SKYLINE LANDFILL
CITY OF FERRIS
DALLAS AND ELLIS COUNTIES, TEXAS
TCEQ PERMIT APPLICATION NO. MSW 42D

PERMIT AMENDMENT APPLICATION

VOLUME 4 OF 5

Prepared for

Waste Management of Texas, Inc.

April 2012

STATE OF TEXAS
JOHN MICHAEL SNYDER
GEOLOGY
595
LICENSED
PROFESSIONAL GEOSCIENTIST

4-12-2012

Prepared by

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TEXAS BOARD OF PROFESSIONAL ENGINEERS
FIRM REGISTRATION NO. F-256

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PART III FACILITY INVESTIGATION AND DESIGN

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PART III – SITE DEVELOPMENT PLAN
ATTACHMENT E
GEOLOGY REPORT

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APPENDIX E6 - SITE HYDROGEOLOGIC DATA

TABLES

1 REGIONAL GEOLOGIC/HYDROGEOLOGIC INFORMATION

30 TAC §§330.57(f)(2), 330.63(e)(1)

This geology and geotechnical report has been prepared by Michael Snyder, P.G., a qualified groundwater scientist, for the Skyline Landfill consistent with 30 Texas Administrative Code (TAC) §§330.57(f)(2) and 330.63(e).

1.1 Regional Physiography and Topography

The project site is in the regional physiographic subdivision known as the Blackland Prairie. This north-south trending belt is underlain by the Eagle Ford, Austin, Taylor, and Navarro formations of the Cretaceous System. Topography of the Blackland Prairie is typically flat to rolling and has a gentle slope to the east. The Blackland Prairie is poorly drained with sparse timber (Nordstrom, 1982).

The nearest surface water body in the area, Ten Mile Creek, is located several hundred feet north of the site. Several small ponds exist on the site property as well as east of the property.

1.2 Regional Stratigraphy and Lithology

Formations of the Cretaceous System were deposited by northward advancing seas over extensively eroded Paleozoic strata. The Comanche and Gulf Series of the Cretaceous System represent two major transgressions of Cretaceous seas. The project site is underlain by strata deposited during the late Cretaceous Gulf Series. Toward the end of the Cretaceous period, marine deposition ceased after a general uplift to the west resulted in regression of the seas gulfward. Subsequent erosion of the Cretaceous deposits continued through the Cenozoic era to the present.

Regional stratigraphy includes geologic units of the Cretaceous System from the lower Comanche Series Trinity Group to the upper Gulf Series Navarro Group. Stratigraphic positions of these groups, along with lithologic characteristics and approximate depths to the formations, are presented in Table E-1. The site is on the outcrop of the Taylor Formation (lower Taylor Marl) as shown on Figure E1-1.

The Eagle Ford Group outcrops in the extreme western portion of the two counties and consists primarily of bluish-black and gray shales of marine origin with a maximum thickness of 300 feet. East and above the Eagle Ford is the Austin Chalk Group, which is made up of chalks and marls up to 500 feet thick. Above the Austin Chalk lies the Taylor Group. This group has an overall thickness estimated to be approximately 500 feet. Locally, the thickness is estimated at approximately 250 feet. The Woodbine Group, stratigraphically situated beneath the Eagle Ford and composed of clay and permeable sandstone up to 250 feet thick, is the first major water bearing zone beneath the counties. The regional dip of the Cretaceous in Dallas and Ellis Counties is approximately 50 feet to the mile and trends to the southeast. The site varies in elevation from about 505 feet above mean sea level (msl) in the center of the property to about 450 feet above msl along the west and east property boundaries. There is no unfavorable topography that would limit the facility present on the site.

Regional cross sections indicate that the Cretaceous System forms a southeastward-thickening wedge extending into the East Texas Basin structural feature. Outcrops of Cretaceous geologic formations generally trend north-northeastward with the regional dip to the east-southeast ranging from about 15 to 40 feet per mile (Nordstrom, 1982). A generalized regional geologic cross section is on Figure E1-3.

Table E-1
Skyline Landfill
Regional Stratigraphic Column

System	Series	Group	Formation	Maximum Thickness (ft)	
Upper Cretaceous	Gulf	Navarro	Kemp Clay	400	
			Corsicana Marl	20	
			Nacatoch Sand	450	
			Neylandville Marl	125	
		Taylor		600	← SITE
		Austin		400	
		Eagle Ford		400	
		Woodbine		400	
Lower Cretaceous	Comanche	Fredericksburg & Washita Groups undifferentiated		1000 250	
		Trinity	Paluxy	100	
			Glen Rose	600	
			Twin Mountains	500	
			Antler	100	

Source: Barnes, 1972

2 GEOLOGIC PROCESSES

30 TAC §§330.63(e)(2), 330.61(j)(2)

A discussion of the geologic processes in the vicinity of the landfill follows.

2.1 Fault Areas

The property on which Skyline Landfill is located was examined for the presence of faulting according to §330.555 criteria. A fault study was conducted by 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.

Aerial photographs of the site were reviewed for indications of faults in the area of the site. The Geologic Atlas of Texas, Dallas Sheet shown in Figure E1-1 shows no evidence of surface faulting in the area.

The study included a review of literature on faulting in the area, interpretation of aerial photographs, interpretation of a topographic map, a review of subsurface geologic structure maps, and personal observations.

A site walkover was conducted by an experienced geologist familiar with both faulting and solid waste disposal facilities. No unusual scarps or topographic breaks were interpreted within 200 feet of the site. No evidence of faulting was found associated with formation outcrops; no evidence of faulting was found by examination of area roadways; no structural influence of stream courses was found; and no unusual relief or topographic features, such as sag ponds or truncated alluvial spurs, were observed on the site. No evidence of structural damage to buildings on the property was identified.

Cores retrieved from exploration borings revealed no evidence of faulting. Fractures seen in the cores showed no evidence of displacement.

No oil and gas wells were identified within one mile of Skyline Landfill. Accordingly, there is no apparent differential subsidence or faulting potential of shallow sediments associated with oil and gas withdrawal.

In summary, no fault scarps were observed at the surface within 200 feet of the site and there was no evidence of vertical subsidence on any outcrops of geologic materials. No vertical displacement or stratigraphic offset indicative of faults was observed in outcrops or in any of the cores from the site borings. There is no active faulting within 200 feet of the site; therefore, the site complies with §330.555.

2.2 Seismic Impact Zones

The location criterion in TAC §330.557 requires that new MSWLF units and lateral expansions shall not be located in seismic impact zones, unless the owner or operator demonstrates to the executive director 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 material for the site. A seismic impact zone is defined as an area with a probability of 10 percent or greater than the maximum horizontal acceleration in rock, expressed as a percentage of the earth's gravitational pull, will exceed 0.10g in 250 years. If the maximum horizontal acceleration is less than 0.10g, then the design of the unit will not be required to incorporate an evaluation of seismic effects.

Areas within the United States where seismic effects need to be evaluated, as determined by the USGS interactive website (http://earthquake.usgs.gov/research/hazmaps), are shown on Figure E4-1. As indicated on this figure, the Skyline Landfill is not located within a seismic impact zone.

2.3 Unstable Areas

Consistent with §§ 330.63(e)(2), 330.61(j)(4), and 330.559, unstable areas documentation was prepared as part of this application to demonstrate that the Skyline Landfill meets the location restriction for unstable areas.

TCEQ regulations require that owners or operators of new MSWLF units, existing MSWLF units, and lateral expansions located in an unstable area shall demonstrate that engineering measures have been incorporated into the MSWLF unit's design to ensure that the integrity of the structural components of the MSWLF unit will not be disrupted.

An unstable area is defined by the TCEQ as a location that is susceptible to natural or human-induced events or forces capable of impairing the integrity of some or all of the landfill's structural components responsible for preventing releases from a landfill. An unstable area can exhibit poor foundation conditions, areas susceptible to mass movement, and karst terrains.

The determination of potential unstable areas at the landfill site is based on site observations and a review of existing documentation for the site. Based on this review, the foundation conditions and the geological formations are stable. In addition, there is no evidence to suspect mass movement of natural formations of earthen material on or in the vicinity of this site. No foundation problems exist at the site. The proposed landfill components were evaluated with respect to settlement, heave and slope stability. The detailed analysis is included in Part III, Attachment D5 – Geotechnical Design. Based on the results of these analyses, the existing and proposed human-made features have been predicted to have adequate factors of safety with respect to stability.

Based on site observations, a review of existing geological data, and geotechnical analysis of the structural components of the landfill development, the site is not located in an unstable area and the integrity of the landfill is not expected to become impaired by actual or human-induced events.

3 REGIONAL AQUIFERS

30 TAC §330.63(e)(3)

Regional Cretaceous aquifers that supply groundwater to wells in Dallas and Ellis counties are the Paluxy and Woodbine formations. Groundwater is obtained for public supply primarily from municipal wells tapping the Woodbine formations. The largest users of groundwater in Ellis County include the cities of Waxahachie, Ennis, Ferris, and Midlothian.

The Woodbine Aquifer is the uppermost aquifer beneath this site. It is separated from the surface by approximately 1100 feet of Taylor, Austin, and Eagle Ford formations. This stratigraphic section forms a regional confining system. The low permeability rocks of these formations retard the vertical and lateral flow of groundwater and separate the underlying aquifers from the surficial groundwater-bearing unit (weathered Ozan) (Dutton et al., 1994). The Dutton et al. (1994) report is a comprehensive geologic/hydrogeologic study conducted in Ellis County in conjunction with the Superconducting Super Collider. That project included boring large-scale tunnels within the Ozan Formation. Groundwater in the Woodbine is separated from the deeper Paluxy Aquifer by several hundred feet of Cretaceous limestone and shales. The Woodbine is not hydraulically connected to other aquifers.

3.1 Paluxy Formation

Outcrops of the Paluxy Formation are located in northwestern Tarrant County and in western Johnson County, almost 60 miles west of the site. Depth to the top of the Paluxy ranges from about 830 feet in northwestern Ellis County to more than 2,950 feet to the east. Depth to the Paluxy in the landfill area is approximately 610 feet (Thompson, 1967). Although the thickness of the Paluxy is irregular, the formation generally thickens northward with thicknesses in Ellis County ranging from 77 to 160 feet. Regional dip of the formation is eastward at approximately 42 feet per mile in west Ellis County and 85 feet per mile in east-central Ellis County (Thompson, 1967).

A few wells in the county tap the Paluxy Formation and yield small to moderate quantities of slightly saline water. The chemical quality of the water deteriorates downdip, resulting in moderately saline groundwater in the eastern part of the county (Thompson, 1967).

3.2 Woodbine Formation

The Woodbine Formation crops out in eastern Tarrant and Johnson counties and in northwestern Ellis County. The site location spans the north central boundary line of Ellis County where it adjoins Dallas County, approximately 30 miles east of the Woodbine outcrop. The top of the formation in the southeastern part of Ellis County is at a depth of approximately 1,980 feet. Depth to the Woodbine in the vicinity of the landfill is approximately 1100 feet (Thompson, 1967). Thicknesses of the Woodbine vary greatly in Ellis County with ranges from 190 to 405 feet. The formation dips east-southeast at an average of about 60 feet per mile (Thompson, 1967). The Woodbine Aquifer is confined by the overlying Eagle Ford, Austin, and Taylor formations in the Ellis County area (Dutton et al., 1994).

The lower part of the Woodbine in the western three-quarters of Ellis County is an important source of groundwater for domestic, livestock, and public-supply use (Thompson, 1967).

3.3 Taylor Group

The Taylor Marl (Ozan Formation) crops out in a north-northwestward trending belt across Ellis County; its maximum thickness is about 625 feet. Skyline Landfill is located on the outcrop of the Ozan. This formation is not considered a regional aquifer but in effect is an aquitard to overlying water-bearing sediments. In areas east of the site where the Taylor Marl (Ozan) is overlain by water-bearing formations, it effectively serves as the lower confining unit. Only a few shallow domestic and livestock wells tap the weathered Taylor Marl in Ellis County and yield small quantities of fresh to slightly saline hard water (Thompson, 1967).

Table E-2
Skyline Landfill
Hydraulic Properties of Regional Aquifer
Compiled from Texas Water Department Board (TWDB), 1999

Parameters	Woodbine	Paluxy
Composition	Sand, sandstone	Sand and shale
Hydraulic Conductivity	44 gal/d/ft^2	78 gal/d/ft^2
Water Table/Confined	Confined	Confined
Groundwater Flow Rate	15 ft/yr	2 ft/yr
Water Quality: Total Dissolved Solids Total Dissolved Chlorides	 877.39 85.88	 606.7 36.08
Recharge Zones	West	West
Regional Water Table	See Figure E1-4	See Figure E1-5
Present Use of Water	Municipal, Industrial, and Irrigation	Municipal, Industrial, and Irrigation
Identification of Water Wells Within One Mile	See Table E-3 and Figure E1-6	See Table E-3 and Figure E1-6

*Potentiometric surface map(s) using site data are included in Appendix E6, Figures E6-1 through E6-5.

3.4 Area Water Wells

A water well search was compiled for a one-mile radius around the site. The search identified 11 wells within one mile of the site. The search included a review of records and maps on file at the TWDB and the TCEQ. One well identified in the TWDB database as 33-27-501 was plugged in 1992 by Waste Management; it is within the permit boundary but outside the limits of the waste disposal area and outside the groundwater monitoring system. Another well identified in the TWDB database as 33-27-601 was abandoned and plugged in 1965. Both wells are listed in the TWDB database. The water wells are shown on the USGS topographic map in Figure E1-6. As shown on Table E-3, the water wells in the area are completed in the Woodbine Aquifer at depths ranging from 1,360 to 1,500 feet below ground surface (bgs).

In addition, a windshield search for water wells was conducted in October 2011. No potential or apparent water wells were identified.

Based on the information in Table E-1, the public supply and industrial water wells within one mile of the site are completed in the lower portions of the Woodbine Group.

