SKYLINE LANDFILL

APPENDIX D7-A
HIGHEST MEASURED WATER LEVELS

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
8-21-12

SKYLINE LANDFILL
HISTORIC WATER LEVEL MEASUREMENTS
BORINGS AND PIEZOMETERS

Location	Date of Highest Measured Level	Highest Measured Water Level
P-1	Mar-88	446.00
P-3	Feb-93	437.45
P-6	Mar-88	461.20
P-7	Mar-88	436.90
P-9	Apr-91	445.31
P-15	Aug-91	497.35
P-17	Apr-93	482.79
P-19	Dec-90	456.20
P-24	Feb-93	402.53
P-26	Feb-93	457.58
P-27	Apr-93	407.75
P-28	Apr-93	426.45
P-29	Feb-93	453.25
P-32	Jun-91	459.35
P-36	Jun-93	490.52

Location	Date of Highest Measured Level	Highest Measured Water Level
CB-26	May-87	436.7
CB-28	Apr-91	412.7
CB-34	Apr-91	456.4
CB-36	Apr-91	419.5
CB-44	Apr-91	465.0
CB-47	Apr-91	457.4
CB-48	Apr-91	482.9
CB-50	May-91	478.4
CB-51	Apr-91	488.8
CB-52	May-91	473.1
B-2	Aug-83	440.0
B-3	Aug-83	448.5
B-4	Aug-83	438.0
B-6	Aug-83	488.0
B-9	Aug-83	426.0
B-11	Aug-83	398.0

See Table E-11 and E-12 in Attachment E for detailed list of all water levels recorded for these borings and piezometers. This table summarizes the highest ever recorded piezometers. This table summarizes the highest ever recorded at each location. These borings and piezometers have been abandoned and highest level recorded will not change.

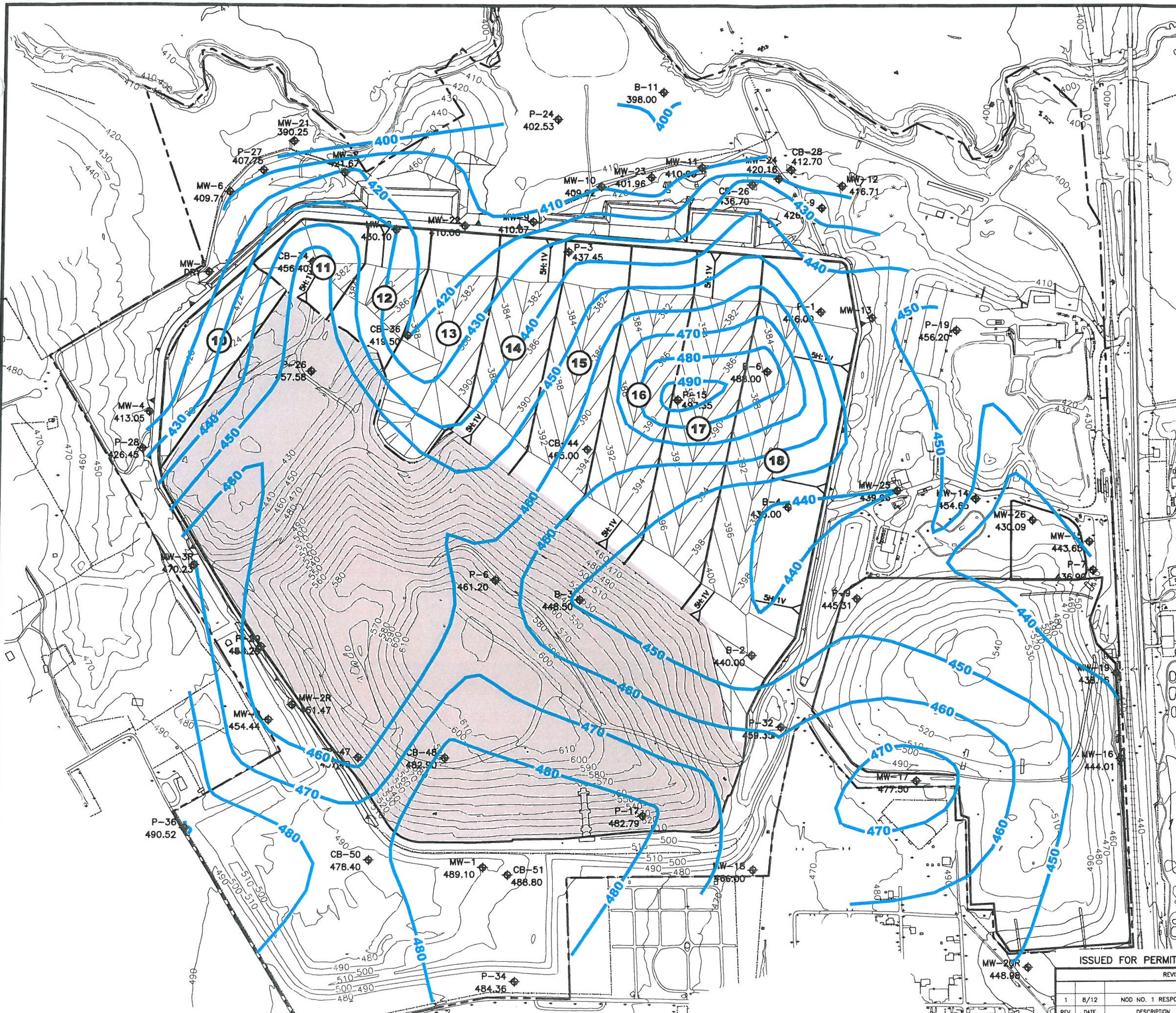
For clustered piezometers or borings that were close together, the location with the highest recorded water is shown on the table.

