Groundwater flow directions and seepage velocities were calculated pursuant to Condition D.4.b of Module VII of the Laidlaw Environmental Services Grassy Mountain Facility Permit (Part B). These flow directions and rates were calculated using a systematic and simple method that was developed specifically to calculate groundwater velocities from irregularly spaced groundwater elevation data points (Pinder, 1981). Thirty-five triangular elements were developed based upon monitoring well locations, hydraulic conductivity data availability, and the locations of active and closed landfill cells. The triangular elements are displayed on the site potentiometric surface map.

Also displayed are the calculated flow vectors. The vectors begin in the center of each triangle and indicate the calculated direction of flow. The vectors are color-coded based upon calculated groundwater seepage velocities. The seepage velocities were calculated from measured values of hydraulic conductivity, (K) hydraulic gradient, (i) and porosity, (n).

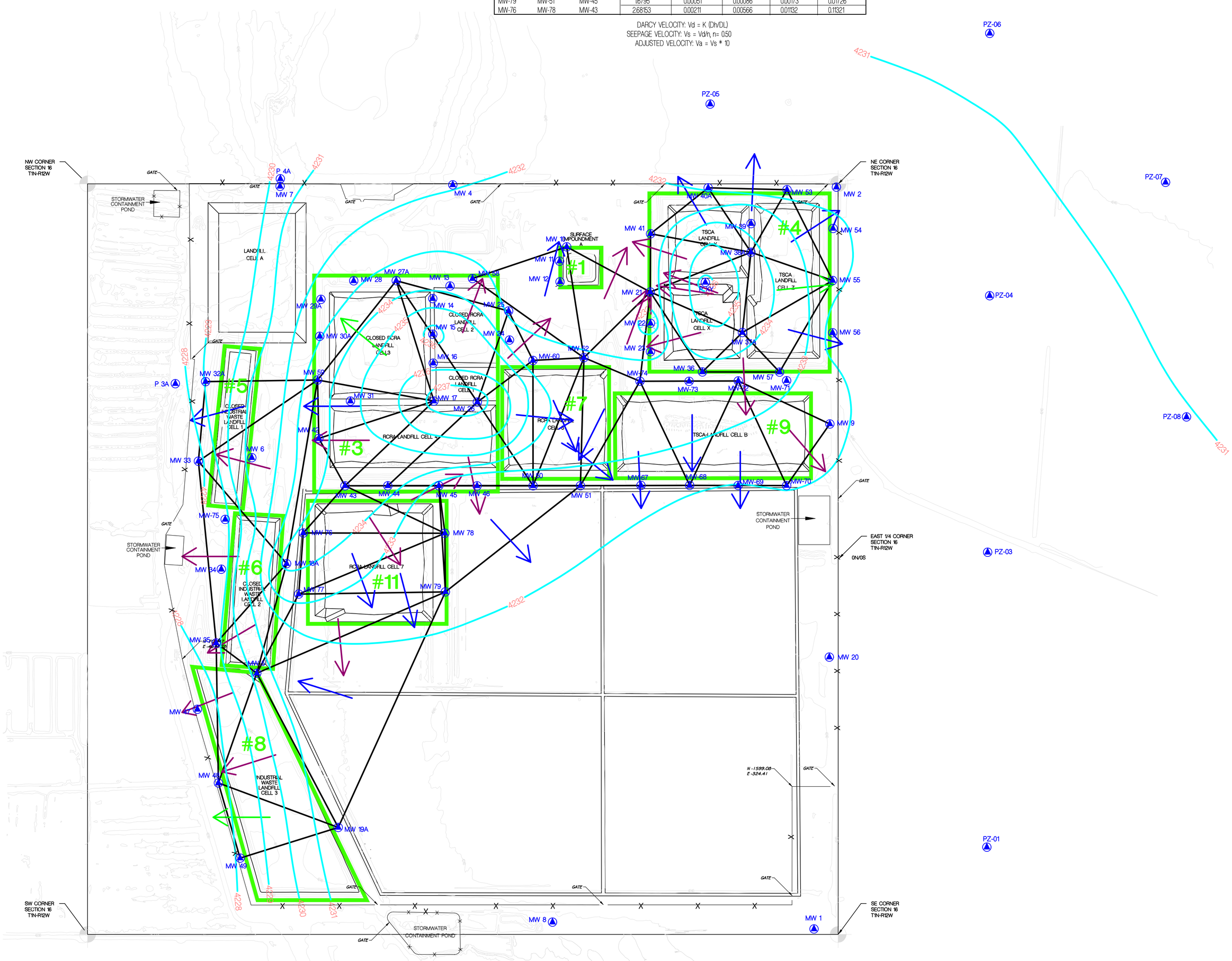
The legend also presents two ranges of seepage velocity which attempt to characterize the heterogeneous nature of subsurface conditions at the site. The ranges include seepage velocity based on "K" values derived from slug tests responding mainly to the upper clayey-silty aquifer matrix. However adjusted "K" values are based on pump test data which describe groundwater flow affected by a relatively more permeable, underlying sandy layer. Seepage velocity estimates incorporating the sand layer result in values that are effectively one order of magnitude higher than seepage velocity values based on the clay-silt layer alone.

