneath the site. Based upon this stratigraphic analysis, the data revealed that there is no evidence of the manifestation of a geologic fault in the upper 300 ft of sediment at the tract.

The upper 300 ft of sediment was evaluated at the site and there was no evidence of Pleistocene or Holocene fault movement. The Brittmoore fault zone was evaluated to identify a proposed area of influence. Based upon this analysis, the zone of influence was approximately 50 ft on the upthrown block of the fault and 150 ft on the downthrown block of the fault. The Brittmoore fault has a zone of influence that is greater than 1600 ft from the northwest corner of the tract. It was concluded that the Brittmoore fault will not impact the proposed development or the integrity of the liners.

2.3 Seismic Impact Zones

Consistent with 30 TAC §330.61(j)(3) and 30 TAC §330.557, seismic impact zones documentation was prepared as part of this application to demonstrate that the Hawthorn Park RDF site meets the location restriction for seismic impact zones.

TCEQ regulations state that no new MSW landfill units or lateral expansions shall be located in seismic impact zones unless the owner or operator demonstrates that all containment structures, including liners, leachate collection systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth for the site.

The seismic impact zone as defined by 30 TAC §330.557 is an area with a 10 % or greater probability that the maximum horizontal acceleration in lithified earthen material, expressed as a percentage of the earth's gravitational pull, will exceed 0.10 g in 250 years. Appendix III-4D, Figure III-4D-1 – Seismic Impact Zone Map shows the site location on the USGS 2014 Seismic Hazard Maps. The existing Hawthorn Park RDF and the proposed expansion area are not located within a seismic impact zone.

3 REGIONAL AQUIFERS

30 TAC §330.63(e)(3)

3.1 Regional Aquifers

Defined regional aquifers discussed in the following sections are the Chicot and Evangeline (Baker, 1979). The site is excavated within deposits of the Chicot Aquifer. Stratigraphically below the Chicot is the Evangeline Aquifer. The Burkeville confining system of the upper Miocene Fleming Formation serves as the lower confining unit to the Evangeline Aquifer. Results of a search for water wells in the area are tabulated in Table III-4-3 and the locations shown on Figure III-4A-6. Detailed site-specific hydrogeologic information is presented in Section 5.2 – Groundwater Occurrence and Section 5.4 – Site Hydrogeology.

3.1.1 Gulf Coast Aquifer

The Gulf Coast Aquifer (Kasmarek and Strom, 2002) is classified by the State of Texas as a major aquifer. In Texas, the Gulf Coast Aquifer extends from the Rio Grande Valley and northeastward to the Louisiana border, encompassing more than 50,000 square miles and all or parts of 54 counties (Ashworth and Hopkins, 1995). The Chicot and Evangeline comprise the Gulf Coast Aquifer (Kasmarek and Strom, 2002). These aquifers are regionally connected in a "leaky artesian aquifer" condition. The Chicot is the uppermost aquifer. The Evangeline occurs below the Chicot. The Burkeville Confining System, including the Fleming Formation, serves as the aquiclude to the Evangeline. The relative stratigraphic positions are shown on Figure III-4A-3. Clay interbeds occurring within the Chicot and Evangeline serve as aquicludes to overlying sandy zones preventing local downward migration of groundwater. Deeper, confined zones within each aquifer results in a "leaky artesian aquifer" situation. This upward pressure gradient condition also prevents downward migration of groundwater. Hydraulic properties of the Chicot and Evangeline are summarized in Table III-4-2 as follows:

Table III-4-2
Hawthorn Park Recycling & Disposal Facility
Hydraulic Properties of Regional Aquifers
Compiled from Wood et al., 1963

Parameters	Chicot Aquifer	Evangeline Aquifer
Composition	Sand, Silt, and Clay	Sand
Transmissivity	225,000 gpd/feet	100,000 gpd/feet
Hydraulic Conductivity	645 gpd/square feet	250-500 gpd/square feet
Water Table/Confined	Confined	Confined
Groundwater Flow Rate*	50 feet/year	25-50 feet/year
Water Quality: Total Dissolved Solids Chlorides	 <500 ppm TDS <250 mg/l	 <500 ppm TDS <100 mg/l
Recharge Zones	Beaumont Formation	Outcrop of Evangeline**
Regional Water Table	See Appendix III-4A, Figure III-4A-4	See Appendix III-4A, Figure III-4A-5
Present Use of Water	Municipal, Industrial, Irrigation	Municipal, Industrial, Irrigation
Identification of Water Wells Within One Mile	Figure III-4A-6, Table III-4-3	Figure III-4A-6, Table III-4-3

Notes: *Regional potentiometric surface maps(s) are included in Appendix E1, Figures E1-4 and E1-5.
**Additional information regarding the Evangeline Aquifer Recharge Zone can be found in Section 3.1.1.2

3.1.1.1 Chicot Aquifer

The Chicot Aquifer includes more permeable sediments in the Pleistocene-age Willis Sand, Lissie Formation, and Beaumont Clay and any overlying Holocene alluvium (Baker, 1979) as shown in Table III-4-1. According to Baker (1979), delineation of Pleistocene units is very difficult because of the similarities in lithology and the lack of correlatable fossil records within those units.

In the vicinity of the Hawthorn Park RDF site, the elevation of the potentiometric surface of the confined groundwater in the primary zones of the Chicot Aquifer is about -75 feet msl (Kasmarek et al., 2006). A generalized potentiometric surface map of the Chicot Aquifer is presented in Appendix III-4A on Figure III-4A-4. At the facility, Layer II serves as the uppermost aquifer for groundwater monitoring purposes. The Layer II sand is separated from the main part of the Chicot by a continuous clay unit (Layer III). The potentiometric surface of the deeper Chicot is approximately 170 feet deeper than the Layer II potentiometric surface. Also noted on Figure III-4A-4 is a localized cone of depression located approximately five miles north of the site. This temporal condition is causing flow within the Chicot to flow slightly northward, a condition that is not reflected in the potentiometric flow maps of Layer II.

Wells in Harris County produce groundwater from 1 to 20 or more different sand beds in the Goliad, Willis, and Lissie Formations and yield from 1,000 to more than 3,000 gallons per minute (gpm), averaging about 2,000 gpm (Wood et al., 1963). Specific capacities range from 20 to 55 gpm per foot (4×10^{-3} to 1×10^{-2} square meters per second) (Wood et al., 1963). Groundwater quality is generally very good, with most water having a total dissolved solids content of less than 500 milligrams per liter (Wood et al., 1963).

Recharge to the Chicot is by precipitation on the outcrops of the formations that comprise the aquifer. The site is on the outcrop of the Lissie Formation, which is a recharge area. The outcrop of the Beaumont is approximately five miles southeast of the site; the Willis is approximately 15 miles northwest of the site. The Goliad Sand formation is discussed in the following section.

3.1.1.2 Evangeline Aquifer

Stratigraphically below the Chicot, the Evangeline Aquifer consists primarily of the Goliad Sand but also includes at its lower boundary sections of sand in the Fleming Formation. Thickness of this aquifer in the site vicinity is approximately 800 feet (Figure III-4A-3). The Evangeline is one of the most prolific aquifers in the Texas Coastal Plain with an abundance of good quality groundwater (Baker, 1979). The potentiometric surface of confined groundwater in the Evangeline is more than 200 feet below msl in the general area of the site (Johnson, M.R., et al., 2011). A regional potentiometric surface map of the Evangeline Aquifer is on Figure III-4A-5.

Hydraulic properties of the sand units that comprise the Chicot and Evangeline Aquifers are tabulated in Table III-4-2. Recharge to the Evangeline is by precipitation on the outcrop of the Goliad and by infiltration from overlying Chicot formations. The nearest outcrop of the Goliad Sand is more than 60 miles west-southwest of the site.

3.1.1.3 Burkeville Confining Unit

The Burkeville confining system consists of clay beds in the Fleming Formation and some upper portions of the Oakville Sandstone. The Burkeville is composed predominantly of silt and clay with many individual layers of sand (Baker, 1979). Because of its large percentage of silt and clay, the Burkeville acts as a lower confining unit to the Evangeline Aquifer above, separating it from the underlying Jasper Aquifer.

3.2 Wells Within One Mile

3.2.1 Water Wells

A water well search was conducted to identify known water wells within a one-mile radius of the proposed site boundary. The water well search included review and data retrieval from the following sources:

- The interactive map and well records available on the Texas Water Development Board (TWDB) website *www.twdb.state.tx.gov* in the Groundwater Data Viewer mapping application.
- A Well Radius Listing was ordered from the database of the Harris-Galveston Subsidence District (HGSD) and wells within one mile were identified according to the location coordinates provided by that search.
- The Texas Commission on Environmental Quality (TCEQ) website *www.tceq.state.tx.gov* online water well records.
- A number of the water wells are identified as public wells. The TCEQ Water District Database (WDD) (*https://www14.tceq.texas.gov/iwud/index.cfm*) was consulted to determine the local active public water utilities.

The search identified approximately 248 water well records within a one-mile radius of the site. Most of the wells are screened in the Chicot, with total depths ranging from approximately 20 to 1700 feet.

In addition to the above records search, an attempt was also made to locate wells visible from nearby roads and streets and confirm water well locations within one mile of the facility. No additional obvious water well production equipment, such as well houses, pump handles, windmills, or pressure tanks was identified from the street. However, any residence in this area may have a water well associated with it, especially where no public water supply is available.

The results of the one-mile radius water well search are shown on Appendix III-4A, Figure III-4A-6 – Water Well Location Map. Table III-4-3 following the water well location map provides a summary of the available information about each of the well records identified in the search.