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	DRY	DRY	DRY	DRY	425.46	398.92	397.75	407.47	409.47	DRY
Sep-11						DRY	DRY	DRY	DRY						DRY
Dec-11	483.39		451.04		466.97	DRY	DRY	DRY	DRY	DRY	396.64	395.61	405.83	403.35	DRY
Mar-12						DRY	DRY	405.96	DRY						DRY
Jun-12	483.33		449.7		466.3	DRY	DRY	DRY	DRY	DRY	396.97	395.72	406.74	403.75	DRY

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								
Jun-10	452.54	440.98	442.05	474.64	462.22	433.76		445.28	DRY	DRY	**401.96**	**420.16**	437.93	DRY
Sep-10		434.05							**390.25**	398.46	400.34	416.99	437.83	DRY
Dec-10	450.57	430.57	439.64	472.27	460.44	435.18		447.83	388.90	**410.06**	398.57	415.97	438.66	DRY
Jan-11				473.90					389.63	400.81	398.42	417.78	438.42	DRY
Mar-11														
May-11									388.35	400.26	399.61	419.82	438.80	DRY
Jun-11	452.08	439.84	440.86	474.03	461.48	434.10		447.73						
Sep-11									DRY	DRY	398.11	416.92	438.81	DRY
Dec-11	451.56	430.64	438.03	472.9	458.55	435.03		445.05	DRY	403.21	396.41	410.80	437.89	DRY
Mar-12									DRY	400.81	395.89	413.83	439.51	**430.09**
Jun-12	451.27	439.84	439.86	473.65	460.3	434.1		**448.98**	DRY	408.26				429.31
									DRY	401.74	396.93	415.27	**439.96**	DRY



LEGEND

— - — -	PERMIT BOUNDARY
———	LANDFILL FOOTPRINT
—550—	EXISTING 10' GROUND CONTOUR
—470—	GROUNDWATER CONTOUR
—420—	PROPOSED EXCAVATION CONTOUR
— · —	PHASE BOUNDARY
———	CELL BOUNDARY
(10)	CELL DESIGNATION
▭	LINED AREA
413.05 ◈	MONITORING WELL, BORING, AND/OR PIEZOMETER W/HIGHEST RECORDED GROUNDWATER ELEVATION

NOTE:

1. EXISTING CONTOURS COMPILED BY AEROMETRIC FROM AERIAL PHOTOGRAPHY. FLOWN MARCH 6, 2011. COORDINATE SYSTEM IS BASED ON TEXAS STATE PLANE NAD 27, TEXAS NORTH CENTRAL ZONE, US FEET.
2. THE HIGHEST RECORDED GROUNDWATER CONTOURS ARE BASED ON GROUNDWATER OBSERVATIONS ON THE DATES SHOWN. THIS IS NOT A POTENTIOMETRIC SURFACE MAP.