A total of 11 water well locations were identified within a one-mile radius of the site. No additional or potential water well locations were identified. The information about each of the wells is summarized in Table E-3.

Table E-3
Skyline Landfill
Water Wells Within One Mile

Well Locator	Well ID No.	Depth (ft)	Completion Date	Completion Formation	Well Use	Longitude	Latitude
501	33-27-501	1,500	1933	Woodbine	Plugged	-96.66888	32.553055
5B	33-27-5B	1,395	3/20/84	Woodbine	D	-96.682892	32.569776
5C	33-27-5C	1,430	3/14/84	Woodbine	D	-96.676943	32.570538
601	33-27-601	1,408	1914	Woodbine	Plugged	-96.665	32.546388
602	33-27-602	1,362	6/1/63	Woodbine	P	-96.664722	32.546944
603	33-27-603	1,360	1964	Woodbine	D	-96.653611	32.563888
6(1)	33-27-6	120	9/28/90	Und	D	-96.658163	32.567895
6(2)	33-27-6	118	10/5/90	Und	D	-96.662449	32.567807
6(3)	33-27-6	Unk	1990	Unk	Unk	-96.659622	32.568472
6(4)	33-27-6	1,362	2/88	Woodbine	D	-96.663692	32.562639
901	33-27-901	1,493	1954	Woodbine	P	-96.666388	32.533054

*No potential wells were identified during a windshield search conducted in October 2011.

Notes: Und – Formation not identified on Well Report.
Unk – Unknown
P – Public
D – Domestic

4 SUBSURFACE INVESTIGATION REPORT

30 TAC §330.63(e)(4)(A)-(H)

The current and previous site characterization investigations of the geology, geotechnical properties, and hydrogeology of the site have resulted in more than 126 borings, piezometers, and 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 of more than 50 feet below the elevation of the deepest excavation. Based on correlation of strata included in the borings, the uppermost aquifer and lower confining unit (aquiclude) were identified. The uppermost aquifer is the Woodbine, the depth of which is well known in published literature (Thompson, 1967).

As discussed in Section 3, the Woodbine aquifer is the uppermost regional aquifer beneath the site. However, groundwater meeting the TCEQ's definition of aquifer for groundwater monitoring purposes exists within the weathered Taylor Marl in the shallow subsurface beneath the site. The unweathered Taylor Marl consists of hundreds of feet of very low permeability clayey material and serves as the lower confining unit (aquiclude), beneath the weathered Taylor Marl groundwater. The weathered Taylor Marl is not recognized by the State of Texas as a regional aquifer, but has been recognized by TCEQ as a regulatory aquifer for groundwater monitoring purposes. The borings have been drilled sufficiently deep enough to allow the identification of this "uppermost aquifer" and the aquiclude boundary.

The thickness of the Taylor Marl which overlies the Woodbine and the depth to the Woodbine are well known from published geological literature (Langley, 1999 and Nordstrom, 1982). The Woodbine is separated from the surface by approximately 1100 feet of Taylor, Austin, and Eagle Ford formations. This stratigraphic section forms a regional confining system. The low permeability rock of these formations retard the vertical and lateral flow of groundwater and separate the underlying aquifer from the surficial groundwater bearing unit (weathered Ozan; Dutton et al., 1994). It is highly unlikely that a contaminant could migrate through several hundred feet of low permeability Taylor, Austin, and Eagle Ford to the confined groundwater in the Woodbine. If it were to migrate, travel times to the Woodbine would be thousands of years.

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

4.1 Biggs and Mathews Environmental – 2011

Field exploration activities were conducted in July and August of 2011. As part of this investigation, 22 previous borings were deepened. New borings were drilled adjacent to previous borings as closely as possible. Borings were drilled and sampled to confirm previous characterizations to original depths. Once the original depth was reached, borings were drilled, logged, and sampled for geotechnical purposes. All borings were drilled to a depth of at least 30 feet below the EDE of 377 ft-msl. All borings were drilled in accordance with the approved soil boring plan. The soil boring plan was approved by the TCEQ in a letter dated May 3, 2011 (see Figure E2-1). All drilling operations were supervised by a professional geoscientist or engineer who is familiar with the geology of the area and is licensed to practice in the state of Texas.

4.2 Previous Drilling Activities

Three previous subsurface investigations conducted at the site are described below. In addition, groundwater monitoring wells have been drilled and installed at the site and are described below. Borings were drilled in accordance with established field exploration methods. Installation, abandonment, and plugging of borings were performed in accordance with the TCEQ rules in effect at the time. Figure E2-2 illustrates the locations of all soil borings, piezometers, and monitoring wells previously advanced on site. All available boring logs are included in Appendix E2.

4.2.1 McBride-Ratcliff – 1987–1990

McBride-Ratcliff conducted an investigation in May 1987 that consisted of 27 borings (CB-1 through CB-27) drilled across the site. During this investigation, 23 piezometers (P-1 through P-23) were drilled in adjacent borings at the site.

4.2.2 HDR Engineering – 1991

HDR conducted an investigation from June 1991–1993 for a permit amendment that consisted of 29 soil borings (CB-28 through CB-56) drilled across the site. During this investigation, 13 piezometers (P-24 through P-36) were installed in adjacent borings at the site.

4.2.3 HDR Engineering – 1993

The near surface hydrogeology of the site was presented in reports prepared by HDR Engineering. Groundwater measurements were made in open boreholes after drilling. The 55 borings ranged in depth from 11 to 128 feet bgs, and water levels were measured in piezometers installed in the boreholes.

Large diameter test borings (LD-1 and LD-2) were drilled in the central portion of the site to provide a visual demonstration of both the source and extremely limited quantities of water in the subsurface clays. The borings were advanced into Stratum II to the approximate depth of the bottom of the proposed excavation. The location of LD-1 and LD-2 are shown on Figure E2-2 in Appendix E2.

The borings were drilled using a bucket auger rig. A 42-inch steel casing was installed in each boring down to a depth of 39 ft bgs that extended through the Stratum I clays. The purpose for the steel casing was to isolate Stratum II clays from the above strata in order to evaluate subsurface water conditions in the Stratum II clays. Both borings were then advanced into the Stratum II clays down to the depth of the proposed excavation grade elevation (432 to 437 ft msl) using a 36-inch diameter bucket. The total depth of LD-1 and LD-2 is 65 ft bgs (elevation 433.55 ft msl) and 75 ft bgs (elevation 428.85 ft msl), respectively. These depths represent penetrations to several feet below proposed excavation grade.

4.2.4 Southwestern Laboratories – 1983

Southwestern Laboratories conducted an investigation in August of 1983 that consisted of 11 borings (B-1 through B-11) drilled across the site.

4.2.5 Southwestern Laboratories – 1978

Southwestern Laboratories conducted an investigation in October of 1978 that consisted of four borings drilled in the vicinity of the original permit boundary.

4.2.6 Monitoring Well Installation

A total of 26 groundwater monitoring wells have been installed and are part of a Subtitle D groundwater monitoring system. Monitoring wells MW-1 and MW-4 through MW-13 were installed in 1995; MW-14 through MW-19 were installed in 1994; MW-20R was installed in 2003; MW-2R and MW-3R were installed in 2007; and MW-21 through MW-26 were installed in 2009.

4.3 Soil Boring Plan

A boring plan for this site was approved as complying with 30 TAC §330.63(e)(4) by a letter dated May 3, 2011 from the TCEQ (Figure E2-1). A plan of the borings is shown in Figure E2-2. The Skyline RDF expansion will include a lateral and vertical expansion. The area of the landfill that will have a modified depth includes 129.1 acres with 106.8 acres below currently permitted depths. As defined in §330.63(e)(4), the number of borings required for site characterization for a site the size of 100 to 150 acres is 20-23 borings, of which 12-13 must be drilled greater than 30 feet below the EDE. The boring plan proposed to deepen 22 previous borings, all of which will be drilled to depths greater than 30 feet below the EDE. All borings were drilled in accordance with 30 TAC §330.63(e)(4)(B). Subsurface conditions were evaluated by examination of logs from previous and recent site investigations. The depths of borings range from 35 to 205 feet. Piezometer installations are addressed in Section 5.4.3 of this attachment.

Table E-4
Skyline Landfill
Historical Borings

Boring No.	Surface Elevation	Depth	Elevation at Total Depth	Depth Above/ Below EDE**	Drill Date	Type
BME Borings (Deepened Previous Boring Location)						
CB-9	500.30	165	335.30	-41.70	8/22/2011	Boring
CB-15	458.50	125	333.50	-43.50	8/11/2011	Boring
CB-16	442.50	110	332.50	-44.50	8/19/2011	Boring
CB-17	524.70	190	334.70	-42.30	8/2/2011	Boring
CB-20	541.70	205	336.70	-40.30	8/5/2011	Boring
CB-21	521.34	185	336.34	-40.66	8/17/2011	Boring
CB-23	447.60	115	332.60	-44.40	7/21/2011	Boring
CB-24	508.70	175	333.70	-43.30	7/19/2011	Boring
CB-25	441.00	105	336.00	-41.00	7/14/2011	Boring
CB-26	422.69	90	332.69	-44.31	7/15/2011	Boring
CB-27	418.10	85	333.10	-43.90	7/14/2011	Boring
CB-28	423.80	90	333.80	-43.20	7/18/2011	Boring
CB-29	405.50	70	335.50	-41.50	7/13/2011	Boring
CB-30	430.90	95	335.90	-41.10	8/9/2011	Boring
CB-32	441.10	105	336.10	-40.90	7/12/2011	Boring
CB-33	432.92	100	332.92	-44.08	7/11/2011	Boring
CB-36	437.70	105	332.70	-44.30	8/10/2011	Boring
CB-37	442.80	110	332.80	-44.20	8/9/2011	Boring
CB-38	448.50	115	333.50	-43.50	8/24/2011	Boring
CB-43	439.00	103.9	335.10	-41.90	8/18/2011	Boring
CB-44	501.00	165	336.00	-41.00	8/15/2011	Boring
CB-56	472.92	140	332.92	-44.08	7/22/2011	Boring
HDR Engineering 1993 Large Diameter Borings						
LD-1	498.55	65	433.55	56.55	Aug 1993	Boring
LD-2	503.85	65	438.85	61.85	Aug 1993	Boring
HDR Engineering 1991 Borings/Piezometers						
CB-28	423.80	35	388.80	11.80	4/17/91	Boring
CB-29 (P-24)	405.50	35	370.50	-6.50	4/17/91	Piezometer
CB-30	430.90	50	380.90	3.90	4/22/91	Boring
CB-31 (P-27)	415.10	35	380.10	3.10	4/22/91	Piezometer
CB-32	438.30	45	393.30	16.30	4/22/91	Boring
CB-33	432.00	45	387.00	10.00	4/19/91	Boring
CB-34	473.30	80	393.30	16.30	4/24/91	Boring
CB-35	434.90	35	399.90	22.90	4/22/91	Boring
CB-36	437.70	45	392.70	15.70	4/23/91	Boring
CB-37	442.80	50	392.80	15.80	4/26/91	Boring
CB-38	448.50	50	398.50	21.50	4/24/91	Boring
CB-39 (P-25) (P-26)	493.80	100	393.80	16.80	4/22/91	Piezometer

Table E-4
Skyline Landfill
Historical Borings

Boring No.	Surface Elevation	Depth	Elevation at Total Depth	Depth Above/ Below EDE**	Drill Date	Type
CB-40 (P-28)	437.10	45	392.10	15.10	4/24/91	Piezometer
CB-41	485.40	85	400.40	23.40	4/25/91	Boring
CB-42	457.20	70	387.20	10.20	4/22/91	Boring
CB-43	439.00	35	404.00	27.00	4/23/91	Boring
CB-44	501.00	105	396.00	19.00	4/29/91	Boring
CB-45	441.50	35	406.50	29.50	4/19/91	Boring
CB-46 (P-29) (P-30)	472.40	65	407.40	30.40	4/26/91	Piezometer
CB-47	464.30	60	404.30	27.30	4/27/91	Boring
CB-48	492.30	80	412.30	35.30	4/20/91	Boring
CB-49 (P-35) (P-36)	493.70	80	413.70	36.70	5/2/91	Piezometer
CB-50	482.30	65	417.30	40.30	5/1/91	Boring
CB-51	492.10	75	417.10	40.10	4/30/91	Boring
CB-52	475.30	65	410.30	33.30	5/1/91	Boring
CB-53 (P-33) (P-34)	486.40	71	415.40	38.40	4/30/91	Piezometer
CB-54	468.90	50	418.90	41.90	4/26/91	Boring
CB-55 (P-31) (P-32)	474.50	60	414.50	37.50	4/29/91	Piezometer
CB-56	456.10	45	411.10	34.10	4/30/91	Boring
McBride-Ratcliff 1987 – 1990 Borings/Piezometers						
CB-1	489.50	70	419.50	42.50	5/21/87	Boring
CB-2	496.70	65	431.70	54.70	5/22/87	Boring
CB-3	479.20	80	399.20	22.20	5/19/87	Boring
CB-4	489.70	70	419.70	42.70	5/19/87	Boring
CB-5	496.00	80	416.00	39.00	5/18/87	Boring
CB-6 (P-5) (P-6) (P-10)	491.40	70	421.40	44.40	5/19/87	Boring
CB-7	474.60	70	404.60	27.60	5/21/87	Boring
CB-8	485.50	75	410.50	33.50	5/21/87	Boring
CB-9	502.70	70	432.70	55.70	5/17/87	Boring
CB-10 (P-7) (P-12)	435.80	40	395.80	18.80	5/21/87	Boring
CB-11	510.10	75	435.10	58.10	5/21/87	Boring
CB-12 (P-8) (P-9)	458.80	50	408.80	31.80	5/22/87	Boring
CB-13	433.40	50	383.40	6.40	5/20/87	Boring
CB-15	443.00	40	403.00	26.00	5/27/87	Boring
CB-16	440.40	50	390.40	13.40	5/20/87	Boring
CB-17	493.60	90	403.60	26.60	5/18/87	Boring
CB-18	414.60	40	374.60	-2.40	5/12/87	Boring
CB-19 (P-19) (P-20) (P-21) (P-22) (P-23)	414.00	60	354.00	-23.00	5/23/87	Boring
CB-20	506.10	100	406.10	29.10	5/16/87	Boring