Table III-4-3
Hawthorn Park Recycling & Disposal Facility
Water Wells Within One Mile

Map ID	TWDB ID	Year Completed	Depth (ft bgs)	Completion Formation	Well Use	Latitude	Longitude	Source
TCEQ, H3=Harris-Galveston Subsidence District Well Report, T1= Submitted Drillers Reports, T2=Groundwater Data Well Type Abbreviations are: A – Agriculture, D – Domestic, G – Plugged or Destroyed, Ind – Industrial, Irr – Irrigation, O – Other, P - Public								
12316	65-12-1	201	460	Chicot	Ind	29.85694444	-95.55916667	H3
2187	65-12-2	1968	50	Chicot	Ind	29.84888889	-95.54944444	H3
2188	65-12-2	1957	325	Chicot	Ind	29.84638889	-95.54583333	H3
2676	65-12-2	1954	309	Chicot	Ind	29.84611111	-95.55222222	H3
2837	65-12-2	1959	302	Chicot	P	29.86750000	-95.54194444	H3
3878	65-12-2	1987	1700	Evangeline	P	29.84472222	-95.55527778	H3
4461	65-12-2	1983	Unknown	Unknown	Ind	29.85055556	-95.55166667	H3
4587	65-12-2	1991	392	Chicot	P	29.84888889	-95.54666667	H3
4770	65-12-2	1994	60	Chicot	D	29.84416667	-95.54611111	H3
4846	65-12-2	Unknown	Unknown	Chicot	D	29.85694444	-95.56805556	H3
4927	65-12-2	Unknown	Unknown	Chicot	P	29.84388889	-95.54611111	H3
4950	65-12-2	1991	320	Chicot	D	29.85666667	-95.56777778	H3
5024	65-12-2	Unknown	300	Chicot	D	29.86222222	-95.54527778	H3
5334	65-12-2	Unknown	50	Chicot	P	29.86472222	-95.55500000	H3
5450	65-12-2	1995	50	Chicot	D	29.86027778	-95.54638889	H3
5756	65-12-2	1996	50	Chicot	D	29.86250000	-95.56472222	H3
6951	65-12-2	1998	350	Chicot	D	29.84833333	-95.55361111	H3
7245	65-12-2	1985	175	Chicot	D	29.85888889	-95.54833333	H3

Map ID	TWDB ID	Year Completed	Depth (ft bgs)	Completion Formation	Well Use	Latitude	Longitude	Source
7295	65-12-2	1980	60	Chicot	Ind	29.90944444	-95.54583333	H3
7296	65-12-2	1960	60	Chicot	Ind	29.85944444	-95.54583333	H3
7297	65-12-2	1982	75	Chicot	Ind	29.85972222	-95.54750000	H3
7298	65-12-2	1979	60	Chicot	Ind	29.86000000	-95.54694444	H3
7299	65-12-2	1978	60	Chicot	D	29.86083333	-95.54666667	H3
7300	65-12-2	1978	60	Chicot	D	29.86027778	-95.54666667	H3
7313	65-12-2	Unknown	Unknown	Unknown	D	29.86138889	-95.54777778	H3
7336	65-12-2	1993	300	Chicot	D	29.85083333	-95.56055556	H3
7393	65-12-2	1981	300	Chicot	D	29.86388890	-95.54611111	H3
7428	65-12-2	1999	160	Chicot	D	29.84872222	-95.55333333	H3
7429	65-12-2	1973	160	Chicot	O	29.85027778	-95.55333333	H3
8336	65-12-2	1976	300	Chicot	D	29.85027778	-95.55916667	H3
8434	65-12-2	Unknown	60	Chicot	D	29.85972222	-95.54833333	H3
8501	65-12-2	2000	425	Chicot	Ind	29.85333333	-95.54027778	H3
8670	65-12-2	1941	20	Chicot	D	29.86277778	-95.54555556	H3
8746	65-12-2	2001	50	Chicot	O	29.84944444	-95.55083333	H3
8752	65-12-2	2002	500	Chicot	L	29.84361111	-95.56277778	H3
8787	65-12-2	1990	350	Chicot	O	29.85694444	-95.56888889	H3
9065	65-12-2	Unknown	Unknown	Unknown	Ind	29.85583333	-95.55805556	H3
9213	65-12-2	1990	Unknown	Unknown	O	29.85916667	-95.55861111	H3
9322	65-12-2	2003	400	Chicot	D	29.86638889	-95.56000000	H3
9949	65-12-2	Unknown	400	Chicot	D	29.85000000	-95.55472222	H3
10015	65-12-2	2005	300	Chicot	D	29.85388889	-95.56333330	H3
10222	65-12-2	2006	400	Chicot	O	29.84805556	-95.55500000	H3
10242	65-12-2	Unknown	2	Chicot	D	29.85944444	-95.54750000	H3
10246	65-12-2	2006	350	Chicot	O	29.85777778	-95.56027778	H3
10294	65-12-2	2006	320	Chicot	O	29.84888889	-95.55750000	H3
10295	65-12-2	Unknown	300	Chicot	O	29.84888889	-95.55777778	H3
10423	65-12-2	Unknown	300	Chicot	Ind	29.86500000	-95.55972222	H3
10448	65-12-2	2006	50	Chicot	D	29.85944444	-95.54666667	H3
10655	65-12-2	2007	50	Chicot	D	29.86361111	-95.55888889	H3
11020	65-12-2	2009	350	Chicot	D	29.85305556	-95.56277778	H3
11130	65-12-2	Unknown	20	Chicot	D	29.85916667	-95.54638889	H3
11286	65-12-2	1991	300	Chicot	Ind	29.85583333	-95.56861111	H3
11391	65-12-2	Unknown	50	Chicot	D	29.85972222	-95.54611111	H3

Map ID	TWDB ID	Year Completed	Depth (ft bgs)	Completion Formation	Well Use	Latitude	Longitude	Source
12087	65-12-2	2011	400	Chicot	O	29.67833333	-95.55500000	H3
12088	65-12-2	201	400	Chicot	O	29.84500000	-95.55472222	H3
12337	65-12-2	Unknown	20	Chicot	D	29.84583333	-95.55361111	H3
13361	65-12-2	Unknown	400	Chicot	D	29.85250000	-95.55694444	H3
13362	65-12-2	Unknown	400	Chicot	O	29.85222222	-95.55722222	H3
13533	65-12-2	1980	60	Chicot	D	29.86500000	-95.56472222	H3
13679	65-12-2	Unknown	300	Chicot	D	29.85722222	-95.55916667	H3
13905	65-12-2	Unknown	200	Chicot	D	29.85333333	-95.55194444	H3
5719	65-12-3	1996	300	Chicot	O	29.86527778	-95.53583333	H3
10308	65-12-5	Unknown	50	Chicot	P	29.86500000	-95.56444444	H3
2770	65-122	1975	240	Chicot	Ind	29.87250000	-95.55750000	H3
1954	65-12-2	1965	335	Chicot	D	29.87027778	-95.54305556	H3
3727	65-12-2	1983	800	Chicot	P	29.85000000	-95.55416667	H3
4	62-12-2	2/7/1996	400	Chicot	D	29.857765	-95.582729	TCEQ
7	65-12-2Y	6/13/1980	285	Chicot	D	29.850773	-95.551782	TCEQ
9	65-12-2X	10/11/1975	118	Chicot	D	29.864351	-95.574999	TCEQ
10	65-12-2K	9/27/1982	51	Chicot	D	29.838065	-95.545846	TCEQ
11	65-12-2EE	8/12/1980	66	Chicot	D	29.852049	-95.581954	TCEQ
12	65-12-2EE	10/28/1978	240	Chicot	D	29.862458	-95.577132	TCEQ
13	65-12-2MM	1/12/1981	297	Chicot	D	29.859337	-95.546881	TCEQ
18	65-12-2U	5/11/1975	316	Chicot	D	29.860355	-95.558566	TCEQ
21	65-12-2QQ	2/8/1982	341	Chicot	D	29.860352	-95.556641	TCEQ
22	65-12-2QQ	7/11/1983	49.5	Chicot	D	29.862465	-95.580723	TCEQ
24	65-12-2E	5/14/1974	122	Chicot	D	29.858101	-95.571471	TCEQ
26	65-12-2S	10/12/1975	56	Chicot	D	29.850968	-95.581954	TCEQ
27	65-12-2S	11/29/1973	43	Chicot	D	29.85533	-95.580362	TCEQ
28	65-12-2E	11/14/1968	43	Chicot	Ind	29.863809	-95.55928	TCEQ
29	65-12-2S	11/23/1984	295	Chicot	D	29.84925	-95.553709	TCEQ
30	65-12-2C	7/5/1979	300	Chicot	D	29.838848	-95.570005	TCEQ
31	65-12-2JJ	2/10/1981	260	Chicot	D	29.86716	-95.574755	TCEQ
32	65-12-2JJ	9/2/1982	252	Chicot	D	29.85815	-95.580989	TCEQ
33	65-12-2JJ	7/1/1972	260	Chicot	D	29.86505	-95.574979	TCEQ
35	65-12-2HH	7/7/1980	115	Chicot	D	29.8663	-95.572517	TCEQ
36	65-12-2BB	12/27/1978	296	Chicot	Warehouse	29.866455	-95.559413	TCEQ
37	65-12-2BB	8/10/1978	77	Chicot	D	29.864373	-95.546916	TCEQ