STATE OF TEXAS
DAVID L. CLARK
81905
REGISTERED PROFESSIONAL ENGINEER
8-21-12

ISSUED FOR PERMITTING PURPOSES ONLY

HIGHEST RECORDED GROUNDWATER ELEVATIONS

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

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
1	8/12	NOD NO. 1 RESPONSE	SRC	DLC	DLC	DLC

REVISIONS

DSN. SAB	DATE : 04/12	DRAWING
DWN. SRC	SCALE : GRAPHIC	D7A-1
CHK. DLC	DWG : D7A-1-HighGWElev.dwg	

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SKYLINE LANDFILL

APPENDIX D7-B
TEMPORARY DEWATERING SYSTEM

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
8-21-12

Includes pages D7-B-1 through D7-B-4

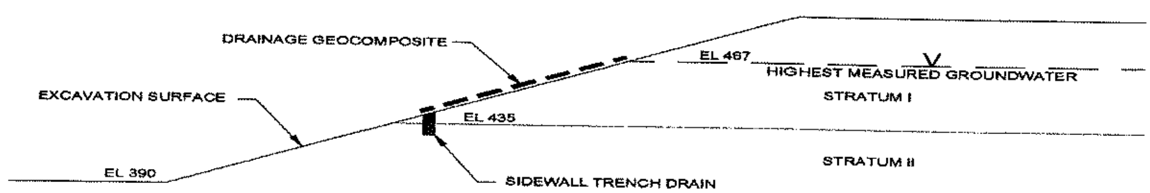
Skyline Landfill
Temporary Dewatering Inflow Rate

Required: Determine the inflow rate to the sideslope trench drain of the temporary dewatering system:

References: *Dewatering and Groundwater Control*, UFC 3-220-05, January 2004 (replaces TM 5-818-5).

Assumptions: The temporary dewatering system will be designed for the highest recorded water levels (see Drawing D7A-1). The dewatering system plan and details are shown on Drawings D3.7 And D3.8.
The boundary of the uppermost ground water bearing unit (GWBU) is at the top of Stratum II as demonstrated in Attachment E.

Solution: ***Sidewall Drain***
The sidewall drain consists of a geocomposite blanket that discharges into the composite trench drain. The geocomposite will extend to the highest measured water level. The critical section will occur in Cell 18 where Stratum I daylights in the excavation sideslope and the highest measured groundwater level is the highest. The critical sidewall drain section is shown below.



WORST CASE GROUNDWATER DEPTH - CELL 18 SIDESLOPE (NTS)

H_1 = design water height =	32	ft
H_2 = trench drain height =	3	ft
H = saturated layer thickness ($H_1 - H_2$) =	29	ft
L = length of trench drain	1940	ft

Use Darcy's equation to estimate the inflow into the toe drain.

$Q = KiA$

where:

Q = design flowrate		
K = hydraulic conductivity of GWBU =	1.00E-07	cm/sec
=	3.28E-09	fps
i = average hydraulic gradient (see Appendix E6) =	0.023	ft/ft
(based on June 2010 potentiometric surface average)		
A = flow area (H x L) =	56260	sf

Q = 4.25E-06 cfs

Skyline Landfill
Temporary Dewatering System

Required: Size the following elements of the temporary dewatering system:
1) Composite Drains
2) Pump

References:
1) *KTC-97-5, SPR-92-143, "Performance and Cost Effectiveness of Pavement Edge Drains",* L. John Fleckenstein, Kentucky Transportation Center, 1997.

Assumptions:
1) The dewatering system plan and details are shown on Drawings D3.7 And D3.8.
2) The largest flow in a composite drain will be the trench drain on the Cell 18 sideslope.
3) Flow rates are from the inflow rate calculations.

Solution

1) Maximum flowrate equals combined underdrain and sidewall flowrate.

