APPENDIX D

Underdrain System

URS CALCULATION SHEET	PROJECT: IP-Riegelwood North Bay Landfill Cell 2				JOB NO. 31826716	
	SUBJECT: Groundwater collection system flow volumes				SHEET NO. 1	
	ORIGINATED BY: Rich Lowe	DATE: 6/3/2009	CHECKED BY: CJK	DATE: 5/29/2009	CALC. NO.	REV. NO. 1

Purpose: Estimate the volume and flow rate for groundwater collected in the landfill Cell 2 groundwater collection system for pump/pipe sizing

Method: Water collected in the underdrain system will originate from:
1. Groundwater seepage from the site perimeter
2. Rainwater falling in the landfill footprint prior to liner installation.

Since the primary function of the underdrain is to provide for long-term groundwater separation from the landfill liner, rainwater control is only a temporary construction concern.

Groundwater collection pipe spacing will duplicate that for Cell 1 in approved construction permit 24-02.

Seepage from around landfill Cell 2 perimeter is estimated as follows:

Seepage Source	GPM	Reference
1. Through east landfill dike and C/B slurry wall.	1.75	see pg 2
2. From northeast of landfill cell.	3.46	see pg 2
3. From northwest of landfill cell.	1.44	see pg 3
Cumulative Groundwater Seepage Volume =	**6.65**	gallons/minute

Check methodology against 5-12-09 measured Cell 1 underdrain pump rate

Seepage Source	GPM	Reference
1. Through east dike and C/B slurry wall	1.64	see pg 4
2. From beneath old landfill on south side	15.60	see pg 4
3. From west side of cell near clarifier	2.61	see pg 5
4. From beneath future cell 2 on north side	-0.49	see pg 5
Cumulative Cell 1 Underdrain Seepage Volume Est=	**19.36**	gallons/minute

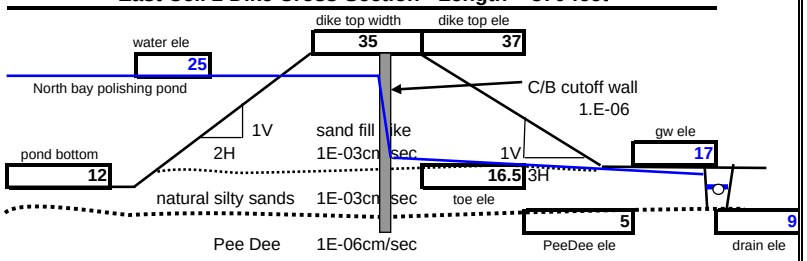
Cell 1 Underdrain pumping records showed following on 5-12-09
Pump ran 47.4 minutes in 4 hours (1:37 to 5:37) @ 60 gpm measured flow rate
This yields an average system flow rate of 11.85 gpm

Therefore, applying same techniques to Cell 2 underdrain, expected flow rate of 3 to 6 gpm expected after liner installation (no direct precip).
Total combined underdrain flow rate likely to rise from 12 gpm to 15-20 gpm.

URS	PROJECT				JOB NO.	
	IP-Riegelwood North Bay Landfill Cell 2				31826716	
	SUBJECT				SHEET NO.	
	Groundwater collection system flow volumes				2	
CALCULATION SHEET	ORIGINATED BY	DATE	CHECKED BY	DATE	CALC. NO.	REV. NO.
	Rich Lowe	6/3/2009	CJK	5/29/2009		1

Purpose: Estimate seepage through/beneath Cell 2 East dike, with an installed cutoff wal collected in groundwater collection and control system to size pumps.

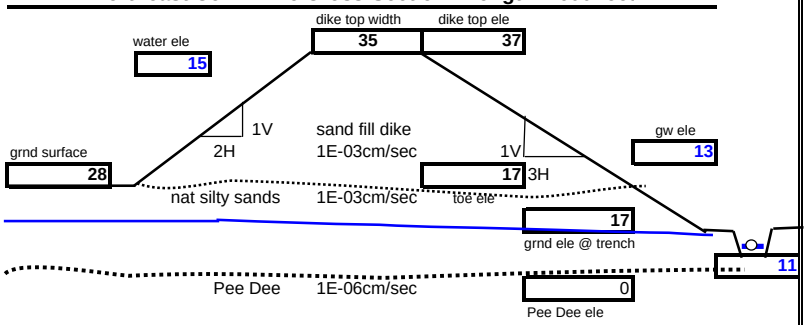
East Cell 2 Dike Cross-Section - Length = 370 feet



layer	k cm/sec	Gradient head loss	Gradient horizontal L	Area sq. ft/L. F.	q gpd/L. F.	Q gpd
sand dike/slurry wall	1.E-06	16	1	8.5	2.9	1,067
nat si sand	1.E-06	16	1	11.5	3.9	1,444
Pee Dee	1.E-06	16	166.5	5	0.0	4
						2,514