Map ID	TWDB ID	Year Completed	Depth (ft bgs)	Completion Formation	Well Use	Latitude	Longitude	Source
39	65-12-2	7/26/1991	310	Chicot	D	29.856312	-95.568476	TCEQ
41	65-12-2	8/30/2002	31	Chicot	Monitor	29.834964	-95.567797	TCEQ
42	65-12-2	10/26/2000	325	Chicot	Unknown	29.864967	-95.568927	TCEQ
44	65-12-2	12/15/1997	325	Chicot	D	29.863899	-95.574486	TCEQ
45	65-12-2	2/1/2000	400	Chicot	Irr	29.840831	-95.544379	TCEQ
46	65-12-2	6/12/1998	315	Chicot	D	29.849184	-95.551515	TCEQ
47	65-12-2	5/17/2001	55	Chicot	D	29.84924	-95.550715	TCEQ
48	65-12-2	10/29/1999	62	Chicot	D	29.853536	-95.57662	TCEQ
49	65-12-2	2/2/1999	142	Chicot	D	29.850699	-95.553545	TCEQ
50	65-12-2	4/12/1989	410	Chicot	Ind	29.867262	-95.562261	TCEQ
51	65-12-2	10/24/1994	325	Chicot	D	29.840319	-95.546529	TCEQ
53	65-12-2	3/3/1999	325	Chicot	D	29.86147	-95.576538	TCEQ
54	65-12-2	10/9/2001	275	Chicot	Unknown	29.858424	-95.57664	TCEQ
55	65-12-2	9/15/1999	1042	Evangeline	P	29.846181	-95.574087	TCEQ
56	65-12-2	4/5/2000	47	Chicot	D	29.859525	-95.577769	TCEQ
57	65-12-2	10/11/1997	52	Chicot	D	29.850562	-95.568599	TCEQ
58	65-12-2	9/9/2000	400	Chicot	D	29.863407	-95.581489	TCEQ
59	65-12-2	10/5/1994	1062	Evangeline	P	29.839549	-95.557461	TCEQ
60	65-12-2	4/2/1990	357	Chicot	D	29.863541	-95.574958	TCEQ
62	65-12-2	7/11/1993	147	Chicot	D	29.839685	-95.545873	TCEQ
64	65-12-2	2/24/1992	377	Chicot	D	29.868126	-95.573625	TCEQ
65	65-12-2	5/27/1987	122	Chicot	D	29.860947	-95.577707	TCEQ
69	65-12-2V	11/25/1973	36	Chicot	I	29.83773	-95.545854	TCEQ
71	65-12-2	3/17/1986	326	Chicot	D	29.837524	-95.545856	TCEQ
72	65-12-2	10/6/1986	358	Chicot	P	29.856311	-95.568496	TCEQ
73	65-12-2	8/22/1987	390	Chicot	D	29.864698	-95.546922	TCEQ
74	65-12-2	2/19/1988	450	Chicot	P	29.857378	-95.559163	TCEQ
75	65-12-2R	6/9/1977	354	Chicot	Ind	29.859024	-95.577379	TCEQ
77	65-12-2HH	1/6/1983	140	Chicot	D	29.848397	-95.547189	TCEQ
78	65-12-2P	12/28/1971	122	Chicot	D	29.85947	-95.57106	TCEQ
81	65-12-2	3/24/1988	400	Chicot	Ind	29.855643	-95.578245	TCEQ
82	65-12-2PP	6/6/1983	320	Chicot	D	29.865526	-95.568624	TCEQ
84	65-12-2	7/25/1990	425	Chicot	D	29.863545	-95.569005	TCEQ
85	65-12-2	10/21/1994	370	Chicot	D	29.855561	-95.584168	TCEQ
86	65-12-2	12/14/1990	320	Chicot	Irr	29.851095	-95.560732	TCEQ

Map ID	TWDB ID	Year Completed	Depth (ft bgs)	Completion Formation	Well Use	Latitude	Longitude	Source
87	65-12-2	6/2/1992	300	Chicot	D	29.850366	-95.56952	TCEQ
88	65-12-2FF	1/5/1981	340	Chicot	P	29.837291	-95.572628	TCEQ
89	65-12-2D	1/18/1969	124	Chicot	D	29.861937	-95.568517	TCEQ
91	65-12-2D	10/5/1983	290	Chicot	D	29.864611	-95.567738	TCEQ
92	65-12-2C	6/18/1980	285	Chicot	Ind	29.850194	-95.553222	TCEQ
93	65-12-2JJ	5/15/1970	312	Chicot	D	29.855223	-95.570794	TCEQ
95	65-12-2AA	8/12/1982	319	Chicot	D	29.86413	-95.567409	TCEQ
96	65-12-2W	5/22/1978	118	Chicot	D	29.864509	-95.574979	TCEQ
97	65-12-2W	12/22/1982	126	Chicot	D	29.862111	-95.571471	TCEQ
98	65-12-2W	8/8/1975	57	Chicot	D	29.850503	-95.54525	TCEQ
100	65-12-2F	10/15/1969	56	Chicot	D	29.849106	-95.545221	TCEQ
101	65-12-2RR	1/26/1984	50	Chicot	D	29.861982	-95.581455	TCEQ
102	65-12-2KK	6/12/1980	360	Chicot	D	29.839451	-95.546655	TCEQ
103	65-12-2N	2/29/1984	125	Chicot	D	29.861329	-95.57784	TCEQ
104	65-12-2T	7/14/1973	128	Chicot	D	29.855931	-95.576381	TCEQ
106	65-12-2C	3/4/1973	63	Chicot	D	29.8509	-95.580237	TCEQ
108	65-12-2R	8/13/1982	50	Chicot	D	29.861826	-95.581491	TCEQ
109	65-12-2R	3/17/1973	51	Chicot	D	29.858317	-95.58263	TCEQ
110	65-12-2R	2/13/1979	255	Chicot	D	29.85865	-95.580354	TCEQ
111	65-12-2DD	5/9/1979	310	Chicot	P	29.87261	-95.56985	TCEQ
112	65-12-GG	4/21/1980	312	Chicot	D	29.873158	-95.569686	TCEQ
113	65-12-2D	2/1/1984	341	Chicot	Business	29.837586	-95.566686	TCEQ
114	65-12-2NN	4/27/1981	302	Chicot	D	29.851251	-95.570958	TCEQ
115	65-12-2N	4/6/1982	226	Chicot	Irr	29.854865	-95.576086	TCEQ
65-12-202	65-12-202	0/0/1923	2000	Evangeline	G	29.838889	-95.558889	T2
65-12-203	65-12-203	12/7/1954	303	Chicot	P	29.846667	-95.552501	T2
65-12-205	65-12-205	0/0/1930	58	Chicot	D	29.849445	-95.569167	T2
65-12-208	65-12-208	0/0/1969	44	Chicot	D	29.842222	-95.545556	T2
65-12-209	65-12-209	0/0/1969	295	Chicot	Ind	29.863612	-95.548889	T2
65-12-210	65-12-210	4/25/1970	323	Chicot	P	29.863889	-95.568055	T2
65-12-214	65-12-214	0/0/1900	48	Chicot	Unknown	29.865278	-95.574167	T2
65-12-215	65-12-215	Unknown	1280	Chicot & Evangeline	P	29.838611	-95.557501	T2
65-12-216	65-12-216	10/5/1994	1062	Chicot & Evangeline	P	29.838889	-95.557778	T2
4729	4729	1/30/2002	310	Chicot	D	29.850556	-95.569167	T1
6308	6308	3/26/2002	320	Chicot	Irr	29.842778	-95.566667	T1

Map ID	TWDB ID	Year Completed	Depth (ft bgs)	Completion Formation	Well Use	Latitude	Longitude	Source
46094	46094	9/6/2004	23.5	Chicot	Monitor	29.853889	-95.546389	T1
46096	46096	9/6/2004	21.5	Chicot	Monitor	29.856389	-95.546389	T1
46097	46097	9/6/2004	23.5	Chicot	Monitor	29.852501	-95.5475	T1
48447	48447	10/19/2004	26	Chicot	Monitor	29.857778	-95.550834	T1
78426	78426	3/8/2006	50	Chicot	D	29.866389	-95.583055	T1
90842	90842	7/23/2006	47	Chicot	D	29.866389	-95.566389	T1
97791	97791	10/29/2006	57	Chicot	D	29.859167	-95.546389	T1
101321	101321	11/20/2006	400	Chicot	D	29.869722	-95.57	T1
101323	101323	11/28/2006	400	Chicot	D	29.870833	-95.57	T1
106920	106920	3/6/2007	300	Chicot	D	29.869722	-95.57	T1
116395	116395	6/28/2007	47	Chicot	D	29.863889	-95.558334	T1
122506	122506	8/30/2007	435	Chicot	D	29.850001	-95.566944	T1
128267	128267	10/29/2007	35	Chicot	Monitor	29.862778	-95.558889	T1
128268	128268	10/29/2007	37	Chicot	Monitor	29.862778	-95.558889	T1
128269	128269	10/29/2007	35	Chicot	Monitor	29.862778	-95.558889	T1
128271	128271	10/30/2007	35	Chicot	Monitor	29.862778	-95.558889	T1
133185	133185	1/3/2008	16	Chicot	Monitor	29.853334	-95.550834	T1
145281	145281	6/4/2008	30	Chicot	Monitor	29.853334	-95.550834	T1
145284	145284	6/4/2008	30	Chicot	Monitor	29.853334	-95.550834	T1
145286	145286	6/3/2008	30	Chicot	Monitor	29.853612	-95.550834	T1
145288	145288	6/3/2008	30	Chicot	Monitor	29.853612	-95.551112	T1
145290	145290	6/3/2008	30	Chicot	Monitor	29.853612	-95.551389	T1
157777	157777	9/5/2008	320	Chicot	D	29.853889	-95.581111	T1
165284	165284	1/7/2009	56.5	Chicot	Dewatering	29.850556	-95.553889	T1
165286	165286	12/30/2008	55	Chicot	Dewatering	29.852223	-95.555556	T1
165294	165294	12/30/2008	65	Chicot	Dewatering	29.852501	-95.553334	T1
165731	165731	12/15/2008	300	Chicot	D	29.850556	-95.583055	T1
171289	171289	12/10/2008	20	Chicot	Monitor	29.850556	-95.57	T1
171332	171332	3/4/2009	70	Chicot	Dewatering	29.851112	-95.554723	T1
171334	171334	3/5/2009	65	Chicot	Dewatering	29.851667	-95.555278	T1
171335	171335	3/8/2009	65	Chicot	Dewatering	29.852778	-95.556112	T1
175052	175052	3/31/2005	303	Chicot	D	29.853612	-95.562501	T1
175093	175093	3/16/2009	270	Chicot	D	29.862223	-95.5775	T1
177133	177133	4/15/2009	25	Chicot	Monitor	29.852778	-95.556389	T1
177135	177135	4/15/2009	23.5	Chicot	Monitor	29.850278	-95.553612	T1

