APPENDIX B

Groundwater Flow Evaluation

Golder Associates	Subject: Groundwater flow Evaluation					
	Job No.	063-3496A	By:	CJW	Date	1/11/2007
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OBJECTIVE

Evaluate the potential for Groundwater flow into each Cell, based on the construction as-built information and groundwater levels available.

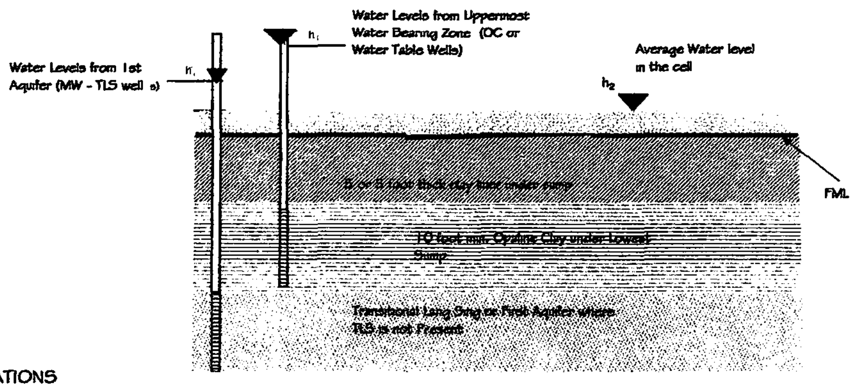
APPROACH

1. Obtain the average elevation of the top of the liner (primary or secondary if one was built) from construction/design information available. Obtain groundwater elevations (use last 5 years) from wells screened (below each Cell) in the upper aquifer (Transitional Lang Sine) or water bearing unit (Opaline Clay) located near each Cell from the Groundwater Detention Monitoring Reports.

2. Use Darcy's Law of Flow to estimate the quantity of groundwater flow through each Cell.

GROUNDWATER INFORMATION

See summary of groundwater elevations on Groundwater Reference Tables, sheet 5 of 5.



CALCULATIONS

The following calculation is an example of how Darcy's Law is used in this calculation package to estimate groundwater flow into the Cells and the time this may take.

Darcy Flow:

$Q = k \times i \times A$

Q = rate of flow (cm3/sec)

k = coefficient of permeability of the liner system (see attached equivalent permeability calculation).

i = $(h_1 - h_2)/L$ where h_1 and h_2 are the elevations of the GW from the aquifer and at the top of the Cell.

A = flow Area (Cell area)

The flow path L, in the equation above, is the thickness of the liner for that respective Cell (either 3 or 5 feet). Water levels in the Opaline Clay are only available around Section I, therefore it is assumed that the water levels in the TLS wells are representative of the water levels in the Opaline clay for Sections II and III

Example of Calculation (see table for calculation at each Cell)

For a 5 foot thick liner (assume Δh = 3 feet), the following illustrates the calculation performed:

Q_{flow} = K^*i^*A = 9.53E-09 cm/sec x 3/5 *A = 5.72E-09 cm/sec*A

4.94E-04 cm/day*A

1.62E-05 ft/day*A

For 1 acre (43560 sq. ft.) Q_{flow} = 0.71 ft3/day or 5.28 gallons per acre per day (gapd)

Calculation table (Section 1 Cells):

Liner hydr. Conductivity k = 9.53E-09 cm/sec - see equiv. liner calculation for 5 foot thick liner

L= Liner thickness = 5.00 ft

Area = 43,560.00 sq. ft. Sump Elevation is approximately floor elevation minus 0.67 ft.