1.75 gpm

Northeast Cell 2 Dike Cross-Section - Length = 600 feet

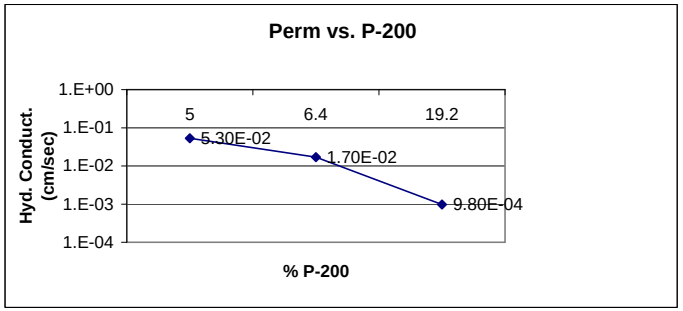


layer	k cm/sec	Gradient head loss	Gradient horizontal L	Area sq. ft/L. F.	q gpd/L. F.	Q gpd
sand dike fill	1.E-03	0				
nat si sand	1.E-03	4	133	13	8.3	4,974
Pee Dee	1.E-06	4	133	5	0.0	2
						4,976

3.46 gpm

All test data from Cell 1 As-Built Rept.

Sample	p-200	k (cm/sec)
SF-7	5	5.30E-02
PC-1	6.4	1.70E-02
stockpile	19.2	9.80E-04
CB wall		1.00E-06



Shallow, naturally occurring silty sand soils are known as the Penholoway aquifer

Penholoway aquifer average horizontal hydraulic conductivity = 4.65E-05 ft/sec (1E-03 cm/sec)

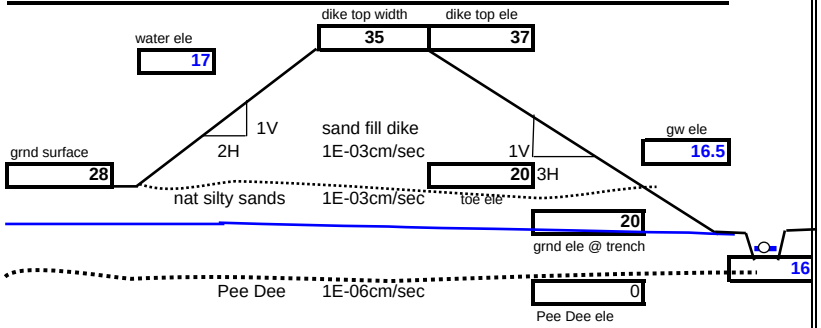
Peedee formation average horiz. Hydraulic conductivity = 3.4E-08 ft/sec (1E-06 cm/sec)
information from December 2004 Water Quality Monitoring Plan prepared by GN Richardson

Upgradient groundwater elevation estimated from following information:
Limited recharge area remaining between landfill perimeter and Cape Fear River bank

URS	PROJECT				JOB NO.	
	IP-Riegelwood North Bay Landfill Cell 2				31826716	
	SUBJECT				SHEET NO.	
	Groundwater collection system flow volumes				3	
CALCULATION SHEET	ORIGINATED BY	DATE	CHECKED BY	DATE	CALC. NO.	REV. NO.
	Rich Lowe	6/3/2009	CJK	5/29/2009		1

Purpose: Estimate seepage through Cell 2 Northwest dike, collected in groundwater collection and control system to size pumps

Northwest Cell 2 Dike Cross-Section - Length = 737 feet

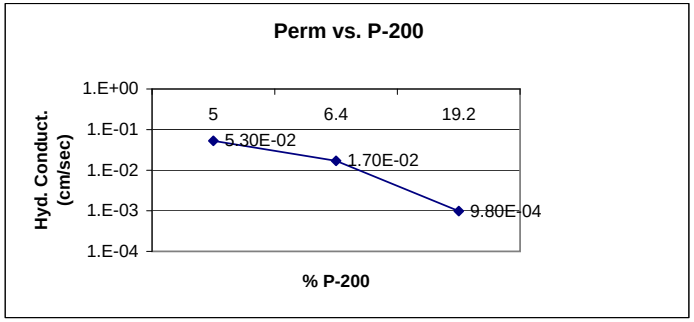


layer	k cm/sec	Gradient head loss	Gradient horizontal L	Area sq. ft/L. F.	q gpd/L. F.	Q gpd
sand dike fill	1.E-03	0				0
nat si sand	1.E-03	1	124	16.5	2.8	2,079
Pee Dee	1.E-06	1	124	5	0.0	1
						2,080

1.44 gpm

All test data from Cell 1 As-Built Rept.