Map ID	TWDB ID	Year Completed	Depth (ft bgs)	Completion Formation	Well Use	Latitude	Longitude	Source
177137	177137	4/15/2009	23.5	Chicot	Monitor	29.851945	-95.553056	T1
177143	177143	4/15/2009	22	Chicot	Monitor	29.853889	-95.553056	T1
177145	177145	4/15/2009	23.5	Chicot	Monitor	29.857778	-95.556389	T1
179489	179489	10/6/2004	260	Chicot	D	29.865001	-95.574167	T1
204240	204240	3/5/2006	360	Chicot	Irr	29.857223	-95.560278	T1
210918	210918	8/7/2009	305	Chicot	D	29.852778	-95.563334	T1
213109	213109	4/14/2010	50	Chicot	D	29.863056	-95.580833	T1
218180	218180	5/25/2010	57	Chicot	D	29.85967	-95.576111	T1
218693	218693	5/31/2010	28	Chicot	Monitor	29.866667	-95.572222	T1
218694	218694	5/31/2010	24	Chicot	Monitor	29.866667	-95.572222	T1
218695	218695	5/31/2010	24	Chicot	Monitor	29.866667	-95.572222	T1
228050	228050	11/10/2009	340	Chicot	D	29.866112	-95.569167	T1
240015	240015	9/28/10	27	Chicot	Monitor	29.863056	-95.578611	T1
240020	240020	9/28/2010	27	Chicot	Monitor	29.863056	-95.578611	T1
240021	240021	9/28/2010	27	Chicot	Monitor	29.863056	-95.578611	T1
240025	240025	9/29/2010	27	Chicot	Monitor	29.863056	-95.578611	T1
240026	240026	9/29/2010	30	Chicot	Monitor	29.863056	-95.578611	T1
268327	268327	9/21/2011	25	Chicot	Monitor	29.856112	-95.554167	T1
268355	268355	8/23/2011	57.5	Chicot	Dewatering	29.854723	-95.553334	T1
268356	268356	8/23/2011	61	Chicot	Dewatering	29.855834	-95.553334	T1
268357	268357	8/23/2011	65	Chicot	Dewatering	29.856112	-95.554723	T1
299319	299319	9/12/2012	450	Chicot	Ind	29.856945	-95.559167	T1
300208	300208	9/26/2012	57.5	Chicot	Dewatering	29.854167	-95.556945	T1
300210	300210	9/26/2012	60	Chicot	Dewatering	29.855278	-95.556945	T1
300213	300213	9/25/2012	61.5	Chicot	Dewatering	29.856112	-95.556945	T1
302607	302607	8/15/2012	45	Chicot	Monitor	29.867222	-95.558889	T1
367090	367090	6/5/2014	62	Chicot	Dewatering	29.857501	-95.556112	T1
367094	367094	6/6/2014	57	Chicot	Dewatering	29.856945	-95.556945	T1
367103	367103	6/7/2014	71	Chicot	Dewatering	29.856945	-95.555556	T1
383628	383628	10/16/2014	20	Chicot	Monitor	29.849445	-95.558334	T1
397840	397840	5/12/2015	466	Chicot	Ind	29.861389	-95.576944	T1
402324	402324	7/1/2015	390	Chicot	D	29.852223	-95.556945	T1
420983	420983	4/9/2016	47	Chicot	D	29.865278	-95.564444	T1
429341	429341	7/15/2016	15.5	Chicot	Monitor	29.851889	-95.560639	T1
432744	432744	8/5/2016	305	Chicot	D	29.870833	-95.559167	T1

Map ID	TWDB ID	Year Completed	Depth (ft bgs)	Completion Formation	Well Use	Latitude	Longitude	Source
447409	447409	3/26/2017	275	Chicot	D	29.858889	-95.576944	T1
451303	451303	11/30/2016	39	Chicot	Monitor	29.86276	-95.54871	T1
451307	451307	11/29/2016	40	Chicot	Monitor	29.86282	-95.55351	T1
451309	451309	12/12/2016	40	Chicot	Monitor	29.86273	-95.55811	T1
451330	451330	2/16/2017	40	Chicot	Monitor	29.86171	-95.58762	T1
451356	451356	5/21/2017	32	Chicot	Monitor	29.863056	-95.549722	T1
451358	451358	5/21/2017	32	Chicot	Monitor	29.862778	-95.550806	T1
451361	451361	5/21/2017	30	Chicot	Monitor	29.862778	-95.551528	T1
451364	451364	5/22/2017	32	Chicot	Monitor	29.863056	-95.552222	T1
451367	451367	5/22/2017	32	Chicot	Monitor	29.863056	-95.552222	T1
451368	451368	5/22/2017	26	Chicot	Monitor	29.863889	-95.553333	T1
451369	451369	5/22/2017	26	Chicot	Monitor	29.863889	-95.551667	T1
451371	451371	5/23/2017	28	Chicot	Monitor	29.863889	-95.551111	T1
451372	451372	5/23/2017	28	Chicot	Monitor	29.863889	-95.550278	T1
451374	451374	5/23/2017	28	Chicot	Monitor	29.863889	-95.565833	T1
451466	451466	12/7/2016	40	Chicot	Monitor	29.85624	-95.563139	T1
459171	459171	8/8/2017	32	Chicot	O	29.858333	-95.580556	T1
459172	459172	8/8/2017	30	Chicot	O	29.858333	-95.580556	T1
459173	459173	8/8/2017	32	Chicot	O	29.858333	-95.580556	T1
459174	459174	8/8/2017	30	Chicot	O	29.858333	-95.580556	T1

3.3 Oil and Gas Well Locations

An oil and gas well search of state records was conducted in June 2018 and updated in July, 2020 to identify locations of any existing or abandoned on-site crude oil or natural gas wells, or other wells associated with mineral recovery that are under the jurisdiction of the Railroad Commission of Texas (RRC) that are inside the permit boundary. According to the information from the RRC, there is one oil well, one gas well, and one dry hole within the permit boundary. In addition, there is one oil well located within 500 feet of the permit boundary. Additional efforts were made to confirm the existence of the well locations through visual observation in the field and viewing historical imagery (aerial photography) and were unsuccessful. It should be noted that the gas well (20104017) would have been located in what would have been the original sand pit and is now currently part of the approved waste footprint. The locations are depicted in Appendix III-4D, Drawing III-4D-3 – Locations of Oil and Gas Producing Wells. The available RRC reports for these wells are provided in Appendix III-4D. Any on-site oil and / or gas well found within the waste footprint during on-site excavation will be plugged, capped, and closed in accordance with applicable rules and regulations of the RRC or other applicable state agency.

A copy of the well plugging report for any found well will be submitted to the RRC and TCEQ Executive Director within 30 days after the well is plugged. A permit modification will be submitted to the TCEQ Executive Director if revisions to the liner installation plan are required as result of well abandonment.

4 SUBSURFACE INVESTIGATION REPORT

30 TAC §330.63(e)(4)(A)-(H)

4.1 Recent Drilling Activities

The current and previous site characterization investigations of the geology, geotechnical properties, and hydrogeology of the site have resulted in approximately 180 borings, piezometers, and monitor wells. Based on the site characterization, a sufficient number of borings were drilled to establish subsurface site stratigraphy and to determine the geotechnical properties of the soils beneath the site. Geologic strata have been characterized to depths up to approximately 300 feet. Based on correlation of strata identified in the borings, the uppermost aquifer and lower confining unit were identified.

Although borings were previously drilled as part of the original permit and subsequent permit amendment, additional borings were drilled in accordance with the TCEQ-approved boring plan in the expansion area. Data and interpretations from these recent borings were lithologically consistent with the previous borings and generally confirm the previous stratigraphic and hydrogeologic interpretations.

Borings were drilled in accordance with TCEQ-approved boring plans and established field exploration methods. Installation, abandonment, and plugging of borings was performed in accordance with the TCEQ rules in effect at the time.

4.1.1 Soil Boring Plan

Drilling activities for the recent site investigation were performed in accordance with the boring plan for this site that was approved in compliance with 30 TAC §330.63(e)(4) by letters dated January 16, 2019 (Figure III-4B-1) and March 1, 2019 (Figure III-4B-2), from the TCEQ. A boring location map is shown in Appendix III-4B, Figure III-4B-3. Subsurface conditions were evaluated by examination of logs from borings, piezometers, and monitoring wells from previous and recent site investigations. The depths of borings and piezometers range from 20 feet to 300 feet. A summary of the borings is provided in Table III-4-4 beginning on the next page.

4.1.2 Biggs & Mathews Environmental 2019 Site Investigation

Field drilling and sampling of the eleven exploratory borings (BME-1 through BME-11) completed in February 2019 were performed using thin-walled tube and mud-rotary drilling techniques in accordance with the TCEQ-approved boring plan and established field exploration methods. Installation, abandonment, and plugging of borings completed in support of previous permit amendment or modification applications were performed in accordance with the TCEQ rules in effect at the time.

Borings were continuously sampled from the surface to total depth. Shallow, highly weathered soils were sampled by hydraulically pushing 3-inch-diameter, thin-walled tubes from the surface to refusal (where the drill rig can no longer push the sample tubes) or to a depth conducive to core sampling. At several locations, after nearby shallow formation layers were characterized as consistent, shallow soils were sampled using rotary wash and a sample catcher until more cohesive formation materials were encountered. Coring then proceeded to total depth. Coring was accomplished using 5-foot length, double-tube core barrels with mud rotary techniques. All samples were extracted in the field and logged, wrapped to protect against moisture loss, identification-marked, and packaged for transportation. Samples were then transported to a soils laboratory for testing of selected physical parameters.