Cell ID(1)	Cell Base Elevation (average) (ft)	Min. Groundwater Elevation (2) (ft)	Max. Groundwater Elevation (2) (ft)	Min. GW flow Rate (gspd)	Max. GW flow Rate (gspd)	Referenced GW Wells
IA, 1P	89	95	105	10.6	28.2	OC13
IA, 2P	89	94	104	8.8	26.4	OC12
IA, 3P	89	94	104	8.8	26.4	OC12
IA, 4P	89	93	103	7.0	24.6	OC3
IB, 1P	89	98	103	15.0	23.8	OC14
IB, 2P	89	98	101	15.4	21.6	OC14/OC11
IB, 3P	89	98	100	15.8	19.4	OC11
IC, 1P	89	108	110	32.6	37.0	OC15
IC, 2P	89	103	105	24.2	28.2	OC15/OC11
IC, 3P	89	98	100	15.8	19.4	OC11
ID, 1P	88	108	110	34.3	38.7	OC15
ID, 2P	88	103	105	26.0	29.9	MW131T/OC10
ID, 3P	88	98	100	17.6	21.1	OC10
IE, 1P	88	103	111	26.4	39.6	OC16
IE, 2P	88	93	98	8.8	17.6	OC6
IE, 3P	88	93	98	8.8	17.6	OC6

Calculation table (Section 2A and 2B, primary Cells):

Liner hydr. Conductivity k = 4.29E-09 cm/sec - see equiv. liner calculation for 5 foot thick liner (but adjst for 80 mil HDPE)

L= 5.00 ft

Area = 43,560.00 sq. ft. Sump Elevation is approximately floor elevation minus 4 ft.

Cell ID(1)	Cell Base Elevation (average) (ft)	Min. Groundwater Elevation (2) (ft)	Max. Groundwater Elevation (2) (ft)	Min. GW flow Rate (gpad)	Max. GW flow Rate (gpad)	Referenced GW Wells
IIA, 1P	94	89	105	NA	8.7	MW19A
IIA, 2P	95	89	100	NA	4.0	MW20A
IIA, 3P	98	85	90	NA	NA	MW54T
IIB, 1P	94	91	111	NA	13.5	MW50T
IIB, 2P	95	89	100	NA	4.0	MW20A
IIB, 3P	98	88	90	NA	NA	MW54T

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Calculation table (Section 2C to 2G Secondary Cells):

Liner hydr. Conductivity k = 3.11E-09 cm/sec - see equiv. liner calculation for 3 ft thick liner

L= Liner thickness = 3.00 ft

Cell bottom Area = 43,560.00 sq. ft. Sump Elevation is approximately floor elevation minus 4 ft.

Cell ID(1)	Cell Base Elevation (average) (ft)	Min. Groundwater Elevation (2) (ft)	Max. Groundwater Elevation (2) (ft)	Min. GW flow Rate (gpad)	Max. GW flow Rate (gpad)	Referenced GW Wells
IIC, 1S	90	97	108	6.7	16.8	MW48TR
IIC, 2S	90	95	101	4.3	10.8	MW48TR/27BTR
IIC, 3S	90	92	95	1.9	4.8	MW27BTR
IID,1S	101	102	107	1.0	5.7	OC8
IID,2S	101	102	107	1.0	5.7	OC8
IID,3S	101	102	107	1.0	5.7	OC8
IIE,1S	95	90	99	NA	3.4	OC8T/MW89T
IIE.2S	95	90	99	NA	3.4	OC8T/MW89T
IIE,3S	91	90	99	NA	7.2	OC8T/MW89T
IIF,1S	92	90	99	NA	6.2	OC8T/MW89T
IIF,2S	92	90	99	NA	6.2	OC8T/MW89T
IIF,3S	88	90	99	1.9	10.1	OC8T/MW89T
IIG,1S	88	108	110	19.2	21.1	MW81T
IIG,2S	89	78	90	NA	1.0	MW89T
IIG,3S	86	78	90	NA	3.8	MW89T

Calculation table (Section 3 Secondary Cells):

Liner hydr. Conductivity k = 3.11E-09 cm/sec - see equiv. liner calculation for 3 ft thick liner

L= Liner thickness = 3 ft

Cell bottom Area = 43,560.00 sq. ft. Sump Elevation is approximately floor elevation minus 3 ft.