Sample	p-200	k (cm/sec)
SF-7	5	5.30E-02
PC-1	6.4	1.70E-02
stockpile	19.2	9.80E-04
CB wall		1.00E-06



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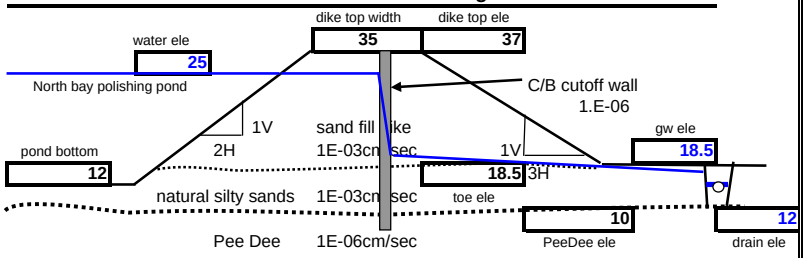
URS	PROJECT				JOB NO.	
	IP-Riegelwood North Bay Landfill Cell 2				31826716	
	SUBJECT				SHEET NO.	
	Groundwater collection system flow volumes				4	
CALCULATION SHEET	ORIGINATED BY	DATE	CHECKED BY	DATE	CALC. NO.	REV. NO.
	Rich Lowe	6/3/2009	CJK	5/29/2009		1

Purpose: Calibrate seepage estimates through/beneath Cell 1 East dike, with an installed collected in groundwater collection with actual 5-12-09 pumping rate records.

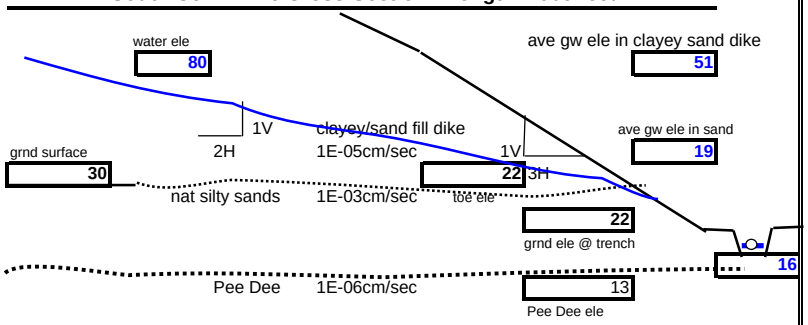
East Cell 1 Dike Cross-Section - Length = 570 feet



layer	k cm/sec	Gradient head loss	Gradient horizontal L	Area sq. ft/L. F.	q gpd/L. F.	Q gpd
sand dike/slurry wall	1.E-06	13	1	6.5	1.8	1,021
nat si sand	1.E-06	13	1	8.5	2.3	1,335
Pee Dee	1.E-06	13	160.5	5	0.0	5
						2,362

1.64 gpm

South Cell 1 Dike Cross-Section - Length = 909 feet

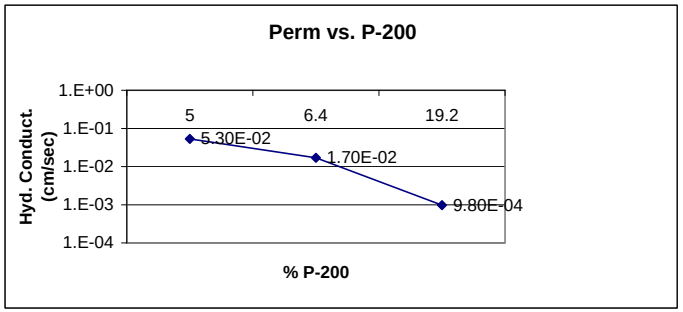


layer	k cm/sec	Gradient head loss	Gradient horizontal L	Area sq. ft/L. F.	q gpd/L. F.	Q gpd
sand dike fill	1.E-05	58	250	29	1.4	1,297
nat si sand	1.E-03	64	350	6	23.3	21,146
Pee Dee	1.E-06	64	350	5	0.0	18
						22,460

15.60 gpm

All test data from Cell 1 As-Built Rept.