Table E-4
Skyline Landfill
Historical Borings

Boring No.	Surface Elevation	Depth	Elevation at Total Depth	Depth Above/ Below EDE**	Drill Date	Type
CB-21 (P-14) (P-15) (P-16)	504.20	100	404.20	27.20	5/16/87	Boring
CB-22	414.30	35	379.30	2.30	5/14/87	Boring
CB-23 (P-1) (P-2)	447.60	45	402.60	25.60	5/21/87	Boring
CB-24	508.70	100	408.70	31.70	5/14/87	Boring
CB-25 (P-3) (P-4) (P-11) (P-13)	441.00	50	391.00	14.00	5/13/87	Boring
CB-26	444.50	50	394.50	17.50	5/12/87	Boring
CB-27	418.10	50	368.10	-8.90	5/13/87	Boring
McBride-Ratcliff 1987 Piezometers						
P-1	447.40	23	424.40	47.40	5/27/87	Piezometer
P-2	447.50	13.5	434.00	57.00	5/27/87	Piezometer
P-3	441.30	25	416.30	39.30	5/27/87	Piezometer
P-4	441.40	24	417.40	40.40	5/28/87	Piezometer
P-5	491.60	53	438.60	61.60	5/28/87	Piezometer
P-6	492.20	42	450.20	73.20	5/28/87	Piezometer
P-7	435.20	30	405.20	28.20	6/2/87	Piezometer
P-8	457.40	40	417.40	40.40	6/2/87	Piezometer
P-9	459.00	39	420.00	43.00	9/30/87	Piezometer
P-10	491.50	41	450.50	73.50	9/30/87	Piezometer
P-11	440.00	20	420.00	43.00	9/30/87	Piezometer
P-12	439.00	11	428.00	51.00	11/7/90	Piezometer
P-13	440.00	35	405.00	28.00	11/14/90	Piezometer
P-14	504.00	30.8	473.20	96.20	11/6/90	Piezometer
P-15	504.00	21.4	482.60	105.60	11/6/90	Piezometer
P-16	504.00	61	443.00	66.00	11/13/90	Piezometer
P-17	485.00	20	465.00	88.00	11/13/90	Piezometer
P-18	485.00	35	450.00	73.00	11/13/90	Piezometer
P-19	422.00	76	346.00	-31.00	11/15/90	Piezometer
P-20	424.00	22	402.00	25.00	11/14/90	Piezometer
P-21	424.00	12	412.00	35.00	11/14/90	Piezometer
P-22	424.00	43	381.00	4.00	11/16/90	Piezometer
P-23	424.00	128.1	295.90	-81.10	11/16/90	Piezometer
Southwestern Labs 1983 Borings						
B-1	530.00	40	490.00	113.00	8/12/1983	Boring
B-2	462.00	40	422.00	45.00	8/12/1983	Boring
B-3	532.00	40	492.00	115.00	8/12/1983	Boring
B-4	476.00	35	441.00	64.00	8/12/1983	Boring
B-5	434.00	15	419.00	42.00	8/12/1983	Boring
B-6	543.00	45	498.00	121.00	8/12/1983	Boring

Table E-4
Skyline Landfill
Historical Borings

Boring No.	Surface Elevation	Depth	Elevation at Total Depth	Depth Above/ Below EDE**	Drill Date	Type
B-7	427.00	20	407.00	30.00	8/12/1983	Boring
B-8	428.00	15	413.00	36.00	8/12/1983	Boring
B-9	434.00	15	419.00	42.00	8/12/1983	Boring
B-10	412.00	40	372.00	-5.00	8/12/1983	Boring
B-11	405.00	40	365.00	-12.00	8/12/1983	Boring
Southwestern Labs 1978 Borings						
B-1	476.00	90	386.00	9.00	10/16/1978	Boring
B-2	538.00	100	438.00	61.00	10/17/1978	Boring
B-3	448.00	60	388.00	11.00	10/18/1978	Boring
B-4	463.00	65	398.00	21.00	10/18/1978	Boring
Monitoring Wells						
MW-1	491.06	55	436.06	59.06	5/23/95	Monitoring Well
MW-2R	494.04	76	418.04	41.04	8/23/07	Monitoring Well
MW-3R	473.63	62	411.63	34.63	8/23/07	Monitoring Well
MW-4	433.82	25	408.82	31.82	5/12/95	Monitoring Well
MW-5	421.92	32	389.92	12.92	5/13/95	Monitoring Well
MW-6	416.81	25	391.81	14.81	5/11/95	Monitoring Well
MW-7	429.73	25	404.73	27.73	5/10/95	Monitoring Well
MW-8	444.06	25	419.06	42.06	5/12/95	Monitoring Well
MW-9	418.19	38	380.19	3.19	5/16/95	Monitoring Well
MW-10	415.30	49	366.30	-10.70	5/23/95	Monitoring Well
MW-11	415.10	37	378.10	1.10	5/17/95	Monitoring Well
MW-12	417.83	22	395.83	18.83	5/1/95	Monitoring Well
MW-13	432.23	25	407.23	30.23	5/15/95	Monitoring Well
MW-14	463.51	32.5	431.01	54.01	9/20/94	Monitoring Well
MW-15	448.66	25.5	423.16	46.16	9/20/94	Monitoring Well
MW-16	446.36	24.5	421.86	44.86	9/20/94	Monitoring Well
MW-17	489.85	57.5	432.35	55.35	9/20/94	Monitoring Well
MW-18	467.00	47.5	419.50	42.50	9/20/94	Monitoring Well
MW-19	441.25	31	410.25	33.25	9/20/94	Monitoring Well
MW-20R	464.63	35.5	429.13	52.13	10/20/03	Monitoring Well
MW-21	412.17	25	387.17	10.17	10/20/09	Monitoring Well
MW-22	429.45	33	396.45	19.45	10/20/09	Monitoring Well
MW-23	416.73	35	381.73	4.73	10/20/09	Monitoring Well
MW-24	421.58	20	401.58	24.58	11/9/09	Monitoring Well
MW-25	459.53	35	424.53	47.53	10/20/09	Monitoring Well
MW-26	448.09	20	428.09	51.09	9/29/09	Monitoring Well

*Surface elevation not included on original log. Surface elevation is an estimate only.

**Elevation of Deepest Excavation – 377 feet msl.

4.4 Site Stratigraphy

The facility is located on the outcrop of the Taylor Marl. The Taylor Marl is a very dense, low permeability formation consisting of calcareous clays. More than 150 borings have been drilled and sampled on the site and were examined to characterize site stratigraphic conditions. Four geologic cross sections are presented in Appendix E3 that incorporate historic and newly drilled borings. For identification purposes, the interpreted units have been labeled Stratum I and Stratum II. These sections illustrate the stratigraphy and lithology present beneath the site. Detailed descriptions of these strata are included in the following sections.

Table E-5
Skyline Landfill
Generalized Site Stratigraphy

Geologic Unit	Lithology	Average Depth to Top of Unit (ft)	Average Thickness of Unit (ft)	Hydrogeologic Unit
Stratum I Weathered Taylor Marl	Clay and Weathered Shale	Surface Outcrop	45	Uppermost Aquifer*
Stratum II Unweathered Taylor Marl	Shale, Clayey	40	400	Aquiclude

*The Taylor Marl is not recognized by the State of Texas as a regional aquifer but has been recognized by the TCEQ as such for groundwater monitoring purposes.

4.4.1 Stratum I – Weathered Taylor Marl

The weathered Taylor consists of 45 feet of brown to yellow to light gray, stiff to hard, clay weathered from the marl. The average thickness is about 45 feet. The samples range from dry and friable where they are above the water table to moist where they occur below the top of the water table. The weathered Taylor contains occasional calcareous and iron nodules and some silt and sand partings. Near vertical fracturing occurs as a result of the weathering process. Occasional angular jointing is present. Fractures and joints may be filled with calcite or gypsum. Fracture frequency decreases with depth. Field permeability testing of the material shows permeabilities ranging from 5.44×10^{-10} to 1.59×10^{-8} cm/sec. The geometric mean of calculated permeabilities is 4.23×10^{-9} cm/sec. A structural contour map of the top of the unweathered Taylor (base of the weathered Taylor) is shown on Figure E3-6. The previous stratigraphic description in the 1993 permit application for the site had divided this stratum into two strata, Stratum I and Stratum II. However, from a hydrogeologic perspective, this identification is not ultimately useful in describing the hydrogeology of the site.

Stratum I, as defined in this application, includes the uppermost groundwater zone at the site, which occurs in shallow, fractured, weathered Taylor Marl under unconfined, water table conditions. Groundwater in Stratum I is characterized by fracture flow. In the weathered marl, fracturing is abundant due to weathering processes and expansion from the release of overburden pressure. The groundwater movement in the weathered marl is characterized by flow through the interconnected vertical and horizontal fractures and bedding planes that have hydraulic characteristics of normally porous medium such as a sand or silt. The flow is generally topographically controlled.

4.4.2 Stratum II – Unweathered Taylor Marl

The unweathered Taylor consists of several hundred feet of dark gray to blue gray, hard clayey shale (marl) with iron stains, gypsum seams, and occasional fossils. The surface of the unweathered Taylor is the contact between the weathered and the unweathered Taylor. This surface is a result of the depth of weathering created by shrinking and swelling as a result of alternating rainfall and drying. Fifty-six soil borings penetrate into this unit at a minimum of 10 feet into this stratum. Geotechnical testing performed on samples from this strata concludes that this unit is primarily a clay. Some investigators refer to this material and this part of the Taylor as claystone.

As stated above, the stratigraphy of the site has been defined by the degree of weathering. To illustrate the unweathered surface of the Taylor Marl, a structural contour map of the top of the unweathered Taylor was prepared using information obtained from the borings (Figure E3-6). This map indicates that the unweathered unit (Stratum II) surface mimics the original surface topography and slopes to the north-northwest, as does the surface topography. These maps and the generalized cross sections (Figures E3-2 through E3-5) support the conclusion that the geologic units generally parallel the surface and are thus related to weathering processes, not to depositional processes.

Fracture density and fracture aperture decreases significantly in the unweathered marl. This decrease in fracturing with depth was observed in the samples from site borings and in excavations in the unweathered zone at this and other sites within the areas of Dallas and Ellis Counties. This decreased fracture density with depth corresponds to the lower permeability seen in permeability tests conducted in the unweathered zone compared to the permeability results for the weathered zones. Field permeability testing of the material shows permeabilities ranging from 1.61×10^{-8} to 8.54×10^{-10} cm/sec. The geometric mean of calculated permeabilities is 2.59×10^{-9}. Geologic and hydrogeologic characteristics observed in the deeper, unweathered Taylor Marl (Stratum II) indicate that this unit functions as an aquiclude or lower confining unit to the uppermost groundwater zone at the site.

5 GEOTECHNICAL DATA

30 TAC §330.63(e)(5)(A)-(F)

The geotechnical properties of the subsurface materials at this site are based on the subsurface investigations that are described in Section 4 of this attachment. The geotechnical design of the facility is provided in Attachment D5 – Geotechnical Design.

5.1 Laboratory Reports

Geotechnical tests were performed on samples recovered from each soil layer or stratum that will form the bottom and sides of the proposed excavation with test samples recovered up to 79 feet below the deepest excavation. The laboratory tests were performed by independent third party laboratories using the industry standards that were applicable at the time that the tests were performed. The results of the laboratory tests are compiled in Appendix E5 of this attachment. Descriptions of the tests, the number performed, and the test standards are summarized in Table E-6.

Table E-6
Skyline Landfill
Laboratory Test Summary

Test Description	Test Method	Number Of Tests
Sieve Analysis	ASTM D 1140	10
Atterberg Limits	ASTM D 4318	194
Moisture Content	ASTM D 2216	204
Unit Dry Weight	ASTM D 2937	54
Permeability	ASTM D 5084	6

Atterberg limits and sieve analysis tests were used to classify the soils according to the Unified Soil Classification System. In addition, the Atterberg limits and sieve analyses were used to estimate the parameters for the settlement/heave and slope stability calculations and to evaluate the suitability of the materials for use as compacted soil liner and final cover infiltration layer. The moisture content and unit dry weight tests were used to estimate the parameters used for the settlement/heave and the slope stability calculations.

The permeability tests were used to estimate the parameters used for the temporary dewatering system design and to evaluate the suitability of the materials for use as compacted soil liner and final cover infiltration layer.

A total of five vertical (two from Stratum I and three from Stratum II) and one horizontal (Stratum I) hydraulic conductivity tests have been performed on undisturbed samples from the current and previous explorations on the units that will form the bottom and sides of the proposed excavations. Attempts to trim horizontally oriented undisturbed samples from Stratum II that will form the sides of the excavations for laboratory hydraulic conductivity tests were unsuccessful. All of the Stratum II samples experienced some disturbance when attempts were made to trim them in a horizontal orientation. Therefore, field tests from the previous explorations were used to determine the horizontal permeability of the excavation sidewall soils. The laboratory and field test results were used to evaluate the hydrogeologic parameters of the site and the hydraulic conductivity of engineered fill constructed from on-site materials.

5.2 Material Characteristics

The results of the laboratory tests were reviewed along with the boring logs to develop the general soil properties of the subsurface materials that will be encountered in the excavations and provide the foundation for the landfill. As shown on the cross sections in Appendix E3 of this attachment, the excavation will encounter clayey material. Average properties of soil included in each stratum are summarized in Table E-7.

Table E-7
Skyline Landfill
Average Properties of On-Site Materials

Stratum	Material Classification	Liquid Limit %	Plastic Limit %	Plasticity Index %	Passing #200 %	Moisture Content %	Unit Dry Weight (lb/ft)	Lab Permeability (cm/sec[2])
I	CH	74	30	44	99	25.0	95.8	5.40×10^{-9}
II	CH	75	33	42	99	20.4	97.7	7.73×10^{-9}

[1]Refer to laboratory test summary in Appendix E5 for source data.
[2]Average lab permeability calculated based on arithmetic mean.

