

Appendix E

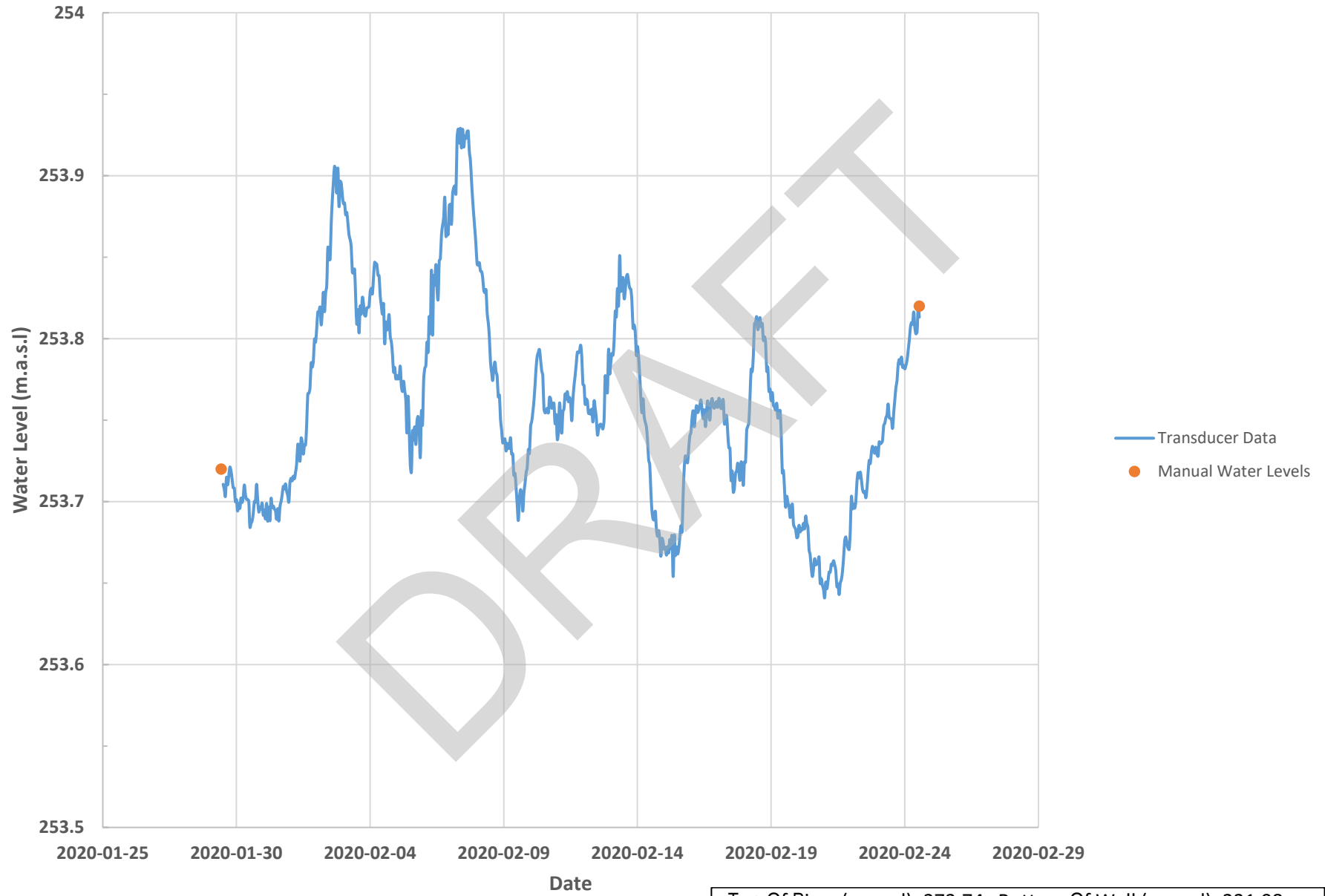
Water Levels and Hydrographs

Monitoring Well Installation Details and Groundwater Level Summary

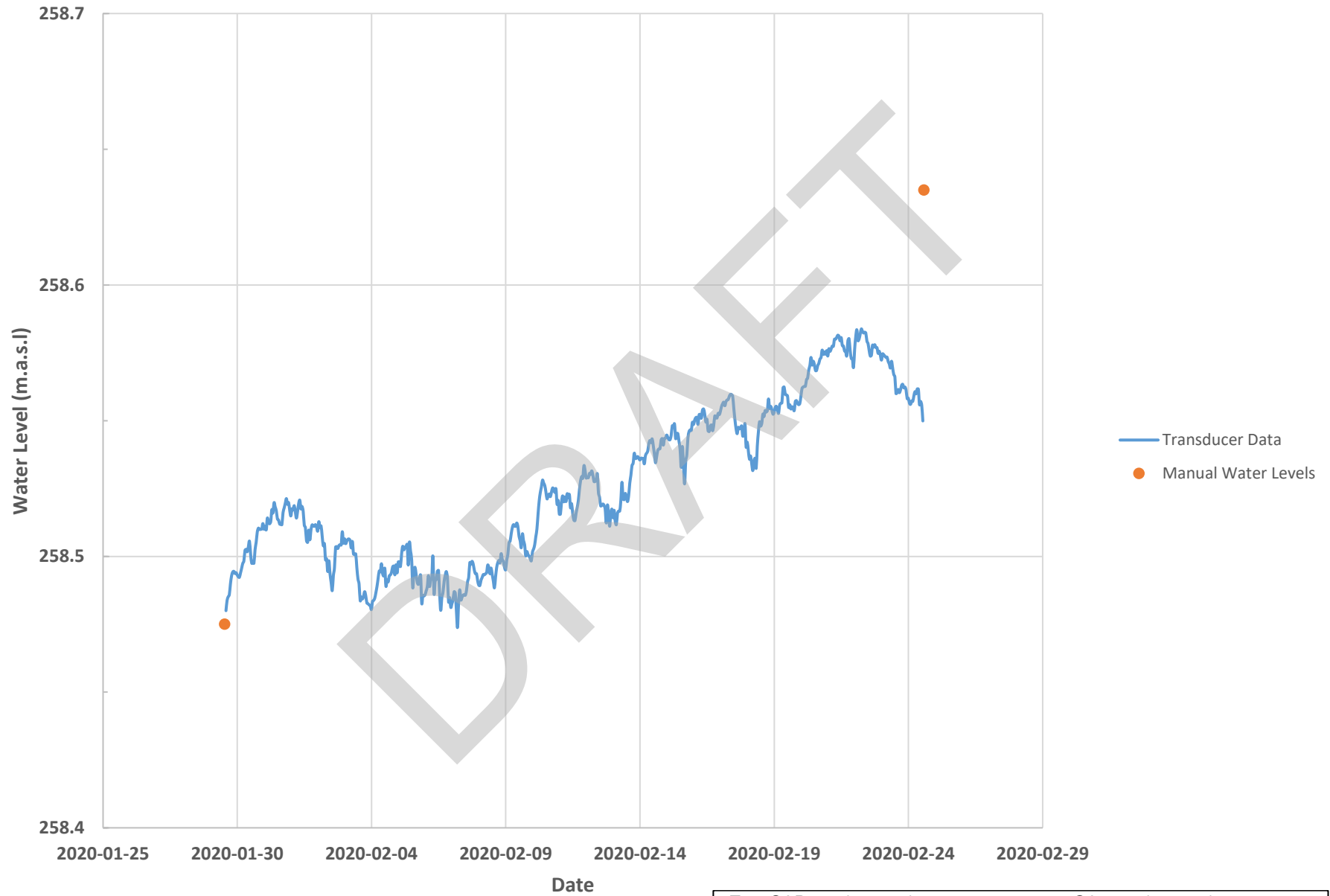
Well Number	Borehole ID	Aquifer	Ground Surface Elevation (masl)	UTM		Well Depth (mbgs)	Well Bottom Elevation (masl)	Top of Riser Elevation (masl)	Top of Well Screen		Bottom of Well Screen		November 27, 2019		January 29, 2020		February 24, 2020	
				Easting (m)	Northing (m)				Depth (mbgs)	Elevation (masl)	Depth (mbgs)	Elevation (masl)	Static Water Level (mbgs)	Static Water Elevation (masl)	Static Water Level (mbgs)	Static Water Elevation (masl)	Static Water Level (mbgs)	Static Water Elevation (masl)
19-1	BH19-1	WOA	272.97	482562	4747433	41.0	232.0	273.739	39.5	233.5	41.0	232.0	19.23	253.74	19.25	253.72	19.15	253.82
19-2a	BH19-2	UA	272.29	482505	4747770	45.6	226.7	273.012	44.1	228.2	45.6	226.7	18.73	253.56	18.34	253.95	18.25	254.04
19-2b	92-7	UA	272.20	482507	4747769	13.8	258.4	272.985	12.3	259.9	13.8	258.4	12.69	259.51	12.76	259.44	12.66	259.54
19-3	BH19-3	WOA	274.34	482425	4748008	48.6	225.8	275.145	47.0	227.3	48.6	225.8	16.67	257.67	15.86	258.48	15.70	258.64
19-4a	BH19-4	WOA	280.34	480896	4748251	39.5	240.9	281.088	38.0	242.4	39.5	240.9	22.08	258.26	21.59	258.75	21.56	258.77
19-4b	BH19-4-2	UA	280.44	480898	4748253	22.8	257.7	281.121	21.3	259.2	22.8	257.7	21.78	258.66	21.66	258.78	21.60	258.84
19-5a	BH19-5	WOA	282.58	481335	4748299	39.5	243.0	283.282	38.0	244.6	39.5	243.0	24.14	258.44	23.80	258.78	23.76	258.82
19-5b	BH19-5-2	UA	282.65	481336	4748300	22.1	260.6	283.439	20.6	262.1	22.1	260.6	21.47	261.19	21.82	260.84	21.79	260.87
19-6a	BH19-6	WOA	280.91	481678	4748289	39.5	241.4	281.647	38.0	242.9	39.5	241.4	22.70	258.21	22.22	258.69	22.17	258.74
19-6b	BH19-6-2	UA	280.92	481679	4748289	12.9	268.0	281.694	11.4	269.5	12.9	268.0	2.88	278.03	1.26	279.65	1.70	279.22
19-7a	BH19-7	WOA	278.49	480718	4748242	41.3	237.2	279.287	39.7	238.7	41.3	237.2	20.05	258.44	19.71	258.78	19.68	258.81
19-7b	BH19-7-2	WOA	278.61	480721	4748242	21.5	257.1	279.373	20.0	258.6	21.5	257.1	19.94	258.67	19.79	258.82	19.77	258.84
19-7c	BH19-7-3	SA	278.55	480715	4748242	5.9	272.6	279.330	4.4	274.1	5.9	272.6	4.80	273.75	1.09	277.46	0.86	277.70

Notes: WOA = White Oak Aquifer; UA= Upper Aquifer; SA = Surficial Aquitard

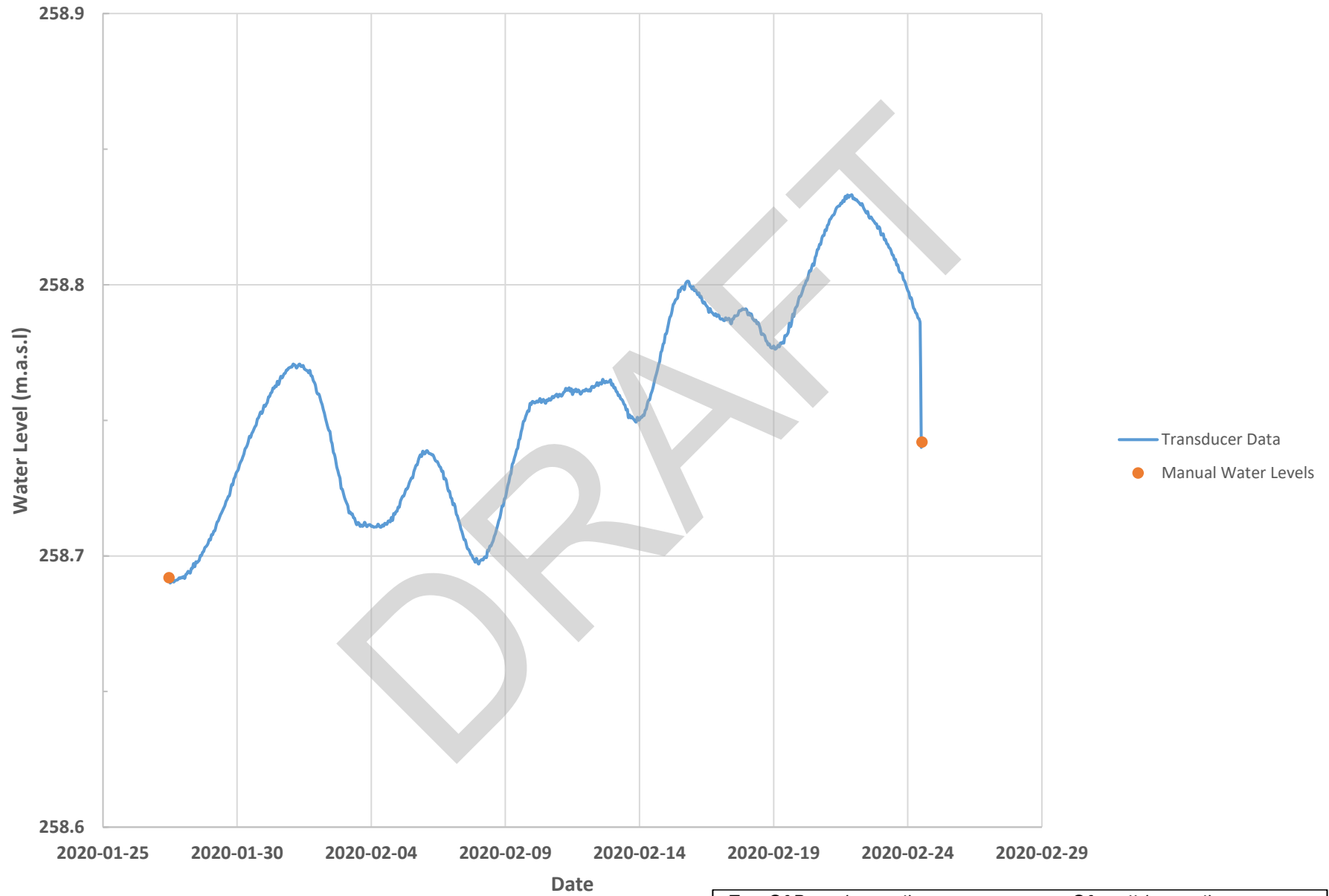
19-1



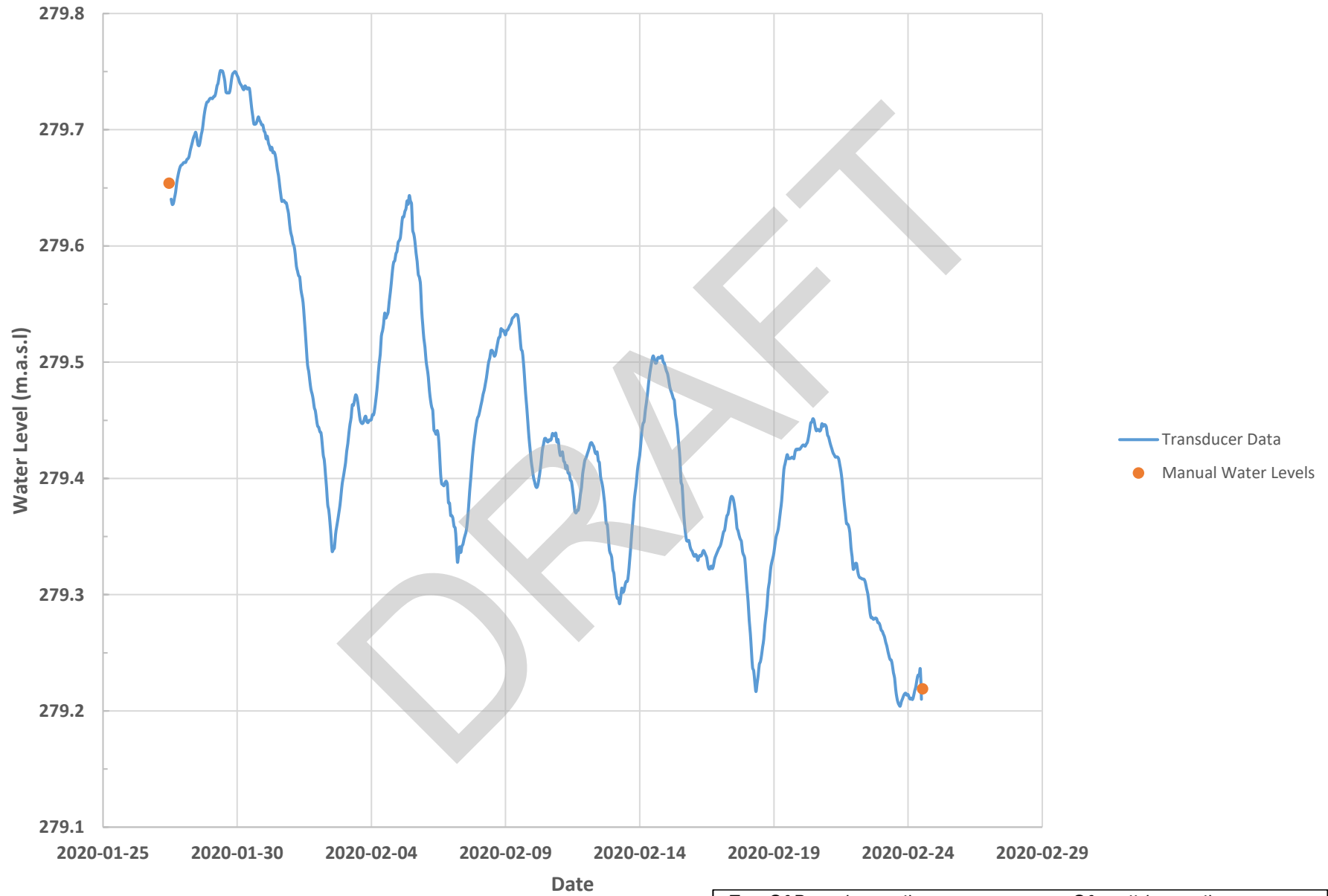
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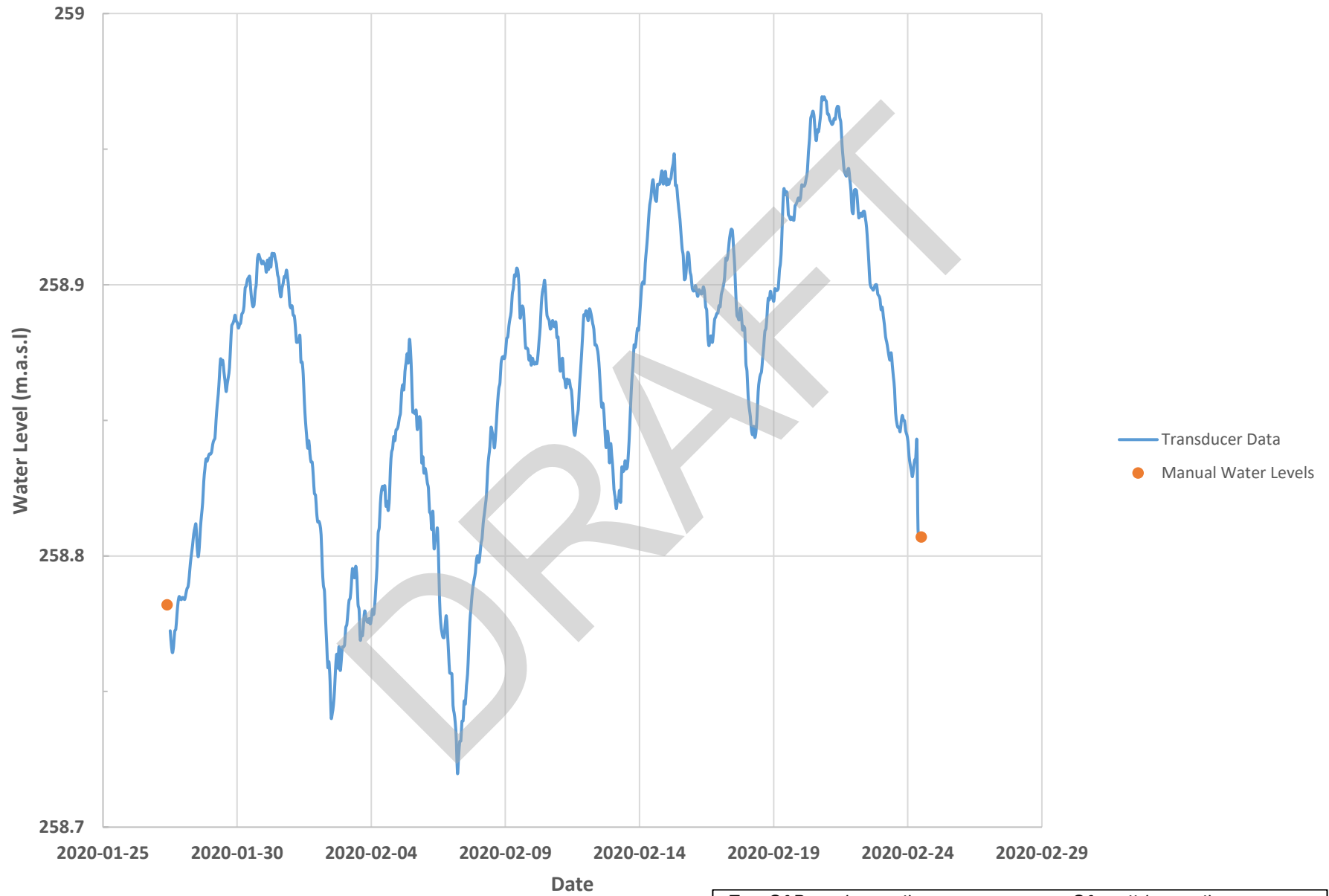
19-6A