Q = maximum flowrate = 4.25E-06 cfs
= 1.91E-03 gpm

Flow capacity of 12" ADS Composite Drain = 39.0 gpm

2) Use the maximum flowrate to the sump to size the pump with a 1.5 factor of safety.

Q_p = pumping rate = 2.86E-03 gpm

Skyline Landfill
Temporary Dewatering Geosynthetic Design

Required: Determine the minimum geosynthetic properties for temporary dewatering system:
1) Geotextile for the composite drain.
2) Gecomposite for the sidewall drain.

References: 1) *Designing with Geosynthetics,* Fourth Edition; Robert M. Koerner.

Assumptions: 1) The adjacent soils will have at least 50% finer than the No. 200 sieve.

Solution: 1) *Geotextile*

Calculate the required permittivity from the equation:

$$\Psi_{req} = q / \Delta hA$$

where: Ψ_{req} = permittivity

q = peak inflow rate =	4.25E-06 cfs
Δh = maximum allowable head =	3.0 ft
L = trench length =	950 ft
H = drain height =	1.0 ft
A = inflow area = $L \times 2H$ =	1900.0 sf

Substitute and solve for required permittivity = 7.448E-10 sec^{-1}

Calculate the allowabe permittivity from Reference 1, Equation 2.25.

$$\Psi_{req} = \Psi_{all} \; (1 / RF_{SCB} \; X \; RF_{CR} \; X \; RF_{IN} \; X \; RF_{CC} \; X \; RF_{BC})$$

where:

RF_{SCB} = soil clogging/binding reduction factor =	7.0 (Ref. 1, Table 2.12)
RF_{CR} = creep reduction factor =	1.5 (Ref. 1, Table 2.12)
RF_{IN} = intrusion reduction factor =	1.2 (Ref. 1, Table 2.12)
RF_{CC} = chemical clogging reduction factor =	1.0 (Ref. 1, Table 2.12)
RF_{BC} = biological clogging reduction factor =	1.0 (Ref. 1, Table 2.12)

Substitute and solve for allowable permittivity = 9.4E-09 sec^{-1}

Determine the appropriate soil retention criteria from Reference 1, Figure 2.4.

For fine-grained, non-dispersive soils the AOS must be less than 0.21mm.

2) *Geocomposite*

Required transmissivity (T_{req}) = inflow rate / max drainage width

where: inflow rate =	4.25E-06 cfs
max drainage width =	120 ft
T_{req} =	3.54E-08 ft^2/sec

Skyline Landfill
Temporary Dewatering Geosynthetic Design

Calculate the allowable transmissivity from Reference 1, Equation 4.5.

$$T_{all} = T_{req} \; (RF_{SCB} \; X \; RF_{CR} \; X \; RF_{IN} \; X \; RF_{CC} \; X \; RF_{BC})$$

where:

RF_{SCB}	= soil clogging/binding reduction factor =	7.0 (Ref. 1, Table 2.12)
RF_{CR}	= creep reduction factor =	1.5 (Ref. 1, Table 2.12)
RF_{IN}	= intrusion reduction factor =	1.2 (Ref. 1, Table 2.12)
RF_{CC}	= chemical clogging reduction factor =	1.0 (Ref. 1, Table 2.12)
RF_{BC}	= biological clogging reduction factor =	1.0 (Ref. 1, Table 2.12)

T_{all} =	**4.46E-07**	**ft^2/sec**
=	**4.14E-08**	**m^2/sec**

SKYLINE LANDFILL

APPENDIX D7-C
BALLAST CALCULATIONS

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER

8-21-12

Includes pages D7-C-1 through D7-C-6

C. Determine the resisting pressure of the protective cover soil against uplift of the bottom and sidewall liner system including normal, vertical, and horizontal components of the resisting pressures as follows:

1. Bottom Liner: Determine the normal resisting pressure at the GM using the unit weight of the protective cover times the thickness of the protective cover.

$$R_N = (\gamma_{pc} \, T_{pc})$$

Where: γ_{pc} = Wet unit weight of the protective cover
T_{pc} = Thickness of the protective cover

The unit weight of the protective cover shall be determined from field measured unit weights.