The geotechnical design calculations that are presented in Attachment D5 – Geotechnical Design, show that the in situ soils will provide adequate support for the proposed landfill. Total settlement beneath the liner system should be less than 6 inches and differential settlement should not exceed 4 inches, which is well within the strain tolerance of the proposed liner system. The factors of safety against slope failure exceeded the recommended factors of safety for all conditions that were analyzed.

5.3 Material Requirements

Onsite soils will be required for construction of the soil liner and protective cover components of the liner system, and the infiltration layer and erosion layer components of the final cover system. Onsite soils will also be required for operational cover (daily and intermediate) and general earthfill. Typical material requirements for the various landfill components are summarized in Table E-8.

The soil liner and final cover infiltration layer must be constructed from soils that can be compacted to form a low hydraulic conductivity barrier. The classification and hydraulic conductivity test results indicate that the clayey soils excavated from the site should be satisfactory for use as compacted soil liner and infiltration layer material.

Protective cover and the erosion layer soils should not contain large rocks or boulders. Operational cover soils shall not have been previously mixed with waste materials and erosion layer material shall be capable of sustaining vegetation. The test results and boring logs indicate that any of the soil material excavated from the site should be suitable for use as operational and protective cover, and that the surface soils should be suitable for use as the upper layer of the final cover system erosion layer.

General earthfill will be used to construct the site roads and embankments. The classification test results indicate that the onsite soils are suitable for use as structural fill material.

Table E-8
Skyline Landfill
Typical Soil Requirements for Landfill Construction

Landfill Component	Classification	LL	PI	% - 200	Hydraulic Conductivity cm/sec	Material Source
Soil Liner	SC, CL, CH, MH	30 min	15 min	30 min	1×10^{-7} max	On-site
Infiltration Layer	SC, CL, CH, MH	30 min	15 min	30 min	1×10^{-7} max	
Protective Cover	SP, SW, SM, SC, CL, CH, ML, MH	No large rocks				
Erosion Layer	SC, CL, CH, SM, ML, CL-ML	30 min	15 min	30 min	NA	
Operational Cover (Daily Cover, Intermediate Cover)	SP, SC, CL, CH, CL-ML, MH, ML	Not mixed with waste				
General Fill	SC, CL, CH, ML, CL-ML, MH	NA	5 min	15 min	NA	

5.4 Groundwater Occurrence

5.4.1 Groundwater Observation Points – Piezometers/Monitoring Wells

Groundwater observation points are summarized in Table E-9. Data from 36 piezometers and 26 groundwater monitoring wells, as well as the information from borings, were used to characterize site hydrogeology (see Appendix E3 for cross sections).

Monitoring well data sheets, well reports, and logs of piezometers are provided in Appendix E2 and are summarized in Table E-9 below. Piezometer locations are shown on Figure E2-2 of this attachment. Monitoring well details are provided in Attachment F.

Table E-9
Skyline Landfill
Piezometer and Groundwater Monitoring Well Details

Well Name	Install Date	Total Depth (ft bgs)	Surface Elevation (ft msl)	Top of Casing Elevation (ft msl)	Filter Pack Top Elevation (ft msl)	Top Screen Elevation (ft msl)	Layer/ Lithology Screened
MONITORING WELLS							
MW-1	5/23/95	55	491.06	506.63	461.06	459.06	Weathered Taylor Marl
MW-2R	8/23/07	76	494.04	497.24	442.04	439.04	Weathered Taylor Marl
MW-3R	8/23/07	62	473.63	476.69	435.63	432.63	Weathered Taylor Marl
MW-4	5/12/95	25	433.82	437.00	428.82	426.82	Weathered Taylor Marl
MW-5	5/13/95	32	421.92	425.14	416.92	414.92	Weathered Taylor Marl
MW-6	5/11/95	25	416.81	419.96	411.81	409.81	Weathered Taylor Marl
MW-7	5/10/95	25	429.73	432.67	424.73	422.73	Weathered Taylor Marl
MW-8	5/12/95	25	444.06	447.06	439.06	437.06	Weathered Taylor Marl
MW-9	5/16/95	38	418.19	421.64	405.19	403.19	Weathered Taylor Marl
MW-10	5/23/95	49	415.30	417.53	391.80	389.30	Weathered Taylor Marl
MW-11	5/17/95	37	415.10	417.59	403.60	401.10	Weathered Taylor Marl
MW-12	5/1/95	22	417.83	420.95	412.83	410.83	Weathered Taylor Marl
MW-13	5/15/95	25	432.23	435.22	427.23	425.23	Weathered Taylor Marl
MW-14	9/20/94	32.5	463.51	466.71	455.51	453.51	Weathered Taylor Marl
MW-15	9/20/94	25.5	448.66	452.20	442.66	440.66	Weathered Taylor Marl
MW-16	9/20/94	24.5	446.36	449.56	441.36	439.36	Weathered Taylor Marl
MW-17	9/20/94	57.5	489.85	492.75	456.85	454.85	Weathered Taylor Marl
MW-18	9/20/94	47.5	467.00	470.20	444.00	442.00	Weathered Taylor Marl
MW-19	9/20/94	31	441.25	444.45	434.25	432.75	Weathered Taylor Marl
MW-20R	10/20/03	35.5	464.63	468.03	452.63	450.13	Weathered Taylor Marl

Table E-9
Skyline Landfill
Piezometer and Groundwater Monitoring Well Details

Well Name	Install Date	Total Depth (ft bgs)	Surface Elevation (ft msl)	Top of Casing Elevation (ft msl)	Filter Pack Top Elevation (ft msl)	Top Screen Elevation (ft msl)	Layer/ Lithology Screened
MW-21	10/20/09	25	412.17	414.90	402.17	400.17	Weathered Taylor Marl
MW-22	10/20/09	33	429.45	432.26	411.45	409.45	Weathered Taylor Marl
MW-23	10/20/09	35	416.73	419.46	396.73	394.73	Weathered Taylor Marl
MW-24	11/9/09	20	421.58	424.62	412.58	409.58	Weathered Taylor Marl
MW-25	10/20/09	35	459.53	462.33	439.53	437.53	Weathered Taylor Marl
MW-26	9/29/09	20	448.09	451.06	438.09	436.09	Weathered Taylor Marl
PIEZOMETERS							
P-1 (CB-23)	5/27/87	23	447.40	451.40	432.40	430.40	Weathered Taylor Marl
P-2 (CB-23)	5/27/87	13.5	447.50	449.50	442.50	439.00	Weathered Taylor Marl
P-3 (CB-25)	5/27/87	25	441.30	445.30	436.30	421.30	Weathered Taylor Marl
P-4 (CB-25)	5/28/87	24	441.40	443.40	425.40	423.40	Unweathered Taylor Marl
P-5 (CB-6)	5/28/87	53	491.60	493.60	448.60	444.60	Unweathered Taylor Marl
P-6 (CB-6)	5/28/87	42	492.20	495.20	487.20	455.20	Weathered Taylor Marl
P-7 (CB-10)	6/2/87	30	435.20	441.20	430.20	411.20	Weathered Taylor Marl
P-8 (CB-12)	6/2/87	40	457.40	461.90	452.40	422.40	Weathered/Unweathered Taylor Marl
P-9 (CB-12)	9/30/87	39	459.00	462.00	430.00	422.00	Unweathered Taylor Marl
P-10 (CB-6)	9/30/87	41	491.50	494.50	460.50	452.50	Weathered Taylor Marl
P-11 (CB-25)	9/30/87	20	440.00	443.00	430.00	422.00	Weathered Taylor Marl
P-12 (CB-10)	11/7/90	11	439.00	442.20	434.00	433.10	Weathered Taylor Marl
P-13 (CB-25)	11/14/90	35	440.00	443.00	412.00	410.10	Unweathered Taylor Marl
P-14 (CB-21)	11/6/90	30.8	504.00	507.00	479.00	477.90	Weathered Taylor Marl
P-15 (CB-21)	11/6/90	21.4	504.00	507.00	489.00	487.70	Weathered Taylor Marl
P-16 (CB-21)	11/13/90	61	504.00	507.00	450.00	448.10	Unweathered Taylor Marl
P-17	11/13/90	20	485.00	488.00	472.00	470.10	Weathered Taylor Marl
P-18	11/13/90	35	485.00	488.00	457.00	455.10	Weathered Taylor Marl
P-19	11/15/90	76	422.00	425.00	352.60	351.10	Unweathered Taylor Marl
P-20	11/14/90	22	424.00	427.00	409.00	407.10	Weathered Taylor Marl
P-21	11/14/90	12	424.00	427.00	420.00	418.10	Weathered Taylor Marl
P-22	11/16/90	43	424.00	426.00	388.00	386.10	Unweathered Taylor Marl
P-23	11/16/90	128.1	424.00	427.00	303.00	301.00	Unweathered Taylor Marl
P-24* (CB-29)	5/9/91	35	405.50	406.78	381.50	385.50	Unweathered Taylor Marl
P-25* (CB-39)	5/9/91	100	493.80	495.53	406.80	401.80	Unweathered Taylor Marl
P-26* (CB-39)	5/9/91	48	493.80	497.44	456.80	451.80	Weathered Taylor Marl
P-27* (CB-31)	5/9/91	35	415.10	417.20	392.10	387.10	Unweathered Taylor Marl

Table E-9
Skyline Landfill
Piezometer and Groundwater Monitoring Well Details

Well Name	Install Date	Total Depth (ft bgs)	Surface Elevation (ft msl)	Top of Casing Elevation (ft msl)	Filter Pack Top Elevation (ft msl)	Top Screen Elevation (ft msl)	Layer/ Lithology Screened
P-28* (CB-40)	5/9/91	45	437.10	440.61	405.10	400.10	Unweathered Taylor Marl
P-29* (CB-46)	5/9/91	65	472.40	474.27	420.90	414.40	Unweathered Taylor Marl
P-30* (CB-46)	5/9/91	31	472.40	475.25	452.40	447.40	Weathered Taylor Marl
P-31* (CB-55)	5/9/91	60	474.50	476.48	426.50	421.50	Unweathered Taylor Marl
P-32* (CB-55)	5/9/91	39	474.50	477.60	446.50	441.50	Unweathered Taylor Marl
P-33* (CB-53)	5/9/91	70	486.40	489.43	428.40	422.40	Unweathered Taylor Marl
P-34* (CB-53)	5/9/91	45	484.40	487.67	451.40	447.90	Unweathered Taylor Marl
P-35* (CB-49)	5/9/91	80	493.70	495.33	430.20	419.70	Unweathered Taylor Marl
P-36* (CB-49)	5/9/91	40	493.70	496.44	493.70	459.70	Unweathered Taylor Marl

**Surface elevations were not given on piezometer installation logs. However, the surface elevations provided are from the corresponding soil boring near the piezometer.*

Note:

The site is founded in fat clay of the Taylor Formation. These clays are subjected to shrink swell, which causes minor fluctuations of survey data.

5.4.2 Water Level Measurements During Drilling

The depth at which groundwater was encountered and records of after-equilibrium measurements in all borings is included in Table E-12. The cross sections are annotated to note the level at which groundwater was first encountered and the level of groundwater after equilibrium was reached prior to plugging. 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 water observation data. Although, in cases where water levels were identified prior to introduction of drilling water, those water levels are included in Table E-12.

5.4.3 Piezometer Installations

Twenty-three piezometers (P-1 through P-23) were installed in adjacent borings during the McBride-Ratcliff investigation (1987 to 1990). During the HDR Engineering (1991) investigation, 13 piezometers were drilled and installed at the site. No piezometers remain at the facility. All were previously plugged and abandoned in accordance with appropriate regulations in effect at the time.

5.4.4 Groundwater Monitoring Well Installations

A total of 26 groundwater monitoring wells have been installed and are part of a Subtitle D groundwater monitoring system. Monitoring wells MW-1 and MW-4 through MW-14 were installed in 1995; MW-15 through MW-19 were installed in 1994; MW-20R was installed in 2003; MW-2R and MW-3R were installed in 2007; and MW-21 through MW-26 were installed in 2009.

5.4.5 Water Level Measurements

Water levels were measured in site piezometers from June 1987 to June 1991. Water levels at the site have been measured from December 1994 to the present in site monitoring wells. These data are compiled in Tables E-10 and E-11. 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).