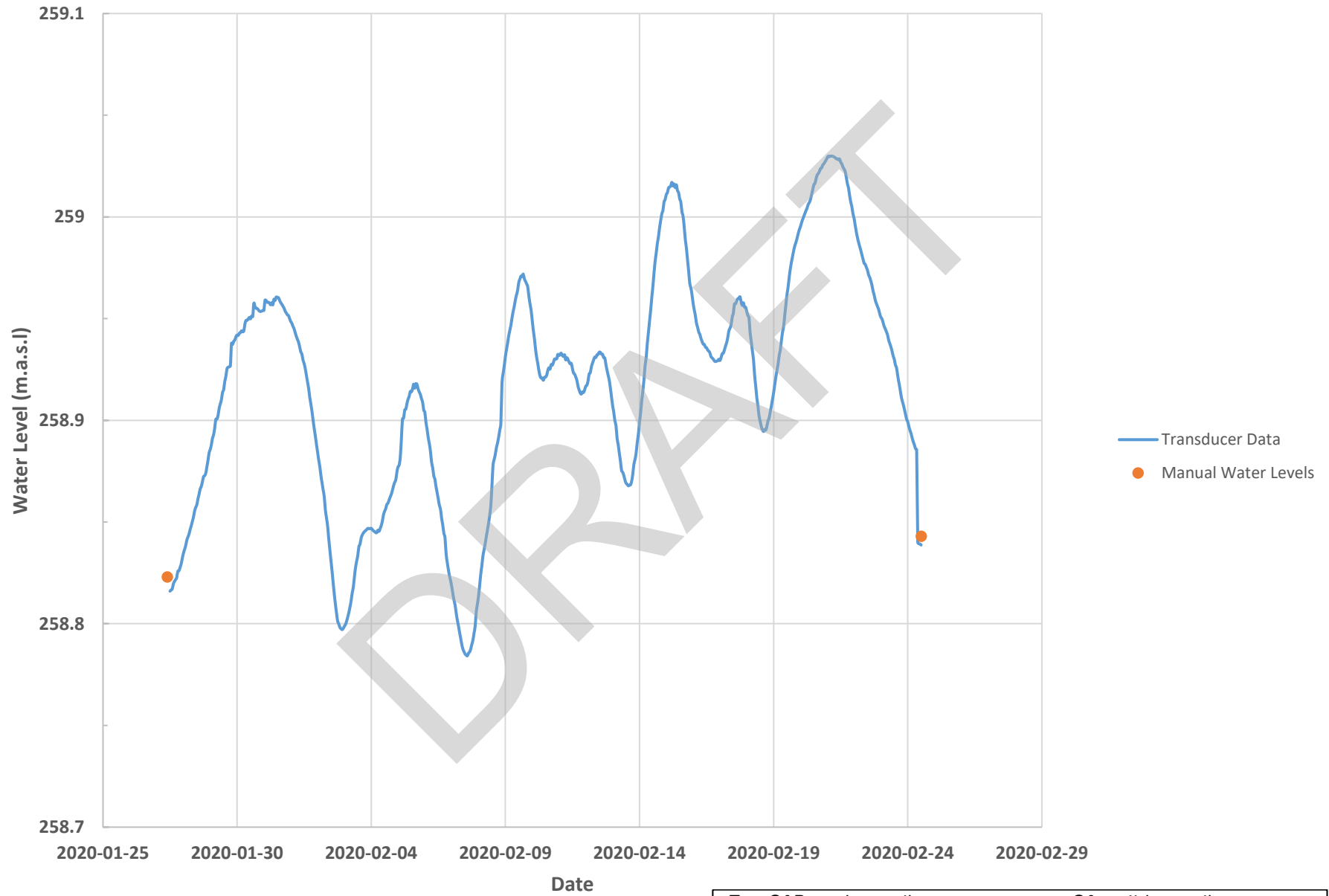
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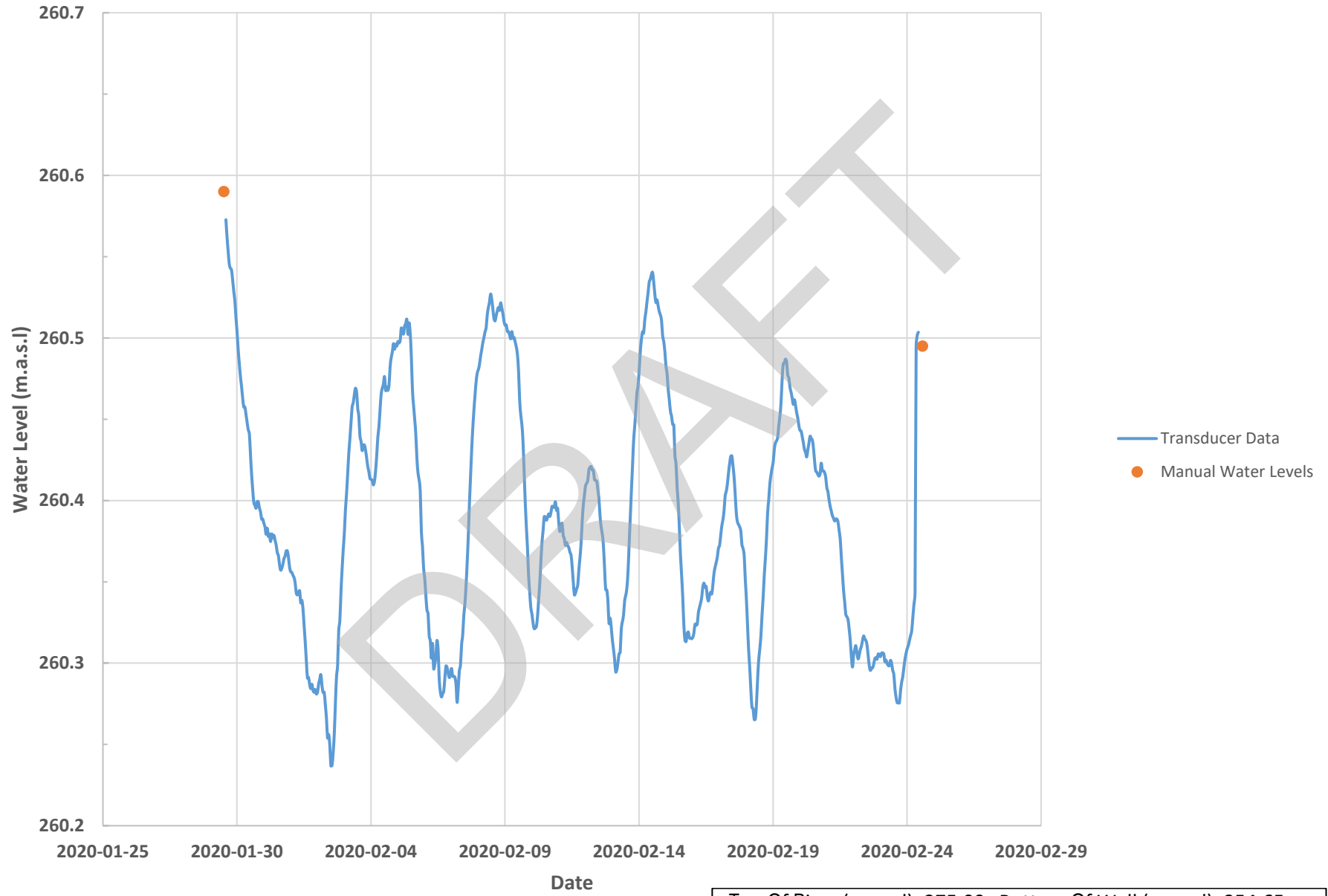
19-7A



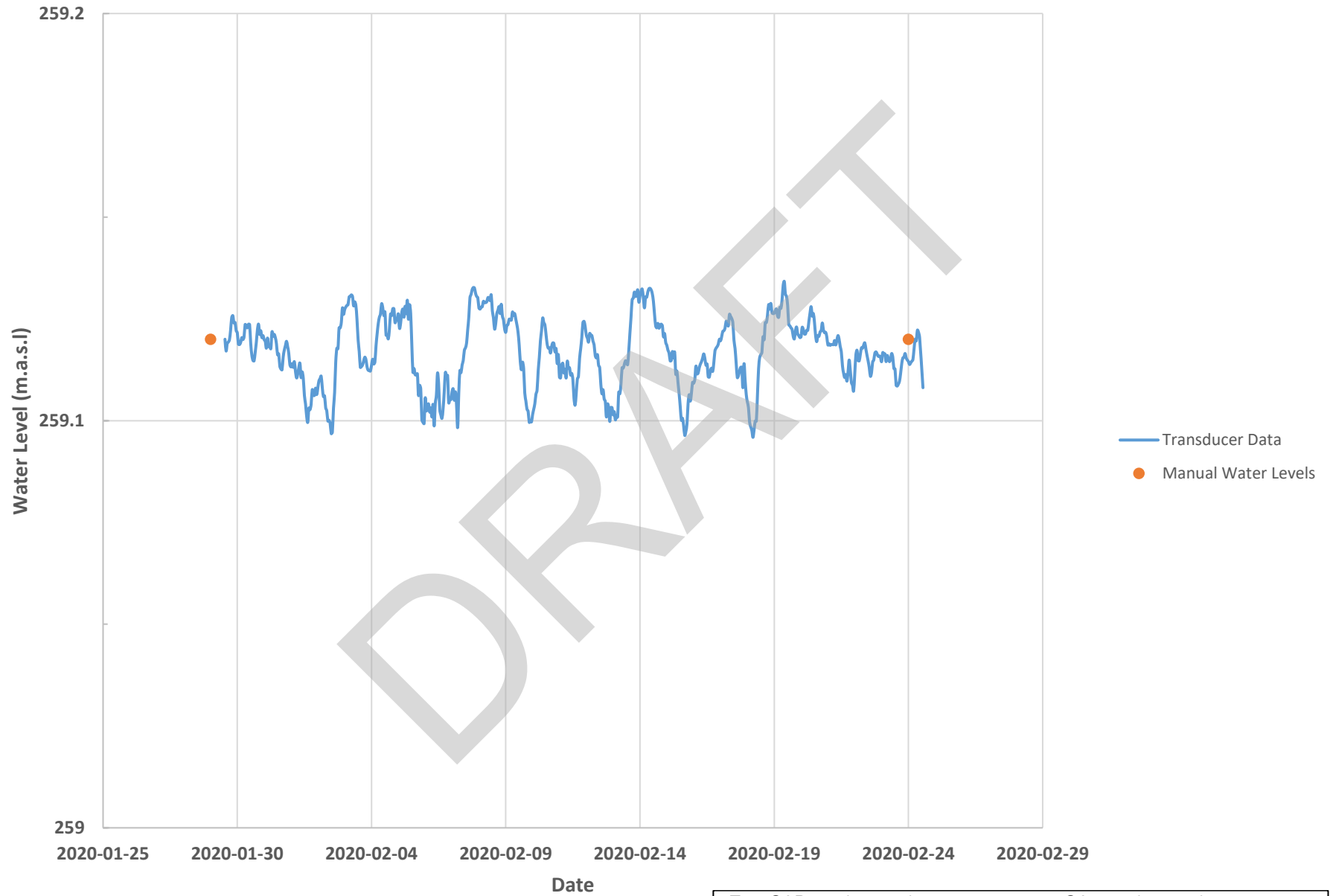
19-7B



92-3



92-4



Appendix F

Groundwater Quality

Summary of Groundwater Quality Results

Monitoring Well		19-1	19-3	19-3 (Dup)	19-4a	19-5a	19-6a	19-6b	19-7a	19-7b	19-7c
Sample ID		BH19-1	BH19-3	BH19-31	BH19-4	BH19-5	BH19-6	BH19-6-2	BH19-7	BH19-7-2	BH19-7-3
Date Sampled		10-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019
	Units										
Physical Tests											
Conductivity	umhos/cm	538	393	394	959	975	1660	1920	1380	978	654
pH	pH units	8.08	7.83	7.83	7.69	7.67	7.40	8.07	7.77	7.89	8.02
Anions and Nutrients											
Alkalinity, Total (as CaCO3)	mg/L	522	247	227	290	304	370	654	317	385	273
Ammonia, Total (as N)	mg/L	0.365	0.118	0.110	0.132	0.050	0.073	0.380	0.081	<0.010	0.049
Bromide (Br)	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.50	<0.50	<0.10	<0.10
Chloride (Cl)	mg/L	8.08	0.97	0.96	52.6	41.3	21.4	8.8	166	32.1	11.2
Fluoride (F)	mg/L	1.04	1.10	1.14	0.177	0.157	0.14	0.70	0.24	0.263	0.278
Nitrate (as N)	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.10	<0.10	<0.10	<0.020	0.182
Nitrite (as N)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.050	<0.050	<0.010	0.032
Total Kjeldahl Nitrogen	mg/L	0.48	0.49	0.33	0.28	0.26	0.38	0.56	0.26	0.28	0.26
Sulfate (SO4)	mg/L	66.0	1.35	1.68	166	175	694	606	230	162	82.3
Organic / Inorganic Carbon											
Dissolved Organic Carbon	mg/L	6.80	7.68	7.66	18.5	14.5	7.27	3.82	24.4	72.1	3.38
Dissolved Metals											
Arsenic (As)-Dissolved	mg/L	0.00792	0.00057	0.00055	0.00160	0.00105	0.0012	0.0021	0.00056	0.00194	0.00097
Barium (Ba)-Dissolved	mg/L	0.0624	0.368	0.354	0.0606	0.143	0.0421	0.0824	0.0450	0.0639	0.114
Boron (B)-Dissolved	mg/L	0.194	0.096	0.091	0.024	0.028	<0.10	0.25	0.026	0.035	0.073
Cadmium (Cd)-Dissolved	mg/L	0.000011	<0.000010	<0.000010	<0.000010	<0.000010	<0.000050	<0.000050	<0.000010	0.000016	<0.000010
Calcium (Ca)-Dissolved	mg/L	32.4	40.8	40.2	123	123	297	93.8	172	117	59.7
Iron (Fe)-Dissolved	mg/L	0.701	0.450	0.451	1.40	1.91	7.66	<0.10	2.67	0.048	0.018
Lead (Pb)-Dissolved	mg/L	0.000619	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.000050	0.000114	<0.000050
Magnesium (Mg)-Dissolved	mg/L	10.5	14.8	14.5	19.7	26.0	56.4	176	32.5	35.0	40.7
Manganese (Mn)-Dissolved	mg/L	0.0614	0.0201	0.0198	0.167	0.0825	0.156	0.0840	0.108	0.268	0.00189
Nickel (Ni)-Dissolved	mg/L	0.00381	0.00134	0.00137	0.00095	0.00129	<0.0050	<0.0050	0.00130	0.0176	<0.00050
Potassium (K)-Dissolved	mg/L	1.47	1.72	1.68	4.82	2.33	2.57	3.20	3.26	2.65	5.50
Sodium (Na)-Dissolved	mg/L	80.4	31.0	30.7	60.9	56.5	42.4	110	92.2	53.9	20.2
Zinc (Zn)-Dissolved	mg/L	0.0028	0.0014	0.0015	0.0029	0.0038	<0.010	<0.010	0.0031	0.0292	<0.0010
Aggregate Organics											
COD	mg/L	40	109	60	43	68	40	<10	27	291	45
Phenols (4AAP)	mg/L	0.0016	0.0022	0.0025	0.0039	0.0040	0.0045	0.0030	0.0032	0.0046	0.0046
Volatile Organic Compounds											
Acetone	ug/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Benzene	ug/L	0.80	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bromodichloromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromoform	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromomethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Carbon Disulfide	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Carbon tetrachloride	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chlorobenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Dibromochloromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroform	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.6	<1.0	3.8	<1.0
Chloromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dibromoethane	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,2-Dichlorobenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,3-Dichlorobenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,4-Dichlorobenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Dichlorodifluoromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1-Dichloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1-Dichloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
cis-1,2-Dichloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
trans-1,2-Dichloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Dichloromethane	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-Dichloropropane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
cis-1,3-Dichloropropene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
trans-1,3-Dichloropropene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Ethylbenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
n-Hexane	ug/L	<0.50	0.53	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
2-Hexanone	ug/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Methyl Ethyl Ketone	ug/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Methyl Isobutyl Ketone	ug/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
MTBE	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Styrene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,1,2-Tetrachloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,2,2-Tetrachloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tetrachloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Toluene	ug/L	0.65	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,1-Trichloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,2-Trichloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Trichloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Trichlorofluoromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vinyl chloride	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
o-Xylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
m+p-Xylenes	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Xylenes (Total)	ug/L	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Trihalomethanes											
Total THMs	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.8	<2.0



The Corporation of the City of London
ATTN: Wesley Abbott
PO Box 5035, 300 Dufferin Ave.,
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Date Received: 10-DEC-19
Report Date: 17-DEC-19 12:53 (MT)
Version: FINAL

Client Phone: 519-661-2489

Certificate of Analysis

Lab Work Order #: L2394310
Project P.O. #: NOT SUBMITTED
Job Reference: W12A LANDFILL
C of C Numbers:
Legal Site Desc:



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ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2394310-1 BH19-1								
Sampled By: MAS on 10-DEC-19 @ 09:45								
Matrix: GW								
Physical Tests								
Conductivity		538		3.0	umhos/cm		12-DEC-19	R4942629
pH		8.08		0.10	pH units		12-DEC-19	R4942629
Anions and Nutrients								
Alkalinity, Bicarbonate (as CaCO3)		522		2.0	mg/L		12-DEC-19	R4942629
Alkalinity, Carbonate (as CaCO3)		<2.0		2.0	mg/L		12-DEC-19	R4942629
Alkalinity, Hydroxide (as CaCO3)		<2.0		2.0	mg/L		12-DEC-19	R4942629
Alkalinity, Total (as CaCO3)		522		2.0	mg/L		12-DEC-19	R4942629
Ammonia, Total (as N)		0.365		0.010	mg/L		11-DEC-19	R4941436
Bromide (Br)		<0.10		0.10	mg/L		12-DEC-19	R4942830
Chloride (Cl)		8.08		0.50	mg/L		12-DEC-19	R4942830
Fluoride (F)		1.04		0.020	mg/L		12-DEC-19	R4942830
Nitrate (as N)		<0.020		0.020	mg/L		12-DEC-19	R4942830
Nitrite (as N)		<0.010		0.010	mg/L		12-DEC-19	R4942830
Total Kjeldahl Nitrogen		0.48		0.15	mg/L	12-DEC-19	12-DEC-19	R4942015
Sulfate (SO4)		66.0		0.30	mg/L		12-DEC-19	R4942830
Organic / Inorganic Carbon								
Dissolved Carbon Filtration Location		FIELD				10-DEC-19	12-DEC-19	R4942130
Dissolved Organic Carbon		6.80		0.50	mg/L	10-DEC-19	16-DEC-19	R4944534
Dissolved Metals								
Dissolved Metals Filtration Location		FIELD					12-DEC-19	R4941324
Arsenic (As)-Dissolved		0.00792		0.00010	mg/L	12-DEC-19	13-DEC-19	R4942544
Barium (Ba)-Dissolved		0.0624		0.00010	mg/L	12-DEC-19	13-DEC-19	R4942544
Boron (B)-Dissolved		0.194		0.010	mg/L	12-DEC-19	13-DEC-19	R4942544
Cadmium (Cd)-Dissolved		0.000011		0.000010	mg/L	12-DEC-19	13-DEC-19	R4942544
Calcium (Ca)-Dissolved		32.4		0.050	mg/L	12-DEC-19	13-DEC-19	R4942544
Iron (Fe)-Dissolved		0.701		0.010	mg/L	12-DEC-19	13-DEC-19	R4942544
Lead (Pb)-Dissolved		0.000619		0.000050	mg/L	12-DEC-19	13-DEC-19	R4942544
Magnesium (Mg)-Dissolved		10.5		0.050	mg/L	12-DEC-19	13-DEC-19	R4942544
Manganese (Mn)-Dissolved		0.0614		0.00050	mg/L	12-DEC-19	13-DEC-19	R4942544
Nickel (Ni)-Dissolved		0.00381		0.00050	mg/L	12-DEC-19	13-DEC-19	R4942544
Potassium (K)-Dissolved		1.47		0.050	mg/L	12-DEC-19	13-DEC-19	R4942544
Sodium (Na)-Dissolved		80.4		0.50	mg/L	12-DEC-19	13-DEC-19	R4942544
Zinc (Zn)-Dissolved		0.0028		0.0010	mg/L	12-DEC-19	13-DEC-19	R4942544
Aggregate Organics								
COD		40		10	mg/L		17-DEC-19	R4944530
Phenols (4AAP)		0.0016		0.0010	mg/L		11-DEC-19	R4941406
Volatile Organic Compounds								
Acetone		<20		20	ug/L		16-DEC-19	R4943976
Benzene		0.80		0.50	ug/L		16-DEC-19	R4943976
Bromodichloromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
Bromoform		<1.0		1.0	ug/L		16-DEC-19	R4943976
Bromomethane		<0.50		0.50	ug/L		16-DEC-19	R4943976

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2394310-1	BH19-1							
Sampled By: MAS on 10-DEC-19 @ 09:45								
Matrix: GW								
Volatile Organic Compounds								
Carbon Disulfide		<1.0		1.0	ug/L		16-DEC-19	R4943976
Carbon tetrachloride		<0.50		0.50	ug/L		16-DEC-19	R4943976
Chlorobenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Dibromochloromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
Chloroethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
Chloroform		<1.0		1.0	ug/L		16-DEC-19	R4943976
Chloromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
1,2-Dibromoethane		<0.20		0.20	ug/L		16-DEC-19	R4943976
1,2-Dichlorobenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,3-Dichlorobenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,4-Dichlorobenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Dichlorodifluoromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
1,1-Dichloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,2-Dichloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,1-Dichloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
cis-1,2-Dichloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
trans-1,2-Dichloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Dichloromethane		<2.0		2.0	ug/L		16-DEC-19	R4943976
1,2-Dichloropropane		<0.50		0.50	ug/L		16-DEC-19	R4943976
cis-1,3-Dichloropropene		<0.50		0.50	ug/L		16-DEC-19	R4943976
trans-1,3-Dichloropropene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Ethylbenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
n-Hexane		<0.50		0.50	ug/L		16-DEC-19	R4943976
2-Hexanone		<20		20	ug/L		16-DEC-19	R4943976
Methyl Ethyl Ketone		<20		20	ug/L		16-DEC-19	R4943976
Methyl Isobutyl Ketone		<20		20	ug/L		16-DEC-19	R4943976
MTBE		<0.50		0.50	ug/L		16-DEC-19	R4943976
Styrene		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,1,1,2-Tetrachloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,1,2,2-Tetrachloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
Tetrachloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Toluene		0.65		0.50	ug/L		16-DEC-19	R4943976
1,1,1-Trichloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,1,2-Trichloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
Trichloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Trichlorofluoromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
Vinyl chloride		<0.50		0.50	ug/L		16-DEC-19	R4943976
o-Xylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
m+p-Xylenes		<1.0		1.0	ug/L		16-DEC-19	R4943976
Xylenes (Total)		<1.1		1.1	ug/L		16-DEC-19	R4943976
Surrogate: 4-Bromofluorobenzene		95.2		70-130	%		16-DEC-19	R4943976

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2394310-1	BH19-1							
Sampled By: MAS on 10-DEC-19 @ 09:45								
Matrix: GW								
Volatile Organic Compounds								
Surrogate: 1,4-Difluorobenzene		100.3		70-130	%		16-DEC-19	R4943976
Trihalomethanes								
Total THMs		<2.0		2.0	ug/L		16-DEC-19	
DRAFT								

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Fluoride (F)	MS-B	L2394310-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L2394310-1
Matrix Spike	Boron (B)-Dissolved	MS-B	L2394310-1
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L2394310-1
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L2394310-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L2394310-1
Matrix Spike	Potassium (K)-Dissolved	MS-B	L2394310-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2394310-1
Matrix Spike	Ammonia, Total (as N)	MS-B	L2394310-1
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L2394310-1

Sample Parameter Qualifier key listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-SPEC-PCT-WT	Water	Automated Speciated Alkalinity	APHA 2320B
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.			
BR-IC-N-WT	Water	Bromide in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
COD-T-WT	Water	Chemical Oxygen Demand	APHA 5220 D
This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.			
DOC-WT	Water	Dissolved Organic Carbon	APHA 5310B
Sample is filtered through a 0.45um filter, then injected into a heated reaction chamber which is packed with an oxidative catalyst. The water is vaporized and the organic carbon is oxidized to carbon dioxide. The carbon dioxide is transported in a carrier gas and is measured by a non-dispersive infrared detector.			
EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510
Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.			
EC-WT	Water	Conductivity	APHA 2510 B
Water samples can be measured directly by immersing the conductivity cell into the sample.			
F-IC-N-WT	Water	Fluoride in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
MET-D-CCMS-WT	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)
Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.			
Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et

al.			
NO2-IC-WT	Water	Nitrite in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
PH-WT	Water	pH	APHA 4500 H-Electrode
Water samples are analyzed directly by a calibrated pH meter.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days			
PHENOLS-4AAP-WT	Water	Phenol (4AAP)	EPA 9066
An automated method is used to distill the sample. The distillate is then buffered to pH 9.4 which reacts with 4AAP and potassium ferricyanide to form a red complex which is measured colorimetrically.			
SO4-IC-N-WT	Water	Sulfate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
THM-SUM-PPB-CALC-WT	Water	Total Trihalomethanes (THMs)	CALCULATION
Total Trihalomethanes (THMs) represents the sum of bromodichloromethane, bromoform, chlorodibromomethane and chloroform. For the purpose of calculation, results less than the detection limit (DL) are treated as zero.			
TKN-WT	Water	Total Kjeldahl Nitrogen	APHA 4500-Norg D
This analysis is carried out using procedures adapted from APHA Method 4500-Norg "Nitrogen (Organic)". Total Kjeldahl Nitrogen is determined by sample digestion at 380 Celsius with analysis using an automated colorimetric method.			
VOC-ROU-HS-WT	Water	Volatile Organic Compounds	SW846 8260
Aqueous samples are analyzed by headspace-GC/MS.			
XYLENES-SUM-CALC-WT	Water	Sum of Xylene Isomer Concentrations	CALCULATION
Total xylenes represents the sum of o-xylene and m&p-xylene.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

mg/kg - milligrams per kilogram based on dry weight of sample

mg/kg wwt - milligrams per kilogram based on wet weight of sample

mg/kg lwt - milligrams per kilogram based on lipid weight of sample

mg/L - unit of concentration based on volume, parts per million.

< - Less than.

D.L. - The reporting limit.