References

Pinder, George F., Michael Celia, and William G. Gray. 1981. Velocity calculation from randomly located hydraulic heads. Ground Water. v. 19, no. 3, pp. 262-264.

MONITORING WELLS			AVERAGE K (FT/DAY)	GRADIENT (dH/dL)	VELOCITY (FT/DAY)		
					DARCY	SEEPAGE	ADJUSTED
MW-19A	MW-48	MW-49	0.05817	0.00518	0.0003	0.0006	0.00603
MW-05	MW-35	MW-48	1.21227	0.00576	0.00699	0.01398	0.13977
MW-17	MW-59	MW-42	0.21689	0.00448	0.00097	0.00195	0.01945
MW-17	MW-42	MW-43	2.05583	0.00454	0.00933	0.01866	0.18656
MW-17	MW-27A	MW-59	0.07796	0.00504	0.00039	0.00079	0.00786
MW-26	MW-25	MW-27A	1.94537	0.00711	0.01384	0.02767	0.27671
MW-72	MW-68	MW-70	0.636	0.00216	0.00137	0.00274	0.02741
MW-72	MW-70	MW-09	4.7448	0.00209	0.00992	0.01983	0.19834
MW-37A	MW-36	MW-57	1.25907	0.00543	0.00683	0.01366	0.13661
MW-37A	MW-55	MW-38A	0.11323	0.00364	0.00041	0.00082	0.00824
MW-38A	MW-53	MW-40A	0.32237	0.00542	0.00175	0.00349	0.03494
MW-37A	MW-38A	MW-21	7.7296	0.003	0.02318	0.04637	0.46366
MW-18A	MW-59	MW-33	1.65112	0.00815	0.01346	0.02691	0.26913
MW-59	MW-32A	MW-33	0.38539	0.00573	0.00221	0.00442	0.04419
MW-26	MW-60	MW-50	0.3601	0.01081	0.00389	0.00779	0.07787
MW-18A	MW-33	MW-35	1.8833	0.01046	0.01971	0.03941	0.39412
MW-26	MW-44	MW-50	2.39387	0.0074	0.01772	0.03544	0.35439
MW-38A	MW-40A	MW-41	0.89093	0.0044	0.00392	0.00784	0.0784
MW-74	MW-51	MW-68	0.51573	0.00208	0.00107	0.00215	0.02146
MW-10	MW-58	MW-52	0.37663	0.00154	0.00058	0.00116	0.01162
MW-19A	MW-05	MW-48	1.00063	0.00632	0.00633	0.01265	0.12654
MW-05	MW-18A	MW-35	2.79483	0.00755	0.02109	0.04218	0.42181
MW-68	MW-72	MW-74	0.72	0.00213	0.00153	0.00306	0.03062
MW-57	MW-55	MW-37A	0.18607	0.00473	0.00088	0.00176	0.0176
MW-55	MW-53	MW-38A	0.3748	0.00537	0.00201	0.00403	0.04026
MW-21	MW-38A	MW-41	8.55973	0.00286	0.02447	0.04894	0.4894
MW-21	MW-36	MW-37A	8.86107	0.00392	0.03474	0.06947	0.69473
MW-52	MW-21	MW-10	8.03663	0.00165	0.01325	0.02651	0.26509
MW-52	MW-74	MW-21	8.208	0.0017	0.01399	0.02798	0.2798
MW-50	MW-52	MW-60	0.60257	0.0012	0.00072	0.00145	0.01448
MW-50	MW-51	MW-52	0.3287	0.00258	0.00085	0.0017	0.01696
MW-51	MW-74	MW-52	0.54933	0.00177	0.00097	0.00195	0.01948
MW-26	MW-60	MW-25	2.19353	0.00804	0.01763	0.03525	0.35254
MW-78	MW-45	MW-43	3.55467	0.00309	0.01098	0.02197	0.21967
MW-76	MW-77	MW-78	1.29193	0.00367	0.00474	0.00948	0.09477
MW-79	MW-78	MW-77	0.62257	0.00168	0.00105	0.0021	0.02098
MW-79	MW-77	MW-05	1.47143	0.0048	0.00706	0.01412	0.14121
MW-19A	MW-79	MW-05	1.04263	0.00189	0.00197	0.00394	0.03936
MW-79	MW-51	MW-45	1.6795	0.00051	0.00086	0.00173	0.01726
MW-76	MW-78	MW-43	2.68153	0.00211	0.00566	0.01132	0.11321