Table E-10
Skyline Landfill
Historic Water Levels – Monitoring Wells

Sampling Date	MW-1	MW-2	MW-2R	MW-3	MW-3R	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12	MW-13
Dec-94															
Mar-95															
Jun-95															
Sep-95	486.95	453.65						394.69		423.12	406.60	409.50	408.47		
Dec-95	485.02	453.17						394.64		421.31	406.17	407.64	407.58	397.73	
Mar-96	484.06	453.71						394.90		421.34	406.00	406.57	407.38	399.06	
Jun-96	483.48	453.16						394.37		420.90	405.60	406.01	407.39	397.77	
Sep-96	484.54	453.33						394.02		420.62	404.80	405.84	407.87	400.52	
Dec-96	486.34	454.05						394.25		420.94	407.94	407.13	408.52	413.31	
Mar-97	487.75	454.03						394.64		430.10	410.37	409.04	409.20	416.71	
Jun-97	485.92	454.31						395.16		428.70	410.67	409.92	409.53	411.90	
Sep-97															
Dec-97	486.48	454.44						396.16		427.05	406.46	407.02	408.38	403.52	
Mar-98									421.67						
Jun-98	489.10	454.18						395.36	408.75	426.31	406.63	406.46	407.97	410.86	
Sep-98															
Jun-01	468.53	454.44								426.68	403.98	403.80	406.47	409.48	
Aug-01														399.99	
Dec-01	469.32	454.09		DRY		DRY	DRY	409.71	DRY	426.30	403.26	402.70	405.92	399.35	DRY
Jun-02	469.52	453.73		DRY		DRY	DRY	399.22	DRY	426.64	404.50	402.98	406.14	411.27	DRY
Dec-02	469.98	453.45		DRY		DRY	DRY	395.39	407.79	425.93	402.30	401.88	405.82	401.61	DRY
Jun-03	470.22	453.10		DRY		DRY	DRY	394.18	DRY	426.07	402.65	401.96	405.76	400.77	DRY
Aug-03															
Dec-03	469.26	452.55		DRY		DRY	DRY	DRY	DRY	425.80	401.36	400.78	405.38	DRY	DRY
Jun-04	469.86	452.71		DRY		DRY	DRY	395.71	DRY	426.70	402.72	402.07	406.28	404.91	DRY
Dec-04	470.71	453.47		DRY		DRY	DRY	395.29	405.30	427.93	402.82	403.12	407.47	403.43	DRY
Jun-05	469.50	452.19		431.60		DRY	DRY	394.11	DRY	426.10	403.50	403.84	407.04	408.97	DRY
Dec-05	469.56	451.09		430.62		DRY	DRY	DRY	DRY	425.69	400.74	400.78	405.44	400.31	DRY
Jun-06	468.60	450.63		430.46		DRY	DRY	407.31	DRY	425.16	400.24	399.68	404.76	403.49	DRY
Dec-06	469.80	451.08		430.50		DRY	DRY	404.79	DRY	422.55	399.88	398.98	404.82	398.73	DRY
Mar-07		450.73		DRY		DRY	DRY	397.33	DRY	426.62	400.66	399.53	405.87	DRY	DRY
Jun-07	469.52	450.63		DRY		DRY	DRY	DRY	DRY	427.20	401.10	399.86	406.75	DRY	DRY
Dec-07	470.38		430.13		DRY	DRY	DRY	395.06	DRY	426.50	401.80	400.30	407.08	DRY	DRY
Jun-08	471.88		424.23		DRY	DRY	DRY	394.69	DRY	426.65	401.90	401.32	407.92	DRY	DRY
Dec-08	470.75		425.98		DRY	DRY	DRY	395.73	DRY	426.05	399.80	399.01	406.12	DRY	DRY
Jun-09	470.05		428.91		464.86	DRY	DRY	395.53	DRY	426.31	399.94	399.26	407.60	411.46	DRY
Sep-09	469.66		423.63		437.80	DRY	DRY	394.48	DRY	424.20	398.30	397.78	406.62	407.07	DRY
Dec-09	470.63		434.68		470.23	DRY	DRY	393.73	DRY	428.06	400.27	399.31	409.00	414.44	DRY
Mar-10			443.28		467.68	DRY	DRY	393.73	DRY	429.18	401.90	400.58	410.00	416.07	DRY
Jun-10	472.25		449.08		465.68	DRY	DRY	DRY	DRY	426.38	400.83	399.98	408.42	411.57	DRY
Sep-10			445.85		468.33	DRY	DRY	DRY	406.67					408.07	DRY
Dec-10	471.63		451.47		465.46	DRY	DRY	DRY	DRY	426.21	398.89	398.34	406.75	405.38	DRY
Jan-11															
Mar-11			445.99		466.68	413.05	DRY	DRY	DRY					414.20	DRY
May-11			439.88												
Jun-11	483.83		430.50		465.88	437.00	425.14	419.96	432.67	425.46	398.92	397.75	407.47	409.47	435.22
Sep-11						DRY	DRY	DRY	DRY						DRY

Table E-10
Skyline Landfill
Historic Water Levels – Monitoring Wells (Continued)

Sampling Date	MW-14	MW-15	MW-16	MW-17	MW-18	MW-19	MW-20	MW-20R	MW-21	MW-22	MW-23	MW-24	MW-25	MW-26
Dec-94	454.65		432.96	453.65	459.26	438.16	434.37							
Mar-95	451.96	424.80	442.36	460.17	463.50	437.38	438.72							
Jun-95	450.21	425.96	443.08	461.91	465.23	436.75	438.93							
Sep-95	450.18	426.01	441.25	461.36	463.27	436.57	437.58							
Dec-95	448.78	425.21	437.20	461.26	461.44	436.51	436.67							
Mar-96	447.36	425.37	437.16	462.60	461.27	436.88	440.40							
Jun-96	447.11		438.74	462.71	461.31	435.88	434.84							
Sep-96	449.63	425.34	440.02	462.68	463.39	436.60	437.19							
Dec-96	449.89	425.05	440.94	463.04	464.80	437.11	438.18							
Mar-97	449.61	424.95	441.01	462.96	466.00	436.40	439.45							
Jun-97	449.23	426.80	441.80	463.42	463.74	435.50	438.64							
Sep-97		426.47												
Dec-97	450.06	429.94	441.42	464.47	462.91	437.80	440.03							
Mar-98		426.80												
Jun-98	448.94	427.63	442.26	465.14	462.37	436.60	441.87							
Sep-98		426.25												
Jun-01	452.19	431.92	442.76	469.69	461.76	435.67	443.54							
Aug-01		427.80	438.26											
Dec-01	452.84	427.16	438.96	468.76	460.53	436.60	439.80							
Jun-02	451.42	428.56	443.34	471.62	462.24	434.92	441.32							
Dec-02	451.14	428.07	441.13	470.52	459.80	436.00	438.36							
Jun-03	452.07	432.60	442.25	470.71	461.34	434.58	DRY							
Aug-03		427.86												
Dec-03	450.69	DRY	440.04	469.12	458.88	435.26								
Jun-04	452.87	429.44	442.99	470.17	461.81	434.70		438.97						
Dec-04	452.02	433.63	443.25	471.54	462.49	436.43		439.93						
Jun-05	451.23	436.56	442.19	470.44	461.04	434.19		439.63						
Dec-05	448.33	428.25	435.62	470.02	457.90	435.02		437.35						
Jun-06	450.77	426.30	437.64	469.56	458.90	433.97		437.99						
Dec-06	451.00	426.47	437.56	469.39	458.24	435.87		437.03						
Mar-07	452.46	427.28	440.44	469.82	459.56	435.65		436.03						
Jun-07	454.26	443.40	442.41	476.64	461.38	434.83		435.58						
Dec-07	452.91	442.52	441.82	470.79	462.05	435.91		440.83						
Jun-08	452.66	441.58	442.73	471.89	462.49	434.50		444.92						
Dec-08	449.41	433.80	437.63	470.42	459.08	435.20		440.88						
Jun-09	453.34	441.87	438.36	470.83	460.90	434.27		440.83						
Sep-09	451.72	432.46	439.08	469.36	459.87	433.90		436.03						
Dec-09	454.31	443.38	443.53	477.50	463.02	435.38		437.03						
Mar-10	454.15	443.65	444.01			435.04			DRY	DRY	401.96	420.16	437.93	DRY
Jun-10	452.54	440.98	442.05	474.64	462.22	433.76		445.28	390.25	398.46	400.34	416.99	437.83	DRY
Sep-10		434.05							388.90	410.06	398.57	415.97	438.66	DRY
Dec-10	450.57	430.57	439.64	472.27	460.44	435.18		447.83	389.63	400.81	398.42	417.78	438.42	DRY
Jan-11				473.90										
Mar-11									388.35	400.26	399.61	419.82	438.80	DRY
May-11														
Jun-11	452.08	439.84	440.86	474.03	461.48	434.10		447.73	DRY	DRY	398.11	416.92	438.81	DRY
Sep-11									DRY	403.21	396.41	410.80	437.89	DRY

Note: The site is founded in fat clay of the Taylor Formation. These clays are subjected to shrink swell, which causes minor fluctuations of survey data.

Table E-11
Skyline Landfill
Historic Water Levels – Piezometers
June 1987 through January 1991

Date	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16	P-17	P-18	P-19	P-20	P-21	P-22	P-23
6/87	DRY	DRY	DRY	429.0	NR	454.4	**	**	-	-	-												
7/87	DRY	DRY	418.5	428.5	445.4	457.9	406.2	442.1	-	-	-												
10/87	DRY	DRY	419.3	425.3	445.4	458.1	406.2	432.7	423.0	458.8	424.3												
11/87*	DRY	DRY	419.8	423.9	444.0	457.7	408.5	436.6	433.6	458.8	427.3												
3/88*	446.0	DRY	426.5	429.0	457.9	461.2	436.9	438.3	441.1	461.1	427.9												
5/88*	430.7	DRY	428.4	427.6	459.2	459.8	PLUG	437.4	440.4	459.4	426.6												
11/7/90	430	DRY	422.7	424.2	443	453.9	PLUG	436.8	426.6	453.7	417.8												
11/16/90	428.2	DRY	417	424.8	445.5	454.3	PLUG	437.6	428.6	454.8	423.9	DRY	DRY	478.2	DRY	DRY	466.5	DRY	DRY	DRY	DRY	DRY	DRY
12/18/90	428.2	DRY	418.5	425.1	450.4	458	PLUG	438.7	439.4	457.7	424.1	DRY	DRY	491.1	DRY	448.6	477.5	465.2	456.2	403.2	DRY	389.1	296.1
1/9/91	428.6	DRY	435.4	426.6	451.3	458.5	PLUG	439.8	441.2	458.3	425.6	DRY	406.0	492.0	483.5	454.9	477.3	470.7	366.3	404.9	DRY	396.0	296.3

Source: Table 11-1, 1995 Permit; includes notes from source.

NR – No Record

* – Observed by WMNA personnel.

** – Installation was performed on this date.

Table E-11
Skyline Landfill
Historic Water Levels – Piezometers (Continued)
April 1991 through June 1991

P-1 through P-18

Date	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16	P-17	P-18
4/16/91	428.34	DRY	432.57	430.08	457.25	458.99	PLUG	443.10	445.31	458.76	428.97	DRY	407.15	491.55	485.44	471.40	479.10	477.36
4/24/91	428.31	DRY	432.33	430.13	457.51	459.01	PLUG	443.12	442.34	458.79	429.03	DRY	407.22	491.49	485.58	471.29	479.39	477.55
5/1/91	428.28	DRY	431.78	429.39	457.67	458.95	PLUG	443.15	442.35	458.70	429.33	DRY	407.31	491.41	485.68	473.07	479.38	477.72
5/7/91	428.25	DRY	431.59	429.29	457.70	458.92	PLUG	443.16	442.39	458.69	428.24	DRY	407.36	491.38	485.79	473.72	479.40	477.82
5/13/91	428.24	DRY	431.37	430.25	457.83	459.15	PLUG	443.14	442.43	458.99	429.19	DRY	407.43	491.38	485.89	474.34	479.61	477.94
5/24/91	428.46	DRY	431.29	429.41	457.92	459.13	PLUG	443.57	442.62	458.96	428.37	DRY	407.54	491.31	486.03	475.35	479.62	478.16
5/30/91	428.13	DRY	431.30	429.80	457.99	459.25	PLUG	443.60	442.71	459.12	428.73	DRY	407.60	491.30	486.14	475.91	479.65	478.23
6/12/91	428.10	DRY	430.86	429.47	458.08	459.27	PLUG	443.55	442.80	459.09	428.43	DRY	407.75	491.25	486.34	475.84	479.67	478.07

P-19 through P-36

Date	P-19	P-20	P-21	P-22	P-23	P-24	P-25	P-26	P-27	P-28	P-29	P-30	P-31	P-32	P-33	P-34	P-35	P-36
4/16/91	392.15	409.95	DRY	409.08	303.57	*	*	*	*	*	*	*	*	*	*	*	*	*
4/24/91	393.21	410.25	DRY	409.55	304.38	*	*	*	*	*	*	*	*	*	*	*	*	*
5/1/91	393.21	410.46	DRY	409.93	305.02	*	*	*	*	*	*	*	*	*	*	*	*	*
5/7/91	394.97	410.67	DRY	410.26	305.77	*	*	*	*	*	*	*	*	*	*	*	*	*
5/13/91	395.68	410.89	DRY	410.58	306.45	#	#	#	#	#	#	#	#	#	#	#	#	#
5/24/91	396.83	411.16	DRY	411.03	307.55	400.23	411.86	452.30	DRY	DRY	420.38	448.79	445.38	458.96	431.13	481.76	428.01	486.81
5/30/91	397.43	411.36	DRY	411.33	308.25	400.40	413.28	452.26	DRY	DRY	420.13	448.60	447.72	459.21	434.98	481.70	431.28	486.98
6/12/91	397.26	411.01	DRY	411.80	309.61	400.41	416.06	452.54	DRY	DRY	420.39	448.07	450.24	459.35	442.55	481.44	437.86	487.06

Source: Table 11-3, 1995 Permit; includes notes from source.

* – Piezometers being installed during 1991 study.

– Piezometers evacuated using air on this date.

Table E-12
Skyline Landfill
Groundwater Observations During Drilling

Boring No.	Install Date	Well Depth (ft)	Surface Elevation (msl)	Water Level During Drilling Depth to Water (ft)	Stabilized Depth to Water (ft)	Groundwater Elevation (msl)
PREVIOUS BORINGS CB-1 THROUGH CB-56						
CB-19	5/23/1987	60	414.00	22.0	7.0	407.00
CB-26	5/12/1987	50	444.50	13.0	7.8	436.70
CB-28	4/17/1991	35	423.80		412.7	11.10
CB-34	4/24/1991	80	473.30		456.4	16.90
CB-36	4/23/1991	45	437.70		419.5	18.20
CB-44	4/29/1991	105	501.00		465.0	36.00
CB-47	4/27/1991	60	464.30		457.4	6.90
CB-48	4/20/1991	80	492.30		482.9	9.40
CB-50	5/1/1991	65	482.30		478.4	3.90
CB-51	4/30/1991	75	492.10		488.8	3.30
CB-52	5/1/1991	65	475.30		473.1	2.20
SOUTHWESTERN LABS BORINGS – 1983						
B-1	8/12/1983	40	530.00		35.0	495.00
B-2	8/12/1983	40	462.00		32.0	430.00
B-3	8/12/1983	40	532.00		39.5	492.50
B-4	8/12/1983	35	476.00		32.0	444.00
B-6	8/12/1983	45	543.00		14.0	529.00
B-9	8/12/1983	15	434.00		8.0	426.00
B-11	8/12/1983	40	405.00		4.0	401.00

Note: Borings not listed had no indication of groundwater observed during drilling prior to the introduction of drilling water.