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L2394310

Report Date: 17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
DOC-WT								
Water								
Batch	R4944534							
WG3241256-3	DUP	L2394310-1						
Dissolved Organic Carbon		6.80	7.02		mg/L	3.2	20	16-DEC-19
WG3241256-2	LCS							
Dissolved Organic Carbon			104.5		%		80-120	16-DEC-19
WG3241256-1	MB							
Dissolved Organic Carbon			<0.50		mg/L		0.5	16-DEC-19
WG3241256-4	MS	L2394310-1						
Dissolved Organic Carbon			98.2		%		70-130	16-DEC-19
EC-WT								
Water								
Batch	R4942629							
WG3241028-2	LCS							
Conductivity			99.0		%		90-110	12-DEC-19
WG3241028-1	MB							
Conductivity			<3.0		umhos/cm		3	12-DEC-19
F-IC-N-WT								
Water								
Batch	R4942830							
WG3240868-4	DUP	L2394310-1						
Fluoride (F)		1.04	1.03		mg/L	0.4	20	12-DEC-19
WG3240868-2	LCS							
Fluoride (F)			103.6		%		90-110	12-DEC-19
WG3240868-1	MB							
Fluoride (F)			<0.020		mg/L		0.02	12-DEC-19
WG3240868-5	MS	L2394310-1						
Fluoride (F)			N/A	MS-B	%		-	12-DEC-19
MET-D-CCMS-WT								
Water								
Batch	R4942544							
WG3240627-2	LCS							
Arsenic (As)-Dissolved			98.3		%		80-120	12-DEC-19
Barium (Ba)-Dissolved			104.4		%		80-120	12-DEC-19
Boron (B)-Dissolved			96.6		%		80-120	12-DEC-19
Cadmium (Cd)-Dissolved			96.5		%		80-120	12-DEC-19
Calcium (Ca)-Dissolved			99.97		%		80-120	12-DEC-19
Iron (Fe)-Dissolved			104.0		%		80-120	12-DEC-19
Lead (Pb)-Dissolved			101.6		%		80-120	12-DEC-19
Magnesium (Mg)-Dissolved			101.1		%		80-120	12-DEC-19
Manganese (Mn)-Dissolved			102.4		%		80-120	12-DEC-19
Nickel (Ni)-Dissolved			99.6		%		80-120	12-DEC-19

Quality Control Report

Workorder: L2394310

Report Date: 17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-4	DUP	L2394310-1						
1,1,1,2-Tetrachloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1,2,2-Tetrachloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1,1-Trichloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1,2-Trichloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,2-Dibromoethane		<0.20	<0.20	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1-Dichloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1-Dichloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,2-Dichlorobenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,2-Dichloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,2-Dichloropropane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,3-Dichlorobenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,4-Dichlorobenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
2-Hexanone		<20	<20	RPD-NA	ug/L	N/A	30	16-DEC-19
Acetone		<20	<20	RPD-NA	ug/L	N/A	30	16-DEC-19
Benzene		0.80	0.80		ug/L	0.0	30	16-DEC-19
Bromodichloromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Bromoform		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Bromomethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Carbon Disulfide		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Carbon tetrachloride		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Chlorobenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Chloroethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Chloroform		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Chloromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
cis-1,2-Dichloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
cis-1,3-Dichloropropene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Dibromochloromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Dichlorodifluoromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Dichloromethane		<2.0	<2.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Ethylbenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
m+p-Xylenes		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Methyl Ethyl Ketone		<20	<20	RPD-NA	ug/L	N/A	30	16-DEC-19
Methyl Isobutyl Ketone		<20	<20	RPD-NA	ug/L	N/A	30	16-DEC-19
n-Hexane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19

Quality Control Report

Workorder: L2394310

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-4	DUP	L2394310-1						
MTBE		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
o-Xylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Styrene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Tetrachloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Toluene		0.65	0.64		ug/L	1.6	30	16-DEC-19
trans-1,2-Dichloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
trans-1,3-Dichloropropene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Trichloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Trichlorofluoromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Vinyl chloride		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
WG3239182-1	LCS							
1,1,1,2-Tetrachloroethane			87.3		%		70-130	16-DEC-19
1,1,2,2-Tetrachloroethane			99.6		%		70-130	16-DEC-19
1,1,1-Trichloroethane			88.6		%		70-130	16-DEC-19
1,1,2-Trichloroethane			88.3		%		70-130	16-DEC-19
1,2-Dibromoethane			93.0		%		70-130	16-DEC-19
1,1-Dichloroethane			86.3		%		70-130	16-DEC-19
1,1-Dichloroethylene			83.1		%		70-130	16-DEC-19
1,2-Dichlorobenzene			88.2		%		70-130	16-DEC-19
1,2-Dichloroethane			94.3		%		70-130	16-DEC-19
1,2-Dichloropropane			88.3		%		70-130	16-DEC-19
1,3-Dichlorobenzene			84.7		%		70-130	16-DEC-19
1,4-Dichlorobenzene			85.7		%		70-130	16-DEC-19
2-Hexanone			91.1		%		60-140	16-DEC-19
Acetone			107.1		%		60-140	16-DEC-19
Benzene			93.5		%		70-130	16-DEC-19
Bromodichloromethane			91.7		%		70-130	16-DEC-19
Bromoform			101.3		%		70-130	16-DEC-19
Bromomethane			88.8		%		60-140	16-DEC-19
Carbon Disulfide			90.7		%		70-130	16-DEC-19
Carbon tetrachloride			94.5		%		70-130	16-DEC-19
Chlorobenzene			84.0		%		70-130	16-DEC-19
Chloroethane			98.7		%		70-130	16-DEC-19
Chloroform			90.6		%		70-130	16-DEC-19

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Workorder: L2394310

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-1	LCS							
Chloromethane			98.4		%		60-140	16-DEC-19
cis-1,2-Dichloroethylene			87.6		%		70-130	16-DEC-19
cis-1,3-Dichloropropene			94.5		%		70-130	16-DEC-19
Dibromochloromethane			95.9		%		70-130	16-DEC-19
Dichlorodifluoromethane			111.3		%		50-140	16-DEC-19
Dichloromethane			91.1		%		70-130	16-DEC-19
Ethylbenzene			85.7		%		70-130	16-DEC-19
m+p-Xylenes			87.5		%		70-130	16-DEC-19
Methyl Ethyl Ketone			111.2		%		60-140	16-DEC-19
Methyl Isobutyl Ketone			98.8		%		50-150	16-DEC-19
n-Hexane			84.0		%		70-130	16-DEC-19
MTBE			87.4		%		70-130	16-DEC-19
o-Xylene			85.1		%		70-130	16-DEC-19
Styrene			86.2		%		70-130	16-DEC-19
Tetrachloroethylene			91.0		%		70-130	16-DEC-19
Toluene			88.1		%		70-130	16-DEC-19
trans-1,2-Dichloroethylene			83.4		%		70-130	16-DEC-19
trans-1,3-Dichloropropene			91.5		%		70-130	16-DEC-19
Trichloroethylene			90.0		%		70-130	16-DEC-19
Trichlorofluoromethane			91.9		%		60-140	16-DEC-19
Vinyl chloride			100.7		%		60-140	16-DEC-19
WG3239182-2	MB							
1,1,1,2-Tetrachloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,2,2-Tetrachloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,1-Trichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,2-Trichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,2-Dibromoethane			<0.20		ug/L		0.2	16-DEC-19
1,1-Dichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichloropropane			<0.50		ug/L		0.5	16-DEC-19
1,3-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19
1,4-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19

Quality Control Report

Workorder: L2394310

Report Date: 17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-2	MB							
2-Hexanone			<20		ug/L		20	16-DEC-19
Acetone			<20		ug/L		20	16-DEC-19
Benzene			<0.50		ug/L		0.5	16-DEC-19
Bromodichloromethane			<1.0		ug/L		1	16-DEC-19
Bromoform			<1.0		ug/L		1	16-DEC-19
Bromomethane			<0.50		ug/L		0.5	16-DEC-19
Carbon Disulfide			<1.0		ug/L		1	16-DEC-19
Carbon tetrachloride			<0.50		ug/L		0.5	16-DEC-19
Chlorobenzene			<0.50		ug/L		0.5	16-DEC-19
Chloroethane			<1.0		ug/L		1	16-DEC-19
Chloroform			<1.0		ug/L		1	16-DEC-19
Chloromethane			<1.0		ug/L		1	16-DEC-19
cis-1,2-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
cis-1,3-Dichloropropene			<0.50		ug/L		0.5	16-DEC-19
Dibromochloromethane			<1.0		ug/L		1	16-DEC-19
Dichlorodifluoromethane			<1.0		ug/L		1	16-DEC-19
Dichloromethane			<2.0		ug/L		2	16-DEC-19
Ethylbenzene			<0.50		ug/L		0.5	16-DEC-19
m+p-Xylenes			<1.0		ug/L		1	16-DEC-19
Methyl Ethyl Ketone			<20		ug/L		20	16-DEC-19
Methyl Isobutyl Ketone			<20		ug/L		20	16-DEC-19
n-Hexane			<0.50		ug/L		0.5	16-DEC-19
MTBE			<0.50		ug/L		0.5	16-DEC-19
o-Xylene			<0.50		ug/L		0.5	16-DEC-19
Styrene			<0.50		ug/L		0.5	16-DEC-19
Tetrachloroethylene			<0.50		ug/L		0.5	16-DEC-19
Toluene			<0.50		ug/L		0.5	16-DEC-19
trans-1,2-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
trans-1,3-Dichloropropene			<0.50		ug/L		0.5	16-DEC-19
Trichloroethylene			<0.50		ug/L		0.5	16-DEC-19
Trichlorofluoromethane			<1.0		ug/L		1	16-DEC-19
Vinyl chloride			<0.50		ug/L		0.5	16-DEC-19
Surrogate: 1,4-Difluorobenzene			100.2		%		70-130	16-DEC-19
Surrogate: 4-Bromofluorobenzene			95.5		%		70-130	16-DEC-19

Quality Control Report

Workorder: L2394310

Report Date: 17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-5	MS	L2394310-1						
1,1,1,2-Tetrachloroethane			83.6		%		50-150	16-DEC-19
1,1,2,2-Tetrachloroethane			89.0		%		50-150	16-DEC-19
1,1,1-Trichloroethane			86.1		%		50-150	16-DEC-19
1,1,2-Trichloroethane			80.3		%		50-150	16-DEC-19
1,2-Dibromoethane			82.8		%		50-150	16-DEC-19
1,1-Dichloroethane			82.2		%		50-150	16-DEC-19
1,1-Dichloroethylene			82.5		%		50-150	16-DEC-19
1,2-Dichlorobenzene			87.8		%		50-150	16-DEC-19
1,2-Dichloroethane			83.8		%		50-150	16-DEC-19
1,2-Dichloropropane			85.4		%		50-150	16-DEC-19
1,3-Dichlorobenzene			87.4		%		50-150	16-DEC-19
1,4-Dichlorobenzene			88.2		%		50-150	16-DEC-19
2-Hexanone			73.8		%		50-150	16-DEC-19
Acetone			85.3		%		50-150	16-DEC-19
Benzene			93.7		%		50-150	16-DEC-19
Bromodichloromethane			85.7		%		50-150	16-DEC-19
Bromoform			91.2		%		50-150	16-DEC-19
Bromomethane			87.3		%		50-150	16-DEC-19
Carbon Disulfide			91.9		%		50-150	16-DEC-19
Carbon tetrachloride			93.3		%		50-150	16-DEC-19
Chlorobenzene			83.0		%		50-150	16-DEC-19
Chloroethane			97.6		%		50-150	16-DEC-19
Chloroform			86.7		%		50-150	16-DEC-19
Chloromethane			92.4		%		50-150	16-DEC-19
cis-1,2-Dichloroethylene			84.7		%		50-150	16-DEC-19
cis-1,3-Dichloropropene			96.4		%		50-150	16-DEC-19
Dibromochloromethane			88.3		%		50-150	16-DEC-19
Dichlorodifluoromethane			97.5		%		50-150	16-DEC-19
Dichloromethane			84.7		%		50-150	16-DEC-19
Ethylbenzene			87.3		%		50-150	16-DEC-19
m+p-Xylenes			89.7		%		50-150	16-DEC-19
Methyl Ethyl Ketone			85.6		%		50-150	16-DEC-19
Methyl Isobutyl Ketone			82.3		%		50-150	16-DEC-19
n-Hexane			86.2		%		50-150	16-DEC-19

Quality Control Report

Workorder: L2394310

Report Date: 17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT	Water							
Batch	R4943976							
WG3239182-5 MS		L2394310-1						
MTBE			87.3		%		50-150	16-DEC-19
o-Xylene			85.3		%		50-150	16-DEC-19
Styrene			85.4		%		50-150	16-DEC-19
Tetrachloroethylene			94.1		%		50-150	16-DEC-19
Toluene			89.1		%		50-150	16-DEC-19
trans-1,2-Dichloroethylene			83.7		%		50-150	16-DEC-19
trans-1,3-Dichloropropene			93.7		%		50-150	16-DEC-19
Trichloroethylene			90.5		%		50-150	16-DEC-19
Trichlorofluoromethane			88.8		%		50-150	16-DEC-19
Vinyl chloride			98.8		%		50-150	16-DEC-19

Quality Control Report

Workorder: L2394310

Report Date: 17-DEC-19

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Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

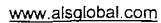
Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

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L2394310.COFC

Page of

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Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.



The Corporation of the City of London
ATTN: Wesley Abbott
PO Box 5035, 300 Dufferin Ave.,
London ON N6A 4L9

Date Received: 11-DEC-19
Report Date: 19-DEC-19 13:26 (MT)
Version: FINAL

Client Phone: 519-661-2489

Certificate of Analysis

Lab Work Order #: L2395008
Project P.O. #: NOT SUBMITTED
Job Reference: W12A LANDFILL
C of C Numbers:
Legal Site Desc:



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ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L2395008-1 GW 11-DEC-19 10:40 BH19-7	L2395008-2 GW 11-DEC-19 11:30 BH19-7-2	L2395008-3 GW 11-DEC-19 11:00 BH19-7-3	L2395008-4 GW 11-DEC-19 12:20 BH19-4	L2395008-5 GW 11-DEC-19 12:50 BH19-5
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (umhos/cm)	1380	978	654	959	975
	pH (pH units)	7.77	7.89	8.02	7.69	7.67
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	317	385	273	290	304
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	317	385	273	290	304
	Ammonia, Total (as N) (mg/L)	0.081	<0.010	0.049	0.132	0.050
	Bromide (Br) (mg/L)	<0.50 ^{DLDS}	<0.10	<0.10	<0.10	<0.10
	Chloride (Cl) (mg/L)	166 ^{DLDS}	32.1	11.2	52.6	41.3
	Fluoride (F) (mg/L)	0.24 ^{DLDS}	0.263	0.278	0.177	0.157
	Nitrate (as N) (mg/L)	<0.10 ^{DLDS}	<0.020	0.182	<0.020	<0.020
	Nitrite (as N) (mg/L)	<0.050 ^{DLDS}	<0.010	0.032	<0.010	<0.010
	Total Kjeldahl Nitrogen (mg/L)	0.26	0.28	0.26	0.28	0.26
	Sulfate (SO4) (mg/L)	230 ^{DLDS}	162	82.3	166	175
Organic / Inorganic Carbon	Dissolved Carbon Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Organic Carbon (mg/L)	24.4	72.1 ^{DLM}	3.38	18.5	14.5
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Arsenic (As)-Dissolved (mg/L)	0.00056	0.00194	0.00097	0.00160	0.00105
	Barium (Ba)-Dissolved (mg/L)	0.0450	0.0639	0.114	0.0606	0.143
	Boron (B)-Dissolved (mg/L)	0.026	0.035	0.073	0.024	0.028
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010	0.000016	<0.000010	<0.000010	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	172	117	59.7	123	123
	Iron (Fe)-Dissolved (mg/L)	2.67	0.048	0.018	1.40	1.91
	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000114	<0.000050	<0.000050	<0.000050
	Magnesium (Mg)-Dissolved (mg/L)	32.5	35.0	40.7	19.7	26.0
	Manganese (Mn)-Dissolved (mg/L)	0.108	0.268	0.00189	0.167	0.0825
	Nickel (Ni)-Dissolved (mg/L)	0.00130	0.0176	<0.00050	0.00095	0.00129
	Potassium (K)-Dissolved (mg/L)	3.26	2.65	5.50	4.82	2.33
	Sodium (Na)-Dissolved (mg/L)	92.2	53.9	20.2	60.9	56.5
	Zinc (Zn)-Dissolved (mg/L)	0.0031	0.0292	<0.0010	0.0029	0.0038
Aggregate Organics	COD (mg/L)	27	291	45	43	68
	Phenols (4AAP) (mg/L)	0.0032	0.0046	0.0046	0.0039	0.0040
Volatile Organic Compounds	Acetone (ug/L)	<20	<20	<20	<20	<20
	Benzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Bromodichloromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L2395008-6 GW 11-DEC-19 15:10 BH19-6	L2395008-7 GW 11-DEC-19 14:40 BH19-6-2	L2395008-8 GW 11-DEC-19 13:50 BH19-3	L2395008-9 GW 11-DEC-19 13:50 BH19-31	
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (umhos/cm)	1660	1920	393	394	
	pH (pH units)	7.40	8.07	7.83	7.83	
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	370	654	247	227	
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	
	Alkalinity, Total (as CaCO3) (mg/L)	370	654	247	227	
	Ammonia, Total (as N) (mg/L)	0.073	0.380	0.118	0.110	
	Bromide (Br) (mg/L)	<0.50 ^{DLDS}	<0.50 ^{DLDS}	<0.10	<0.10	
	Chloride (Cl) (mg/L)	21.4 ^{DLDS}	8.8 ^{DLDS}	0.97	0.96	
	Fluoride (F) (mg/L)	0.14 ^{DLDS}	0.70 ^{DLDS}	1.10	1.14	
	Nitrate (as N) (mg/L)	<0.10 ^{DLDS}	<0.10 ^{DLDS}	<0.020	<0.020	
	Nitrite (as N) (mg/L)	<0.050 ^{DLDS}	<0.050 ^{DLDS}	<0.010	<0.010	
	Total Kjeldahl Nitrogen (mg/L)	0.38	0.56	0.49	0.33	
	Sulfate (SO4) (mg/L)	694 ^{DLDS}	606 ^{DLDS}	1.35	1.68	
Organic / Inorganic Carbon	Dissolved Carbon Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Dissolved Organic Carbon (mg/L)	7.27	3.82	7.68	7.66	
Dissolved Metals	Dissolved Metals Filtration Location	FIELD ^{DLHC}	FIELD ^{DLHC}	FIELD	FIELD	
	Arsenic (As)-Dissolved (mg/L)	0.0012 ^{DLHC}	0.0021 ^{DLHC}	0.00057	0.00055	
	Barium (Ba)-Dissolved (mg/L)	0.0421 ^{DLHC}	0.0824 ^{DLHC}	0.368	0.354	
	Boron (B)-Dissolved (mg/L)	<0.10 ^{DLHC}	0.25 ^{DLHC}	0.096	0.091	
	Cadmium (Cd)-Dissolved (mg/L)	<0.000050 ^{DLHC}	<0.000050 ^{DLHC}	<0.000010	<0.000010	
	Calcium (Ca)-Dissolved (mg/L)	297 ^{DLHC}	93.8 ^{DLHC}	40.8	40.2	
	Iron (Fe)-Dissolved (mg/L)	7.66 ^{DLHC}	<0.10 ^{DLHC}	0.450	0.451	
	Lead (Pb)-Dissolved (mg/L)	<0.00050 ^{DLHC}	<0.00050 ^{DLHC}	<0.000050	<0.000050	
	Magnesium (Mg)-Dissolved (mg/L)	56.4 ^{DLHC}	176 ^{DLHC}	14.8	14.5	
	Manganese (Mn)-Dissolved (mg/L)	0.156 ^{DLHC}	0.0840 ^{DLHC}	0.0201	0.0198	
	Nickel (Ni)-Dissolved (mg/L)	<0.0050 ^{DLHC}	<0.0050 ^{DLHC}	0.00134	0.00137	
	Potassium (K)-Dissolved (mg/L)	2.57 ^{DLHC}	3.20 ^{DLHC}	1.72	1.68	
	Sodium (Na)-Dissolved (mg/L)	42.4 ^{DLHC}	110 ^{DLHC}	31.0	30.7	
	Zinc (Zn)-Dissolved (mg/L)	<0.010 ^{DLHC}	<0.010 ^{DLHC}	0.0014	0.0015	
Aggregate Organics	COD (mg/L)	40	<10	109	80	
	Phenols (4AAP) (mg/L)	0.0045	0.0030	0.0022 ^{OWP}	0.0025 ^{OWP}	
Volatile Organic Compounds	Acetone (ug/L)	<20	<20	<20 ^{OWP}	<20 ^{OWP}	
	Benzene (ug/L)	<0.50	<0.50	<0.50 ^{OWP}	<0.50 ^{OWP}	
	Bromodichloromethane (ug/L)	<1.0	<1.0	<1.0 ^{OWP}	<1.0 ^{OWP}	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L2395008-1 GW 11-DEC-19 10:40 BH19-7	L2395008-2 GW 11-DEC-19 11:30 BH19-7-2	L2395008-3 GW 11-DEC-19 11:00 BH19-7-3	L2395008-4 GW 11-DEC-19 12:20 BH19-4	L2395008-5 GW 11-DEC-19 12:50 BH19-5
Grouping	Analyte					
WATER						
Volatile Organic Compounds	Bromoform (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Bromomethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Carbon Disulfide (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Carbon tetrachloride (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Chlorobenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Dibromochloromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Chloroethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Chloroform (ug/L)	<1.0	3.8	<1.0	<1.0	<1.0
	Chloromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	1,2-Dibromoethane (ug/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	1,2-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,3-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,4-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Dichlorodifluoromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	1,1-Dichloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,2-Dichloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	cis-1,2-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	trans-1,2-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Dichloromethane (ug/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	1,2-Dichloropropane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	cis-1,3-Dichloropropene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	trans-1,3-Dichloropropene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Ethylbenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	n-Hexane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	2-Hexanone (ug/L)	<20	<20	<20	<20	<20
	Methyl Ethyl Ketone (ug/L)	<20	<20	<20	<20	<20
	Methyl Isobutyl Ketone (ug/L)	<20	<20	<20	<20	<20
	MTBE (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Styrene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1,1,2-Tetrachloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1,2,2-Tetrachloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Tetrachloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Toluene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1,1-Trichloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1,2-Trichloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Trichloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L2395008-6 GW 11-DEC-19 15:10 BH19-6	L2395008-7 GW 11-DEC-19 14:40 BH19-6-2	L2395008-8 GW 11-DEC-19 13:50 BH19-3	L2395008-9 GW 11-DEC-19 13:50 BH19-31	
Grouping	Analyte					
WATER						
Volatile Organic Compounds	Bromoform (ug/L)	<1.0	<1.0	<1.0 OWP	<1.0 OWP	
	Bromomethane (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Carbon Disulfide (ug/L)	<1.0	<1.0	<1.0 OWP	<1.0 OWP	
	Carbon tetrachloride (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Chlorobenzene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Dibromochloromethane (ug/L)	<1.0	<1.0	<1.0 OWP	<1.0 OWP	
	Chloroethane (ug/L)	<1.0	<1.0	<1.0 OWP	<1.0 OWP	
	Chloroform (ug/L)	<1.0	1.6	<1.0 OWP	<1.0 OWP	
	Chloromethane (ug/L)	<1.0	<1.0	<1.0 OWP	<1.0 OWP	
	1,2-Dibromoethane (ug/L)	<0.20	<0.20	<0.20 OWP	<0.20 OWP	
	1,2-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	1,3-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	1,4-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Dichlorodifluoromethane (ug/L)	<1.0	<1.0	<1.0 OWP	<1.0 OWP	
	1,1-Dichloroethane (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	1,2-Dichloroethane (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	1,1-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	cis-1,2-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	trans-1,2-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Dichloromethane (ug/L)	<2.0	<2.0	<2.0 OWP	<2.0 OWP	
	1,2-Dichloropropane (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	cis-1,3-Dichloropropene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	trans-1,3-Dichloropropene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Ethylbenzene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	n-Hexane (ug/L)	<0.50	<0.50	0.53 OWP	<0.50 OWP	
	2-Hexanone (ug/L)	<20	<20	<20 OWP	<20 OWP	
	Methyl Ethyl Ketone (ug/L)	<20	<20	<20 OWP	<20 OWP	
	Methyl Isobutyl Ketone (ug/L)	<20	<20	<20 OWP	<20 OWP	
	MTBE (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Styrene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	1,1,1,2-Tetrachloroethane (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	1,1,2,2-Tetrachloroethane (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Tetrachloroethylene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Toluene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	1,1,1-Trichloroethane (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	1,1,2-Trichloroethane (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	
	Trichloroethylene (ug/L)	<0.50	<0.50	<0.50 OWP	<0.50 OWP	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L2395008-1	L2395008-2	L2395008-3	L2395008-4	L2395008-5
		Description	GW	GW	GW	GW	GW
		Sampled Date	11-DEC-19	11-DEC-19	11-DEC-19	11-DEC-19	11-DEC-19
		Sampled Time	10:40	11:30	11:00	12:20	12:50
		Client ID	BH19-7	BH19-7-2	BH19-7-3	BH19-4	BH19-5
Grouping	Analyte						
WATER							
Volatile Organic Compounds	Trichlorofluoromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0	
	Vinyl chloride (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50	
	o-Xylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50	
	m+p-Xylenes (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0	
	Xylenes (Total) (ug/L)	<1.1	<1.1	<1.1	<1.1	<1.1	
	Surrogate: 4-Bromofluorobenzene (%)	93.9	94.6	93.7	94.0	94.1	
	Surrogate: 1,4-Difluorobenzene (%)	101.4	101.0	100.9	101.3	101.3	
Trihalomethanes	Total THMs (ug/L)	<2.0	3.8	<2.0	<2.0	<2.0	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L2395008-6	L2395008-7	L2395008-8	L2395008-9	
		Description	GW	GW	GW	GW	
		Sampled Date	11-DEC-19	11-DEC-19	11-DEC-19	11-DEC-19	
		Sampled Time	15:10	14:40	13:50	13:50	
		Client ID	BH19-6	BH19-6-2	BH19-3	BH19-31	
Grouping	Analyte						
WATER							
Volatile Organic Compounds	Trichlorofluoromethane (ug/L)	<1.0	<1.0	<1.0 ^{OWP}	<1.0 ^{OWP}		
	Vinyl chloride (ug/L)	<0.50	<0.50	<0.50 ^{OWP}	<0.50 ^{OWP}		
	o-Xylene (ug/L)	<0.50	<0.50	<0.50 ^{OWP}	<0.50 ^{OWP}		
	m+p-Xylenes (ug/L)	<1.0	<1.0	<1.0 ^{OWP}	<1.0 ^{OWP}		
	Xylenes (Total) (ug/L)	<1.1	<1.1	<1.1	<1.1		
	Surrogate: 4-Bromofluorobenzene (%)	94.2	94.3	92.6	91.5		
	Surrogate: 1,4-Difluorobenzene (%)	101.4	101.0	100.4	99.4		
Trihalomethanes	Total THMs (ug/L)	<2.0	<2.0	<2.0	<2.0		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Laboratory Control Sample	2-Hexanone	MES	L2395008-8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Boron (B)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Iron (Fe)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Potassium (K)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Ammonia, Total (as N)	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MES	Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
OWP	Organic water sample contained visible sediment (must be included as part of analysis). Measured concentrations of organic substances in water can be biased high due to presence of sediment.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-SPEC-PCT-WT	Water	Automated Speciated Alkalinity	APHA 2320B

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-IC-N-WT	Water	Bromide in Water by IC	EPA 300.1 (mod)
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Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)
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Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

COD-T-WT	Water	Chemical Oxygen Demand	APHA 5220 D
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This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

DOC-WT	Water	Dissolved Organic Carbon	APHA 5310B
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Sample is filtered through a 0.45um filter, then injected into a heated reaction chamber which is packed with an oxidative catalyst. The water is vaporized and the organic carbon is oxidized to carbon dioxide. The carbon dioxide is transported in a carrier gas and is measured by a non-dispersive infrared detector.

EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510
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Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

EC-WT	Water	Conductivity	APHA 2510 B
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Water samples can be measured directly by immersing the conductivity cell into the sample.

F-IC-N-WT	Water	Fluoride in Water by IC	EPA 300.1 (mod)
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Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

MET-D-CCMS-WT	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)
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Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Reference Information

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-F-WT Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-IC-WT Water Nitrite in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-IC-WT Water Nitrate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-WT Water pH APHA 4500 H-Electrode

Water samples are analyzed directly by a calibrated pH meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

PHENOLS-4AAP-WT Water Phenol (4AAP) EPA 9066

An automated method is used to distill the sample. The distillate is then buffered to pH 9.4 which reacts with 4AAP and potassium ferricyanide to form a red complex which is measured colorimetrically.

SO4-IC-N-WT Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

THM-SUM-PPB-CALC-WT Water Total Trihalomethanes (THMs) CALCULATION

Total Trihalomethanes (THMs) represents the sum of bromodichloromethane, bromoform, chlorodibromomethane and chloroform. For the purpose of calculation, results less than the detection limit (DL) are treated as zero.

TKN-WT Water Total Kjeldahl Nitrogen APHA 4500-Norg D

This analysis is carried out using procedures adapted from APHA Method 4500-Norg "Nitrogen (Organic)". Total Kjeldahl Nitrogen is determined by sample digestion at 380 Celsius with analysis using an automated colorimetric method.

VOC-ROU-HS-WT Water Volatile Organic Compounds SW846 8260

Aqueous samples are analyzed by headspace-GC/MS.

XYLENES-SUM-CALC-WT Water Sum of Xylene Isomer Concentrations CALCULATION

Total xylenes represents the sum of o-xylene and m&p-xylene.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
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WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA
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Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

DRAFT

Quality Control Report

Workorder: L2395008

Report Date: 19-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
COD-T-WT								
Water								
Batch	R4946309							
WG3246025-2	LCS							
COD			96.3		%		85-115	19-DEC-19
WG3246025-1	MB							
COD			<10		mg/L		10	19-DEC-19
DOC-WT								
Water								
Batch	R4944534							
WG3241256-2	LCS							
Dissolved Organic Carbon			104.5		%		80-120	16-DEC-19
WG3241256-1	MB							
Dissolved Organic Carbon			<0.50		mg/L		0.5	16-DEC-19
EC-WT								
Water								
Batch	R4943257							
WG3241759-2	LCS							
Conductivity			100.1		%		90-110	13-DEC-19
WG3241759-1	MB							
Conductivity			<3.0		umhos/cm		3	13-DEC-19
Batch	R4943258							
WG3241761-2	LCS							
Conductivity			100.7		%		90-110	13-DEC-19
WG3241761-1	MB							
Conductivity			<3.0		umhos/cm		3	13-DEC-19
F-IC-N-WT								
Water								
Batch	R4944045							
WG3241855-4	DUP	L2395008-3						
Fluoride (F)		0.278	0.276		mg/L	1.0	20	13-DEC-19
WG3241855-2	LCS							
Fluoride (F)			103.0		%		90-110	13-DEC-19
WG3241855-1	MB							
Fluoride (F)			<0.020		mg/L		0.02	13-DEC-19
WG3241855-5	MS	L2395008-3						
Fluoride (F)			99.3		%		75-125	13-DEC-19
MET-D-CCMS-WT								
Water								
Batch	R4941530							
WG3241047-2	LCS							
Arsenic (As)-Dissolved			98.2		%		80-120	12-DEC-19
Barium (Ba)-Dissolved			102.9		%		80-120	12-DEC-19
Boron (B)-Dissolved			102.8		%		80-120	12-DEC-19

Quality Control Report

Workorder: L2395008

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-IC-N-WT								
Water								
Batch	R4944045							
WG3241855-4	DUP	L2395008-3						
Sulfate (SO4)		82.3	82.2		mg/L	0.0	20	13-DEC-19
WG3241855-2	LCS							
Sulfate (SO4)			103.0		%		90-110	13-DEC-19
WG3241855-1	MB							
Sulfate (SO4)			<0.30		mg/L		0.3	13-DEC-19
WG3241855-5	MS	L2395008-3						
Sulfate (SO4)			103.3		%		75-125	13-DEC-19
TKN-WT								
Water								
Batch	R4944028							
WG3241908-2	LCS							
Total Kjeldahl Nitrogen			97.7		%		75-125	16-DEC-19
WG3241908-1	MB							
Total Kjeldahl Nitrogen			<0.15		mg/L		0.15	16-DEC-19
VOC-ROU-HS-WT								
Water								
Batch	R4943663							
WG3235779-1	LCS							
1,1,1,2-Tetrachloroethane			87.1		%		70-130	16-DEC-19
1,1,2,2-Tetrachloroethane			99.98		%		70-130	16-DEC-19
1,1,1-Trichloroethane			94.0		%		70-130	16-DEC-19
1,1,2-Trichloroethane			93.2		%		70-130	16-DEC-19
1,2-Dibromoethane			94.4		%		70-130	16-DEC-19
1,1-Dichloroethane			96.2		%		70-130	16-DEC-19
1,1-Dichloroethylene			90.8		%		70-130	16-DEC-19
1,2-Dichlorobenzene			84.6		%		70-130	16-DEC-19
1,2-Dichloroethane			105.3		%		70-130	16-DEC-19
1,2-Dichloropropane			92.2		%		70-130	16-DEC-19
1,3-Dichlorobenzene			88.5		%		70-130	16-DEC-19
1,4-Dichlorobenzene			89.3		%		70-130	16-DEC-19
2-Hexanone			80.4		%		60-140	16-DEC-19
Acetone			101.1		%		60-140	16-DEC-19
Benzene			98.9		%		70-130	16-DEC-19
Bromodichloromethane			94.5		%		70-130	16-DEC-19
Bromoform			88.5		%		70-130	16-DEC-19
Bromomethane			87.6		%		60-140	16-DEC-19
Carbon Disulfide			98.0		%		70-130	16-DEC-19

Quality Control Report

Workorder: L2395008

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943663							
WG3235779-1	LCS							
Carbon tetrachloride			96.1		%		70-130	16-DEC-19
Chlorobenzene			86.0		%		70-130	16-DEC-19
Chloroethane			102.2		%		70-130	16-DEC-19
Chloroform			98.9		%		70-130	16-DEC-19
Chloromethane			94.9		%		60-140	16-DEC-19
cis-1,2-Dichloroethylene			87.5		%		70-130	16-DEC-19
cis-1,3-Dichloropropene			94.1		%		70-130	16-DEC-19
Dibromochloromethane			87.4		%		70-130	16-DEC-19
Dichlorodifluoromethane			94.8		%		50-140	16-DEC-19
Dichloromethane			93.4		%		70-130	16-DEC-19
Ethylbenzene			87.6		%		70-130	16-DEC-19
m+p-Xylenes			89.0		%		70-130	16-DEC-19
Methyl Ethyl Ketone			99.3		%		60-140	16-DEC-19
Methyl Isobutyl Ketone			86.4		%		50-150	16-DEC-19
n-Hexane			91.5		%		70-130	16-DEC-19
MTBE			95.9		%		70-130	16-DEC-19
o-Xylene			87.4		%		70-130	16-DEC-19
Styrene			87.4		%		70-130	16-DEC-19
Tetrachloroethylene			88.6		%		70-130	16-DEC-19
Toluene			89.5		%		70-130	16-DEC-19
trans-1,2-Dichloroethylene			93.5		%		70-130	16-DEC-19
trans-1,3-Dichloropropene			88.0		%		70-130	16-DEC-19
Trichloroethylene			94.0		%		70-130	16-DEC-19
Trichlorofluoromethane			97.2		%		60-140	16-DEC-19
Vinyl chloride			102.5		%		60-140	16-DEC-19
WG3235779-2	MB							
1,1,1,2-Tetrachloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,2,2-Tetrachloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,1-Trichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,2-Trichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,2-Dibromoethane			<0.20		ug/L		0.2	16-DEC-19
1,1-Dichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19

Quality Control Report

Workorder: L2395008

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943663							
WG3235779-2 MB								
1,2-Dichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichloropropane			<0.50		ug/L		0.5	16-DEC-19
1,3-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19
1,4-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19
2-Hexanone			<20		ug/L		20	16-DEC-19
Acetone			<20		ug/L		20	16-DEC-19
Benzene			<0.50		ug/L		0.5	16-DEC-19
Bromodichloromethane			<1.0		ug/L		1	16-DEC-19
Bromoform			<1.0		ug/L		1	16-DEC-19
Bromomethane			<0.50		ug/L		0.5	16-DEC-19
Carbon Disulfide			<1.0		ug/L		1	16-DEC-19
Carbon tetrachloride			<0.50		ug/L		0.5	16-DEC-19
Chlorobenzene			<0.50		ug/L		0.5	16-DEC-19
Chloroethane			<1.0		ug/L		1	16-DEC-19
Chloroform			<1.0		ug/L		1	16-DEC-19
Chloromethane			<1.0		ug/L		1	16-DEC-19
cis-1,2-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
cis-1,3-Dichloropropene			<0.50		ug/L		0.5	16-DEC-19
Dibromochloromethane			<1.0		ug/L		1	16-DEC-19
Dichlorodifluoromethane			<1.0		ug/L		1	16-DEC-19
Dichloromethane			<2.0		ug/L		2	16-DEC-19
Ethylbenzene			<0.50		ug/L		0.5	16-DEC-19
m+p-Xylenes			<1.0		ug/L		1	16-DEC-19
Methyl Ethyl Ketone			<20		ug/L		20	16-DEC-19
Methyl Isobutyl Ketone			<20		ug/L		20	16-DEC-19
n-Hexane			<0.50		ug/L		0.5	16-DEC-19
MTBE			<0.50		ug/L		0.5	16-DEC-19
o-Xylene			<0.50		ug/L		0.5	16-DEC-19
Styrene			<0.50		ug/L		0.5	16-DEC-19
Tetrachloroethylene			<0.50		ug/L		0.5	16-DEC-19
Toluene			<0.50		ug/L		0.5	16-DEC-19
trans-1,2-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
trans-1,3-Dichloropropene			<0.50		ug/L		0.5	16-DEC-19
Trichloroethylene			<0.50		ug/L		0.5	16-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch R4943663								
WG3235779-2 MB								
Trichlorofluoromethane			<1.0		ug/L		1	16-DEC-19
Vinyl chloride			<0.50		ug/L		0.5	16-DEC-19
Surrogate: 1,4-Difluorobenzene			102.2		%		70-130	16-DEC-19
Surrogate: 4-Bromofluorobenzene			96.6		%		70-130	16-DEC-19
Batch R4944729								
WG3243806-1 LCS								
1,1,1,2-Tetrachloroethane			85.0		%		70-130	17-DEC-19
1,1,2,2-Tetrachloroethane			85.2		%		70-130	17-DEC-19
1,1,1-Trichloroethane			98.3		%		70-130	17-DEC-19
1,1,2-Trichloroethane			82.6		%		70-130	17-DEC-19
1,2-Dibromoethane			80.2		%		70-130	17-DEC-19
1,1-Dichloroethane			99.1		%		70-130	17-DEC-19
1,1-Dichloroethylene			98.8		%		70-130	17-DEC-19
1,2-Dichlorobenzene			85.2		%		70-130	17-DEC-19
1,2-Dichloroethane			91.7		%		70-130	17-DEC-19
1,2-Dichloropropane			88.0		%		70-130	17-DEC-19
1,3-Dichlorobenzene			93.7		%		70-130	17-DEC-19
1,4-Dichlorobenzene			94.0		%		70-130	17-DEC-19
2-Hexanone			57.4	MES	%		60-140	17-DEC-19
Acetone			78.6		%		60-140	17-DEC-19
Benzene			99.7		%		70-130	17-DEC-19
Bromodichloromethane			88.0		%		70-130	17-DEC-19
Bromoform			76.9		%		70-130	17-DEC-19
Bromomethane			91.9		%		60-140	17-DEC-19
Carbon Disulfide			107.7		%		70-130	17-DEC-19
Carbon tetrachloride			102.3		%		70-130	17-DEC-19
Chlorobenzene			86.2		%		70-130	17-DEC-19
Chloroethane			110.0		%		70-130	17-DEC-19
Chloroform			97.5		%		70-130	17-DEC-19
Chloromethane			106.9		%		60-140	17-DEC-19
cis-1,2-Dichloroethylene			85.6		%		70-130	17-DEC-19
cis-1,3-Dichloropropene			87.0		%		70-130	17-DEC-19
Dibromochloromethane			79.1		%		70-130	17-DEC-19
Dichlorodifluoromethane			128.0		%		50-140	17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4944729							
WG3243806-1	LCS							
Dichloromethane			89.8		%		70-130	17-DEC-19
Ethylbenzene			91.9		%		70-130	17-DEC-19
m+p-Xylenes			93.6		%		70-130	17-DEC-19
Methyl Ethyl Ketone			72.6		%		60-140	17-DEC-19
Methyl Isobutyl Ketone			62.1		%		50-150	17-DEC-19
n-Hexane			104.1		%		70-130	17-DEC-19
MTBE			96.6		%		70-130	17-DEC-19
o-Xylene			89.1		%		70-130	17-DEC-19
Styrene			85.4		%		70-130	17-DEC-19
Tetrachloroethylene			96.4		%		70-130	17-DEC-19
Toluene			92.9		%		70-130	17-DEC-19
trans-1,2-Dichloroethylene			98.2		%		70-130	17-DEC-19
trans-1,3-Dichloropropene			79.7		%		70-130	17-DEC-19
Trichloroethylene			97.6		%		70-130	17-DEC-19
Trichlorofluoromethane			107.8		%		60-140	17-DEC-19
Vinyl chloride			116.9		%		60-140	17-DEC-19
WG3243806-2	MB							
1,1,1,2-Tetrachloroethane			<0.50		ug/L		0.5	17-DEC-19
1,1,2,2-Tetrachloroethane			<0.50		ug/L		0.5	17-DEC-19
1,1,1-Trichloroethane			<0.50		ug/L		0.5	17-DEC-19
1,1,2-Trichloroethane			<0.50		ug/L		0.5	17-DEC-19
1,2-Dibromoethane			<0.20		ug/L		0.2	17-DEC-19
1,1-Dichloroethane			<0.50		ug/L		0.5	17-DEC-19
1,1-Dichloroethylene			<0.50		ug/L		0.5	17-DEC-19
1,2-Dichlorobenzene			<0.50		ug/L		0.5	17-DEC-19
1,2-Dichloroethane			<0.50		ug/L		0.5	17-DEC-19
1,2-Dichloropropane			<0.50		ug/L		0.5	17-DEC-19
1,3-Dichlorobenzene			<0.50		ug/L		0.5	17-DEC-19
1,4-Dichlorobenzene			<0.50		ug/L		0.5	17-DEC-19
2-Hexanone			<20		ug/L		20	17-DEC-19
Acetone			<20		ug/L		20	17-DEC-19
Benzene			<0.50		ug/L		0.5	17-DEC-19
Bromodichloromethane			<1.0		ug/L		1	17-DEC-19
Bromoform			<1.0		ug/L		1	17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4944729							
WG3243806-2	MB							
Bromomethane			<0.50		ug/L		0.5	17-DEC-19
Carbon Disulfide			<1.0		ug/L		1	17-DEC-19
Carbon tetrachloride			<0.50		ug/L		0.5	17-DEC-19
Chlorobenzene			<0.50		ug/L		0.5	17-DEC-19
Chloroethane			<1.0		ug/L		1	17-DEC-19
Chloroform			<1.0		ug/L		1	17-DEC-19
Chloromethane			<1.0		ug/L		1	17-DEC-19
cis-1,2-Dichloroethylene			<0.50		ug/L		0.5	17-DEC-19
cis-1,3-Dichloropropene			<0.50		ug/L		0.5	17-DEC-19
Dibromochloromethane			<1.0		ug/L		1	17-DEC-19
Dichlorodifluoromethane			<1.0		ug/L		1	17-DEC-19
Dichloromethane			<2.0		ug/L		2	17-DEC-19
Ethylbenzene			<0.50		ug/L		0.5	17-DEC-19
m+p-Xylenes			<1.0		ug/L		1	17-DEC-19
Methyl Ethyl Ketone			<20		ug/L		20	17-DEC-19
Methyl Isobutyl Ketone			<20		ug/L		20	17-DEC-19
n-Hexane			<0.50		ug/L		0.5	17-DEC-19
MTBE			<0.50		ug/L		0.5	17-DEC-19
o-Xylene			<0.50		ug/L		0.5	17-DEC-19
Styrene			<0.50		ug/L		0.5	17-DEC-19
Tetrachloroethylene			<0.50		ug/L		0.5	17-DEC-19
Toluene			<0.50		ug/L		0.5	17-DEC-19
trans-1,2-Dichloroethylene			<0.50		ug/L		0.5	17-DEC-19
trans-1,3-Dichloropropene			<0.50		ug/L		0.5	17-DEC-19
Trichloroethylene			<0.50		ug/L		0.5	17-DEC-19
Trichlorofluoromethane			<1.0		ug/L		1	17-DEC-19
Vinyl chloride			<0.50		ug/L		0.5	17-DEC-19
Surrogate: 1,4-Difluorobenzene			101.5		%		70-130	17-DEC-19
Surrogate: 4-Bromofluorobenzene			94.5		%		70-130	17-DEC-19

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Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MES	Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Appendix G

Isotope Analysis



Isotope Analyses for:
Dillon Consulting

IT2 FILE #
190229

2020-02-24

Approved by:

Orfan SStash

Orfan Shouakar-Stash, PhD
Director

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Client: Dillon Consulting Limited
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Tel: 519-438-6192
Attn.: Rob Kell
E-mail: rkell@dillon.ca

File Number: 190229
Project P.O.: W12A London Landfill (19-1230)

#	Sample ID	Sample #	$\delta^{18}\text{O}$	Aver	Stdv	$\delta^2\text{H}$	Aver	Stdv
			H_2O	VSMOW		H_2O	VSMOW	
1	15'-BH19-3-SS2	60412	X	-9.60	0.02	X	-64.6	0.2
2	20'-BH19-3-SS3	60413	X	-9.54	0.03	X	-64.6	0.4
3	30'-BH19-3-SS5	60414	X	-8.84	0.04	X	-61.9	0.3
4	40'-BH19-3-SS7	60415	X	-8.99	0.02	X	-62.3	0.1
5	15'-BH19-5-SS1	60416	X	-8.82	0.01	X	-59.8	0.4
6	30'-BH19-5-SS4	60417	X	-8.97	0.03	X	-61.4	0.2
7	45'-BH19-5-SS7	60418	X	-9.42	0.03	X	-62.6	0.3
8	55'-BH19-5-SS10	60419	X	-8.52	0.04	X	-59.6	0.3

^{18}O & ^2H (CRDS)

Instrument Used: Cavity Ring Down Spectroscopy (CRDS)
 CRDS (Model L2130-i) (Picarro, California, USA).

Standard Used:
 IT2-2B / IT2-11B / IT2-13B Calibrated with IAEA Standards (V-SMOW, SLAP, and GISP)

Typical Standard deviation:

$(^{18}\text{O} \pm 0.1\text{‰})$ $(^2\text{H} \pm 1\text{‰})$

Approved by:

Orfan S-Stash

Orfan Shouakar-Stash, PhD

Director

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Attn.: Rob Kell
E-mail: rkell@dillon.ca

File Number: 190229
Project P.O.: W12A London Landfill (19-1230)

#	Sample ID	Sample #	E ³ H	Result	± 1σ
1	15'-BH19-3-SS2	60412	X	3.7	1.0
2	20'-BH19-3-SS3	60413	X	< 0.8	0.7
3	30'-BH19-3-SS5	60414	X	2.0	0.8
4	40'-BH19-3-SS7	60415	X	< 0.8	0.7
5	15'-BH19-5-SS1	60416	X	4.1	0.8
6	30'-BH19-5-SS4	60417	X	1.4	0.7
7	45'-BH19-5-SS7	60418	X	0.9	0.6
8	55'-BH19-5-SS10	60419	X	2.3	0.9

E³H ANALYSES

Tritium is reported in Tritium Units.

1TU = 3.221 Picocuries/L per IAEA, 2000 Report.

1TU = 0.11919 Becquerels/L per IAEA, 2000 Report.

Approved by:

Orfan S-Stash

Orfan Shouakar-Stash, PhD

Director

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ATTACHMENT B

**Groundwater Impact Assessment –
Golder Associates Ltd.**

DRAFT



GOLDER

DRAFT

REPORT

Groundwater Impact Assessment

W12A Landfill Expansion EA, City of London, Ontario

Submitted to:

Mike Losee, Division Manager, Solid Waste Management

City of London

300 Dufferin Avenue

London, Ontario

PO BOX 5035

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November 2020

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APPENDICES

APPENDIX A

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APPENDIX B

Example POLLUTE Output File

APPENDIX C

Service Life

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Acronyms and Glossary of Terms

Term / Acronym	Definition
EA	Environmental Assessment
EASR	Environmental Assessment Study Report
ECA	Environmental Compliance Approval
EPA	<i>Environmental Protection Act</i>
f_{oc}	fraction organic carbon
HELP	Hydrologic Evaluation of Landfill Performance
k	hydraulic conductivity
K_{oc}	soil/organic carbon partition coefficient
LCS	Leachate Collection System
LFG	Landfill Gas
m	metres
m^2	square metres
m^3	cubic metres
masl	Metres Above Sea Level
MECP	Ministry of Environment, Conservation and Parks
mg/L	milligram per litre
mg/kg	milligram per kilogram
mL/g	millilitre per gram
MNRF	Ministry of Natural Resources and Forestry
MRF	Material Recovery Facility
ODWQS	Ontario Drinking Water Quality Standards
POLLUTE	contaminant transport model
RUC	Reasonable Use Criteria
RUG	Reasonable Use Guidelines
ToR	Terms of Reference
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

The City of London is proposing an expansion of the existing W12A Landfill site (the Project) located at 3502 Manning Drive, part of Lots 18, 19 and 20 of Concession 6 in the former Township of Westminster, in the south end of the City of London Ontario.

The environment is considered in broad terms to include the natural, social, cultural, and economic aspects of the environment. This document presents the assessment of impacts on long-term groundwater quality and quantity for the Environment Assessment (EA) of the proposed W12A Landfill expansion. This work has been conducted in accordance with the requirements set out in the approved Amended Terms of Reference (ToR), dated February 2019 and the Work Plan dated November 2019 that was developed with input from First Nation Communities (Aamjiwnaang First Nation, Chippewas of the Thames First Nation, Munsee-Delaware First Nation, Oneida First Nation) and their consultant (Dragun Corporation) and circulated to the Ministry of the Environment, Conservation and Parks (MECP). In addition, the work also included additional contaminant transport modelling as a result of feedback from a First Nation Communities workshop held in August 2020.

This report is a supporting document to the Environmental Assessment Study Report (EASR).

2.0 PROJECT DESCRIPTION

2.1 General Description

During the first 25 years of operations at the W12A Landfill (1977 to 2002), approximately 5 million tonnes of waste was deposited in six cells that comprise the Phase 1 area of the landfill. Phase 1 covers 59.3 ha and occupies the eastern portion of the landfill footprint (Appendix A, Figure 1.3-1 of the EASR). It currently has final cover in place throughout its full area.

Phase 2 of the existing landfill covers an area of 47.7 ha and occupies the western portion of the landfill. Phase 2 has been the active area of landfilling from the time it received regulatory approval in 2002. It has an approved waste fill capacity of 5.5 million tonnes divided amongst eight cells as shown in Appendix A, Figure 1.3-1 of the EASR.