This field exploration program was designed and supervised by a certified professional geologist and / or registered professional engineer.

Borings were field logged by a qualified geologist. The field logs, in conjunction with field and laboratory testing, were used to prepare the final boring logs. The data generated during the field exploration program are presented on the final logs of borings provided in Appendix III-4B of this attachment as Figures III-4B-4 through III-4B-231. General notes supplementing the logs are on Drawing III-4B-3.

Table III-4-4
Hawthorn Park Recycling & Disposal Facility
History of Borings

Boring Number	Northing	Easting	Surface Elevation (ft above msl)	Total Depth (ft)	Bottom Elevation (ft msl)	Completion Date	Feet Above(+) or Below(-) the EDE
Biggs and Mathews Environmental 2019							
BME-1	752515.88	3090557.29	107.5	100	7.5	2/18/2019	32.5
BME-2	751539.62	3091109.96	105.7	100	5.7	2/21/2019	34.3
BME-3	751196.59	3090897.53	107.5	100	7.5	2/22/2019	32.5
BME-4	750230.39	3089895.27	102.4	100	2.4	2/15/2019	37.6
BME-5	750058.11	3090967.2	105.0	100	5.0	2/12/2019	35.0
BME-6	751729.95	3092220.36	103.1	100	3.1	2/7/2019	36.9
BME-7	752026.25	3092531.1	97.8	100	-2.2	2/7/2019	42.2
BME-8	751761.29	3093811.59	104.7	100	4.7	2/6/2019	35.3
BME-9	750048.96	3093911.74	100.0	100	0.0	2/1/2019	40.0
BME-10	749367.82	3091288.73	105.2	100	5.2	2/25/2019	34.8
BME-11	749703.04	3091286.85	103.1	100	3.1	2/18/2019	36.9
McBride Ratcliff Associates Geophysical Borings							
B-1	752061	3089893	106	300	-194	1992	-234
B-2	751487	3090477	105	300	-195	1992	-235
B-3	750681	3091123	104	300	-196	1992	-236
B-4	750361	3091377	103	300	-197	1992	-237
B-5	750064	3092675	103	300	-197	1992	-237
B-6	750761	3092649	103	300	-197	1992	-237
B-7	751807	3092611	104	300	-196	1992	-236
B-8	752157	3091824	103	300	-197	1992	-237
B-9	752127	3091140	103	300	-197	1992	-237
B-10	752108	3090558	106	300	-194	1992	-234
B-11	749480	3092697	104	300	-196	1992	-236

Boring Number	Northing	Easting	Surface Elevation (ft above msl)	Total Depth (ft)	Bottom Elevation (ft msl)	Completion Date	Feet Above(+) or Below(-) the EDE
B-12	751326	3092631	103	300	-197	1992	-237
B-13	751474	3091787	103	300	-197	1992	-237
B-14	751595	3091122	106	300	-194	1992	-234
B-15	751137	3091160	103	300	-197	1992	-237
B-16	749836	3091790	105	300	-195	1992	-235
B-17	749364	3092155	105	300	-195	1992	-235
B-18	751664	3093307	103	300	-197	1992	-237
B-19	750646	3093337	105	300	-195	1992	-235
B-20	752258	3092595	103	300	-197	1992	-237
B-21	752290	3093202	103	300	-197	1992	-237
B-22	752202	3093835	102	300	-198	1992	-238
B-23	752235	3094395	100	300	-200	1992	-240
B-24	752267	3094987	100	300	-200	1992	-240
B-25	751966	3094994	100	300	-200	1992	-240
B-26	751589	3094991	99	300	-201	1992	-241
B-27	750950	3095013	100	300	-200	1992	-240
B-28	750438	3094984	101	300	-199	1992	-239
B-29	749924	3095007	101	300	-199	1992	-239
B-30	749510	3095038	101	300	-199	1992	-239
B-31	749466	3094372	102	300	-198	1992	-238
B-32	749447	3093693	104	300	-196	1992	-236
McBride Ratcliff Associates 1987							
CB-20	750697	3093242	97	100	-3	3/9/1987	-43
CB-21	751006	3092838	106	100	6	3/5/1987	-34
CB-22	751427	3093145	106	100	6	3/9/1987	-34
CB-23	749381	3092051	103.5	100	3.5	9/1/1987	-36.5
CB-24	749828	3092390	104	100	4	9/1/1987	-36
CB-25	749557	3092242	102.5	100	2.5	9/4/1987	-37.5
CB-26	749661	3092044	88.2	100	-11.8	9/6/1987	-51.8
CB-27	749694	3091901	105	100	5	10/17/1987	-35
WB-28	749617	3091962	105	100	5	10/16/1987	-35
McBride Ratcliff Associates 1986							
CB-1	751948	3091488	104	80	24	2/13/1986	-16
CB-2	751268	3091200	104	80	24	2/12/1986	-16
CB-3	751263	3091822	104	80	24	2/12/1986	-16
CB-4	751550	3092505	102	80	22	2/11/1986	-18
CB-5	750680	3092576	103	80	23	11/16/1985	-17
CB-6	750035	3092526	102	80	22	2/11/1986	-18
CB-7	751877	3091156	104	100	4	2/26/1986	-36

Boring Number	Northing	Easting	Surface Elevation (ft above msl)	Total Depth (ft)	Bottom Elevation (ft msl)	Completion Date	Feet Above(+) or Below(-) the EDE
CB-8	752088	3091149	103	100	3	2/26/1986	-37
CB-9	751568	3091810	103	100	3	2/24/1986	-37
CB-10	751279	3092341	102	100	2	2/24/1986	-38
CB-11	750981	3091194	104	100	4	2/24/1986	-36
CB-12	750761	3091689	86	100	-14	2/26/1986	-54
CB-13	750814	3092245	87	100	-13	2/25/1986	-53
CB-14	750332	3091213	103	100	3	2/21/1986	-37
CB-15	750291	3091714	104	100	4	2/27/1986	-36
CB-16	749977	3092032	106	100	6	2/28/1986	-34
CB-17	750345	3092531	106	100	6	2/24/1986	-34
CB-18	752110	3091762	103	100	3	2/26/1986	-37
Western Contractor Services, Inc.							
CB-1	749984	3091220	105	90	15	9/6/1983	-25
CB-2	750629	3091024	105	100	5	8/31/1983	-35
CB-3	749977	3090482	105	100	5	8/31/1983	-35
CB-4	750382	3090817	89	65	24	9/6/1983	-16
CB-5	750919	3089885	105	80	25	11/21/1983	-15
CB-6	751245	3090149	105	80	25	11/21/1983	-15
CB-7	751624	3090282	105	100	5	1/3/1984	-35
CB-8	751622	3089857	105	75	30	11/21/1983	-10
CB-9	749347	3090141	105.5	78	27.5	1/24/1984	-12.5
CB-10	749565	3090082	105	70	35	1/26/1984	-5
CB-11	749899	3089898	105.5	75	30.5	1/26/1984	-9.5
CB-12	749885	3090085	105	90	15	9/28/1984	-25
CB-13	750171	3089857	105	90	15	10/2/1984	-25
CB-14	750676	3089839	105	90	15	10/2/1984	-25
CB-15	751297	3089868	105	90	15	10/1/1984	-25
McBride Ratcliff Associates 1983							
CB-1C	750010	3091120	105	90	15	9/6/1983	-25
CB-2C	750613	3091149	105	100	5	8/3/1983	-35
CB-2T	751801	3093175	101.8	60	41.8	1/9/1981	1.8
CB-10E	750397	3093243	107.6	50	57.6	4/5/1982	17.6
Aviles Engineering							
B-1	749896	3090235	106	60	46	10/7/1982	6
B-2	750396	3089854	106	60	46	10/5/1982	6
B-3	751328	3090534	106	60	46	10/4/1982	6
B-4	750609	3090621	106	60	46	10/5/1982	6
B-5	750115	3090356	74	40	34	9/30/1982	-6
B-6	750096	3090044	85	40	45	9/28/1982	5

Boring Number	Northing	Easting	Surface Elevation (ft above msl)	Total Depth (ft)	Bottom Elevation (ft msl)	Completion Date	Feet Above(+) or Below(-) the EDE
B-7	750413	3090341	56	40	16	9/30/1982	-24
B-8	750400	3090037	56	40	16	9/29/1982	-24
B-9	750788	3090354	56	40	16	9/30/1982	-24
B-10	750750	3090701	56	40	16	10/4/1982	-24
B-11	750792	3090931	56	40	16	10/4/1982	-24
B-12	751124	3090668	56	40	16	9/30/1982	-24
McBride Ratcliff Associates							
CB-1[1]	751805	3092535	103.5	50	53.5	1/5/1981	13.5
CB-2[1]	751795	3093180	101.8	60	41.8	1/9/1981	1.8
CB-3[1]	751925	3093846	102.4	50	52.4	1/5/1981	12.4
CB-4[1]	751390	3093855	103	42	61	1/9/1981	21
CB-5[1]	751711	3093673	102	35	67	1/5/1981	27
CB-6[1]	751770	3092886	102	35	67	1/9/1981	27
CB-7[1]	751280	3093215	101.5	48	53.5	4/1/1981	13.5
CB-8[1]	751868	3093468	102	24	78	4/1/1981	38
CB-1	752190	3093272	102.7	50	52.7	1/20/1982	12.7
CB-2	752155	3093835	102.2	60	42.2	1/21/1982	2.2
CB-3	752143	3092520	104	50	54	4/5/1982	14
CB-4	749889	3093930	104	50	54	3/31/1982	14
CB-5	750429	3093905	104.1	50	54.1	4/1/1982	14.1
CB-6	750840	3093886	103.9	60	43.9	4/1/1982	3.9
CB-7	750274	3093646	84.5	20	64.5	4/2/1982	24.5
CB-8	751081	3093556	90.8	50	40.8	4/2/1982	0.8
CB-9	750043	3093251	107.1	50	57.1	4/5/1982	17.1
CB-10	750397	3093243	107.6	50	57.6	4/5/1982	17.6
CB-11	750600	3093435	97	58	39	4/2/1982	-1
Southwestern Laboratories							
B-1	749449	3091878	103.5	60	43.5	5/10/1977	3.5
B-2	749779	3091773	102.7	60	42.7	5/9/1977	2.7
B-3	749910	3091568	102.5	60	42.5	5/9/1977	2.5
B-4	749427	3091268	103.1	60	43.1	5/10/1977	3.1
Piezometers Installed							
(P-1)	750176	3092543	106	20	86	2/28/1986	46
(P-1P)	752079	3091184	103	86	17	4/24/1986	-23
(P-1PC)	752079	3091196	103	60	43	7/1/1986	3
(P-1PD)	752093	3091226	103	60	43	3/10/1987	3
(P-1PE)	752090	3091468	103	62	41	3/10/1987	1
(W-1)	752085	3091177	103	63	40	7/1/1986	0