5.5 Groundwater Monitoring Analytical Data

A tabulation of historic groundwater chemistry results is provided in Appendix E7. The history of the groundwater monitoring program at the site is discussed in Attachment F.

5.6 Site Hydrogeology

5.6.1 Hydrogeologic Units

5.6.1.1 Stratum I – Weathered Taylor Marl / Uppermost Aquifer

Groundwater is contained in the weathered Taylor Marl as seen in site piezometers and groundwater monitoring wells. Groundwater enters the Taylor Marl at its surface outcrop. Groundwater flow generally mimics the natural site topography and flows predominantly to the east and northeast parts of the site. The groundwater movement in the weathered marl is characterized by flow through the weathered, interconnected vertical and horizontal fractures and bedding planes. Fracture frequency decreases with depth. Extensive near surface weathering of the upper portions (30 to 40 feet) of the Taylor have created fractures and slickensides from the repeated shrinking and swelling of the clays that make up the Taylor so that it has hydraulic characteristics (hydraulic conductivity) equivalent to a normally porous medium such as sand or silt. The geometric mean of calculated permeabilities for Stratum I is 4.23 x 10^{-9} cm/sec. Figures E6-1 through E6-5 show a series of potentiometric surface maps of the groundwater in the weathered Taylor.

The Taylor Marl is a clayey shale that is made up of clay particles. Clay particles have large surface areas per unit weight compared to typical sand and silt particles. The large surface areas can attract negatively and positively charged ions through adsorption. Inorganic constituents in the groundwater may be adsorbed to the clay particles thereby slowing or stopping contaminant movement (Brady and Weil, 2007).

5.6.1.2 Stratum II – Unweathered Taylor Marl / Lower Confining Unit

Groundwater occurring in deeper fractures of the unweathered marl would be recharged by the slow, downward movement of groundwater from the overlying shallow, weathered marl zone. Vertical movement of groundwater is retarded by unfractured or slightly fractured, low permeability materials in the Taylor Formation. Only a small fraction (less than 1 percent) of the groundwater that moves through the surficial bedrock moves downward into the unweathered bedrock (Dutton et al., 1994). Once the overlying weathered marl is removed, the underlying unweathered marl will not produce any significant hydrostatic pressure. This has been observed for years in actual constructions at the existing landfill site. Other than surface runoff from heavy periods of rain, open excavations in the existing landfill area remain dry. The minimal seeps observed in weathered sections of excavation walls dissipate rapidly, with no ponding on the excavation floor.

Observations made during the large diameter test borings demonstrate the limited quantities of water in the subsurface and that saturated conditions do not exist in the unweathered Taylor Marl.

Studies of the Taylor Marl in Ellis County, Texas that employed groundwater dating methods suggest that groundwater in weathered Taylor Marl was recharged within the last 40 to 50 years; that groundwater in the slightly weathered, less fractured, less interconnected Taylor bedrock was recharged within the last 15,000 to 20,000 years; and that the average age of the groundwater in the unweathered Taylor Marl is 1 million years (Dutton et al., 1994). This age dating of groundwater in the unweathered suggests that the deeper water is either not recharged from overlying infiltration through connection to shallow fracturing or poorly recharged. It also suggests that groundwater infiltrating from the surface moves slowly downward in the weathered zone until it meets the lower permeability, unweathered zone. Groundwater then flows laterally within the weathered zone. The mean hydraulic conductivity for Stratum II is 4.23 x 10^{-9} cm/sec.

Due to the scarcity of fractures and the resulting lower hydraulic conductivity in the decreasing fractures with depth, the unweathered Taylor Marl is the lower confining unit (aquiclude) to the overlying weathered Taylor that serves as the uppermost aquifer at this site for groundwater monitoring purposes.

5.6.2 Hydraulic Conductivity – Field Permeability Tests

Field permeability tests were performed in twenty-one piezometers. The test results are summarized in Table E-13. The geometric mean of permeabilities calculated for Stratum I is 4.23×10^{-9} cm/sec and 2.59×10^{-9} cm/sec for Stratum II.

Hydraulic conductivity values were calculated using Hvorslev's method for piezometers P-3, P-5, P-6, P-8, P-9, P-11, P-14, P-16, P-17, P-18, P-19, P-20, P-22, P-23, P-25, P-26, P-29, P-30, P-31, P-33, and P-35.

5.6.3 Groundwater Flow Direction and Rate

5.6.3.1 Groundwater Flow Direction

Groundwater occurs at the site in the weathered Taylor Marl and upper part of the unweathered Taylor Marl. Groundwater flow is structurally controlled and mimics the topography. Permeability in the Taylor Marl is related to the depth of weathering of the Taylor and is thus related to the surface topographic expression. The top of the unweathered map (Figure E3-6) shows a strong resemblance to the topography. Groundwater in the Taylor Marl at the site flows from the south end of the site to the north, generally toward Ten Mile Creek. Groundwater flow direction is influenced by the depth of weathering and the unweathered surface (Figure E3-6) , which is influenced by the topography (Figure E6-8). Minor fluctuations in the unweathered surface and thus the potentiometric surface show minor variations in the groundwater flow directions to the northwest and northeast perimeters. Groundwater flow from the south is diverted around the composite lined excavation. Normal groundwater flow directions prevail north of the site as precipitation infiltration reaches the water table. A conceptual hydrogeologic cross section and a conceptual hydrogeologic flow model are included as Figures E6-9 and E6-10. The excavation is extended well into the low permeability unweathered Taylor. As such, a leachate leak is unlikely to migrate into the unweathered Taylor groundwater. Because normal recharge caused by infiltration of precipitation has been cut off over a larger area (the landfill footprint), water levels may be lower than normal in some areas. Because of this, several monitoring wells are periodically dry. Wells MW-2R, MW-3R, MW-4, and MW-5 on the west side of the site are frequently dry. MW-7 is dry on the north side. MW-13 on the northeast side of the site are also often dry, indicating that normal recharge and thus groundwater flow in those areas has been cut off.

The original site characterization included in the 1991 permit application showed multiple piezometers installed to identify groundwater in the weathered Taylor. Water levels from piezometers are included in Table E-11. A pre-excavation potentiometric surface map from June 1991 is included as Figure E6-7. Most of the piezometers demonstrated groundwater occurrence during the characterization. Thirty-five piezometers were installed in clustered locations, and piezometers at all locations encountered groundwater during the characterization period of 1987–1993. Water levels from existing monitoring wells are shown in Table E-10. As shown in the table, the areas near MW-4, MW 5, MW-7, and MW-13 are now consistently dry.

Initial development occurred with excavation of Cell 1 in the center of the site. This cell opened in 1995 so excavation was completed prior to that. Cell development then moved southward. By 1999 excavation and cell development had proceeded through the center of the site to the southern extent of the site. All development then moved clockwise from south to north along the west side.

Cell development consists first of excavation of the Taylor Marl. The process of excavation and the accompanying dewatering creates an inward gradient. Once the liner and underdrain are installed, the inward gradient persists. Also, when the liner is installed, recharge by infiltration of precipitation is prevented by the liner.

There are currently three areas along the site perimeters where monitoring wells are periodically dry. First, on the west side, MW-3R, MW-4, and MW-5 are dry. MW-3R was dry upon installation in 2007, but has produced water since June 2009. MW-4 and MW-5 have been dry since 2001, except during two groundwater events.

The second area, near MW-7 on the north side, initially had water and then was intermittently dry through 2010. Since 2010, MW-7 has remained typically dry, only having water during two monitoring events. MW-6, located on the northwest side between MW-5 and MW-7 (both of which are dry), currently has water but has been periodically dry. Monitoring well MW-21 (located between MW-6 and MW-7) has been dry since June 2011.

Because the entire upgradient (south) end of the site was excavated, lined, and filled early in the site history, precipitation infiltration that would otherwise have flowed northward to the downgradient end of the site has been prevented. As the excavation and fill sequence has progressed along the west side, monitoring wells on the west (MW-4 and MW-5) are now dry. In addition, MW-7 and occasionally MW-6 and new monitoring well MW-21 along the northeast part of the site are dry. As cell development continues, additional wells will become dry or at least intermittently dry.

Finally, there is the area near MW-13 on the northern end of the east side of the site. MW-13 has been dry since June 2002. Monitoring well MW-26 has been dry since installation (September 2009).

Multiple potentiometric surface maps were created over both temporal and seasonal variations and are included in Appendix E6, Figures E6-1 through E6-5. These potentiometric surface maps reflect the altered groundwater flow pattern created by the placement of the lined excavations that extend well into the unweathered Taylor. Groundwater contours reflect "no-flow" boundaries adjacent to the excavation and the dry areas near MW-4 and MW-5 on the west and MW-13 on the east. On the downgradient side of the site (north boundaries) groundwater flow follows the topography and the unweathered surface, and in places flows parallel to the site boundaries.

5.6.3.2 Groundwater Flow Rate

Groundwater flow velocity is estimated to flow at approximately 2.01 x 10^{-4} ft/yr in Stratum I (Figure E6-6). Stratum I values were used for calculation and are shown in Table E-13.

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

Recharge for the uppermost water bearing zone appears to occur entirely within the property boundary. Therefore, as construction of the landfill progresses and areas are lined and capped, the water levels shown on the potentiometric surface maps (Figures E6-1 through E6-5) would be expected to decrease due to a reduction of the recharge. In some areas, groundwater may be divided around a lined cell. Groundwater will continue to flow toward the hydraulic downgradient northern part of the site.

Table E-13
Skyline Landfill
Hydraulic Conductivity Values

Piezometer No.	**Hvorslev's Hydraulic Conductivity (cm/sec)**
STRATUM I	
P-3	5.86E-10
	5.44E-10
	9.09E-09
	1.13E-09
P-6	1.78E-09
P-11	1.66E-08
	3.35E-09
P-14	2.91E-08
P-17	2.82E-08
	4.82E-09
P-18	1.59E-08
	8.65E-09
	1.99E-09
P-20	4.24E-09
	3.67E-09
	1.83E-09
	6.04E-09
P-26	3.05E-09
P-30	4.40E-09
Stratum I Mean	**4.23E-09**
STRATUM I/II	
P-8	4.07E-09
STRATUM II	
P-5	4.23E-09
	3.90E-09
	3.63E-09
	3.08E-09
	2.55E-09
P-9	5.77E-09
	3.42E-09
	8.38E-09
	7.59E-09
P-16	5.63E-09
	2.40E-09

Table E-13
Skyline Landfill
Hydraulic Conductivity Values
(Continued)

Piezometer No.	Hvorslev's Hydraulic Conductivity (cm/sec)
SCREENED INTERVAL STRATUM II (CONTINUED)	
P-19	6.79E-09
	5.47E-09
	4.99E-09
	4.69E-09
	4.14E-09
P-22	1.14E-08
	3.12E-09
	5.63E-09
	3.03E-09
	5.13E-09
P-23	3.99E-10
	8.01E-10
	6.51E-10
P-25	8.54E-10
	8.24E-10
	1.24E-09
	1.40E-09
P-29	6.57E-10
	1.89E-09
	1.15E-09
P-31	5.89E-09
	3.78E-09
	1.26E-09
P-33	1.93E-09
	1.82E-09
	1.61E-08
	1.57E-09
P-35	1.08E-09
	1.32E-09
	1.39E-09
	1.42E-09
Stratum II Mean	**2.59E-09**

Note – From HDR, 1991.

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.

7 REFERENCES

Algermissen, S.T., et al., 1991, *Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States,* U. S. Geological Survey Open File Report 82-1033.

Barnes, V.E., 1966, *Geologic Atlas of Texas, Tyler Sheet,* Bureau of Economic Geology, University of Texas, Austin, Texas, revised 1975.

Bouwer, H., and Rice, R.C., 1976, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells", *Water Resources Research,* Vol. 12, No. 3.

Brady, N.C., and Weil, R., 2007, *The Nature and Properties of Soils,* Prentice Hall, Upper Saddle River, N.J.

Bureau of Economic Geology of Texas, 1990, Tectonic Map of Texas, Austin, Texas.

Bureau of Economic Geology of Texas, 1996, Physiographic Map of Texas, Austin, Texas.

Cooper, H.H., Jr., Bredehoeft, J.D., and Papadopulos, I.S., 1967, "Response of a Finite-Diameter Well to an Instantaneous Charge of Water", *Water Resources Research,* Vol. 3, No. 1.

Dutton, A.R., Collins, E.W., Hovorka, S.D., Mace, R.E., Scanlon, B.R., and Xiang, J., 1994, Occurrence and Movement of Ground Water in Austin Chalk and Eagle Ford and Ozan Formations at the Superconducting Super Collider (SSC) Site, Ellis County, Texas, Contract report prepared by Bureau of Economic Geology for Texas National Research Laboratory Commission, Contract No. IAC(92-93)-0301, May.

Ewing, T.E., 1991, *The Tectonic Framework of Texas,* Bureau of Economic Geology, Austin, Texas.

Fogg, Graham E., and Kreitler, Charles W., 1982, *Groundwater Hydraulics and Hydrochemical Facies in Eocene Aquifers of the East Texas Basin*, Bureau of Economic Geology, Austin, Texas.

Kreitler, C.W. et al, 1981, *Geology and Geohydrology of the East Texas Basin*, Texas Bureau of Economic Geology, The University of Texas at Austin.

Langley, Tom, *Updated Evaluation of Water Resources of Part of North-Central Texas, 1990 – 1999*, Texas Water Development Board Report 349.

McWhorter, D.B., and Sunada, D.K., 1977, *Groundwater Hydrology and Hydraulics,* Water Resources Publications, Fort Collins, Colorado.