As shown in Figure 8.1.-1 of the EASR (Appendix A), a vertical expansion of the existing approved waste fill area (i.e., vertical expansion of the Phase 1 and 2 areas) is being proposed, to provide an additional 13.8 million m³ of airspace for waste and daily cover. The vertical expansion will have a final peak elevation (top of waste and daily cover) of 318.43 masl.

To accommodate ancillary features and provide additional on-Site buffer width compared to the existing landfill, the northern boundary of the landfill property will be expanded northward to Scotland Drive and a 100 m buffer width will be provided on the east side of the landfill footprint. In addition, some additional area will be provided at the southeast corner of the site to tie into the adjacent Material Recovery Facility (MRF) property line. As shown in Figure 8.1.-1 of the EASR (Appendix A) this proposed expansion of the landfill site boundary results in an overall landfill site area of 191.7 ha.

2.2 Landfill Phasing and Development

The proposed vertical expansion will be developed sequentially in eight phases, referred to as Areas 1E through 8E (Appendix A, Figure 8.1-2 of the EASR), progressing from west to east. The duration of landfilling in each Area will be approximately 2.5 to 3.5 years based on an expected typical annual air space consumption of 500,000 m³ per year, which corresponds to an average annual waste receipt of 370,000 tonnes per year. The estimated operating period of the landfill expansion to reach the proposed final contours is approximately 25 years.

A separate cell dedicated for disposal of the non-decomposable portion of the waste stream will be provided in the southeastern area of the landfill expansion. Filling in this non-decomposable waste cell will take place in lifts over the 25 year expansion period, and will be blended in to meet the temporary sideslopes in the adjacent Areas 7E and 8E as they are developed. As only non-decomposable waste will be placed in this cell, daily cover will not be applied; however, if it is observed that specific materials are generating odours or are otherwise of concern if left uncovered, daily cover material will be placed. Final cover will be placed progressively over the fill areas as the waste fill reaches the design final contours.

To commence filling in each Area of the proposed landfill expansion, the existing cover material will be progressively stripped from a large enough area (approximately 4 ha) to accommodate one year of disposal. The surface area of exposed waste on any given day of operation will be limited to that needed to spread, compact and cover the waste received on that day, and will have dimensions typically ranging from approximately 40 m by 25 m (1,000 m²) to 50 m by 30 m (1,500 m²). The working face of the waste fill will be advanced as a 3 m high layer, with the waste spread/compacted in 0.6 m thick lifts to the 3 m height. All exposed waste will be covered daily.

For the southern Fill Areas of the proposed vertical expansion (Areas 1E, 3E, 5E and 7E), the waste will be placed initially to build a berm along the south side of the landfill and will be covered with final cover soil and seeded to establish vegetation; the berm will screen the view of subsequent filling operations north of the berm (Areas 2E, 4E, 6E and 8E) from off-Site vantage points to the south. The south side perimeter waste berm will be raised sequentially and filled in behind until the peak elevation is reached. On an annual or biannual basis, final cover will be constructed over areas reaching final grade.

2.3 Leachate Control and Management

Phase 2 utilizes the clay till as a natural low permeability liner, and has a continuous granular leachate drainage blanket and piping system over a shaped subgrade to collect leachate and direct it by gravity to the south end of the Phase 2 area where the collected leachate is removed for subsequent off-site treatment. This existing leachate collection system will continue to be used to collect and remove leachate from the proposed vertically expanded Phase 2 area.

The waste in the Phase 1 area rests directly on the underlying natural low permeability clay till and does not have a continuous granular drainage blanket to collect leachate over its base area. Instead, Phase 1 has a perimeter leachate collection system (LCS) around the north, east and south sides to intercept lateral leachate seepage through the upper weathered/fractured clay till. The leachate collected by this perimeter leachate collection system either drains into the Phase 2 granular drainage blanket or into a separate storage tank from where it is removed for subsequent off-site treatment. For the vertical expansion above the Phase 1 area, it is proposed to replace the existing perimeter LCS with a new perimeter LCS that will more effectively serve the same function as the existing system. Furthermore, to control the potential for leachate seeps along the perimeter sideslopes that could occur as a result of leachate mounding and/or perched leachate in Phase 1, it is proposed to construct granular finger drains along the north, east and south perimeter slopes of the Phase 1 area and connect them into the replacement Phase 1 perimeter LCS.

The leachate collected from the Phase 1 and Phase 2 LCS will continue to be routed through on-Site piping to the main leachate pumping station located at the southeast corner of the Site. From this station, the leachate will be pumped off-Site through a leachate forcemain to the Dingman Drive pump station, where it will be combined with municipal sewage and conveyed via the municipal sanitary sewer system to the Greenway Wastewater Treatment Plant (WWTP).

2.4 Closure and Post-closure

Each Area of the proposed vertical expansion will be progressively closed as final waste contours are reached in that Area. The final cover will consist of a 600 mm thick soil layer topped with a 150 mm thick vegetated topsoil layer. Vertical landfill gas (LFG) extraction wells will be installed to collect gas from within the expanded waste mass as part of the progressive construction of the final cover system (horizontal gas collectors will be used for interim control of landfill gas during the landfilling period).

Post-closure activities will involve continued operation and maintenance of the leachate collection and removal system, the LFG control system and the stormwater management system. In addition to general inspection of the Site, there will be inspection of the landfill cover for evidence of erosion, leachate seeps or instability, and maintenance / repair as required.

3.0 ASSESSMENT OF LONG-TERM GROUNDWATER QUALITY IMPACTS

3.1 Regulatory Objectives

Modelling of long-term groundwater quality impacts for new or expanding landfill sites is required under O.Reg. 232/98 (Ministry of Environment, Conservation and Parks (MECP), 1998) to demonstrate that the proposed design will meet the requirements of the MECP Reasonable Use Guideline (RUG) B-7 (MECP, 1994). The Reasonable Use Guideline B-7 establishes a quantitative benchmark for protecting off-Site groundwater quality for drinking water purposes. The Reasonable Use Guideline makes the following statement regarding groundwater impact at the landfill property boundary:

“In the case of drinking water, the quality must not be degraded by an amount in excess of 50% of the difference between background and the Ontario Drinking Water Objectives for non-health related parameters and in excess of 25% of the difference between background and the Ontario Drinking Water Objectives for health related parameters. Background is considered to be the quality of the groundwater prior to any man-made contamination.”

3.2 Contaminant Transport Model

The assessment of potential long-term groundwater quality impacts from the expanded landfill was carried out using the contaminant transport model POLLUTE (Rowe et. al., 1994). POLLUTE is a one-dimensional, analytical contaminant transport model that can simulate vertical contaminant migration from a landfill situated on a multi-layered soil deposit. The model considers individual cross-sections through the landfill that are oriented in the direction of principal groundwater flow. The geologic units below the landfill for each cross-section are modelled as individual layers, with each assigned a set of physical and chemical parameters.

The time zero for the modelling ($t=0$) was taken as the Year 1987 for Phase 1 and 2010 for Phase 2, corresponding to ten years from the start of landfilling in each Phase. The simulation period was for 1000 years ($t=1000$ years).

The boundary condition used for contaminant source concentrations in the landfill is that of a depleting contaminant concentration with time from an initial representative peak value occurring at $t=0$ years and then from a second representative peak value occurring during the landfill expansion period. The depletion in contaminant source concentration is due to wash-out by moisture infiltration/percolation through the waste mass and to bio-chemical decay (for organic contaminants). The rate of concentration decrease with time is a function of the bio-chemical decay half-life, the representative peak leachate concentration, the contaminant mass inventory in the landfill and the moisture infiltration rate through the landfill cover. POLLUTE does not account for volatilization of volatile organic contaminants and, as such, is conservative in this respect.

Transport mechanisms modelled by POLLUTE are advection and dispersion (which includes mechanical mixing and molecular diffusion). Advection refers to the process whereby the solute is transported as a result of groundwater movement. Dispersion, on the other hand, refers to spreading of the solute due to a gradient in its concentration (the diffusion mechanism), and due to mechanical mixing of groundwater arising from heterogeneity in the

size and geometry of soil pores (the hydrodynamic mechanism). The model can also account for adsorption onto the soil solids and biological/chemical decay, which are processes that remove the solute from the porewater phase and hence decrease the net rate of migration. The adsorption process is modelled according to a linear/reversible isotherm and the biological/chemical decay process according to a first order decay rate.

The POLLUTE model output is in the form of calculated concentrations versus time at any specified depth below the waste, at the down-gradient edge of the landfill cross-section.

3.3 Geological and Hydrogeological Input Parameters

Based on the site geological and hydrogeological conditions described in the document entitled “Existing Groundwater Conditions” (Dillon, 2020) that is meant to be a companion study to this report, the landfill is underlain by the following soil layers in sequence starting from the base of the waste fill:

- Surficial Aquitard (Silty Clay)
- Upper Aquifer (Sand)
- Lower Aquitard (Silty Clay)
- Lower Sand Aquifer (White Oak Aquifer)

The selected locations of the POLLUTE model cross-sections are shown in Figure 1 in relation to the Upper Aquifer groundwater piezometric surface contours and Surficial Aquitard thickness contours. The cross-sections with the greatest potential to impact groundwater quality beneath the landfill are Sections A-A' and B-B' through Phase 1, which does not have an underdrain leachate collection system. Section A-A' passes through the central part of Phase 1 where the post-expansion waste fill thickness (up to 36 m) and landfill footprint length in the direction of groundwater flow (800 m) are the greatest. Section B-B' is through the southeastern portion of Phase 1 where the thickness of the Surficial Aquitard beneath the waste fill is the least.

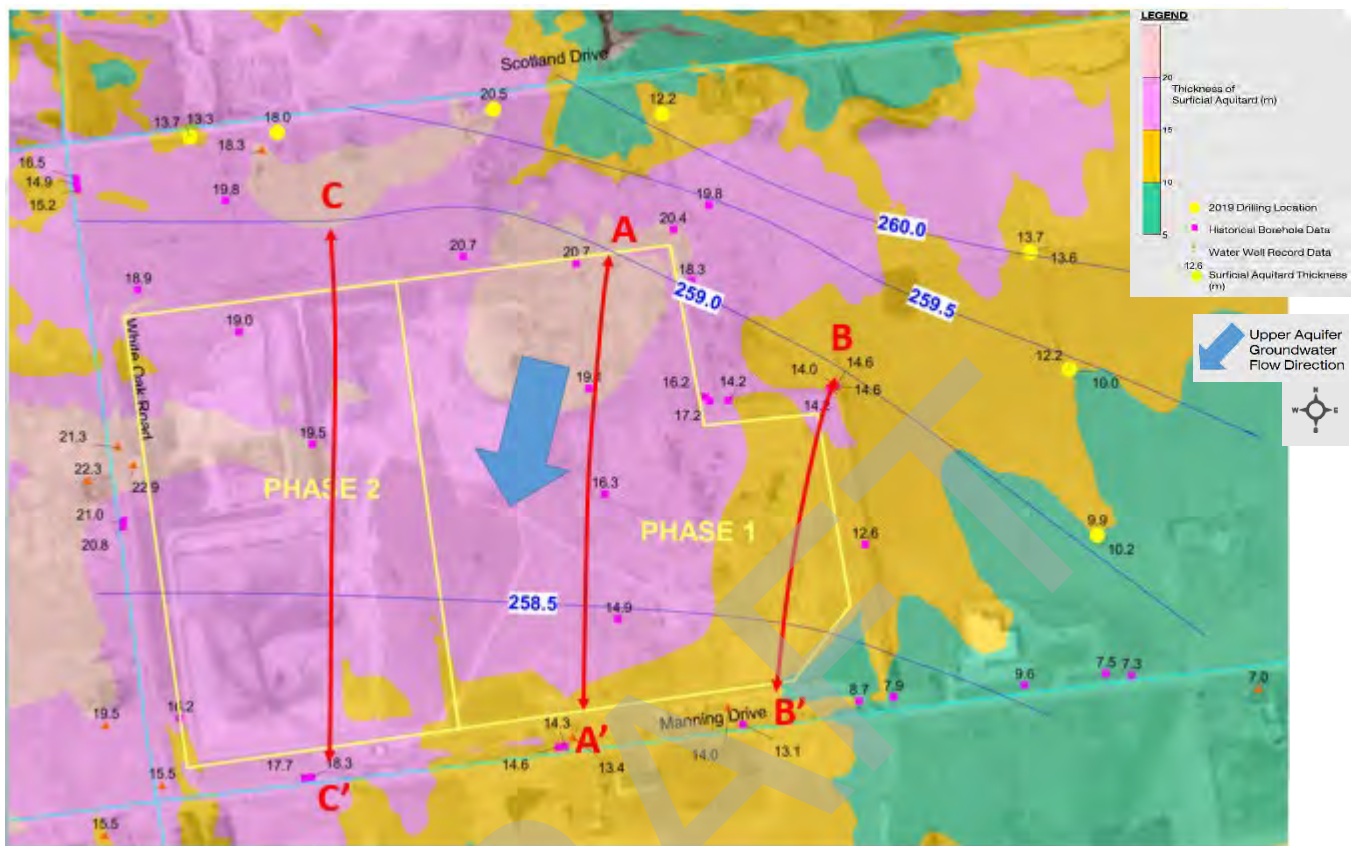


Figure 1: Plan View of The Landfill Showing Modelled Cross-Sections (A-A', B-B' and C-C'), Inferred Thickness of the Surficial Aquitard and Fall 2019 Groundwater Elevations In the Upper Aquifer (Based on Dillon, 2020).

The geological and hydrogeological input parameters used for the POLLUTE model cross-sections are based on the information provided in the Existing Groundwater Conditions Report (Dillon, 2020) and are summarized below:

Section A-A'

The soil layer thicknesses beneath the waste fill for Section A-A' are as follows:

- 14 metres (m) Surficial Aquitard - from Figure 1, the inferred average thickness of Surficial Aquitard relative to the original (pre-landfilling) ground surface along Section A-A' is approximately 17 m, of which the uppermost approximately 5 m is fractured. Considering that construction of the Phase 1 base grade involved excavation to approximately 3 m below grade, the average Surficial Aquitard thickness beneath the waste fill for Section A-A' was taken as 14 m, of which 2 m is fractured. It is noted, however, that based on an investigation of the Surficial Aquitard conducted by the University of Western Ontario (Western, 2000) any fractures originally present beneath Phase 1 may have self-healed due to consolidation of the clay from the overlying effective stress (weight) of the waste fill.

- 0.4 m unsaturated Upper Aquifer - the water level in the Upper Aquifer is consistently below the interface with the overlying Surficial Aquitard except for the southwest corner and hence the Upper Aquifer was divided into an upper unsaturated and an underlying saturated zone
- 7.6 m saturated Upper Aquifer
- 20 m Lower Aquitard
- 3 m thick White Oak Aquifer

The vertical hydraulic conductivity of the unfractured Surficial Aquitard was found to vary between 1.4×10^{-10} m/sec and 9×10^{-11} m/sec with a geometric mean value of 1.0×10^{-10} m/sec, based on the results of laboratory testing summarized in the Existing Groundwater Conditions Report (Dillon, 2020). There are no measurements of the hydraulic conductivity of the fractured Surficial Aquitard; however, the University of Western Ontario (Western, 2000) have indicated that the fractures self heal under the effective stress (weight) induced by the overlying waste fill placement. The hydraulic conductivity of the fractured zone has been assumed to be 1×10^{-7} m/sec, similar to other clays/tills regionally under natural conditions. Assuming 2 m of fractured zone with a hydraulic conductivity of 1×10^{-7} m/sec and 12 m of unfractured zone with a hydraulic conductivity of 1×10^{-10} m/sec, the calculated harmonic mean hydraulic conductivity for the Surficial Aquitard beneath Section A-A' is 1.2×10^{-10} m/sec. To account for a reduction in hydraulic conductivity due to consolidation of the aquitard material under the weight of the waste fill, the harmonic mean is rounded down to 1×10^{-10} m/sec. The Surficial Aquitard was therefore modelled as one unit with a thickness of 14 m and a hydraulic conductivity of 1×10^{-10} m/sec.

The fraction organic carbon content of the Surficial Aquitard was calculated to be 0.21%, which is the average of six fraction organic carbon analyses completed on samples obtained in 2019 as reported in the Existing Groundwater Conditions Report (Dillon, 2020). It is noted that the University of Western Ontario (Western, 2000) also completed a fraction organic carbon analysis from one sample in the fractured zone of the Surficial Aquitard and obtained a value of 0.4%. Conservatively, the modelling used the fraction organic carbon results from 2019.

The saturated portion of the Upper Aquifer was modelled as a horizontal "sink" to reflect lateral migration of contaminants out of this layer from beneath the landfill footprint. Using the Hazen formula, the hydraulic conductivity of the Upper Aquifer was estimated at approximately 1.1×10^{-5} m/sec based on grain size distributions from four samples obtained in 2019 (Dillon, 2020). The groundwater flow direction in the Upper Aquifer is to the southwest as shown in Figure 1. The hydraulic gradient in the Upper Aquifer upgradient of the landfill was taken as 0.0036 based on the groundwater piezometric surface shown in Figure 1.

The hydrogeologic characteristics of the Lower Aquitard have not been studied. This unit is described in the borehole records as silty clay and, as such, was assigned a low hydraulic conductivity of 1×10^{-10} m/sec for the purpose of the POLLUTE modelling similar to the unfractured Surficial Aquitard.

The top three metres of the White Oak Aquifer (assumed mixing zone of landfill contaminants within this aquifer) was included in the POLLUTE modelling. Using the Hazen formula, the hydraulic conductivity of the White Oak Aquifer was estimated at approximately 5.3×10^{-6} m/sec based on grain size distributions from four samples obtained in 2019. Based on groundwater level monitoring data, the primary groundwater flow path within the White Oak Aquifer is interpreted to be to the southeast at a horizontal hydraulic gradient of approximately 0.0004 (Dillon, 2020).

Section B-B'

The geological and hydrogeological input parameters for Section B-B' are the same as those for Section A-A', except that the Surficial Aquitard beneath the waste was assigned a smaller thickness of 9 m (versus 14 m for Section A-A').

Section C-C'

The geological and hydrogeological input parameters for the Phase 2 Section C-C' are the same as those for Section A-A' except that the Surficial Aquitard beneath the waste was assigned a greater thickness of 16 m (versus 14 m for Section A-A').

3.4 Leachate Generation Rates

The potential percolation rate of atmospheric water through the daily/interim and final cover of the W12A Landfill was estimated using the Hydrologic Evaluation of Landfill Performance (HELP) Model Version 3.07 (USEPA, 1997).

The HELP model is a quasi-two-dimensional water-balance model for water movement in the landfill (Schroeder et. al., 1994). The model accepts the weather data and landfill design data and uses solution techniques that account for the effect of different processes such as surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetation growth, soil moisture storage, lateral subsurface drainage, leachate recirculation, unsaturated vertical drainage and leakage through liners (Schroeder et. al., 1994 and Sharma and Lewis, 1994). The site-specific runoff, evapotranspiration, infiltration, drainage, leachate collection and liner leakage can be determined using the HELP model.

3.4.1 Climatological Input Parameters

Daily precipitation and temperature input data for the W12A Landfill Site were synthetically generated using the HELP model (Ref. 1). This involved taking 30 years of continuous precipitation and temperature data for Detroit, Michigan, USA (nearest reference station included in the HELP model database) and then adjusting the data with mean monthly precipitation and temperature values based on the average values for the London Airport meteorological station as shown in Table 1.

Daily solar radiation data was synthetically generated using the HELP model by taking the Detroit, Michigan solar radiation data (included in the HELP model database) and correcting the latitude for the W12A Landfill Site.

Average quarterly relative humidity and average annual wind speed for the London Airport meteorological station were used (refer to Table 2).

Table 1: Normal Mean Monthly Precipitation and Temperature at London Airport Meteorological Station

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Precipitation	mm	74.2	65.5	71.5	83.4	89.8	91.7	82.7	82.9	103	81.3	98	87.5
Temperature	°C	-5.6	-4.5	-0.1	6.8	13.1	18.3	20.8	19.7	15.5	9.2	3.4	-2.6

Climate ID: 6144475

Elevation: 278.0 masl

Latitude: 43°01'59.000" N

Longitude: 81°09'04.000" W

Source: Canadian Climate Normals 1981-2010 (Environment Canada).

Table 2: Normal Relative Humidity and Windspeed at London Airport Meteorological Station

	units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Relative Humidity at 06:00	%	83.5	81.4	81.2	79.8	80.7	84.5	88.1	91.0	90.7	87.2	84.9	84.4
Relative Humidity at 15:00	%	75.9	71.9	65.0	56.9	54.8	57.0	57.6	59.7	59.9	63.1	72.0	76.9
Average Quarterly Relative Humidity	%	76			69			75			78		
Windspeed	km/h	17.3	16.2	16.3	16.3	14.0	11.9	10.6	9.7	11.1	13.4	15.6	16.5
Average Annual Windspeed	km/h	14.1											

Climate ID: 6144475**Elevation:** 278.0 m masl**Latitude:** 43°01'59.000" N**Longitude:** 81°09'04.000" W

Source: Canadian Climate Normals 1981-2010 (Environment Canada).

3.4.2 Daily/Interim Cover, Final Cover and Waste Layer Input Parameters

The HELP model input parameters for the daily/interim cover, final cover and waste are summarized in Table 3. The values used in the HELP model for total porosity, field capacity and wilting point are according to the HELP model default values as shown in Table 3. The initial water content was taken as equal to or greater than the field capacity water content, which is the water content at which the soil can no longer absorb/retain additional moisture under free drainage. With respect to modelling the leachate generation rate, this is a conservative assumption as it reduces the time to reach peak leachate generation.

The model for the filling period was run for a daily/interim cover slope of 1 % and drainage path length of 500 m. The model for the post closure period was run for a final cover slope of 5 % and drainage path length of 500 m.

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Table 3: HELP Model Input Parameters

Input Parameters [†]	Units	Daily/Interim Cover	Final Cover		Waste
			Topsoil	Cover Soil	
HELP Model Soil Texture Class [†]	[-]	8	8	11	18
USDA Soil Texture Class	[-]	Loam (L)	Loam (L)	Clayey Loam (CL)	Municipal Waste
Thickness	m	0.15	0.15	0.60	35
Total porosity	[-]	0.463	0.463	0.464	0.67
Field capacity	[-]	0.232	0.232	0.310	0.29
Wilting point	[-]	0.116	0.116	0.187	0.08
Initial volumetric water content	[-]	0.232	0.232	0.310	0.29
Hydraulic Conductivity [*]	cm/sec	3.7E-4	3.7E-4	6.4E-5	1.0E-3

Notes:

[†] HELP model default soil texture class were used together with model default parameters for total porosity, field capacity, wilting point, initial volumetric water content and hydraulic conductivity.

^{*} Effective saturated hydraulic conductivity.

3.4.3 Vegetation Input Parameters

The HELP model requires input data for the type and extent of vegetation growing on the cover, as well as input data for the evaporative zone depth. For daily/interim cover, a bare ground condition was assumed with a maximum leaf area index of 0. The leaf area index is defined as the dimensionless ratio of the leaf area of actively transpiring vegetation to the nominal surface area of the final cover. For the final cover, a good stand of grass with a maximum leaf area index of 4 was used.

For the daily/interim cover, an evaporative zone depth of 15 cm was assumed. The evaporative zone depth is defined as the maximum depth from which water may be removed by evapotranspiration. For the post-closure period, an evaporative zone depth of 55 cm was assumed for loam / clayey loam soil with good stand of grass.

3.4.4 Results

The average annual water balance and peak daily values obtained from the HELP modelling are provided in Table 4. The average annual percolation rate through daily/interim cover during the filling period is approximately 245 mm/year. The average annual percolation rate through the final cover during the post-closure period is approximately 235 mm/year. The peak daily percolation rates are approximately 5 mm in 24 hours for the filling period and approximately 4 mm in 24 hours for the post closure period.

**Table 4: HELP Model Output
(Average Annual Water Balance and Peak Daily Percolation Rate)**

Average Annual	Daily/Interim Cover	Final Cover
Precipitation	995 mm/year	995 mm/year
Runoff	305 mm/year	210 mm/year
Evapotranspiration	445 mm/year	550 mm/year
Percolation into the Waste	245 mm/year	235 mm/year
Peak Daily		
Percolation into the Waste	5 mm/day (24 hours)	4 mm/day (24 hours)

3.5 Landfill Key Contaminants and Associated Transport Parameters

In accordance with O.Reg. 232/98 (MECP, 1998), the key leachate contaminants modelled to address long-term compliance with the MECP Reasonable Use Guideline (RUG) B-7 (MECP, 1994) are: benzene, cadmium, chloride, lead, 1,4-dichlorobenzene, dichloromethane, toluene and vinyl chloride. These are the parameters that the MECP has determined to have the greatest potential to cause exceedances of the Guideline B-7 values at municipal landfill sites, because they have relatively high initial source concentrations, higher ability to diffuse through liner systems and natural soil deposits, and/or lower decay rates and adsorption ability. Chloride is typically the critical inorganic parameter for landfill compliance and therefore is the focus of this modelling.