Boring Number	Northing	Easting	Surface Elevation (ft above msl)	Total Depth (ft)	Bottom Elevation (ft msl)	Completion Date	Feet Above(+) or Below(-) the EDE
(P-2)	751537	3092429	102	60	42	3/3/1986	2
(P-3)	750245	3092600	106	64	42	2/28/1986	2
(P-3PB)	750910	3091194	104	70	34	6/27/1986	-6
(P-4)	751770	3091172	104	58	46	2/27/1986	6
(P-4P)	751261	3092295	102	76	26	4/29/1986	-14
(P-5)	750338	3092550	106	85	21	2/28/1986	-19
(P-5P)	750402	3092558	106	75	31	4/29/1986	-9
(P-5PA)	750393	3092570	106	74	32	6/23/1986	-8
(P-6)	752085	3091188	103	85	18	2/28/1986	-22
(P-7)	749396	3092075	103.4	85	18.4	9/3/1987	-21.6
(P-8)**	752100	3091179	103.9	140	-36.1	6/17/1988	-76.1
(P-9)**	750468	3091237	104.1	150	-45.9	6/16/1988	-85.9
(P-10)**	751688	3092424	104	135	-31	6/15/1988	-71
Piezometers Installed 1983-1984							
P-A	749315	3090167	105.5	60	45.5	1/24/1984	5.5
P-B	749859	3089899	105.5	75	30.5	1/24/1984	-9.5
P-1	749986	3091164	105	62	43	9/6/1983	3
P-2	750619	3091073	105	100	5	8/31/1983	-35
P-3	749977	3090522	105	56	49	9/2/1983	9
P-4	750378	3090862	89	35	54	9/6/1983	14
P-5	750888	3089918	105	62	43	1/9/1984	3
P-6	751207	3090163	105	61	44	1/3/1984	4
P-7	751574	3090281	105	100	5	1/3/1984	-35
P-8	751585	3089871	105	48	57	1/4/1984	17
P-10	750939	3089815	105	83	22	11/6/1984	-18
P-12	751163	3090160	105	85	20	11/9/1984	-20
Monitoring Wells							
MW-A1***	752187	3093153	100	50	50	Unknown	10
MW-A2***	752180	3093817	102	55	47	Unknown	7
MW-A3***	751493	3092475	98	41	57	Unknown	17
MW-S4***	750952	3093865	101	50	51	Unknown	11
MW-A5***	749475	3093923	103.5	50	53.5	Unknown	13.5
MW-B1***	749345	3090192	106	60	46	Unknown	6
MW-B2***	749968	3090507	106	54	52	Unknown	12
MW-B3***	750582	3091230	108	50	58	Unknown	18
MW-B4***	751622	3089884	104.7	50	54.7	Unknown	14.7
MW-6	751676	3089869	104.5	63	41.5	2/3/1995	1.5
MW-7	752099	3091197	102.4	68	34.4	2/7/1995	-5.6
MW-8	752106	3091756	102.2	64	38.2	2/7/1995	-1.8

Boring Number	Northing	Easting	Surface Elevation (ft above msl)	Total Depth (ft)	Bottom Elevation (ft msl)	Completion Date	Feet Above(+) or Below(-) the EDE
MW-9	751552	3092479	105.2	55	50.2	2/16/1995	10.2
MW-10	752168	3092511	102.2	60	42.2	2/17/1995	2.2
MW-11	751582	3093876	102.6	54	48.6	2/17/1995	8.6
MW-12	750508	3093951	102.4	55	47.4	2/15/1995	7.4
MW-13	749432	3093938	102.1	57	45.1	2/15/1995	5.1
MW-14	750428	3092521	103.5	60	43.5	2/24/1995	3.5
MW-15	749415	3092553	104	70	34	2/14/1995	-6
MW-16	749378	3092270	103.1	65	38.1	2/14/1995	-1.9
MW-17	749988	3091737	103	66	37	2/13/1995	-3
MW-18	750341	3091231	103.4	70	33.4	2/6/1995	-6.6
MW-19	750056	3090816	106.1	63	43.1	2/4/1995	3.1
MW-20	749994	3090199	107.8	63	44.8	2/5/1995	4.8
MW-21	750845	3089837	104.5	70	34.5	2/6/1995	-5.5

* Surface elevation estimated from current existing site topography map
Note: Surface elevations taken from Figure 1 – Plan of Borings (McBride-Ratcliff Associates, June 1982)

** To be plugged,

*** Monitoring wells MW-A1 through MW-A5 and MW-B1 through MW-B4 were part of the previous groundwater monitoring system. These wells were plugged and abandoned in 1995. The plugging reports are included in Appendix III-4B as Figures III-4B-300 through III-4B-309. The original logs and construction details of these wells no longer exist.

4.2 Previous Drilling Activities

Subsurface investigations conducted at the site in the past are described below. The descriptions of each of the previous field investigations at the facility have been summarized from the McBride-Ratcliff & Associates, Inc., Attachment 11 permit document. Borings were drilled in accordance with established field exploration methods. Figure III-4B-3 of Appendix III-4B illustrates the locations of all soil borings, piezometers, and monitoring wells previously advanced on site. The available boring logs are included in Appendix III-4B as Figures III-4B-4 through III-4B-231. Borings are summarized in Table III-4-4. Monitoring well installations that are included in Table III-4-4 are not described below as site exploration events.

4.2.1 McBride-Ratcliff and Associates, Inc. 1986 through 1987 Site Investigation

The field exploration phase for this project was performed during February 1986, March, September and October 1987. The exploration phase consisted of 27 borings drilled to depths of 67 ft to 100 ft and the installation of 19 piezometers. The scope of the field work was in general accordance with the proposed boring plan submitted to the Texas Department of Health (TDH) in a letter dated February 16, 1986 by McBride-Ratcliff and Associates, Inc. The locations of all borings and piezometers are shown on Figure III-4B-3. The boring logs are presented in Appendix III-4B, Figures III-4B-35 through III-4B-109.

All borings were drilled with a truck-mounted drill rig with hydraulic drawdown. Most of the borings were dry augered until free water was encountered or until the borehole would not remain open. The borings were then completed by the wash bore method. Samples were

WB-28 was drilled using the wash bore method and no samples were obtained. Visual logging of the cuttings was performed. All soil borings were grouted from the depth of termination to the ground surface. The grout used to seal holes consisted of a cement-bentonite mixture.

Undisturbed tube samples were obtained in most cohesive and semi-cohesive strata using a 3-in. diameter Shelby tube sampler advanced hydraulically by one stroke of the drill rig system (ASTM D 1587). Samples were extruded in the field, visually classified, and a strength estimate obtained with a pocket penetrometer. Penetrometer readings are tabulated on the individual boring logs. Representative portions of the sample were wrapped and sealed for transport to the laboratory.

Most cohesionless strata were sampled with Standard Penetration Test sampler driven 18 inches by blows from a 140-pound hammer falling 30 in. (ASTM D 1586). The number of blows (N) required to advance the sampler the last 12 in. are recorded for each corresponding sample on the individual logs of boring. Samples obtained from the split-barrel sampler were visually classified and placed in glass jars with screw top caps.

4.2.2 BSI Construction Services 1982 Site Investigation

The field investigation was conducted from January 5 to 9 and on April 1, 1981, in the manner consistent with ASTM D 1586 and ASTM D 1587 and consisted of drilling 8 test borings 35 to 60 feet below the existing ground surface (CB-1 through CB-8). The approximate locations of all borings are shown on Figure III-4B-3. Borings CB-5 and CB-8 were drilled within the existing excavation at an elevation of approximately 72 feet. The remaining borings were drilled outside the excavation at elevations of 102 to 103 feet.

Borings were drilled using a Failing 36 drill rig with hydraulic drawdown. A number of the borings were dry augered until free water was encountered. Below that depth they were advanced by the wet rotary method. The balance of the project borings were dry augered to 10 to 30 ft depths and completed by wet rotary.

Samples were typically obtained continuously over the initial 10 ft and at 5 ft intervals thereafter. Undisturbed tube samples were obtained in most cohesive and semi-cohesive strata using a three inch diameter Shelby tube sampler advanced hydraulically by one stroke of the drill rig system (ASTM D 1587). Samples were extruded in the field, visually classified and a strength estimate obtained with a pocket penetrometer. Penetrometer readings are tabulated on the individual boring logs. Representative portions of the sample were wrapped and sealed for transport to the laboratory.

Most cohesionless strata were generally sampled with the Standard Penetration Test sampler driven 18 inches by blows from a 140-pound hammer falling 30 inches (ASTM D 1586). The number of blows (N) required to advance the sampler the last 12 inches are recorded for each corresponding sample on the individual boring logs. Samples obtained from the split-barrel sampler were visually classified and placed in glass jars with screw top caps.

Boring logs from this investigation are included in Appendix III-4B as Figures III-4B-110 through III-4B-158.