2. Sidewall Liner:

(a) Determine the vertical resisting pressure of the sidewall liner using the unit weight of the protective cover material times the vertical thickness of the protective cover layer. This is equal to the normal resisting pressure divided by the cosine of the slope angle.

$$R_v = R_N / \cos \beta$$

(b) Determine the horizontal resisting pressure of the sidewall liner using the coefficient of at-rest earth pressure of the liner system components times the vertical resisting pressure.

$$R_H = K_O \, R_V$$

The coefficient of at-rest earth pressure, K_O, is based on the assumed angle of internal friction, ϕ, of the material resisting hydrostatic pressures (compacted soil).

(c) Determine the normal resisting pressure of the sidewall liner system using the normal components of the horizontal and vertical resisting pressures calculated in steps (a) and (b) above.

$$R_N = R_H \sin \beta + R_V \cos \beta$$

D. Evaluate the factor of safety against uplift of the bottom and sidewall liner system due to hydrostatic pressures.

1. Bottom Liner: Determine the factor of safety against uplift of the bottom liner system due to hydrostatic forces acting normal to the base of the bottom liner system.

$$FS = R_N / P_N$$

If the factor of safety is greater than or equal to 1.2, the protective cover provides sufficient ballast to offset the hydrostatic uplift forces.

If the factor of safety is less than 1.2, additional ballast in the form of solid waste or additional soil will be necessary to offset the hydrostatic forces. See Step E for determining the geometry of solid waste or additional ballast.

2. Sidewall Liner:

Determine the factor of safety against uplift of the sidewall liner system due to hydrostatic pressures acting normal, vertical, and horizontal to the sidewall liner system.

(a) $FS_N = R_N / P_N$

(b) $FS_V = R_V / P_V$

(c) $FS_H = R_H / P_H$

If the factors of safety are greater than or equal to 1.2, the protective cover provides sufficient ballast to offset the hydrostatic forces.

If the factor of safety is less than 1.2 for any of the components (normal, vertical, or horizontal), additional ballast in the form of solid waste or additional soil will be necessary to offset the hydrostatic forces. See Step E for determining the geometry of solid waste or additional soil ballast.

E. Use a factor of safety of 1.5 against uplift of the liner and ballast system for solid waste ballast ~~and a factor of safety of 1.2 for soil ballast~~.

Assume a unit weight of 44 pcf for solid waste and a unit weight of 100 pcf for soil if field measurements are not available, or if conditions indicate the field measurements are no longer applicable.

1. Bottom Liner

The factor of safety against uplift of the liner and ballast system is calculated as follows:

$$FS = (R_N + B_N) / P_N$$

Where R_N = Normal protective cover pressure
B_N = Normal ballast pressure
B_N = $H_{sw} * \gamma_{sw}$ (Height and unit weight of solid waste ballast)
FS = 1.5 for waste~~, 1.2 for soil~~

Solving the above equation for the height of ballast:

$$H = (FS\ P_N - R_N) / \gamma$$

2. Sidewall Liner

The factor of safety against uplift of the liner and ballast system is calculated as follows:

(a) $FS = (R_V + B_V) / P_V$

Where R_V = Vertical protective cover pressure
B_V = Vertical ballast pressure
B_V = H * γ
FS = 1.5 for waste~~, 1.2 for soil~~

Solving the above equation for the height of ballast:

$$H = (FS\ P_V - R_V) / \gamma$$

(b) $FS = (R_H + B_H) / P_H$

Where R_H = Horizontal protective cover pressure
B_H = Horizontal ballast pressure
B_H = $B_V * K_O$
B_H = H * γ * 0.7
FS = 1.5 for waste, 1.2 for soil

Solving the above equation for the height of ballast:

$$H = (FS\ P_H - R_H) / \gamma * k_O$$

~~(c) $FS = ((R_v+B_v)cosB + (R_h+B_h)sinB) / P_n$~~

Example calculations are provided on pages D7-C-5 through D7-C-6.

Skyline Landfill
Example Ballast Calculation

Required: Example calculation to evaluate the long-term hydrostatic uplift pressures on the liner system and determine the ballast requirements.