Modelling input parameters required for each key landfill leachate contaminant are the representative peak leachate source concentration, mass inventory in the landfill (i.e., contaminant mass as a proportion of total mass of waste), half-life in the groundwater flow system, soil diffusion coefficient and soil adsorption coefficient. As shown on Table 5, the input for representative peak leachate source concentration, mass inventory and half-life are conservatively the same as the values recommended in Table 1 of O.Reg. 232/98, which are based on historical leachate quality monitoring for a number of municipal solid waste landfill sites in Ontario.

The soil adsorption coefficients for the organic contaminants were calculated using literature values for soil/organic carbon partition coefficient (i.e., K_{oc}) and a laboratory fraction organic carbon (f_{oc}) for the Surficial Aquitard. Soil adsorption coefficients for the metals (i.e., cadmium and lead) were assumed based on literature values for similar soil types. Diffusion coefficients for all parameters were assumed based on literature values for similar soil types.

The background concentrations in groundwater in the Upper Aquifer are based on the median of concentrations in background monitoring wells 92-11, 82-6 and 01-14 from 2015 to 2019, using the data presented in the 2019 Annual Monitoring Report (City of London, 2020).

Table 5: Key Contaminants and Associated Soil Transport Parameters

Key Contaminant	Representative Peak Leachate Source Concentration ¹ (mg/L)	Mass Proportion of Total (Wet) Mass of Waste ¹ (mg/kg)	Half-Life ¹ (years)	Soil Adsorption Coefficient (mL/g)	Soil Diffusion Coefficient ² (m ² /year)	Background Concentration in Upper Aquifer ⁵ (mg/L)	Ontario Drinking Water Quality Objective ⁶ (mg/L)
Chloride	2,000 to 2,500 ⁷	1,800	Infinite	0	0.02	5	250 (A)
Cadmium	0.05	0.035	Infinite	70 ³	0.02	<0.0002	0.005 (H)
Lead	0.6	0.42	Infinite	1900 ³	0.02	<0.002	0.01 (H)
Benzene	0.02	0.014	25	0.12 ⁴	0.02	<0.0005	0.005 (H)
1,4-Dichlorobenzene	0.01	0.007	50	1.3 ⁴	0.02	<0.0005	0.005 (H)
Dichloromethane	3.3	2.3	10	0.03 ⁴	0.02	<0.0020	0.05 (H)
Toluene	1	0.7	15	0.38 ⁴	0.02	0.00075	0.024 (A)
Vinyl Chloride	0.055	0.039	25	0.12 ⁴	0.02	<0.0005	0.002 (H)

Notes:

¹ Values taken from Table 1 of O.Reg. 232/98 for municipal solid waste.

² Assumed diffusion coefficient based on literature values for similar soils.

³ Rowe et.al., 2004.

⁴ Based on a fraction organic carbon content (foc) of 0.21% for the Surficial Aquitard and soil/organic carbon partition coefficients (Koc) of 59 ml/g for benzene, 617 ml/g for 1,4-dichlorobenzene, 12 ml/g for dichloromethane, 182 ml/g for toluene and 56 mL/g for vinyl chloride, (Ref. USEPA Technical Fact Sheets)

⁵ Median of concentrations in background monitoring wells 92-11, 82-6 and 01-14 from 2015 to 2019.

⁶ Ontario Drinking Water Quality Standards.

⁷ Used 2,000 mg/L for the existing waste fill based on leachate monitoring data and then 2,500 mg/L per Reg 232/98 for the vertically expanded landfill.

(A) Denotes aesthetic drinking water objective.

(H) Denotes health related drinking water objective.

3.6 Landfill Leachate Mound Height

For Phase 1, which does not have a continuous leachate drainage blanket, the existing maximum leachate mound height relative to the base of the landfill is approximately 12 m based on monitoring of leachate levels at monitoring wells screened within the waste fill. Using this maximum leachate mound height together with the maximum distance of 800 m between the perimeter leachate collector on the north and south sides of Phase 1 and the HELP Model infiltration rate of 0.235 m/y through the existing Phase 1 final cover soil, an average waste hydraulic conductivity of 8×10^{-6} m/sec was back-calculated using the Harr Equation:

$$h_{max} = 0.5L \sqrt{\frac{q_{net}}{k_w}}$$

or

$$k_w = \left(\frac{0.5L}{h_{max}} \right)^2 q_{net}$$

where,

h_{max} = maximum mound height (m) = 12 m

q_{net} = infiltration rate = 0.235 m (based on HELP model)

L = maximum distance between the perimeter leachate collector systems on the north and south sides of Phase 1 = 800 m

k_w = hydraulic conductivity of waste (m/year)

Using the back-calculated waste hydraulic conductivity, an average leachate head (h_{avg}) of 9.5 m was calculated for the Phase 1 Section A-A' pre-expansion using the Harr Equation:

$$h_{avg} = 0.393L \sqrt{\frac{q_{net}}{k_w}}$$

After vertical expansion, an average mound height of 19 m was calculated for Phase 1 Section A-A' using a reduced waste hydraulic conductivity k_w of 2×10^{-6} m/sec based on the range of literature values for similar thickness of waste fill (up to 36 m thick). The reduced hydraulic conductivity accounts for further compression of waste after expansion. The average mound height of 19 m was estimated to be reached approximately 22 years after the start of the vertical expansion.

For the Phase 1 Cross-Section B-B', a leachate head (h) of 7 m was calculated using the Harr Equation for estimating mound height at distance (x = 75 m) from the perimeter collector:

$$h = \sqrt{\frac{q_{net}}{k_w} (L - x) x}$$

The 7 m leachate head for Section B-B' applies to the periods prior to and after the vertical expansion, as this cross-section is located along the perimeter slope (southeast corner of the landfill) where there will be only a minor increase in waste thickness and hence a minor if any decrease in waste hydraulic conductivity.

For Phase 2 (Cross-Section C-C'), which has a blanket leachate collection system over its full base area, the average leachate head above the base of the landfill was assumed to remain constant at 0.3 m for 100 years from the start time (t=0) of the POLLUTE modelling (where t=0 corresponds to 10 years from the start of landfilling in the Phase 2 area). This 100 year period represents the assumed service life of the leachate drainage layer as specified in Regulation 232/98 for the purpose of contaminant transport modelling. It is noted that in the application to amend the W12A ECA for Phase 2 (Earth Tech, 2003) the calculated service life of the site-specific leachate collection system design was 200 years. The service life is limited by bio-chemical clogging of the drainage layer over time. After failure of the leachate drainage layer, a leachate mound will develop in Phase 2. Using the waste hydraulic conductivity of 2×10^{-6} m/sec for the post-expansion period, an average mound height of 19 m was calculated. This average mound height was estimated to be reached approximately 35 years after the failure of the leachate collection system.

3.7 Vertical Leakage Rates

The average leachate head, leachate removal rates via the leachate collection systems, Darcy fluxes and horizontal Darcy (rate of removal) via the cross flow in the Upper Aquifer (Sink Layer) are presented in Table 6 for the Phase 1 Cross Section A-A', in Table 7 for the Phase 1 Cross Section B-B' and in Table 8 for the Phase 2 Cross-Section C-C'.

Table 6: Average Darcy Fluxes, Rate of Removals and Leachate Collected (Phase 1 Cross-Section A-A')

Time ¹ (years)	Average Leachate Head on Surficial Aquitard ² (m)	Darcy Flux through Surficial Aquitard ³ (m/year)	Rate of Removal in Upper Aquifer ⁴ (m/year)	Darcy Flux through Lower Aquitard ⁵ (m/year)	Rate of Removal in White Oak Aquifer ⁶ (m/year)	Collected Leachate ⁷ (m ³ /m ² /year)
1987-1991	0	0.0032	1.560	0.0003	0.0669	0.037
1991-1996	2.0	0.0037	1.607	0.0003	0.0669	0.049
1996-2002	4.4	0.0042	1.663	0.0003	0.0669	0.061
2002-2010	7.5	0.0049	1.738	0.0003	0.0669	0.157
2010-2015	9.5	0.0054	1.785	0.0003	0.0669	0.218
2015-2023	9.5	0.0054	1.785	0.0003	0.0669	0.230
2023-2030	11.0	0.0057	1.821	0.0003	0.0669	0.239
2030-2043	15.2	0.0067	1.920	0.0003	0.0669	0.228
2043-4043	19.0	0.0075	2.010	0.0003	0.0669	0.227

Notes:

- ¹ Model starts at 10 years from the beginning of landfilling (1977) in Phase 1.
- ² Stabilized average mound heights of 9.5 m prior to expansion and 19 m after expansion were calculated using Harr Equation as described in the previous section. Mound height was assumed to increase gradually during the intermediate timesteps.
- ³ Vertical flux in the Surficial Aquitard calculated using Darcy's Law [where, $k = 1 \times 10^{-10}$ m/sec and $i = (\text{mound height} + \text{thickness of Surficial Aquitard} + \text{thickness of unsaturated aquifer}) / \text{thickness of Surficial Aquitard}$].
- ⁴ Calculated using continuity of flow and upgradient horizontal flux in the Upper Aquifer of 1.25 m/year in the Phase 1 area.
- ⁵ Vertical flux in the Lower Aquitard calculated using Darcy's Law (where, $k = 1 \times 10^{-10}$ m/sec and $i = 0.0875$ in Phase 1 area).
- ⁶ Horizontal flux in the White Oak Aquifer calculated using Darcy's Law (where, $k = 5.3 \times 10^{-6}$ m/sec and $i = 0.0004$).
- ⁷ Leachate collected between 1987 to 2002 was based on 73% of the recorded total pumping rate from the perimeter LCS pump station. The percentage of leachate in the pumped volume is based on the average chloride concentration in leachate wells compared to the LCS pump station pumped volume from the perimeter LCS pump station. Leachate collection rate between 2002 to 2023 is assumed to gradually increase as the mound height increases. Leachate collection rate after 2023 is based on the infiltration rate obtained from the HELP model minus the Darcy flux through the Surficial Aquitard.

Table 7: Average Darcy Fluxes, Rate of Removals and Leachate Collected (Phase 1 Cross-Section B-B')

Time ¹ (years)	Average Leachate Head on Surficial Aquitard ² (m)	Darcy Flux through Surficial Aquitard ³ (m/year)	Rate of Removal in Upper Aquifer ⁴ (m/year)	Darcy Flux through Lower Aquitard ⁵ (m/year)	Rate of Removal in White Oak Aquifer ⁶ (m/year)	Collected Leachate ⁷ (m ³ /m ² /year)
1987-1991	0	0.0033	1.447	0.0003	0.0669	0.037
1991-1996	1.0	0.0036	1.469	0.0003	0.0669	0.049
1996-2002	2.1	0.0040	1.496	0.0003	0.0669	0.061
2002-2010	3.7	0.0046	1.532	0.0003	0.0669	0.112
2010-2015	4.7	0.0049	1.555	0.0003	0.0669	0.144
2015-2023	7.0	0.0057	1.608	0.0003	0.0669	0.195
2023-2030	7.0	0.0057	1.608	0.0003	0.0669	0.239
2030-2045	7.0	0.0057	1.608	0.0003	0.0669	0.229
2045-4045	7.0	0.0057	1.608	0.0003	0.0669	0.229

Notes:

- ¹ Model starts at 10 years from the beginning of landfilling (1977) in Phase 1.
- ² Stabilized mound height of 7.0 m was calculated using Harr Equation as described in the previous section for prior to and after expansion. Mound height was assumed to increase gradually during the intermediate timesteps.
- ³ Vertical flux in the Surficial Aquitard calculated using Darcy's Law [where, $k = 1 \times 10^{-10}$ m/sec and $i = (\text{mound height} + \text{thickness of Surficial Aquitard} + \text{thickness of unsaturated aquifer}) / \text{thickness of Surficial Aquitard}$].
- ⁴ Calculated using continuity of flow and upgradient horizontal flux in the Upper Aquifer of 1.25 m/year in the Phase 1 area.
- ⁵ Vertical flux in the Lower Aquitard calculated using Darcy's Law (where, $k = 1 \times 10^{-10}$ m/sec and $i = 0.0875$ in Phase 1 area).
- ⁶ Horizontal flux in the White Oak Aquifer calculated using Darcy's Law (where, $k = 5.3 \times 10^{-6}$ m/sec and $i = 0.0004$).
- ⁷ The rate of leachate collection between 1987 to 2002 was based on 73% of the recorded total pumping rate from the perimeter LCS pump station. The percentage of leachate in the pumped volume is based on the average chloride concentration in leachate wells compared to the LCS pump station. The leachate collection rate between 2002 to 2023 is assumed to gradually increase as the mound height increases. Leachate collected after 2023 is based on the infiltration rate obtained from the HELP model minus the Darcy flux through the Surficial Aquitard.

Table 8: Average Darcy Fluxes, Rate of Removals and Leachate Collected (Phase 2)

Time ¹ (years)	Average Leachate Head on Surficial Aquitard ² (m)	Darcy Flux through Surficial Aquitard ³ (m/year)	Rate of Removal in Upper Aquifer ⁴ (m/year)	Darcy Flux through Lower Aquitard ⁵ (m/year)	Rate of Removal in White Oak Aquifer ⁶ (m/year)	Collected Leachate ⁷ (m ³ /m ² /year)
2010-2040	0.3	0.0033	1.536	0.0001	0.0669	0.242
2040-2050	0.3	0.0033	1.536	0.0001	0.0669	0.242
2050-2110	0.3	0.0033	1.536	0.0001	0.0669	0.232
2110-2117	4.0	0.0040	1.614	0.0001	0.0669	0.000
2227-2124	7.8	0.0048	1.691	0.0001	0.0669	0.046
2024-2131	11.5	0.0055	1.769	0.0001	0.0669	0.091
2131-2138	15.3	0.0062	1.846	0.0001	0.0669	0.137
2138-2145	19.0	0.0070	1.924	0.0001	0.0669	0.228
2145-4145	19.0	0.0070	1.924	0.0001	0.0669	0.228

Notes:

- ¹ Model starts at 10 years from the beginning of landfilling (2010) in Phase 2.
- ² Mound height assumed to remain constant at 0.3 m up to 100 years at which the LCS fails. Stabilized mound height of 19 m was calculated using Harr Equation and estimated to be reached at 35 years after the failure of the LCS. Mound height was assumed to increase gradually during the intermediate timesteps.
- ³ Vertical flux in the Surficial Aquitard calculated using Darcy's Law [where, $k = 1 \times 10^{-10}$ m/sec and $i = (\text{mound height} + \text{thickness of Surficial Aquitard} + \text{thickness of unsaturated aquifer}) / \text{thickness of Surficial Aquitard}$].
- ⁴ Calculated using continuity of flow and upgradient horizontal flux into the Upper Aquifer of 1.2 m/year for the Phase 2 area.
- ⁵ Vertical flux in the Lower Aquitard calculated using Darcy's Law (where, $k = 1 \times 10^{-10}$ m/sec and $i = 0.0225$ in Phase 2 area).
- ⁶ Horizontal flux in the White Oak Aquifer calculated using Darcy's Law (where, $k = 5.3 \times 10^{-6}$ m/sec and $i = 0.0004$).
- ⁷ Leachate collected between 2010 to 2110 is based on the infiltration rate obtained from the HELP model minus the Darcy flux through the Surficial Aquitard. It was assumed that no leachate was collected between 2110 to 2117 after the failure of LCS. Leachate collected between 2117 and 2145 is assumed to gradually increase as the mound height increases and leachate flows laterally to a perimeter leachate collector system. The rate of leachate collection after 2145 is based on the infiltration rate obtained from the HELP model minus the Darcy Flux through the Surficial Aquitard.

3.8 Results of Contaminant Transport Modelling

The results of the hydrogeologic/contaminant transport modelling are described below. An example of the POLLUTE output file is provided in Appendix B. The results of the modelling for all key landfill leachate contaminants are summarized in Table 9 for the Phase 1 and Phase 2 cross-sections. The results are presented as predicted peak concentration and time of peak concentration in the Upper Aquifer at the downgradient (southern) limit of the waste fill. For all parameters modelled, the Reasonable Use Criteria for the Upper Aquifer is met over the 1000 year modelling time frame except for chloride at the Phase 1 Section A-A, which gave a peak impact of 129 mg/L versus the Reasonable Use Guideline value of 128 mg/L at approximately $t=700$ years. Figures 2, 3 and 4 show the predicted concentrations for chloride versus time in the Upper Aquifer at the downgradient (southern) limit of the waste fill for the modelling cross-sections. The modelling indicated no impacts on the Lower Aquifer (White Oak Aquifer).

The negligible predicted impact for the organic contaminants (i.e., benzene, 1,4-dichlorobenzene, dichloromethane, toluene and vinyl chloride) on the Upper Aquifer relates primarily to biodegradation, mass removal through leachate collection, the very slow (diffusion controlled) rate of transport into the Surficial Aquitard and adsorption uptake within the Surficial Aquitard. For lead and cadmium, the negligible impact is due to the same processes noted above, except that biodegradation does not apply for these parameters.

Table 9: Predicted Concentrations of Key Leachate Contaminants in the Upper Aquifer

Contaminant	Background Concentration in the Aquifer (mg/L) ¹	Ontario Drinking Water Quality Objective ² (mg/L)	Reasonable Use Guideline ³ (mg/L)	Phase 1 (Section A-A')		Phase 1 (Section B-B')		Phase 2 (Section C-C')	
				Predicted Peak Conc.* (mg/L)	Time of Peak Conc.** (years)	Predicted Peak Conc.* (mg/L)	Time of Peak Conc.** (years)	Predicted Peak Conc.* (mg/L)	Time of Peak Conc.** (years)
Chloride	5	250 (A)	128	129	706	75	808	72	855
Cadmium	<0.0002	0.005 (H)	0.0014	<0.00002	>1000	<0.00002	>1000	<0.00002	>1000
Lead	<0.002	0.01 (H)	0.004	<0.0002	>1000	<0.0002	>1000	<0.0002	>1000
Benzene	<0.0005	0.005 (H)	0.0016	<0.00005	>1000	<0.00005	>1000	<0.00005	>1000
1,4-Dichlorobenzene	<0.0005	0.005 (H)	0.0008	<0.00005	>1000	<0.00005	>1000	<0.00005	>1000
Dichloromethane	<0.0020	0.05 (H)	0.014	<0.0002	>1000	<0.0002	>1000	<0.0002	>1000
Toluene	0.00075	0.024 (A)	0.0124	<0.00005	>1000	<0.00005	>1000	<0.00005	>1000
Vinyl Chloride	<0.0005	0.002 (H)	0.0009	<0.00005	>1000	<0.00005	>1000	<0.00005	>1000

Notes:

¹ Median of 2015 to 2019 concentration in background monitoring wells 92-11, 82-6 and 01-14.

² Ontario Drinking Water Quality Standards (ODWQS).

³ Reasonable Use Guideline = Background Concentration + X (ODWQS Criteria - Background Concentration):
where X = 0.25 for health related drinking water parameters
= 0.50 for aesthetic related drinking water parameters

* Based on a 1,000 year contaminant transport modelling time frame, has been added to the background concentration.

** Relative to year 10 of the landfilling period.

(A) Denotes aesthetic drinking water objective.

(H) Denotes health related drinking water objective.

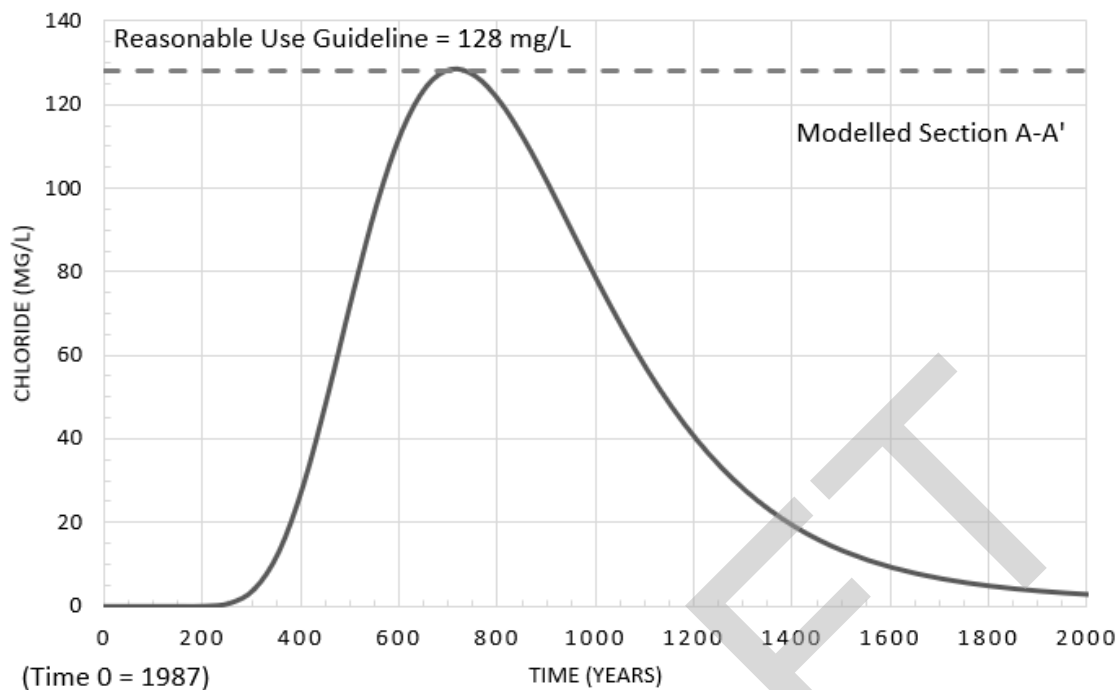


Figure 2: Chloride Concentration Versus Time for Cross-Section A-A'

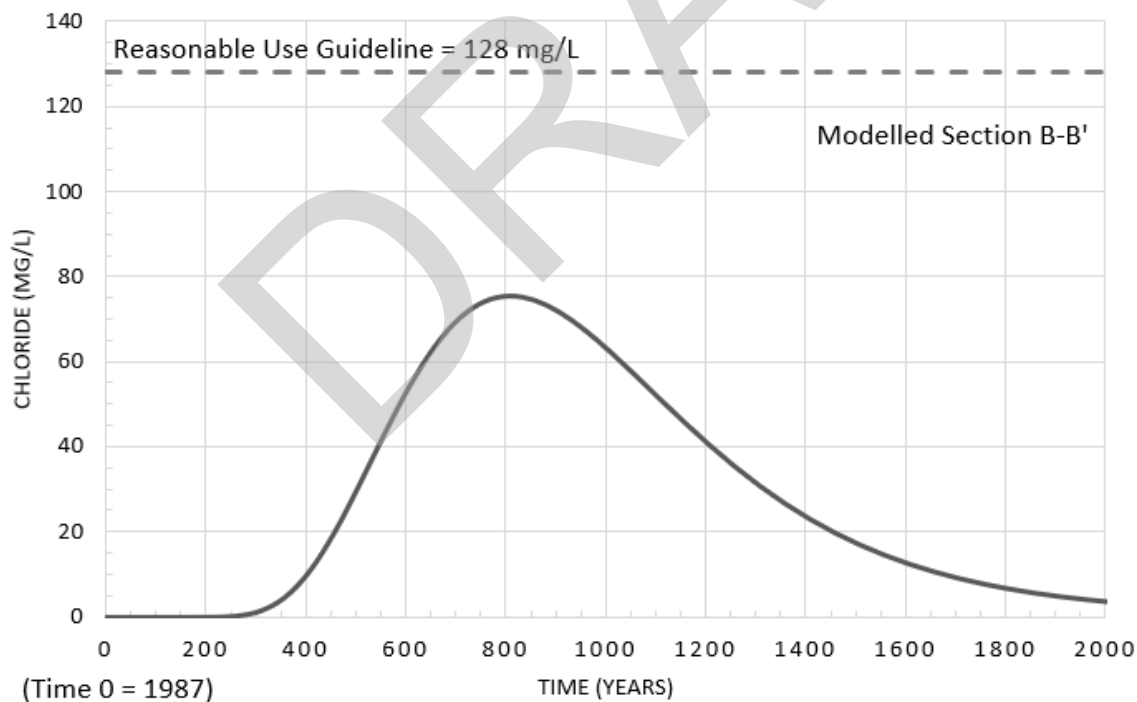


Figure 3: Chloride Concentration Versus Time for Cross-Section B-B'

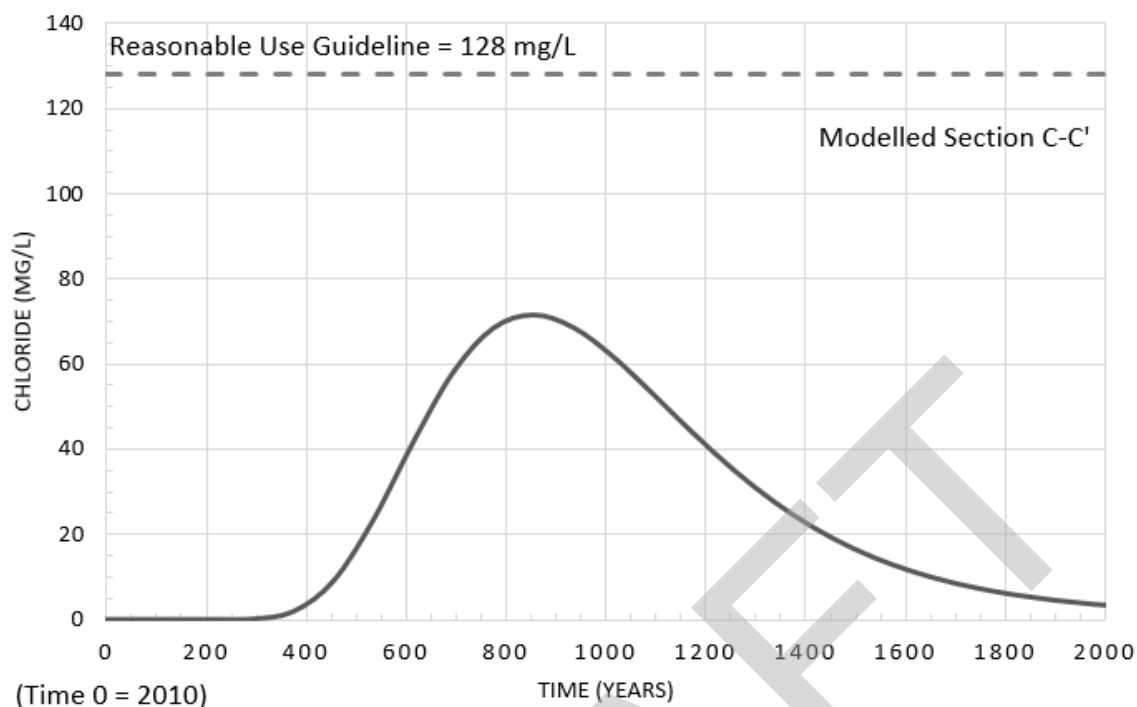


Figure 4: Chloride Concentration Versus Time for Cross-Section C-C'

4.0 ASSESSMENT OF GROUNDWATER QUANTITY IMPACTS

As described in the Existing Groundwater Conditions report, the W12A landfill is underlain by a deposit of low permeability clayey till that is about 15 to 20 m thick beneath much of the landfill and decreasing to about 10 m in the southeast corner area. This is in turn underlain by a sandy Upper Aquifer layer (a local aquifer) that is about 2 to 8 m thick, then about 20 m of clayey till (Lower Aquitard) and then the White Oak Aquifer (a regional scale aquifer). Because the upper few metres of the Surficial Aquitard is fractured to a variable degree, precipitation can infiltrate towards the lower limit of the fracture zone; however, because of the low permeability and very slow groundwater velocity associated with the unfractured remainder of the Surficial Aquitard deposit, the infiltration of precipitation to greater depth is very low. The sand and gravel deposits exposed at ground surface and ponds in the gravel pits in the area north of Scotland Drive (north of the landfill site) have been identified as the groundwater recharge zone to both the Upper Aquifer and White Oak Aquifer, since both of these aquifers are directly connected to these exposed sand and gravel deposits. The groundwater flow direction in the Upper Aquifer is generally from northeast to southwest/south, while the flow direction in the regional White Oak Aquifer is from northwest to southeast.