4.2.3 McBride-Ratcliff and Associates, Inc. 1982 Site Investigation

The field investigation was conducted on January 20 and 21 and from March 31 to April 5, 1982, in the manner consistent with ASTM D 1586 and ASTM D 1587. Eleven borings (CB-1 through CB-11) were drilled for this investigation at the locations shown in Figure III-4B-3.

Borings CB-7, CB-8, and CB-11 were drilled within the existing pits at elevations of about 84 feet, 91 feet, and 97 feet, respectively. The remainder of the borings were drilled at the original ground surface at elevations of about 102 feet to 107 feet. The boring depths ranged from 50 to 70 feet below the original ground surface.

Borings were drilled using a Failing 36 drill rig with hydraulic drawdown. Five of the borings were dry augered until free water was encountered. Below that depth, they were advanced by the wet rotary method. Four of the borings were dry augered to 20 to 30 feet depths without encountering groundwater and completed by wet rotary. Two of the borings were drilled by the wet rotary method the full depth.

Samples were typically obtained continuously over the initial 10 ft and at 5 ft intervals thereafter. Undisturbed tube samples were obtained in most cohesive and semi-cohesive strata using a three inch diameter Shelby tube sampler advanced hydraulically by one stroke of the drill rig system (ASTM D 1587). Samples were extruded in the field, visually classified and a strength estimate obtained with a pocket penetrometer. Penetrometer readings are tabulated on the individual boring logs. Representative portions of the sample were wrapped and sealed for transport to the laboratory.

Most cohesionless strata were general sampled with the Standard Penetration Test sampler driving 18 inches by blows from a 140 pound hammer falling 30 inches (ASTM D 1586). The number of blows (N) required to advance the sampler the last 12 inches are recorded for each corresponding sample on the individual boring logs. Samples obtained from the split-barrel sampler were visually classified and placed in glass jars with screw top caps.

Boring logs from this investigation are included in Appendix III-4B, as Figures III-4B-191 through III-4B-211.

4.2.4 Aviles Engineering Corporation 1982 Site Investigation

Subsurface exploration at the site was accomplished by means of twelve undisturbed sample core borings drilled to depths ranging from forty to sixty feet below existing ground surface.

The borings were of three (3) inch nominal diameter. Undisturbed samples of the cohesive soils were obtained from the borings by means of thin-wall, seamless Steel Shelby Tube samplers. All undisturbed samples were extruded mechanically from the core barrels in the field, wrapped in aluminum foil, and sealed in plastic bags to prevent moisture loss and disturbance. All samples were placed in core boxes and transported to the laboratory for testing and further study. Boring logs from this investigation are included in Appendix III-4B as Figures III-4B-159 through III-4B-176.

4.2.5 Southwestern Laboratories – Geotechnical Engineering Division – 1977

Southwestern Laboratories investigated the subsurface conditions at the facility by drilling four soil borings. These soil borings were each drilled to a depth of 60 ft bgs. These borings were 3-inch diameter and were drilled with a truck mounted, rotary wash drill rig. Shelby tubes were used to obtain undisturbed samples of cohesive soils. The soil samples obtained during the exploration were sealed at the site and transported to the laboratory where they were visually inspected and classified according to the Unified Soil Classification System (ASTM Standard D 2487) by the geotechnical project engineer. A testing program was conducted on selected samples to aid in classification and evaluation of the engineering properties required for analyses.

The locations of these borings are shown on Figure III-4B-3. Boring logs from this investigation are included in Appendix III-4B as Figures III-4B – 212 through III-4B – 219.

4.3 Site Stratigraphy and Structure

The site is located on the surface outcrop of the Lissie Formation. In general, the Lissie Formation consists of beds and lenses of fine to coarse-grained sand grading into and interbedded with sandy clay and clay and shown on the cross-sections included in Appendix III-4C.

The site stratigraphy has been divided into four distinct layers: Layers I, II, III, and IV. The four generalized units are listed in Table 3 and are described in the following section, (McBride-Ratcliff, 1993).

Layer I is composed predominantly of clays and sandy clays with minor amounts of sand and silt. Layer I is found from ground surface to approximately 22 to 31 feet below ground surface (ft bgs). Due to this layer's high clay content it serves as an effective confining bed to the underlying transmissive unit.

Layer II is composed of channel fill deposits consisting predominantly of fine sands with gradations to silty fine sands and silts. These intermittent sand and silt layers are identified as Layer IIA. This layer is considered the uppermost aquifer of the site.

Layer III is found approximately 59 to 100 ft bgs and is correlatable across the site. This layer consists primarily of clays, sandy clays, and silty clays and is primarily a zone of low permeability; however, due to the sand and silt content present within this layer, internal transmissive zones are present. Intermittent sand and silt layers within this unit are identified as Layer IIIA, shown on the cross-sections included in Appendix III-4C.

Layer IV is composed of fine sands and varying amounts of silt within the stratum. This layer is found at depths greater than 100 ft bgs.

Table III-4-5
Hawthorn Park Recycling & Disposal Facility
Generalized Site Stratigraphy (McBride-Ratcliff, 1993)

Geologic Unit	Approximate Average Depth to Top of Unit (ft)	Approximate Average Thickness of Unit (ft)	Hydrogeologic Unit
Layer I	Surface	20	Vadose Zone
Layer II	20	30	Uppermost Aquifer
Layer III	50	50	Lower Confining Unit
Layer IV	100	25	Lower Transmissive Unit

5 GEOTECHNICAL DATA

30 TAC §330.63(e)(4)(A)-(F)

The geotechnical laboratory results are included in Appendix III-4E.

5.1 Geotechnical Properties

The geotechnical properties of the subsurface soil materials along with a discussion and conclusions about the suitability of the soils and strata for use as MSW landfill facility are included in Part III, Attachment 3, Waste Management Unit Design.

5.2 Groundwater Occurrence

5.2.1 Groundwater Observation Points – Piezometers/Monitoring Wells

Groundwater observation points are summarized in Table III-4-6. Data from over 45 piezometers and groundwater monitoring wells were used to characterize site hydrogeology (see Appendix III-4C for cross sections).

Monitoring well logs, data sheets, well reports, and logs of piezometers are provided in Appendix III-4B as Figures III-4B-232 through III-4B-299. All piezometer and monitoring well details are summarized in Table III-4-6. Piezometer and monitoring well locations are shown on Figure III-4B-3 of Appendix III-4B.

Table III-4-6
Hawthorn Park Recycling & Disposal Facility
Piezometer and Groundwater Monitoring Well Details

Well Name	Install Date	Location Northing	Location Easting	Total Depth (feet)	Surface Elevation	Casing Top Elevation (ft msl)	Filter Pack Elevation (ft msl)	Screen Elevation (ft msl)	Layer / Lithology Screened
P-A	1/24/1984	749327	3090174	60.00	105.50	108.70	63.50 to 45.50	53.50 to 48.50	Layer II
P-B	1/24/1984	749864	3089910	75.00	105.50	107.60	63.50 to 30.50	52.50 to 47.50	Layer II
P-1	9/6/1983	749990	3091137	62.00	105.00	108.00	73.00 to 43.00	46.50 to 44.0	Layer II
P-2	8/31/1983	750628	3091082	100.00	105.00	108.00	69.00 to 5.00	53.00 to 50.00	Layer III
P-3	9/2/1983	749975	3090532	56.00	105.00	108.00	71.00 to 49.00	53.00 to 50.00	Layer II
P-4	9/6/1983	750382	3090869	35.00	89.00	92.50	73.50 to 54.00	59.00 to 56.50	Layer II
P-5	1/9/1984	750886	3089912	62.00	105.00	108.00	60.00 to 43.00	49.00 to 44.00	Layer II
P-6	1/3/1984	751217	3090175	61.00	105.00	106.50	60.00 to 44.00	55.00 to 45.00	Layer II
P-7	1/3/1984	751607	3090245	100.00	105.00	106.00	49.00 to 5.00	18.00 to 8.00	Layer III
P-8	1/4/1984	751581	3089892	48.00	105.00	108.50	73.00 to 57.00	62.50 to 57.50	Layer II
P-10	11/6/1984	750938	3089912	83.00	105.00	107.20	35.00 to 22.00	28.50 to 24.00	Layer III
P-12	11/9/1984	751162	3090164	85.00	105.00	107.50	31.00 to 20.00	30.00 to 24.00	Layer III
P-1	2/28/1986	750171	3092565	20.00	106.00	109.00	20.00 to 11.00	18.00 to 13.00	Layer II
P-1P	4/24/1986	752030	3091289	89.00	103.00	107.00	86.00 to 67.00	85.00 to 75.00	Layer III
P-1PC	7/1/1986	752039	3091355	60.00	103.00	105.00	60.00 to 53.00	60.00 to 58.00	Layer II
P-1PD	3/10/1987	752105	3091209	60.00	103.00	107.80	60.00 to 36.00	58.00 to 53.00	Layer II

Table III-4-6
Hawthorn Park Recycling & Disposal Facility
Piezometer and Groundwater Monitoring Well Details