Sample	p-200	k (cm/sec)
SF-7	5	5.30E-02
PC-1	6.4	1.70E-02
stockpile	19.2	9.80E-04
CB wall		1.00E-06



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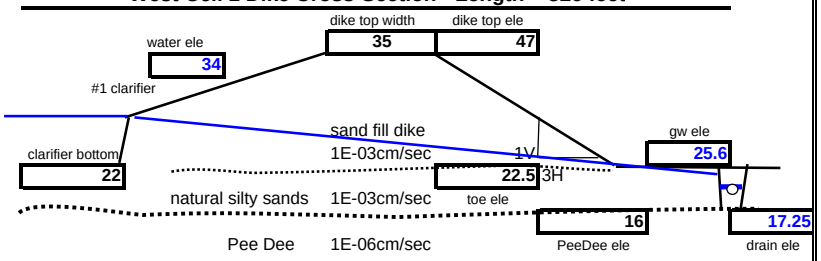
information from December 2004 Water Quality Monitoring Plan prepared by GN Richardson

Clayey sand dike fill hydraulic conductivity of south Cell 1 dike based on visual recollections of author from 2002 construction observation. Source: Wright Chemical beneath power lines. No testing was performed on the material.

URS	PROJECT				JOB NO.	
	IP-Riegelwood North Bay Landfill Cell 2				31826716	
	SUBJECT				SHEET NO.	
	Groundwater collection system flow volumes				5	
CALCULATION SHEET	ORIGINATED BY	DATE	CHECKED BY	DATE	CALC. NO.	REV. NO.
	Rich Lowe	6/3/2009	CJK	5/29/2009		1

Purpose: Calibrate seepage estimates through/beneath Cell 1 East dike, with an installed collected in groundwater collection with actual 5-12-09 pumping rate records.

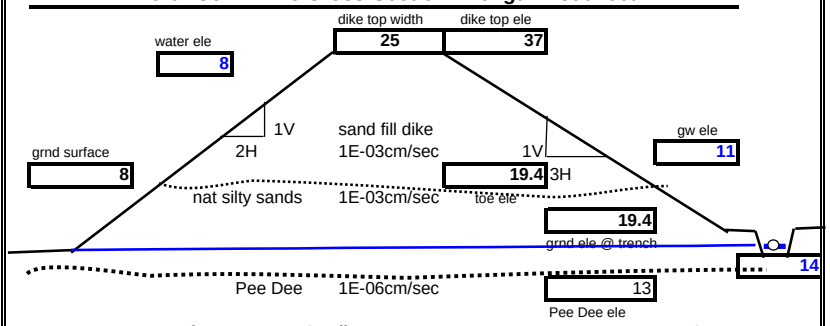
West Cell 1 Dike Cross-Section - Length = 326 feet



layer	k cm/sec	Gradient head loss	Gradient horizontal L	Area sq. ft/L. F.	q gpd/L. F.	Q gpd
sand dike fill	1.E-03					0
nat si sand	1.E-03	16.75	162	5.25	11.5	3,752
Pee Dee	1.E-06	16.75	162	5	0.0	4
						3,756

2.61 gpm

North Cell 1 Dike Cross-Section - Length = 856 feet

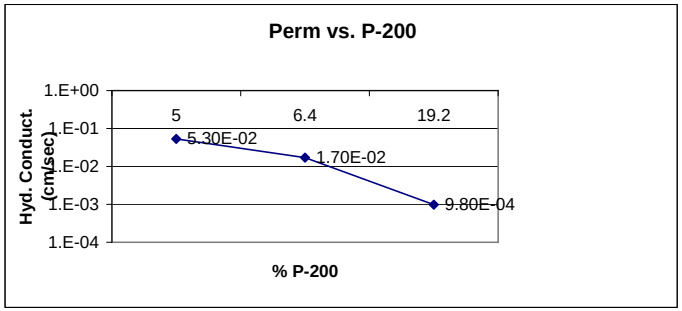


layer	k cm/sec	Gradient head loss	Gradient horizontal L	Area sq. ft/L. F.	q gpd/L. F.	Q gpd
sand dike fill	1.E-03		155.8			
nat si sand	1.E-03	-6	155.8	1	-0.8	-699
Pee Dee	1.E-06	-6	155.8	5	0.0	-3
						-702

-0.49 gpm

All test data from Cell 1 As-Built Rept.

Sample	p-200	k (cm/sec)
SF-7	5	5.30E-02
PC-1	6.4	1.70E-02
stockpile	19.2	9.80E-04
CB wall		1.00E-06



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