Because of the existing landfill's location overlying the Surficial Aquitard, its presence does not affect the recharge of the groundwater system and has no effect on groundwater levels or groundwater quantity in the Upper and White Oak Aquifers beneath the landfill or off-Site further to the south of the landfill site. With the proposed landfill expansion consisting of a vertical expansion above the existing landfill footprint, the expansion will not have an effect on

downgradient groundwater levels or groundwater quantity off-Site to the south of the landfill site. As such, the expansion is not expected to affect: the groundwater supply available to water supply wells in the area; groundwater baseflow to off-Site watercourses or other natural environment features in the area of the landfill, or; off-Site groundwater levels that support vegetation.

5.0 ADDITIONAL MITIGATION MEASURES

The results of the groundwater impact assessment indicate that the leachate control systems currently proposed in the design of the proposed vertical expansion will result in the W12A Landfill complying with MECP requirements for impacts on off-Site groundwater quality, with the exception of potentially chloride that gave a predicted peak concentration slightly higher than that allowed by the Reasonable Use Guideline in the Upper Aquifer at the downgradient (south) limit of the Phase 1 waste fill area at Section A-A' (i.e., 129 mg/L peak impact versus the RUG value of 128 mg/L, at approximately time $t=700$ years). The exceedance is primarily the result of leachate mounding within the Phase 1 area, which unlike the Phase 2 area does not have a leachate drainage layer throughout its base.

To address the predicted RUG exceedance for chloride at the downgradient limit of the Phase 1 waste fill, consideration was given to acquisition of an additional approximately 50 m of buffer zone lands downgradient (south) of the landfill, with the objective of meeting the RUG for chloride at the limit of the buffer zone. However, by applying the POLLUTE model to simulated one-dimensional (horizontal) advective-dispersive transport within the Upper Aquifer downgradient of the landfill, it was determined that the additional buffer zone would have very little effect in attenuating chloride impacts. Chloride does not undergo adsorption or biochemical decay reactions and therefore the attenuation mechanism would be by longitudinal dispersion and mixing with the downgradient recharge to the Upper Aquifer, which in this case is minimal given the low vertical hydraulic conductivity of the Surficial Aquitard.

Consideration was also given to incorporating leachate collection into the design of a first tier of horizontal landfill gas collector trenches installed in a north-south direction at 30 m spacing and to a depth of 3 m into the existing waste fill over the top surface of the Phase 1 area prior to the vertical expansion. These trenches would be backfilled with 50 mm clear stone and connect to the perimeter leachate collector system to allow leachate removal. The POLLUTE modelling for chloride was repeated for Phase 1 Section A-A' with mound control by these horizontal collectors over a service life period of 100 years from the start of the vertical expansion in Phase 1 (refer to Appendix C for service life calculation with respect to biochemical clogging). The input parameters used for this modelling are presented in Table 10. The results of the modelling indicate a peak chloride concentration of 120 mg/L, which meets the RUG of 128 mg/L (Table 11). It is therefore recommended that the horizontal landfill gas collectors be designed for dual purpose as gas and leachate collectors, at the horizontal spacing/depth described above.

Table 10: Average Darcy Fluxes, Rate of Removals and Leachate Collected (Phase 1 Cross-Section A-A' with Mound Control)

Time ¹ (years)	Average Leachate Head on Surficial Aquitard ² (m)	Darcy Flux through Surficial Aquitard ³ (m/year)	Rate of Removal in Upper Aquifer ⁴ (m/year)	Darcy Flux through Lower Aquitard ⁵ (m/year)	Rate of Removal in White Oak Aquifer ⁶ (m/year)	Collected Leachate ⁷ (m ³ /m ² /year)
1987-1991	0	0.0032	1.560	0.0003	0.0669	0.037
1991-1996	2.0	0.0037	1.607	0.0003	0.0669	0.049
1996-2002	4.4	0.0042	1.663	0.0003	0.0669	0.061
2002-2010	7.5	0.0049	1.738	0.0003	0.0669	0.157
2010-2015	9.5	0.0054	1.785	0.0003	0.0669	0.218
2015-2023	9.5	0.0054	1.785	0.0003	0.0669	0.230
2023-2030	10.6	0.0056	1.811	0.0003	0.0669	0.239
2030-2038	11.8	0.0059	1.840	0.0003	0.0003	0.229
2038-2124	14.5	0.0065	1.904	0.0003	0.0003	0.228
2124-2135	17.0	0.0071	1.963	0.0003	0.0003	0.228
2135-4135	19.0	0.0075	2.010	0.0003	0.0003	0.227

Notes:

- ¹ Model starts at 10 years from the beginning of landfilling (1977) in Phase 1.
- ² Stabilized average mound heights of 9.5 m prior to expansion and 19 m after expansion were calculated using Harr Equation as described in the previous section. Mound height was assumed to increase gradually during the intermediate timesteps.
- ³ Vertical flux in the Surficial Aquitard calculated using Darcy's Law [where, $k = 1 \times 10^{-10}$ m/sec and $i = (\text{mound height} + \text{thickness of Surficial Aquitard} + \text{thickness of unsaturated aquifer}) / \text{thickness of Surficial Aquitard}$].
- ⁴ Calculated using continuity of flow and upgradient horizontal flux in the Upper Aquifer of 1.25 m/year in the Phase 1 area.
- ⁵ Vertical flux in the Lower Aquitard calculated using Darcy's Law (where, $k = 1 \times 10^{-10}$ m/sec and $i = 0.0875$ in Phase 1 area).
- ⁶ Horizontal flux in the White Oak Aquifer calculated using Darcy's Law (where, $k = 5.3 \times 10^{-6}$ m/sec and $i = 0.0004$).
- ⁷ Leachate collected between 1987 to 2002 was based on 73% of the recorded total pumping rate from the perimeter LCS pump station. The percentage of leachate in the pumped volume is based on the average chloride concentration in leachate wells compared to the LCS pump station pumped volume from the perimeter LCS pump station. Leachate collection rate between 2002 to 2023 is assumed to gradually increase as the mound height increases. Leachate collection rate after 2023 is based on the infiltration rate obtained from the HELP model minus the Darcy flux through the Surficial Aquitard.

**Table 11: Predicted Concentrations of Key Leachate Contaminants in the Upper Aquifer
(Phase 1 Cross-Section A-A' with Mound Control)**

Contaminant	Background Concentration in the Aquifer (mg/L) ¹	Ontario Drinking Water Quality Objective ² (mg/L)	Reasonable Use Guideline ³ (mg/L)	Phase 1 (Section A-A' with Mound Control)	
				Predicted Peak Conc.* (mg/L)	Time of Peak Conc.** (years)
Chloride	5	250 (A)	128	120	708
Cadmium	<0.0002	0.005 (H)	0.0014	<0.00002	>1000
Lead	<0.002	0.01 (H)	0.004	<0.0002	>1000
Benzene	<0.0005	0.005 (H)	0.0016	<0.00005	>1000
1,4-Dichlorobenzene	<0.0005	0.005 (H)	0.0008	<0.00005	>1000
Dichloromethane	<0.0020	0.05 (H)	0.014	<0.0002	>1000
Toluene	0.00075	0.024 (A)	0.0124	<0.00005	>1000
Vinyl Chloride	<0.0005	0.002 (H)	0.0009	<0.00005	>1000

Notes:

¹ Median of 2015 to 2019 concentration in background monitoring wells 92-11, 82-6 and 01-14.

² Ontario Drinking Water Quality Standards (ODWQS).

³ Reasonable Use Guideline = Background Concentration + X (ODWQS Criteria - Background Concentration):
 where X = 0.25 for health related drinking water parameters
 = 0.50 for aesthetic related drinking water parameters

* Based on a 1,000 year contaminant transport modelling time frame, has been added to the background concentration.

** Relative to year 10 of the landfilling period.

(A) Denotes aesthetic drinking water objective.

(H) Denotes health related drinking water objective.

Although the results of the contaminant transport modelling indicate that the proposed expanded landfill will meet the Reasonable Use Guideline B-7 criteria for the Upper and Lower Aquifer layers, for the successful performance of the landfill in this regard it is important that the perimeter leachate collection system (i.e., perimeter leachate collector trench and sideslope finger drains) for the Phase 1 area and the Phase 2 area (to be installed when the Phase 2 blanket leachate collection system reaches the end of its service life) be maintained over the long term to protect against leachate break-out to surface. These perimeter control systems are accessible for inspection, maintenance and replacement as necessary. The implications of not maintaining these systems over the long-term include potential impacts to surface water, aesthetic impacts (e.g. leachate staining on the perimeter slopes and along perimeter drainage ditches) and erosion/vegetation kill on the final cover.

6.0 GROUNDWATER AND LEACHATE MONITORING PROGRAM

The City of London has an existing comprehensive groundwater monitoring program for the existing landfill that has been updated to reflect current Site information and the proposed landfill expansion. A summary of the proposed groundwater monitoring program for the landfill expansion, leachate and neighbouring water wells is provided in Table 12, Table 13 and Table 14, respectively and locations are shown on Figure 5. The monitoring parameters are provided in Table 15.

Table 12: Groundwater Monitoring Program

Monitoring Wells		Parameters	Sampling Dates
Description	Identification #		
<i>Shallow Aquifer – On-site</i> All monitoring wells located at or near the property boundary that are screened in the shallow aquifer	01-12b, 01-14, 13-1a, 13-3a, 91-4a, 84-5b, 82-6, 92-11, 94-1, 94-3, 01-9a, 04-2a, 06-1, 06-2, 92-7a, 19-4b, 19-5b	Comprehensive List Indicator List	June April, October
<i>Shallow Aquifer – Off-site</i> Representative monitoring wells located in adjacent City owned properties that are screened in the shallow aquifer	04-6a, 05-1, 05-2, 05-3	Indicator List	June
<i>White Oak Aquifer</i> Representative monitoring wells (on-site and off-site) that are screened in the White Oak Aquifer	92-8, 92-9, 92-10, 92-12, 94-2, 01-3a, 14	Indicator List	June

Monitoring Wells		Parameters	Sampling Dates
Description	Identification #		
<i>Till</i> Till monitor below garbage	00-7a	Comprehensive List	June
<i>All Monitoring Wells</i>	Monitoring wells listed above plus 92-1, 92-2, 92-3, 92-4, 92-7, 01-12a, 01-13, 00-3a, 00-3b, 05-4, 05-5, 19-1, 19-2, 19-3, 19-4a, 19-5a, 19-6a, 19-6b, 19-7a, 19-7b, 19-7c, 92-10a	Water levels	April, June, October

Table 13: Leachate Monitoring Program

Location	Parameters	Sampling Dates
<i>Representative Leachate Monitoring Wells</i> Monitoring wells 97-2, 97-5 and 97-7	Comprehensive List Indicator List	June April, October
<i>Leachate Loading Station</i> Leachate loading station #2	Comprehensive List Indicator List	June April, September, November
<i>All Leachate Monitoring Wells</i> Monitoring wells 97-2, 97-3, 97-4, 97-5 and 97-7	Water Levels	June

Table 14: Water Well Monitoring Program

Location	Parameters	Sampling Dates
Water Wells – Off-site Upgradient and Downgradient Wells if access granted by owner and if not destroyed/decommissioned by owner – 9, 20, 21, 23, 24, 25, 26, 27, 31, 32, 33, 36, 113, 131	Comprehensive List Indicator List	June 2017, 2020, etc. June

Table 15: Parameters Monitored

Parameter	Groundwater Monitoring Wells		Leachate Monitoring		Water Wells	
	Comp.	Indicator	Comp.	Indicator	Comp.	Indicator
General						
Alkalinity	X	X	X	X	X	X
Biological Oxygen Demand ₅			X	X		
Chemical Oxygen Demand	X	X	X	X		
Conductivity	X	X	X	X	X	X
Dissolved Organic Carbon	X	X	X	X	X	X
pH	X	X	X	X	X	X
Phenols	X		X		X	
Sulphate	X	X	X	X	X	X
Suspended Solids			X	X		
General – Nutrients						
Ammonia	X	X	X	X		
Nitrate	X		X		X	X
Nitrite	X		X			
Total Kjeldahl Nitrogen	X		X			
Total Phosphorus			X			

Parameter	Groundwater Monitoring Wells		Leachate Monitoring		Water Wells	
	Comp.	Indicator	Comp.	Indicator	Comp.	Indicator
General – Major Ions						
Chloride	X	X	X	X	X	X
Calcium	X	X	X	X	X	X
Iron	X	X	X	X	X	X
Magnesium	X	X	X	X	X	X
Manganese	X		X			
Potassium	X	X	X	X	X	X
Sodium	X	X	X	X	X	X
Trace Metals						
Arsenic	X		X		X	
Barium	X		X		X	
Boron	X		X		X	
Cadmium	X		X		X	
Chromium	X		X		X	
Copper	X		X		X	
Lead	X		X		X	
Mercury	X		X			
Nickel	X		X		X	

Parameter	Groundwater Monitoring Wells		Leachate Monitoring		Water Wells	
	Comp.	Indicator	Comp.	Indicator	Comp.	Indicator
Selenium			X		X	
Silver					X	
Strontium					X	
Zinc	X		X		X	
Volatiles						
EPA 624 Scan	X		X			
Field						
Conductivity	X	X	X	X	X	X
pH	X	X	X	X	X	X
Temperature	X	X				

Notes:

The parameters to be tested for in the groundwater and leachate are the same as the parameters suggested in the Landfill Standards (MECP, 1998) except for:

- Potassium – added to groundwater and leachate indicator and included in Environmental Compliance Approval (ECA)
- Selenium – added to leachate comprehensive and tested for in water wells
- EPA 624 VOC Scan – added to groundwater and leachate comprehensive as recommended from leachate characterization study but not included on water wells
- Temperature – added to groundwater comprehensive and indicator lists
- Nitrate – removed from groundwater and leachate indicator lists and will add based on results of groundwater and leachate comprehensive list analysis
- Total Phosphorus – removed from groundwater comprehensive list and will be added if leachate testing shows a need
- Total Dissolved Solids – removed from groundwater and leachate indicator and comprehensive lists as not considered necessary to evaluate water quality.

As described in the Design and Operation Report (Volume IV, Appendix D.13) a leachate mound monitoring component in the Phase 1 area of the landfill is required to assess groundwater predictions and future performance. The mound monitoring wells would be installed in the central part (not necessarily on the peak but in the higher parts of the waste) of the Phase 1 area after completion of each of Phases 5E through 8E. These mound monitoring wells would be evaluated for leachate levels following the same schedule for leachate levels outlined in Table 13.

7.0 OTHER APPROVALS

The groundwater component of this EA will also require approval under the *Environmental Protection Act* (EPA) as part of the ECA waste disposal approval.

8.0 LIMITATIONS / USE OF THE REPORT

8.1 General

This report has been prepared for the exclusive use of the City of London. The factual information, descriptions, interpretations and summary comments contained herein are specific to the scope of work described in this report and do not apply to any other project or site. Under no circumstances may this information be used for any other purposes than those specified in the scope of work unless explicitly stipulated in the text of this report or formally authorized by Golder. This report must be read in its entirety as some sections could be falsely interpreted when taken individually or out-of-context. As well, the final version of this report and its content supersedes any other text, opinion or preliminary version produced by Golder.

8.2 Groundwater Modelling Limitations

Hydrogeological investigations and groundwater modelling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time, and in the sense that the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that groundwater systems are complicated beyond human capability to evaluate them comprehensively in detail, and we invariably do not have sufficient data to do so. A groundwater model uses the laws of science and mathematics to draw together the available data into a mathematical or computer-based representation of the essential features of an existing hydrogeological system. While the model itself obviously lacks the detailed reality of the existing hydrogeological system, the behaviour of a valid groundwater model reasonably approximates that of the real system. The validity and accuracy of the model depends on the amount of data available relative to the degree of complexity of the geologic formations, the site geochemistry, the fate and transport of the dissolved compounds, and on the quality and degree of accuracy of the data entered. Therefore, every groundwater model is a simplification of a reality and the models described herein are not an exception.

The groundwater modelling services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practising under similar conditions, subject to the quantity and quality of available data, the time limits and financial and physical constraints applicable to the services. Unless otherwise specified, the results of previous or simultaneous

work provided by sources other than Golder and quoted and/or used herein are considered as having been obtained according to recognised and accepted professional rules and practices, and therefore deemed valid. This model provides a predictive scientific tool to evaluate the impacts on a real groundwater system of specified hydrological stresses and/or to compare various scenarios in a decision-making process. However, and despite the professional care taken during the construction of the model and in conducting the simulations, its accuracy is bound to the normal uncertainty associated to groundwater modelling and no warranty, express or implied, is made.

Noting the intended use of this report, any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

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9.0 REFERENCES

- City of London (2020). W12A Landfill, Annual Status Report, January 1 to December 31, 2019. Prepared by City of London, March 2020, London, Ontario.
- Dillon Consulting Limited (2020). Existing Groundwater Conditions Report, Environmental Assessment of the Proposed W12A Landfill Expansion, July 2020.
- Earth Tech Inc. (September 2003). Design and Operations Report, Application to Amend C of A A042102 for Phase 2 of the W12A Landfill. Prepared for the City of London. File Ref 011692.
- Ministry of the Environment, Conservation and Parks (1994). Guideline B-7: Incorporation of the Reasonable Use Concept into MOE Groundwater Management, (Formerly Policy 15-08): MOE Program Development Branch: Ontario Ministry of Environment, Conservation and Parks, April 1994, 8p.
- Ministry of the Environment, Conservation and Parks (1998). *Ontario Regulation 232/98* made under Part V of the *Environmental Protection Act*.
- Ministry of the Environment, Conservation and Parks, (1998). The Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfilling Sites (Landfill Standards) (1998, revised January 2012).
- Rowe, R.K., Booker, J.R. and Fraser, M.J. (1994). POLLUTE (Version 7); Distributed by GAEA Environmental Engineering Ltd.
- Rowe, R.K., Quigley, R.M., Brachman, R.W.I., and Booker, J.R. (2004). Barrier Systems for Waste Disposal Facilities, 2nd Edition, Spon Press, 587p.
- Schroeder, P.R., Dozier, T.S., Zappi, P.A., McEnroe, B.M., Sjostrom, J.W., and Peyton, R.L. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3," EPA/600/R-94/168b, September 1994, U.S. Environmental Protection Agency, Office of Research and Development, Washington DC.
- Sharma, H.P. and Lewis, S.P. (1994). Waste Containment Systems, Waste Stabilization and Landfills: Design and Evaluation, John Wiley and Sons, Inc. New York, 588p.
- USEPA (1997). The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 (1 November 1997), Developed by Environmental Laboratory, USAE Waterways Experiment Station for U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, OH.
- USEPA (2020). Technical Fact Sheets Accessed in 2020.
<https://semspub.epa.gov/work/HQ/175223.pdf> for benzene, 1-4-dichlorobenzene, dichloromethane and toluene and <https://archive.epa.gov/water/archive/web/pdf/archived-technical-fact-sheet-on-vinyl-chloride.pdf> for vinyl chloride.
- Western (2020). University of Western Ontario, Geotechnical Research Center, 2000. City of London W12A Landfill Investigation (2000).