Well Name	Install Date	Location Northing	Location Easting	Total Depth (feet)	Surface Elevation	Casing Top Elevation (ft msl)	Filter Pack Elevation (ft msl)	Screen Elevation (ft msl)	Layer / Lithology Screened
P-1PE	3/10/1987	752104	3091452	62.00	103.00	107.70	62.00 to 35.00	60.00 to 55.00	Layer II
W-1	7/1/1986	752067	3091240	63.00	103.00	107.00	63.00 to 53.00	63.00 to 59.00	Layer II
P-2	5/2/1986	751537	3092429	60.00	102.00	104.60	60.00 to 42.00	60.00 to 55.00	Layer II
P-3	2/28/1986	750240	3092626	64.00	106.00	110.00	64.00 to 37.00	62.00 to 58.00	Layer II
P-3PB	6/27/1986	750910	3091194	70.00	104.00	106.00	70.00 to 63.00	70.00 to 68.00	Layer III
P-4	2/27/1986	751770	3091172	58.00	104.00	107.00	58.00 to 20.00	56.00 to 51.00	Layer II
P-4P	4/29/1986	751261	3092295	76.00	102.00	105.00	76.00 to 61.00	74.00 to 64.00	Layer III
P-5	2/28/1986	750338	3092550	85.00	106.00	108.00	85.00 to 71.00	83.00 to 78.00	Layer III
P-5P	4/29/1986	750383	3092729	79.00	106.00	108.80	75.00 to 63.00	69.00 to 64.00	Layer III
P-5PA	6/23/1986	750292	3092760	74.00	106.00	109.00	74.00 to 68.00	74.00 to 72.00	Layer III
P-6	2/28/1986	751945	3091259	85.00	103.00	105.20	85.00 to 75.00	85.00 to 80.00	Layer III
P-7	9/3/1987	749401	3092083	85.00	103.40	106.20	85.00 to 69.00	83.40 to 73.40	Layer III
P-8	6/17/1988	752113	3091159	140.00	103.90	105.90	140.00 to 105.00	138.00 to 108.00	Layer IV
P-9	6/16/1988	750468	3091237	150.00	104.10	106.10	150.00 to 109.00	145.00 to 115.00	Layer IV
P-10	6/15/1988	751688	3092424	135.00	104.00	106.00	135.00 to 106.00	128.00 to 108.00	Layer IV
MW-6	2/3/1995	751676	3089869	58.50	104.50	107.80	64.50 to 41.50	56.50 to 46.50	Layer II
MW-7	2/7/1995	752099	3091197	68.00	102.40	105.34	82.40 to 34.40	46.40 to 36.40	Layer II
MW-8	2/7/1995	752106	3091756	64.00	102.20	105.29	78.20 to 38.20	49.20 to 39.20	Layer II
MW-9	2/16/1995	751552	3092479	55.00	105.20	108.45	62.20 to 50.20	60.20 to 55.20	Layer II
MW-10	2/17/1995	752168	3092511	60.00	102.20	105.20	63.20 to 42.20	61.20 to 51.20	Layer II
MW-11	2/17/1995	751582	3093876	54.00	102.60	105.51	59.60 to 48.60	57.60 to 52.60	Layer II
MW-12	2/15/1995	750508	3093951	55.00	102.40	105.10	88.40 to 47.40	62.40 to 52.40	Layer II
MW-13	2/15/1995	749432	3093938	57.00	102.10	105.14	88.10 to 45.10	62.10 to 52.10	Layer II
MW-14	2/24/1995	750428	3092521	60.00	103.50	106.43	57.50 to 43.50	55.50 to 45.50	Layer II
MW-15	2/14/1995	749415	3092553	70.00	104.00	106.76	71.00 to 34.00	51.00 to 41.00	Layer II
MW-16	2/14/1995	749378	3092270	65.00	103.40	106.26	85.70 to 38.10	53.10 to 43.10	Layer II
MW-17	2/13/1995	749988	3091737	66.00	103.00	105.83	69.00 to 37.00	53.50 to 43.50	Layer II
MW-18	2/6/1995	750341	3091231	70.00	103.40	106.34	67.40 to 35.40	57.40 to 37.40	Layer II
MW-19	2/4/1995	750056	3090816	63.00	106.10	109.07	64.10 to 43.10	58.10 to 48.10	Layer II
MW-20	2/5/1995	749994	3090199	63.00	107.80	110.69	67.80 to 44.80	59.80 to 49.80	Layer II
MW-21	2/6/1995	750845	3089837	70.00	104.50	107.94	78.50 to 34.50	49.50 to 39.50	Layer II

5.2.2 Water Level Measurements

Water levels at the site have been measured from August 1994 to present in site monitoring wells and piezometers. These data are compiled in Tables III-4-9 and III-4-10 and are included in Appendix III-4E. Water level measurements from previous piezometers are tabulated in Table III-4-8 and are included in Appendix III-4E. Measurements of water levels were made to 0.01 foot using an electronic water level indicator. Water level elevations were calculated using measured water levels and surveyed well elevations (top of casing).

5.2.3 Water Level Measurements During Drilling

The depth at which groundwater was encountered and records of after-equilibrium measurements noted on boring logs are summarized in Table III-4-11 and are included in Appendix 4E. The cross sections in Appendix III-4C are annotated to document the level at which stabilized groundwater levels were obtained from site monitoring wells and piezometers. Borehole water level data are noted on the logs. However, because the borings were drilled with water, it was not generally possible to distinguish between drilling water and formation water. Borehole fluid level data were not used in engineering calculations because the piezometers were properly constructed and screened to provide water level data on individual strata; these data are much more reliable than borehole data.

5.3 Groundwater Monitoring Historical Analytical Data

A tabulation of historic groundwater chemistry results is provided in Appendix III-4F. The history of groundwater monitoring program at the site is discussed in Part III, Attachment 5, Section 3.4 – Groundwater Quality.

5.4 Site Hydrogeology

5.4.1 Hydrogeologic Units

The site hydrogeologic units were initially identified in the previous studies, including the 1990 McBride-Ratcliff and Associates (MRA) study for Sanifill of Texas, Inc. The site hydrogeology is composed of two discrete groundwater flow systems.

Groundwater flow is primarily contained within the more permeable sand beds of Layer II, which is the uppermost aquifer. Underlying the uppermost aquifer is an aquitard composed of clay and silty clay and it is considered the lower confining unit (Layer III). Underlying the lower confining unit is a lower transmissive layer consisting of primarily fine sand and varying amounts of silt (Layer IV).

Figures III-4C-2 through III-4C-5 of Appendix III-4C depict the relationship between the various hydrogeologic zones and the excavation depths of the facility sectors. A discussion of each hydrogeologic unit follows.

Historical cross sections from previous characterizations are presented in Appendix III-4I – Previous Permit Data.

5.4.1.1 Layer II – Uppermost Aquifer

Groundwater flow is primarily contained within the sand beds of Layer II and generally flows to the southeast under natural conditions. The geometric mean of the hydraulic conductivity for Layer II is 1.97×10^{-2} cm/sec (Table III-4-7). Groundwater velocity is estimated to be approximately 306 feet/year in this unit.

5.4.1.2 Layer III – Lower Confining Unit

Layer III is considered the lower confining unit to the uppermost aquifer, Layer II. Layer III is continuous and correlatable across the site. Where Layer III was completely penetrated, it is 40 to 50 feet thick. Layer III consists primarily of clays, sandy clays, and silty clays and is primarily a zone of low permeability with some internal transmissive zones present.

5.4.1.3 Layer IV – Deeper Transmissive Unit

Layer IV is a transmissive layer located at a depth greater than 100 ft bgs. This layer consists primarily of fine sand and varying amounts of silt.

5.5 Field Permeability Tests – Pumping Tests

McBride- Ratcliff and Associates conducted pumping tests in 1993 as part of Hydrogeologic Investigation to determine hydraulic conductivity in Layer II at the facility. A total of five borings (P-6PA, P-6PB, P-6PC, P-6PD, and P-6PE) were drilled utilizing wet rotary methods. After each boring was drilled, a truck mounted Comprobe Geophysical Logger was used to obtain geophysical logs. The geophysical logs were used to determine appropriate screen intervals for well installation.

Using a submersible pump, Well W-2 was pumped continuously for 26 hours. To ensure accuracy of water level readings, electric water level indicators were used.

The pumping test data were analyzed using the Cooper-Jacob Non-Equilibrium method for a confined aquifer. The recovery portion of the data were analyzed using the Theis Non-Equilibrium method for confined aquifers. The analysis of data was performed using ACTESOLV. Table III-4-7 summarizes the hydraulic conductivity results for both pumping and recovery portions of the tests.

Table III-4- 7
Hawthorn Park Recycling & Disposal Facility
Field Hydraulic Conductivity

Location	Hydraulic Conductivity (cm/sec)	
	Pumping Test	Recovery
W-2	2.65×10^{-2}	1.06×10^{-2}
P-6PA	1.36×10^{-2}	1.13×10^{-2}
P-6PB	1.65×10^{-2}	1.76×10^{-2}
P-6PC	2.18×10^{-2}	1.78×10^{-2}
P-CPD	2.09×10^{-2}	2.22×10^{-2}
P-6PE	3.24×10^{-2}	4.95×10^{-2}
Geometric Mean	2.10×10^{-2}	1.85×10^{-2}

The geometric mean for both the pumping and recovery test is calculated to 1.97×10^{-2}.

5.6 Groundwater Flow Direction and Rate

5.6.1 Groundwater Flow Direction

Multiple potentiometric surface maps (Figures III-4E-6 through III-4E-19, Appendix III-4E) representing seasonal and temporal groundwater variations show groundwater in Layer II has been altered by depressurization activities and flows toward the southeast, east, and northeast.

Prior to 2016, depressurization activities were ongoing on the north side of the landfill, in the vicinity of MW-9, and all landfill monitoring wells were considered to be upgradient due to an inward gradient. At this time, depressurization activities are ongoing in the southern portion of the landfill, in the vicinity of MW-18; however, a portion of the depressurization system was reported to be non-operational during the December 2019 sampling event and general groundwater flow in the uppermost groundwater bearing unit was observed to the northeast.

Groundwater Flow Rate

Travel times across the site were estimated using the formula:

$$v = (k * i) / n_e$$

Where: v = travel velocity
k = hydraulic conductivity of the aquifer
i = hydraulic gradient
n_e = effective porosity

The estimated flow velocity for the Layer II - Uppermost Aquifer at the site is 306 ft/year. Unit II piezometer hydraulic conductivity values were used for calculation and are shown in Table III-4-7. The groundwater flow velocity calculation is included in Appendix III-4E, page III-4E-20.

6 ARID EXEMPTION

30 TAC §330.63(e)(6)

The applicant is not seeking an arid exemption for the landfill unit; therefore, 30 TAC §330.63(e)(6) is not applicable to this application.

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