Cell ID(1)	Cell Base Elevation (average) (ft)	Min. Groundwater Elevation (2) (ft)	Max. Groundwater Elevation (2) (ft)	Min. GW flow Rate (gpad)	Max. GW flow Rate (gpad)	Referenced GW Wells
IIIA,1S	66	79	90	12.4	23.0	MW101T
IIIA,2S	64	78	90	13.4	24.9	MW89T
IIIA,3S	70	78	90	7.7	19.2	MW89T
IIIB,1S	73	79	90	5.7	16.3	MW101T
IIIB,2S	59	79	90	19.2	29.7	MW101T
IIIBX, 3S	68	78	90	9.1	21.1	MW116T
IIIC, 1S	83	79	90	.	6.7	MW101T
IIIC, 2S	70	79	90	8.6	19.2	MW101T

(1) Cell IDs follows the Cell where it is located. P designates a primary Cell and S designates a Secondary Cell

(2) Last 5 years minimum and maximum groundwater elevations near each specific Cell.

SUMMARY/CONCLUSIONS

Groundwater levels used to estimate flows were obtained from hydrographs of wells screened in the Oplaine Clay (Water Table) and in the Transitional Lang Syne Unit, which is the first confined aquifer under the Opaline Clay. It is noted that the water levels in the TLS are reported to be generally lower that those measured in the Opaline Clay (i.e. flow goes from the OC to the TLS), but higher than lowest elevations of all sumps (i.e flow goes from the TLS and the OC into the sumps). Therefore the actual flow conditions within the cells are governed by an effective hydraulic head resulting from continuously changing water levels in the sumps, in the Opaline Clay and in the TLS. The flows estimated in this calculation package are approximations of the hydrogeologic flow conditions that exist, and the intent of the calculation is to determine the likelihood of groundwater flow into the cells based on known conditions.

Section I:

1) Groundwater wells used to estimate flows in Section I are shallow wells, screened in the Opaline Clay.
2) The bottom of all Section I sumps are below the low and high groundwater levels in nearby OC wells, therefore assuming no perched leachate conditions within the cells, an inward hydraulic gradient exists (GW flows INTO cells - not out) into the sumps and into most of the base of this Section.
3) Based on the assumptions made, flow into Section I is calculated to range from 8 to 40 gallons per acre per day.

Section II:

1) Except of one well near Cell D of Section II, all groundwater wells used to estimate flows in Section II are wells screened in the Transitional Lang Syne Unit, which is conservative (water levels in the Oplaine Clay are usually higher).
2) Groundwater levels in the TLS range from below to above the LDS or the LCRS base grades, therefore there is both inwward and outward hydraulic gradients acting at the bottom of some cells
3) All cells experience groundwater inflow sometimes, except for Cells A3 and B3.
4) Outflows are calculated to range from 1 to 10 gpad and inflows from 3.4 to 21 gpad.

Section III:

1) Most of the LDS base grades, are below the low and high groundwater levels in nearby groundwater wells. Therefore assuming no perched leachate conditions within the cells, an inward hydraulic gradient exists under the entire section.
2) Based on groundwater levels from the TLS, the calculated rate of flow into Section III ranges from 6 gpad to 30 gpad.

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Groundwater Reference Tables:

(based on last 5 years GW data in applied wells)