Assumptions:

1) The design water elevations are shown on Drawing D7A-1.
2) All cells must be re-evaluated based on updated groundwater data prior to construction.
3) Assume normal and vertical forces to be the same in the bottom, and design for normal forces.
4) Uplift is evaluated at the clay liner geomembrane interface.
5) Groundwater is present in Stratum I but not in Stratum II as demonstrated in Attachment E.

Solution: Calculations are shown for the sideslope of Cell 18 where the exposed Stratum I material has the highest groundwater potential.

The forces acting upon the liner system are:

P_N = normal pressure	R_N = normal resistance
P_V = vertical pressure	R_V = vertical resistance
P_H = horizontal pressure	R_H = horizontal resistance

Section B — 1) Determine the uplift pressure upon the FML at the bottom and at the toe of the slopes.

γ_w = unit weight of water =	62.4 pcf
Groundwater elevation =	467 ft-msl
Liner elevation =	437 ft-msl
H = design water level above liner =	30 ft
b = sidewall slope =	11.3 deg

Equation B1	**Bottom**	$P_N = H\gamma_w =$	1872.0 psf (No groundwater pressure acts at toe/bottom calculation provided only for future reference)
Equation B2(a)	**Slope**	$P_N = H\gamma_w =$	1872.0 psf
Equation B2(b)		$P_V = P_N \cos\beta =$	1835.7 psf
Equation B2(c)		$P_H = P_N \sin\beta =$	366.8 psf

Section C — 2) Determine the resistance pressure of protective cover at the bottom and on the slope.

Protective cover:

γ = density (92% std proctor or field data) =	115.0 pcf
T_N = normal thickness =	2.0 ft
T_V = vertical thickness =	2.04 ft
ϕ = angle of internal friction =	11.3 deg

Equation C1	**Bottom**	$R_N = \gamma_{pc} T_N =$	230.0 psf (No groundwater pressure acts at toe/bottom calculation provided only for future reference)
Equation C2(a)	**Slope**	$R_V = R_N / \cos\beta$	234.5 psf
Equation C2(b)		$R_H = k_o R_V =$	117.3 psf (k_0 assumed as 0.5)
Equation C2(c)		$R_N = R_H \sin\beta + R_V \cos\beta =$	253.0 psf

Section D — 3) Determine the factors of safety against uplift and evaluate the need for additional ballast.

Equation D1	**Bottom**	$FS_N = R_N / P_N =$	0.1 (No groundwater pressure acts at toe/bottom - calculation provided only for future reference)
Equation D2(a)	**Slope**	$FS_N = R_N / P_N =$	0.1
Equation D2(b)		$FS_V = R_V / P_V =$	0.1
Equation D2(c)		$FS_H = R_H / P_H =$	0.3

The factor of safety for protective cover providing ballast against hydrostatic uplift is less than 1.2. Evaluate the height of waste ballast required to provide a factor of safety of at least 1.5.

γ_{sw} = unit weight of solid waste = 44.0 pcf

Section E

Equation E1 — **Bottom** $FS = (R_N + B_N) / P_N$ (No groundwater pressure acts at toe/bottom - calculation provided only for future reference)

Equation E2(a) — **Slope** $FS = (R_v + B_v) / P_v$

For FS = 1.5 $H = (FS * P_v - R_v) / \gamma_{sw}$

H = 57.3 ft

Equation E2(b) — $FS = (R_H + B_H) / P_H$

For FS = 1.5 $H = (FS*P_H - R_H) / (\gamma_{sw}*k_0)$

H = 19.7 ft

Using waste height calculated for vertical forces, check FS with normal forces:

For H_{sw} = 57.3 ft

Equation E2(c) — $FS = ((R_v + B_v)cosB + (R_h + B_h)sinB) / P_n$

FS = 1.8 Factor of safety is greater than 1.5 so vertical forces control

This example calculation was performed at the location in Cell 18 that has the largest hydrostatic force at the site based on the highest measured groundwater map included in Appendix D7-A .

The GP will evaluate the highest measured water levels to determine where the largest hydrostatic force is located and perform these calculations to determine how much ballast is required when preparing the Ballast Evaluation Report for submittal to the TCEQ prior to decommissioning any dewatering system.