DARCY VELOCITY: Vd = K (Dh/DL)
SEEPAGE VELOCITY: Vs = Vd/n, n= 0.50
ADJUSTED VELOCITY: Va = Vs * 10



Location	Surveyed	Top Of Casing	Easting	Northing	Potentiometric Surface Elevation (MSL)
MW-01	9/1/99	4240.05	-169.74	-261.06	423.173
MW-02	9/1/99	4240.73	-12.64	262.87	423.156
MW-04	9/1/99	4252.46	-270.56	262.82	423.192
MW-05	9/1/99	4257.01	-409.03	-81.25	423.009
MW-06	9/1/99	4262.39	-413.71	75.52	423.137
MW-07	9/1/99	4249.20	-391.05	262.93	423.042
MW-08	9/1/99	4243.96	-200.21	-253.55	423.150
MW-09	9/1/99	4243.81	-9.24	96.77	423.230
MW-10	9/1/99	4244.93	-191.13	2191.78	423.254
MW-11	9/1/99	4244.91	-196.48	2097.07	423.242
MW-12	9/1/99	4245.19	-195.70	195.93	423.253
MW-13	9/1/99	4262.25	-273.25	192.50	423.160
MW-14	9/1/99	4261.01	-285.91	183.33	423.604
MW-15	9/1/99	4259.63	-285.53	158.80	423.602
MW-16	9/1/99	4259.71	-284.91	137.79	423.581
MW-17	9/1/99	4260.45	-284.25	111.37	423.705
MW-18A	6/10/99	4253.73	-388.51	-31.75	423.427
MW-19A	9/1/99	4250.42	-359.15	-190.74	423.173
MW-20	9/1/99	4248.38	-62.83	-698.23	423.194
MW-21	9/1/99	4243.47	-132.65	1880.11	423.662
MW-22	9/1/99	4243.16	-132.45	1860.41	423.163
MW-23	9/1/99	4243.89	-132.46	1460.41	423.287
MW-24	9/1/99	4243.20	-233.15	154.90	423.328
MW-25	9/1/99	4243.60	-233.53	174.58	423.288
MW-26	9/1/99	4262.09	-254.32	110.28	423.769
MW-27A	9/1/99	4252.35	-311.85	192.36	423.329
MW-28	9/1/99	4248.77	-349.93	195.38	423.283
MW-29A	9/1/99	4253.78	-363.12	182.73	423.274
MW-30A	9/1/99	4253.26	-363.01	158.96	423.236
MW-31	9/1/99	4261.77	-343.78	111.31	423.483
MW-32A	9/1/99	4241.14	-443.15	124.93	423.903
MW-33	9/1/99	4241.08	-452.08	68.67	422.733
MW-34	9/1/99	4241.36	-434.85	-49.98	422.861
MW-35	9/1/99	4241.77	-437.58	-58.54	422.887
MW-36	9/1/99	4242.70	-365.59	131.38	423.342
MW-37A	9/1/99	4261.15	-67.462	158.23	423.475
MW-38A	9/1/99	4264.03	-615.09	216.23	423.432
MW-39	9/1/99	4261.12	-613.39	236.01	423.321
MW-40A	9/1/99	4242.34	-91.421	-267.89	423.193
MW-41	9/1/99	4244.71	-120.22	228.77	423.228
MW-42	9/1/99	4246.87	-365.46	85.043	423.343
MW-43	9/1/99	4248.10	-347.057	51.735	423.432
MW-44	9/1/99	4246.07	-319.395	51.766	423.438
MW-45	9/1/99	4243.95	-280.997	51.816	423.533
MW-46	9/1/99	4243.75	-254.103	51.720	423.217
MW-47	9/1/99	4243.22	-459.806	-165.559	422.707
MW-48	9/1/99	4244.04	-436.126	-157.413	422.731
MW-49	9/1/99	4243.93	-420.882	-210.276	422.810