Nordstrom, P.L., 1982, *Occurrence, availability, and chemical quality of groundwater in the Cretaceous aquifers of north-central Texas:* Texas Department of Water Resources, Report 269, v. 1 and 2.

Sellards, E.H., Adkins, W.S., and Plummer, F.B., 1932, *The Geology of Texas, Volume I: Stratigraphy,* The University of Texas Bulletin No. 3232.

Texas Water Department Board [TWDB], 1990, Minor Aquifers of Texas.

Thompson, G.L., 1967, *Groundwater Resources of Ellis County, Texas*, Texas Water Development Board Report 62.

U.S. Environmental Protection Agency, 1993, Technical Manual, *Solid Waste Disposal Facility Criteria*, EPA 530-R-93-017.

U.S. Geological Survey, 1959, Photo Revised 1968; Topographic Map, Ferris Quadrangle.

Woodruff, C.M., 1990, *Geothermal Resource Assessment for the State of Texas,* Appendix E, D.O.E. I.D. 12057, Status of Progress, November 1980, Bureau of Economic Geology, 1982.

SKYLINE LANDFILL

APPENDIX E1

REGIONAL GEOLOGIC/HYDROGEOLOGIC DATA

STATE OF TEXAS
JOHN MICHAEL SNYDER
GEOLOGY
595
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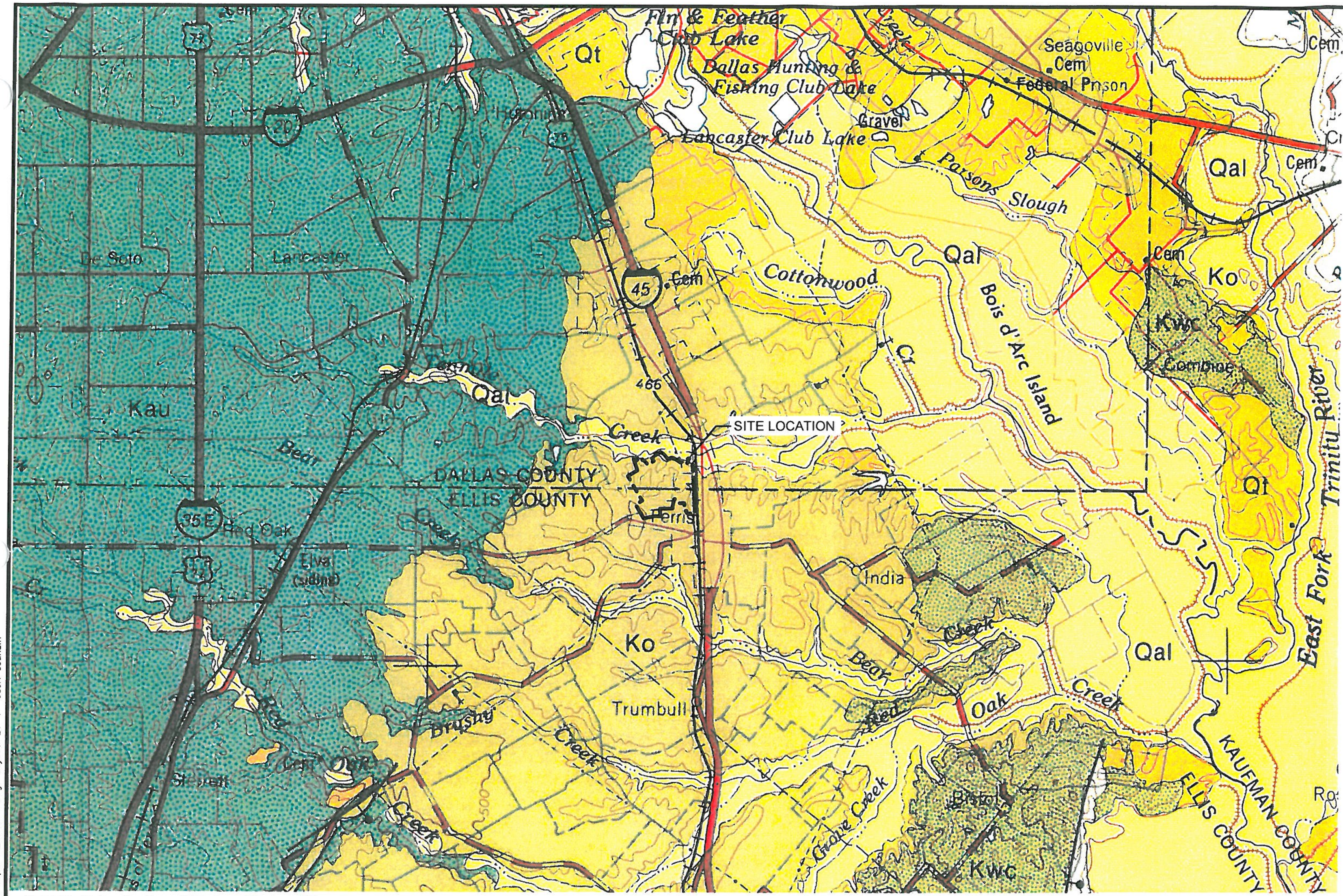
4-12-2012



INDEX OF GEOLOGIC MAPPING
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NOTE:

1. SEE FIGURE E1–2 FOR LEGEND.

STATE OF TEXAS
Elizabeth Floyd
GEOLOGY
2045
LICENSED
PROFESSIONAL GEOSCIENTIST

Elizabeth Floyd
4/12/2012

Prepared by the Army Map Service (AJEE), Corps of Engineers, U.S. Army, Washington, D.C. Compiled in 1954 by photogrammetric methods. Horizontal and vertical control by USC&GS and USGS. Aerial photography 1952–53. Photography field annotated 1954.

Base map revisions by the Bureau of Economic Geology. 10,000–meter Universal Transverse Mercator grid tics, zone 14, shown in blue.

VIRGIL E. BARNES, PROJECT DIRECTOR
Geologic mapping by Shell Oil Company, Humble Oil & Refining Company, Dallas Geological Society, Fort Worth Geological Society, Shell Development Company, J. H. McGowen, C.V. Proctor, Jr., W. T. Haenggi, and D. F. Reaser compiled the geologic mapping on high altitude aerial photographs, compiled unmapped areas photogeologically, and field checked all mapping. V. E. Barnes remapped, but did not field check, Quaternary deposits of Dallas and Tarrant counties using U. S. Geological Survey 7.5–minute quadrangles. Geologic mapping reviewed by Geologic Atlas Project Committees of the Dallas Geologic Society, R. J. Cordell (Sun Oil Company), Chairman, E. G. Wermund (Mobil Research and Development Corporation), and R. L. Laury (Southern Methodist University); and the fort Worth Geological Society, W. J. Nolte (Independent Geologist), Chairman, Leo Hendricks (Texas Christian University), and Edward Heuer, Cartographic revisions by R. L. Dillon and J. T. Ames.

CONTOUR INTERVAL 50 FEET

TRANSVERSE MERCATOR PROJECTION
1987 MAGNETIC DECLINATION FOR THIS SHEET IS 6°20'E. MEAN ANNUAL CHANGE IS 5'42" WESTWARD

GEOLOGIC ATLAS OF TEXAS, DALLAS SHEET

GAYLE SCOTT MEMORIAL EDITION

REVISED 1987

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REVISIONS							
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY	

GEOLOGIC VICINITY MAP

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
MAJOR PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
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TBPE FIRM NO. F-256		TBPG FIRM NO. 50222	
DSN. ESF	DATE : 04/12		FIGURE
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CHK. JMS	DWG : E1–1_GeoVicin.dwg		

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EXPLANATION

Formations Described in Separate Text

QUATERNARY

Holocene / Pleistocene

- Qal, Qu — Alluvium and Quaternary deposits undivided
- Qt — Fluviatile terrace deposits

TERTIARY

Paleocene

- EPAwi — Wilcox Group undivided
- PAwp, PAkp — Midway Group

CRETACEOUS

Upper Cretaceous

- Kkc — Kemp Clay and Corsicana Marl undivided
- Kns — Nacatoch Sand
- Knm, Kne, Kmb — Neylandville Marl and Marlbrook Marl
- Kpg — Pecan Gap Chalk (?)
- Kwc — Wolfe City Sand
- Ko — Ozan Formation ("lower Taylor marl")
- Kau — Austin Chalk
- Kef — Eagle Ford Formation
- Kwb — Woodbine Formation
- Kgm — Grayson Marl and Main Street Limestone undivided

Lower Cretaceous

- Kpw, Kwl, Kdc, Kfd — Pawpaw Formation, Weno Limestone, Denton Clay, Fort Worth Limestone, and Duck Creek Formation
- Kki — Kiamichi Formation
- Ked, Kcp, Kgl — Edwards Limestone, Comanche Peak Limestone, and Goodland Limestone
- Kwa — Walnut Clay
- Kpa — Paluxy Sand
- Kgr — Glen Rose Formation
- Ktm — Twin Mountains Formation

PENNSYLVANIAN

Missouri Series ?

- ss2, IPmw, IPlp, IPvb, IPmw, ss1, IPhm — Mineral Wells Formation
- IPbr — Brazos River Formation
- IPm, IPdv, IPm — Mingus Formation
- IPbc, IPgr, IPbb2, IPbb1 — Grindstone Creek Formation

Des Moines Series

- IPmb, IPlb, ls, IPkf ? IPdb — Lazy Bend Formation
- IPu — Unnamed Pennsylvanian rocks

Fault

Tics with ball indicate downthrown side; dashed where inferred; short dashes show position of fault in Ham Gossett oil field at top of Woodbine Formation.

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REVISIONS							
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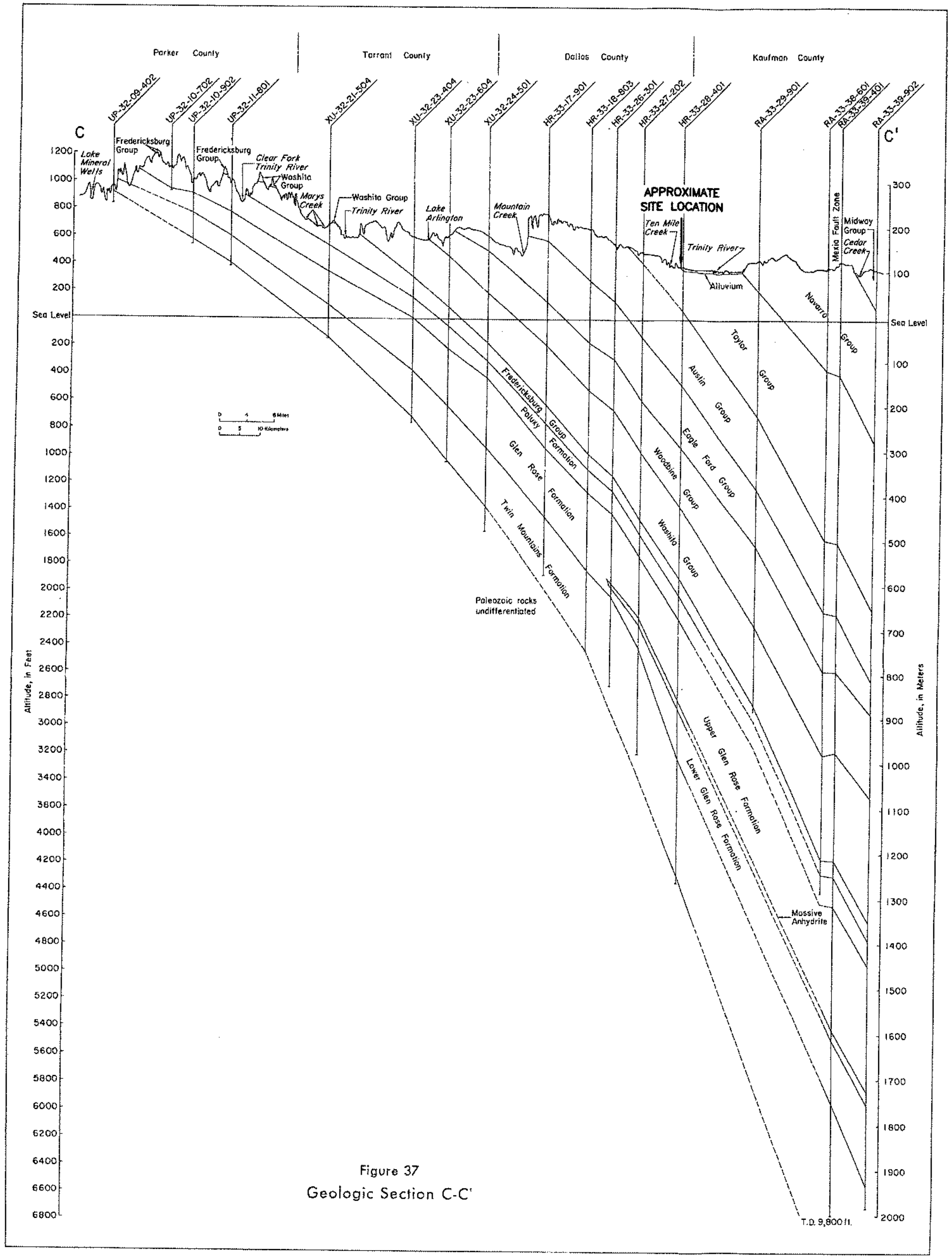

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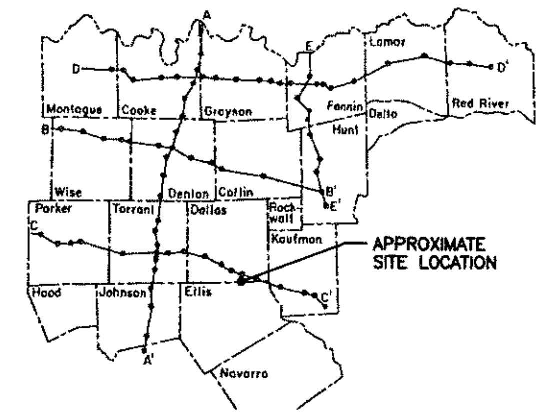

Index Map

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STATE OF TEXAS
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4/12/2012

SOURCE: NORDSTROM, P.L., TEXAS DEPARTMENT OF WATER RESOURCES, REPORT 269: OCCURRENCE, AVAILABILITY, AND CHEMICAL QUALITY OF GROUNDWATER IN CRETACEOUS AQUIFERS OF NORTH-CENTRAL TEXAS, APRIL 1982.