Section I

Well ID	Min. GW Elevation	Time @ Min. GW El.	Max. GW Elevation	Time @ Max. GW El.	Near by Sumps	Screened Elv. (ft)
WT32	118.00	Oct-05	120.2	Jul-03	1D1	
WT 27	107.50	Dec-05	114.00	Apr-03	1A1	
OC9	99.50	Feb-03	100.5	Jan-04/Apr-05	1E3	85to 95
OC6	93.00	Oct-02	98.0	Dec-03	1E3	79 to 84
OC4	97.00	Oct-02	102.0	Jan-04	1D3/1E3	77 to 82
OC16	103.00	Jan-06	110.5	May-03	1E1	82 to 92
OC15	107.50	Oct-05	110.0	Mar-03	1C1	78.5 to 88
OC14	97.50	Jan-06	102.50	May-03	1B1	74 to 83
OC13	95.00	Aug-05	105.00	Dec-03	1A1	82 to 92
OC12	99.50	Jul-05	104.0	Feb-04	1A2/1A3	84 to 94
OC11	98.00	Sep-04	100.0	Dec-03/Mar-05	1B3/1C3	77 to 87
OC10	98.00	Sep-04/Oct-05	100.0	Dec-03	1D3	78 to 88
MW9A	N/A, GW below pea gravel base				1C3	
MW73T	89.00	Jan-06	95.0	Oct-01	1B1/1C1	
MW5A	100.00	Jan-06	102.5	Jul-03	1E3	
MW45T	96.00	Jul-05	101.0	Oct-03	1A3/1A4	
MW43T	92.00	Jul-05/Jan-06	95.0	Apr-04	1A4	
MW42TR	89.00	Dec-02/Jan-06	92.0	Oct-03	1B3	
MW16TR	90.00	Apr-05	103.5	Oct-03	1A1	
MW134T	91.50	Jan-06	98.0	Jul-03	1E1	
MW132T	102.00	Apr-02/Jan-06	104.0	Jul-03	1E1	
MW131T	101.00	Apr-02	103.0	Jul-03	1D1	

Section II

Well ID	Min. GW Elevation	Time @ Min. GW El.	Max. GW Elevation	Time @ Max. GW El.	Near by Sumps	Screened Elv. (ft)
OC8	102.00	Jan-02	107.0	Feb-03	2D1/2D2	91 to 96
MW89T	78.00	Jan-05	87.50	Jul-03	2G2/2G3	50 to 51
MW81T	108.00	Apr-05	110.00	Oct-05	2G1/2C1	68 to 73
MW61T	100.50	Oct-02	102.5	Aug-03	2D1	78 to 83
MW51T	92.00	Apr-05	110.0	Jun-03	2A1/2B1	
MW50T	91.00	Apr-05	111.0	Sep-03	2B1	69 to 74
MW49T	92.50	Apr-05	110.0	Aug-03	2B1/2C1	
MW48TR	97.00	Sep-05	107.5	Oct-03	2C1	70 to 72
MW29	94.00	Nov-01	98.0	Mar-03	2D2/2D3	
MW28A	92.50	Oct-02	97.0	Aug-03	2D3	80 to 85
MW27BTR	92.00	Oct-02	95.0	Jul-03	2C3	80 to 85
MW26ATR	87.00	Aug-02	93.5	Apr-03	2B3/2C3	80 to 85
MW24TR	84.50	Oct-02	88.5	Apr-03	2A3/2B3	
MW23ATR	84.50	Sep-02	89.0	Mar-03	2A3	76 to 81
MW22TR	85.00	Sep-02	89.0	Apr-03	2A3	
MW21	86.00	Jan-06	89.0	Oct-03	2A2/2A3	
MW20A	89.00	Oct-05	100.0	Aug-03	2A2/2B2	72 to 75
MW19A	88.50	Oct-05	105.0	Oct-03	2A1	68 to 73
MW127T	90.00	Oct-05	104.5	Oct-03	2A1/2B1	

Section III

Well ID	Min. GW Elevation	Time @ Min. GW El.	Max. GW Elevation	Time @ Max. GW El.	Near by Sumps	Screened Elv. (ft)	
MW89T	79.00	Jan-04	87.00	Jul-03	3A2/3A3	50 to 55	GW fluc. Significantly
MW81T	108.50	Apr-05	110.00	Oct-05	3C2		GW fluc. Significantly
MW116T	77.50	Jan-04	90.0	Jun-05	3B3		GW fluc. Significantly
MW101T	79.00	Dec-04	90.0	Apr-05	3C1	47 to 57	GW fluc. Significantly
PSDL1	94.00	Jan-06	98.5	Oct-01	3A3/3B1/3B2		