MW-50	9/1/99	4244.65	-214.697	51.770	423.233
MW-51	9/1/99	4244.98	-181.533	51.778	423.217
MW-52	9/1/99	4249.83	-178.913	141.727	423.963
MW-53	9/1/99	4244.32	-358.46	253.607	423.188
MW-54	9/1/99	4244.11	-36.25	232.527	423.220
MW-55	9/1/99	4244.10	-36.68	196.989	423.230
MW-56	9/1/99	4244.13	-37.74	158.917	423.149
MW-57	9/1/99	4243.22	-412.45	131.669	423.322
MW-58	9/1/99	4250.15	-258.162	197.107	423.317
MW-59	9/1/99	4255.41	-367.267	126.866	423.333
MW-60	9/1/99	4250.48	-214.762	139.750	423.379
MW-67	9/1/99	4247.23	-138.798	51.825	423.214
MW-68	9/1/99	4246.41	-104.543	51.906	423.212
MW-69	9/1/99	4245.94	-70.437	51.867	423.191
MW-70	9/1/99	4246.12	-36.853	51.784	423.209
MW-71	9/1/99	4243.85	-362.92	125.537	423.220
MW-72	9/1/99	4244.89	-103.15	125.361	423.369
MW-73	9/1/99	4245.96	-104.936	125.102	423.375
MW-74	9/1/99	4246.45	-139.535	125.164	423.367
MW-75	9/1/99	4259.89	-431.39	27.950	422.887
MW-76	9/1/99	4253.83	-374.269	18.455	423.405
MW-77	9/1/99	4252.05	-377.531	-24.504	423.11
MW-78	9/1/99	4244.65	-274.724	18.299	423.292
MW-79	9/1/99	4245.18	-274.361	-22.971	423.223
P-3A	9/1/99	4232.02	-467.141	1226.06	422.748
P-3B	9/1/99	4232.13	-467.221	1216.21	422.622
P-3C	9/1/99	4232.24	-467.316	1205.76	423.139
P-4A	9/1/99	4248.47	-391.665	2638.85	423.012
P-4B	9/1/99	4247.43	-388.61	2626.06	423.081
P-4C	9/1/99	4249.53	-391.74	2608.93	423.078
PXY	9/1/99	4261.65	-935.01	1947.76	423.635
PZ-01	9/1/99	4241.97	1045.59	-2035.85	423.158
PZ-03	9/1/99	4242.10	1049.00	48.36	423.199
PZ-04	9/1/99	4242.32	1060.05	1852.72	423.195
PZ-05	9/1/99	4242.33	-899.86	3189.75	423.171
PZ-06	9/1/99	4243.39	1092.80	3714.34	423.060
PZ-07	9/1/99	4243.97	2299.98	2647.85	423.029
PZ-08	9/1/99	4244.05	2449.79	999.19	423.108

LEGEND

- MONITORING WELL LOCATION
- POTENTIOMETRIC SURFACE CONTOUR FEET ABOVE M.S.L. (INTERVAL = 1 FT.)
- TOPOGRAPHIC SURFACE CONTOUR
- #4 WASTE MANAGEMENT AREA
- TRIANGULAR ELEMENT USED IN VELOCITY CALCULATION

	ADJUSTED	SEEPAGE
VELOCITY (FT/DAY) =	10^{-3} - 10^{-2}	10^{-4} - 10^{-3}
VELOCITY (FT/DAY) =	10^{-2} - 10^{-1}	10^{-3} - 10^{-2}
VELOCITY (FT/DAY) =	10^{-1} - 10^{0}	10^{-2} - 10^{-1}

safety-kleen

	BY	DATE
DRAWN	CJJ	3-22-00
CHECKED		
APPROVED		
APPROVED		
APPROVED		

safety-kleen consulting

GRASSY MOUNTAIN FACILITY
KNOLLS, UTAH

ATTACHMENT VII-1
POTENTIOMETRIC SURFACE/FLOW VELOCITIES, WELL AND WMA LOCATIONS

SCALE 1' = 400'

DWG. NO. 963225-07