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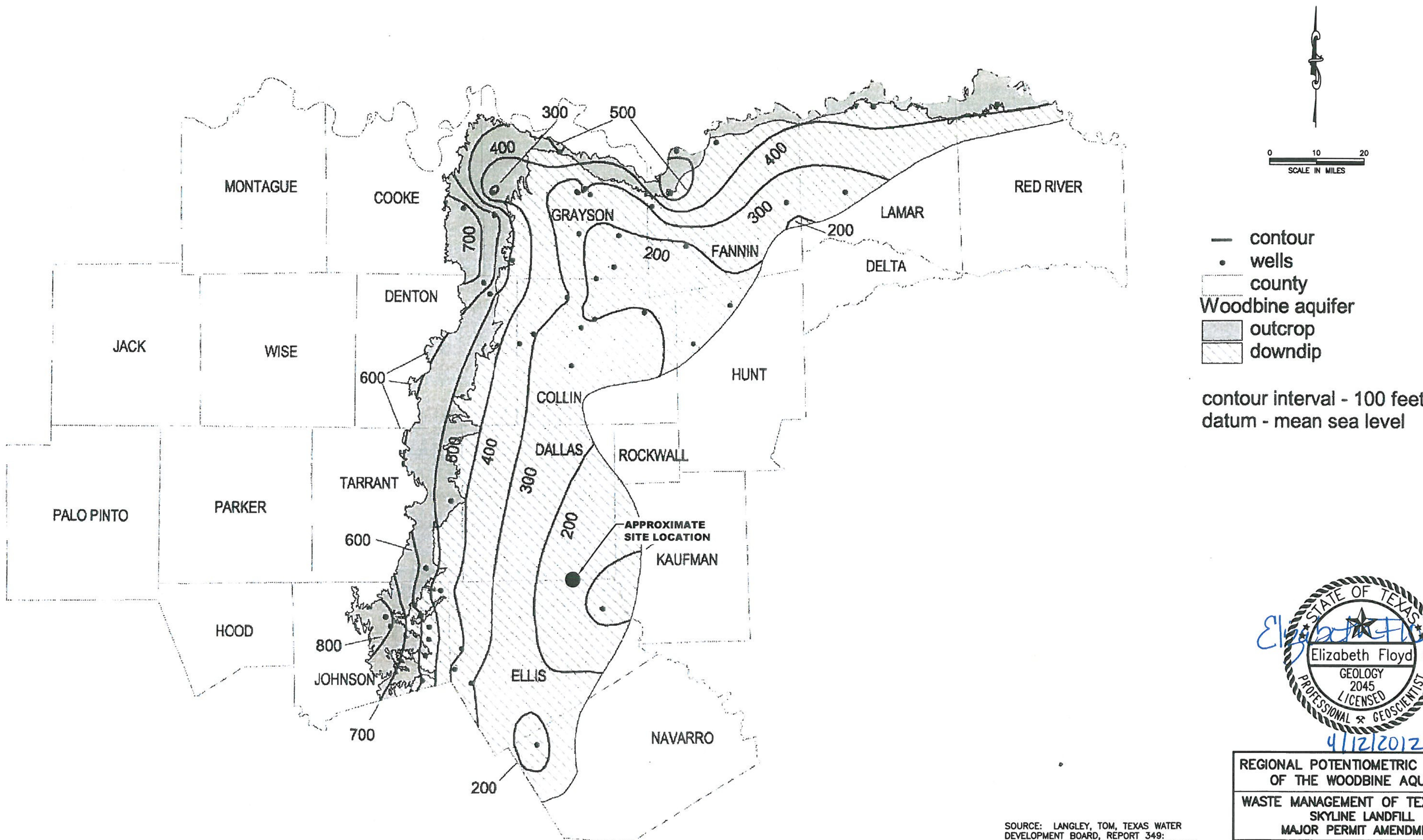

SOURCE: LANGLEY, TOM, TEXAS WATER DEVELOPMENT BOARD, REPORT 349: UPDATE EVALUATION OF WATER RESOURCES IN PART OF NORTH-CENTRAL TEXAS 1990–1999, NOVEMBER 1999.

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4/12/2012

REGIONAL POTENTIOMETRIC SURFACE OF THE WOODBINE AQUIFER

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REVISIONS

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DWN. SRC
CHK. JMS

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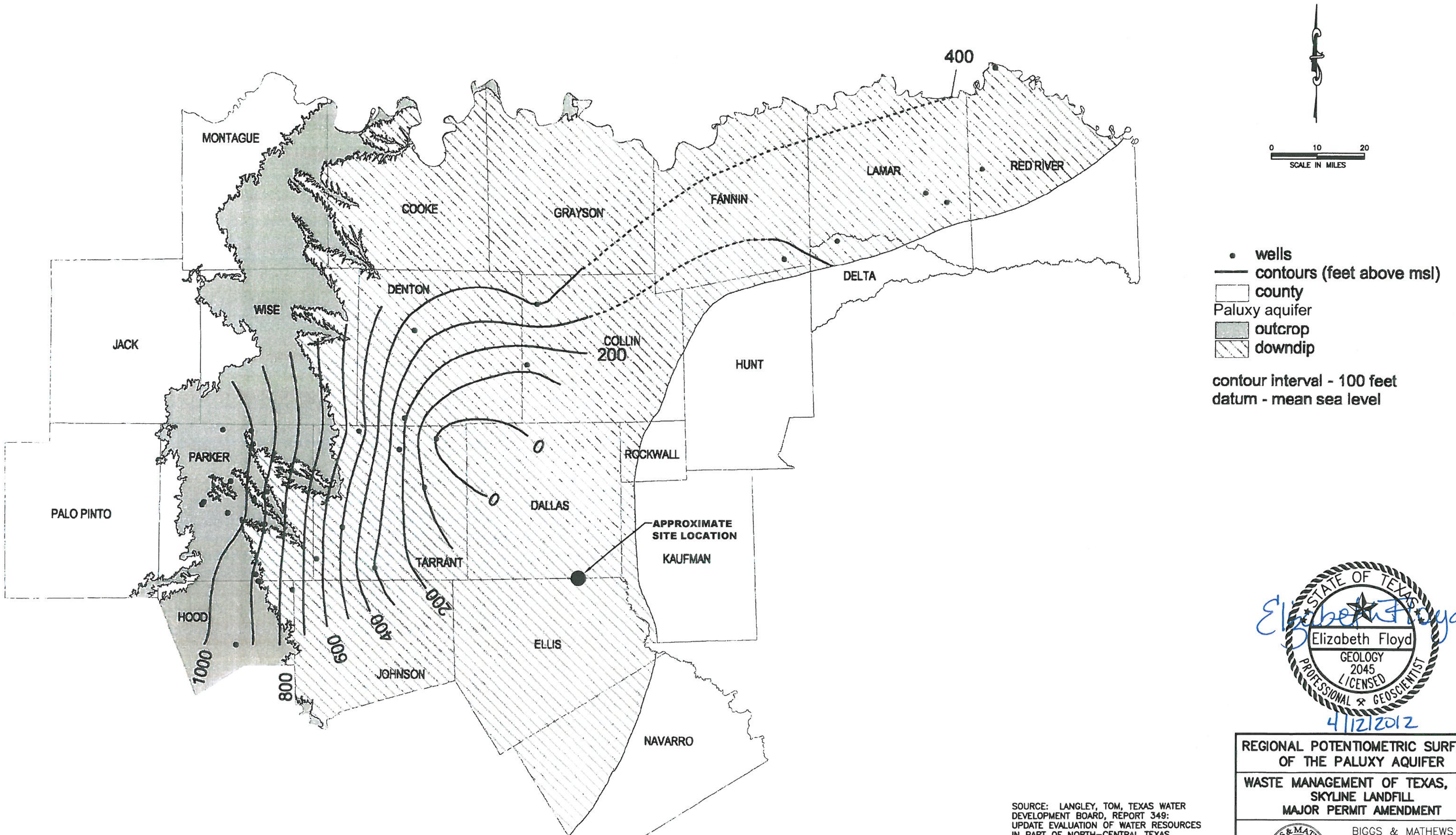

SOURCE: LANGLEY, TOM, TEXAS WATER DEVELOPMENT BOARD, REPORT 349: UPDATE EVALUATION OF WATER RESOURCES IN PART OF NORTH-CENTRAL TEXAS 1990-1999, NOVEMBER 1999.

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REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

REGIONAL POTENTIOMETRIC SURFACE OF THE PALUXY AQUIFER

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
MAJOR PERMIT AMENDMENT

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TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

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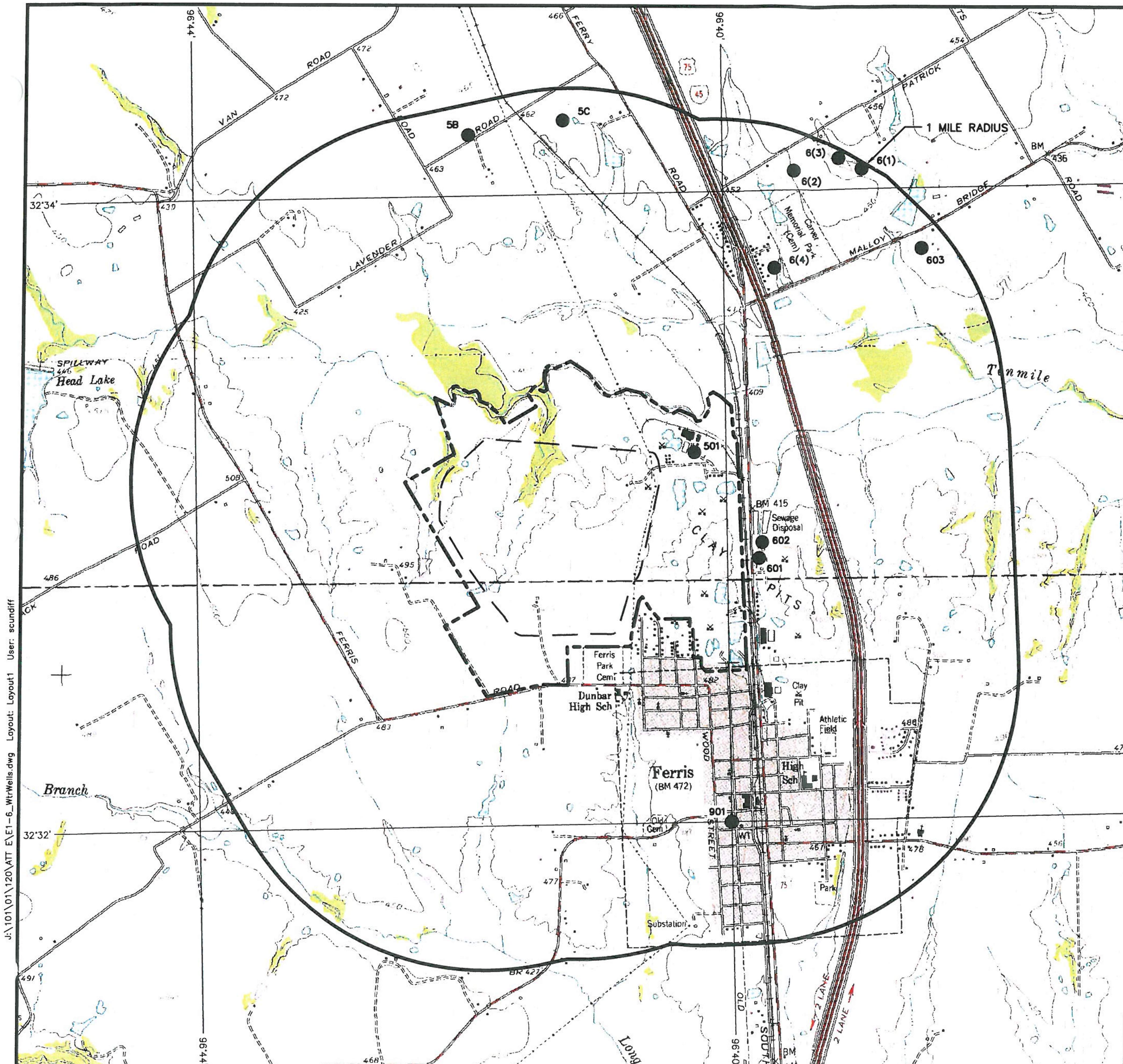
CHK. JMS	DWG : E1-5_Paluxy.dwg		

J:\101\01\120\ATT E\E1-5_Paluxy.dwg Layout: E1-5 User: scundiff



0 1000 2000
SCALE IN FEET

LEGEND

(dash-dot line)	PERMIT BOUNDARY
(dashed line)	LANDFILL FOOTPRINT
501 ●	WATER WELL

FERRIS, TEX.
SW/4 SEAGOVILLE 15' QUADRANGLE
N3230–W9637.5/7.5
1959
AMS 6649 II SW–SERIES V882

ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
Interstate Route
U.S. Route

STATE OF TEXAS
Elizabeth Floyd
GEOLOGY
2045
LICENSED
PROFESSIONAL GEOSCIENTIST
Elizabeth Floyd
4/12/2012

WATER WELL LOCATION MAP

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
MAJOR PERMIT AMENDMENT

BIGGS & MATHEWS
ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 TBPG FIRM NO. 50222

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS							
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DSN. ESF	DATE : 04/12	FIGURE	
DWN. SRC	SCALE : GRAPHIC	E1–6	
CHK. JMS	DWG : E1-6_WtrWells.dwg		

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