Signature Page

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Principal

SR/FSB/PLE/PAS/sg

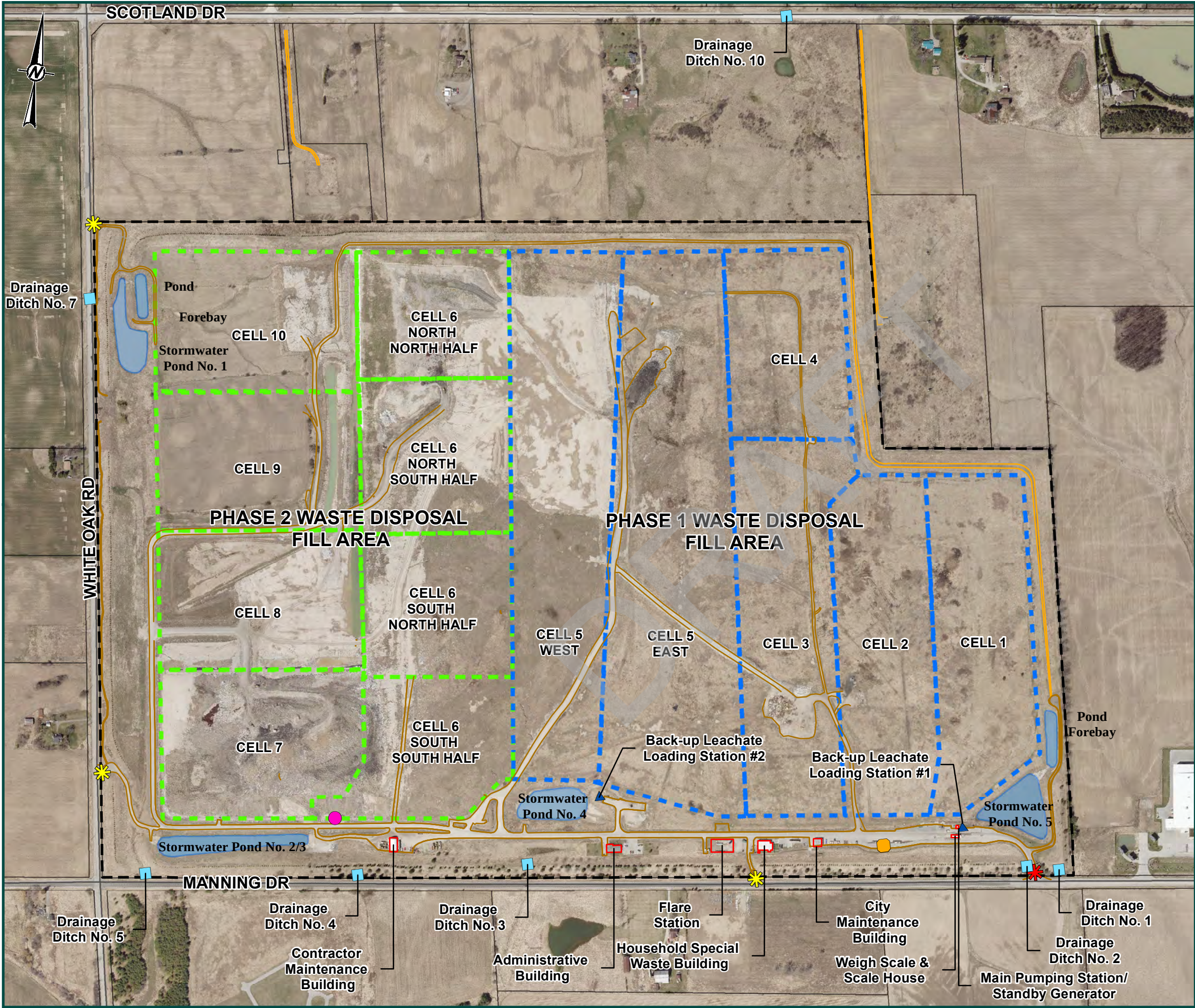
[https://golderassociates.sharepoint.com/sites/114635/project files/5 technical work/1.0 - technical components/03 - hydrogeology/3.8 report pollute modelling-ia/1648176-report w12a-landfill_pollute_modelling-nov2020.docx](https://golderassociates.sharepoint.com/sites/114635/project%20files/5%20technical%20work/1.0%20-%20technical%20components/03%20-%20hydrogeology/3.8%20report%20pollute%20modelling-ia/1648176-report%20w12a-landfill_pollute_modelling-nov2020.docx)

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APPENDIX A

Reference Figures

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LEGEND

LANDFILL SITE ENTRANCE

LANDFILL SITE SECONDARY ENTRANCE

PUBLIC DROP OFF AREA

MH 701 PUMPING STATION/STANDBY GENERATOR

LEACHATE STORAGE

DRAINAGE DITCH

LANDFILL ACCESS ROADS

MONITORING ACCESS ROADS

PHASE 1 WASTE DISPOSAL FILL AREA (59.3 HA)

PHASE 2 WASTE DISPOSAL FILL AREA (47.7 HA)

EXISTING W12A LANDFILL

STORMWATER PONDS/FOREBAY

BUILDINGS

PROPERTY INFORMATIONEXISTING W12A LANDFILLSTORMWATER PONDS/FOREBAYBUILDINGS

REFERENCE(S)

1. DATA PROVIDED BY THE CITY OF LONDON

2. CITY OF LONDON AERIAL PHOTOGRAPHY, APRIL 2016

3. SITE FEATURES PREPARED BY CALLON DIETZ INC. LTD., OCTOBER 19, 2016.

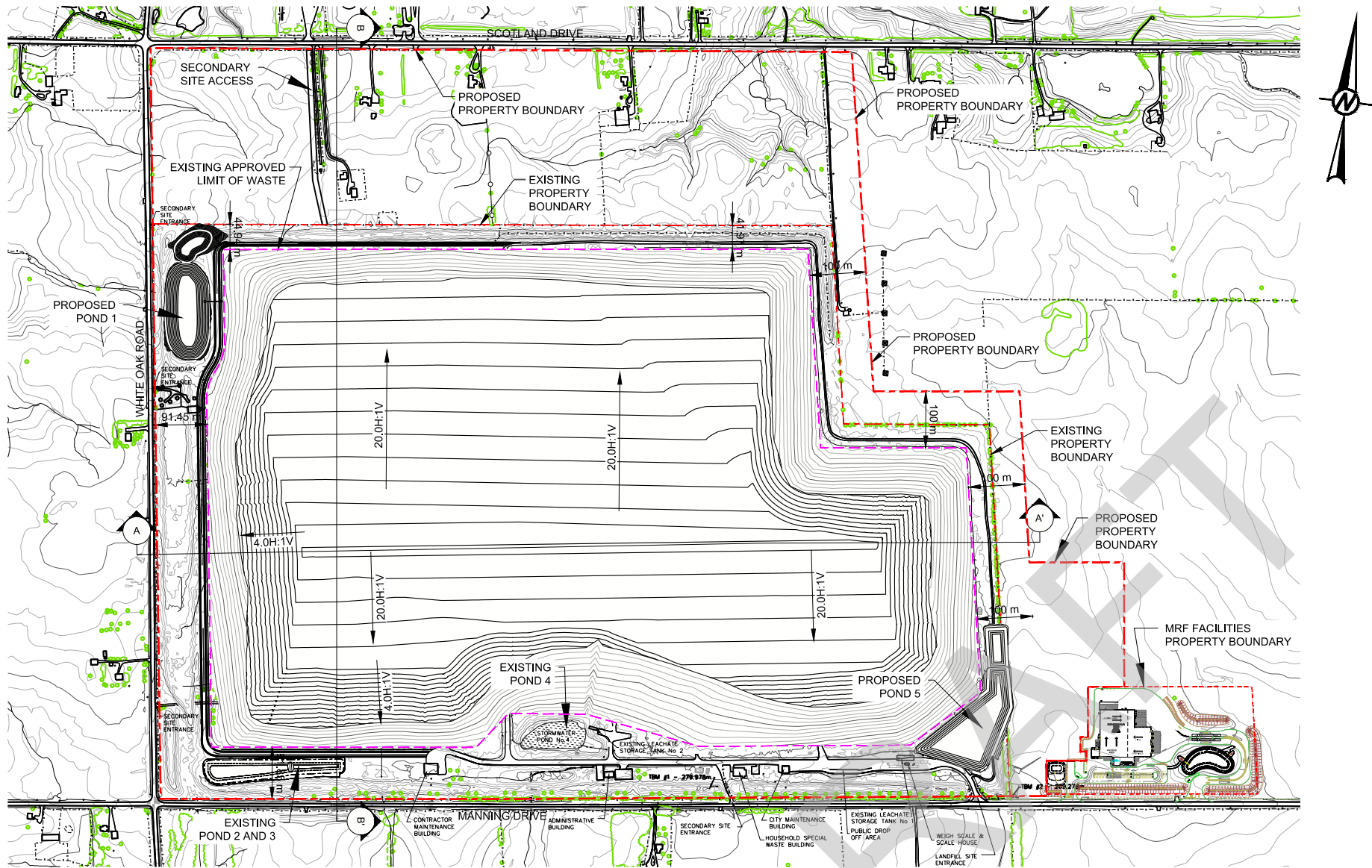
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COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

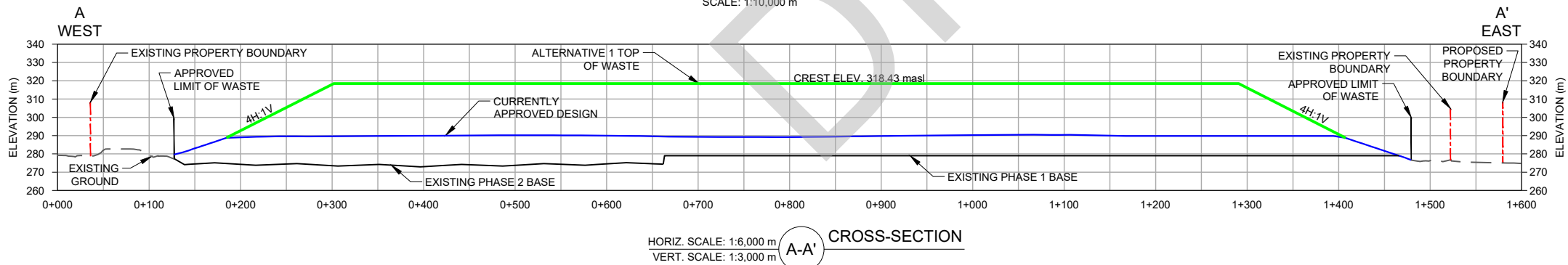


CLIENT			
CORPORATION OF THE CITY OF LONDON			
PROJECT			
INDIVIDUAL EA OF THE PROPOSED W12A LANDFILL EXPANSION			
TITLE			
EXISTING LANDFILL SITE DEVELOPMENT PLAN			
CONSULTANT			
		YYYY-MM-DD	2020-09-08
		DESIGNED	---
		PREPARED	JEM
		REVIEWED	TG
		APPROVED	PAS
PROJECT NO.	CONTROL	REV.	FIGURE
1648176	0017	0	1.3-1

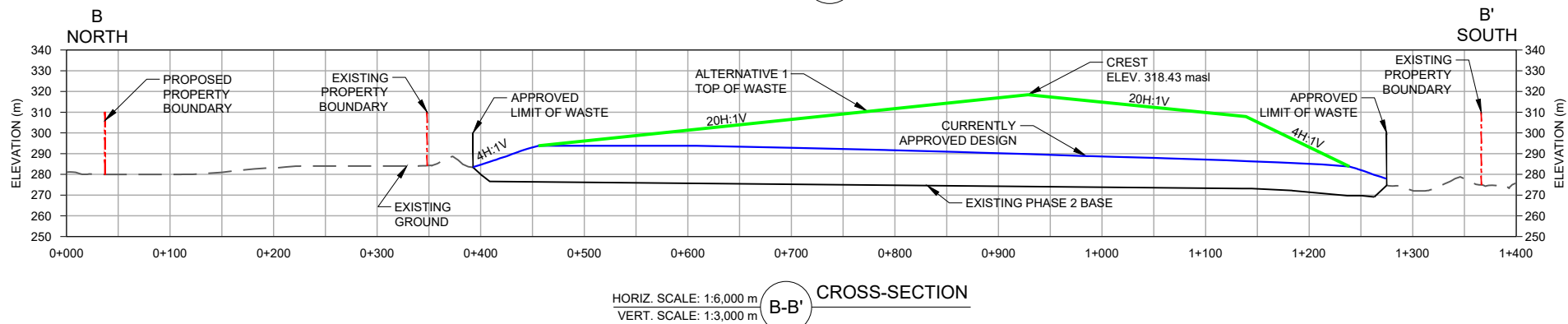
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SITE PLAN
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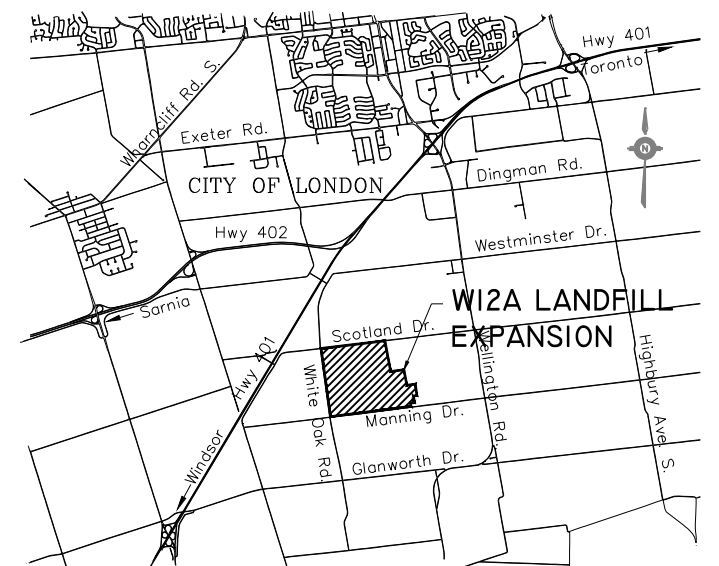


A-A' CROSS-SECTION



B-B' CROSS-SECTION

KEY MAP



NOTE(S)

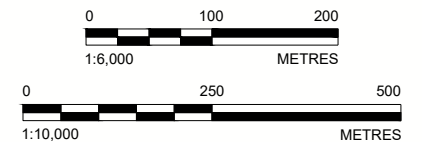
- ELEVATION CONTOURS SHOWN ARE TOP OF WASTE, masl.

REFERENCE(S)

BASE INFORMATION AND EXISTING CONTOURS AS PER CITY OF LONDON SURVEY DATED NOVEMBER 22, 2016.

NOT FOR CONSTRUCTION

DRAFT



CLIENT

CITY OF LONDON
LONDON, ONTARIO
CANADA

PROJECT

ENVIRONMENTAL ASSESSMENT OF THE PROPOSED
W12A LANDFILL EXPANSION, CITY OF LONDON

TITLE

LANDFILL EXPANSION FINAL CONTOUR PLAN AND
CROSS-SECTIONS

CONSULTANT



YYYY-MM-DD	2020-05-02
DESIGNED	MLF
PREPARED	MLF
REVIEWED	PAS
APPROVED	PAS

PROJECT NO.
1648176

CONTROL
0017

REV.
A

FIGURE
8.1-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

APPENDIX B

Example POLLUTE Output File

DRAFT

POLLUTEv7

Version 7.13

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Phase 2 - Chloride

THE VARIABLE VELOCITY AND/OR CONCENTRATION OPTION HAS BEEN USED
NOTE THAT THE ACCURACY OF THE CALCULATIONS WITH THIS OPTION WILL DEPEND ON THE NUMBER
OF SUBLAYERS USED

THE PASSIVE SINK OPTION HAS BEEN USED
NOTE : THE USER IS RESPONSIBLE FOR ENSURING THAT VELOCITY
CHANGES ARE CONSISTENT WITH THE PASSIVE SINK

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Till	16 m	62	0.02 m ² /a	0.35	0 m ³ /kg	1.8 g/cm ³
Unsaturated	0.4 m	5	0.02 m ² /a	0.3	0 m ³ /kg	1.8 g/cm ³
Upper Aquifer	7.6 m	20	5 m ² /a	0.35	0 m ³ /kg	1.8 g/cm ³
Upper Aquifer	20 m	40	0.02 m ² /a	0.35	0 m ³ /kg	1.8 g/cm ³
Lower Aquitard						

Boundary Conditions

Finite Mass Top Boundary

Fixed Outflow Bottom Boundary

Landfill Length = 800 m

Landfill Width = 1 m

Base Thickness = 3 m

Base Porosity = 0.3

VARIATION IN PROPERTIES WITH TIME:

TIME PERIODS WITH THE SAME SOURCE AND VELOCITY

Period	Start Time	No. of Steps	Time Step	Source Conc	Rate of Change	Height of Leachate	Volume Collected
1	0 year	5	6 year	2500 mg/L	0	9 m	0.242 m/a
2	30 year	5	2 year	2500 mg/L	0	13 m	0.242 m/a
3	40 year	5	12 year	-1 mg/L	0	13 m	0.232 m/a
4	100 year	7	1 year	-1 mg/L	0	13 m	0 m/a
5	107 year	7	1 year	-1 mg/L	0	13 m	0.046 m/a
6	114 year	7	1 year	-1 mg/L	0	13 m	0.091 m/a
7	121 year	7	1 year	-1 mg/L	0	13 m	0.137 m/a
8	128 year	7	1 year	-1 mg/L	0	13 m	0.228 m/a
9	135 year	25	80 year	-1 mg/L	0	13 m	0.228 m/a

Period	Start Time	End Time	Darcy Velocity	Dispersivity	Base Velocity
1	0 year	30 year	1 m/a	0 m	0.0669 m/a
2	30 year	40 year	1 m/a	0 m	0.0669 m/a
3	40 year	100 year	1 m/a	0 m	0.0669 m/a
4	100 year	107 year	1 m/a	0 m	0.0669 m/a
5	107 year	114 year	1 m/a	0 m	0.0669 m/a
6	114 year	121 year	1 m/a	0 m	0.0669 m/a
7	121 year	128 year	1 m/a	0 m	0.0669 m/a
8	128 year	135 year	1 m/a	0 m	0.0669 m/a
9	135 year	2135 year	1 m/a	0 m	0.0669 m/a

VELOCITY AND SINK PROFILE:

Time Period	Minimum Depth	Maximum Depth	Vertical Velocity	Horizontal Outflow
1 / 1	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
1 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
1 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
1 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
1 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
2 / 1	0 m	16.4 m	0.0033 m/a	0 m/a

	16.4 m 24 m	24 m 44 m	0 m/a 0.0001 m/a	1.536 m/a 0 m/a
2 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
2 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
2 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
2 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
3 / 1	0 m 16.4 m 24 m	16.4 m 14 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
3 / 2	0 m 16.4 m 24 m	16.4 m 14 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
3 / 3	0 m 16.4 m 24 m	16.4 m 14 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
3 / 4	0 m 16.4 m 24 m	16.4 m 14 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
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4 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.004 m/a 0 m/a 0.0001 m/a	0 m/a 1.614 m/a 0 m/a
4 / 6	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.004 m/a 0 m/a 0.0001 m/a	0 m/a 1.614 m/a 0 m/a
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5 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0048 m/a 0 m/a 0.0001 m/a	0 m/a 1.691 m/a 0 m/a
5 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0048 m/a 0 m/a 0.0001 m/a	0 m/a 1.691 m/a 0 m/a
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7 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0062 m/a 0 m/a 0.0001 m/a	0 m/a 1.846 m/a 0 m/a
7 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0062 m/a 0 m/a 0.0001 m/a	0 m/a 1.846 m/a 0 m/a
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8 / 4	0 m 16.4 m	16.4 m 24 m	0.007 m/a 0 m/a	0 m/a 1.924 m/a

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9 / 21	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 22	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 23	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 24	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a

9 / 25	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
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Laplace Transform Parameters

TAU = 7 N = 200 SIG = 0 RNU = 20

Calculated Concentrations at Selected Times and Depths

Time year	Depth m	Concentration mg/L
6	0.000E+00 1.640E+01 2.020E+01	2.095E+03 2.974E-49 5.306E-50
12	0.000E+00 1.640E+01 2.020E+01	1.772E+03 3.260E-33 9.933E-34
18	0.000E+00 1.640E+01 2.020E+01	1.503E+03 5.926E-27 2.438E-27
24	0.000E+00 1.640E+01 2.020E+01	1.275E+03 3.750E-22 1.376E-22
30	0.000E+00 1.640E+01 2.020E+01	1.083E+03 5.720E-19 2.663E-19
32	0.000E+00 1.640E+01 2.020E+01	2.400E+03 9.353E-19 4.422E-19
34	0.000E+00 1.640E+01 2.020E+01	2.308E+03 1.522E-18 7.306E-19
36	0.000E+00 1.640E+01 2.020E+01	2.221E+03 2.430E-18 1.186E-18
38	0.000E+00 1.640E+01 2.020E+01	2.138E+03 3.820E-18 1.895E-18
40	0.000E+00 1.640E+01 2.020E+01	2.057E+03 5.919E-18 2.981E-18

52	0.000E+00 1.640E+01 2.020E+01	1.654E+03 6.351E-17 3.503E-17
64	0.000E+00 1.640E+01 2.020E+01	1.332E+03 4.874E-16 2.866E-16
76	0.000E+00 1.640E+01 2.020E+01	1.074E+03 2.184E-14 1.445E-14
88	0.000E+00 1.640E+01 2.020E+01	8.665E+02 1.068E-12 7.938E-13
100	0.000E+00 1.640E+01 2.020E+01	6.999E+02 1.746E-11 1.305E-11
101	0.000E+00 1.640E+01 2.020E+01	6.998E+02 1.919E-11 1.401E-11
102	0.000E+00 1.640E+01 2.020E+01	6.998E+02 2.149E-11 1.521E-11
103	0.000E+00 1.640E+01 2.020E+01	6.997E+02 2.438E-11 1.669E-11
104	0.000E+00 1.640E+01 2.020E+01	6.996E+02 2.806E-11 1.854E-11
105	0.000E+00 1.640E+01 2.020E+01	6.996E+02 3.278E-11 2.086E-11
106	0.000E+00 1.640E+01 2.020E+01	6.995E+02 3.888E-11 2.382E-11
107	0.000E+00 1.640E+01 2.020E+01	6.994E+02 4.677E-11 2.759E-11
108	0.000E+00 1.640E+01 2.020E+01	6.967E+02 5.691E-11 3.232E-11
109	0.000E+00 1.640E+01	6.941E+02 7.098E-11

	2.020E+01	3.868E-11
110	0.000E+00 1.640E+01 2.020E+01	6.915E+02 8.917E-11 4.705E-11
111	0.000E+00 1.640E+01 2.020E+01	6.889E+02 1.128E-10 5.797E-11
112	0.000E+00 1.640E+01 2.020E+01	6.863E+02 1.434E-10 7.220E-11
113	0.000E+00 1.640E+01 2.020E+01	6.838E+02 1.830E-10 9.069E-11
114	0.000E+00 1.640E+01 2.020E+01	6.812E+02 2.342E-10 1.147E-10
115	0.000E+00 1.640E+01 2.020E+01	6.762E+02 2.987E-10 1.447E-10
116	0.000E+00 1.640E+01 2.020E+01	6.713E+02 3.875E-10 1.851E-10
117	0.000E+00 1.640E+01 2.020E+01	6.665E+02 5.008E-10 2.380E-10
118	0.000E+00 1.640E+01 2.020E+01	6.616E+02 6.453E-10 3.063E-10
119	0.000E+00 1.640E+01 2.020E+01	6.569E+02 8.294E-10 3.941E-10
120	0.000E+00 1.640E+01 2.020E+01	6.521E+02 1.063E-09 5.065E-10
121	0.000E+00 1.640E+01 2.020E+01	6.474E+02 1.359E-09 6.498E-10
122	0.000E+00 1.640E+01 2.020E+01	6.404E+02 1.724E-09 8.260E-10
123	0.000E+00	6.335E+02

	1.640E+01 2.020E+01	2.217E-09 1.059E-09
124	0.000E+00 1.640E+01 2.020E+01	6.266E+02 2.833E-09 1.357E-09
125	0.000E+00 1.640E+01 2.020E+01	6.199E+02 3.604E-09 1.735E-09
126	0.000E+00 1.640E+01 2.020E+01	6.132E+02 4.565E-09 2.212E-09
127	0.000E+00 1.640E+01 2.020E+01	6.066E+02 5.762E-09 2.810E-09
128	0.000E+00 1.640E+01 2.020E+01	6.001E+02 7.248E-09 3.559E-09
129	0.000E+00 1.640E+01 2.020E+01	5.895E+02 9.051E-09 4.462E-09
130	0.000E+00 1.640E+01 2.020E+01	5.790E+02 1.145E-08 5.633E-09
131	0.000E+00 1.640E+01 2.020E+01	5.688E+02 1.439E-08 7.108E-09
132	0.000E+00 1.640E+01 2.020E+01	5.587E+02 1.800E-08 8.945E-09
133	0.000E+00 1.640E+01 2.020E+01	5.489E+02 2.242E-08 1.122E-08
134	0.000E+00 1.640E+01 2.020E+01	5.392E+02 2.784E-08 1.402E-08
135	0.000E+00 1.640E+01 2.020E+01	5.297E+02 3.446E-08 1.747E-08
215	0.000E+00 1.640E+01 2.020E+01	1.295E+02 1.364E-03 9.625E-04

295	0.000E+00 1.640E+01 2.020E+01	3.252E+01 1.621E-01 1.310E-01
375	0.000E+00 1.640E+01 2.020E+01	8.468E+00 2.176E+00 1.886E+00
455	0.000E+00 1.640E+01 2.020E+01	2.332E+00 1.003E+01 9.052E+00
535	0.000E+00 1.640E+01 2.020E+01	7.006E-01 2.538E+01 2.350E+01
615	0.000E+00 1.640E+01 2.020E+01	2.375E-01 4.445E+01 4.186E+01
695	0.000E+00 1.640E+01 2.020E+01	9.270E-02 6.119E+01 5.830E+01
775	0.000E+00 1.640E+01 2.020E+01	4.134E-02 7.141E+01 6.863E+01
855	0.000E+00 1.640E+01 2.020E+01	2.045E-02 7.415E+01 7.173E+01
935	0.000E+00 1.640E+01 2.020E+01	1.085E-02 7.071E+01 6.876E+01
1015	0.000E+00 1.640E+01 2.020E+01	6.021E-03 6.333E+01 6.183E+01
1095	0.000E+00 1.640E+01 2.020E+01	3.440E-03 5.410E+01 5.300E+01
1175	0.000E+00 1.640E+01 2.020E+01	2.005E-03 4.461E+01 4.382E+01
1255	0.000E+00 1.640E+01 2.020E+01	1.185E-03 3.583E+01 3.527E+01
1335	0.000E+00 1.640E+01 2.020E+01	7.080E-04 2.821E+01 2.784E+01

1415	0.000E+00 1.640E+01 2.020E+01	4.268E-04 2.191E+01 2.166E+01
1495	0.000E+00 1.640E+01 2.020E+01	2.592E-04 1.687E+01 1.670E+01
1575	0.000E+00 1.640E+01 2.020E+01	1.584E-04 1.293E+01 1.282E+01
1655	0.000E+00 1.640E+01 2.020E+01	9.727E-05 9.897E+00 9.831E+00
1735	0.000E+00 1.640E+01 2.020E+01	6.002E-05 7.597E+00 7.557E+00
1815	0.000E+00 1.640E+01 2.020E+01	3.719E-05 5.866E+00 5.843E+00
1895	0.000E+00 1.640E+01 2.020E+01	2.312E-05 4.568E+00 4.557E+00
1975	0.000E+00 1.640E+01 2.020E+01	1.442E-05 3.598E+00 3.594E+00
2055	0.000E+00 1.640E+01 2.020E+01	9.022E-06 2.871E+00 2.872E+00
2135	0.000E+00 1.640E+01 2.020E+01	5.659E-06 2.326E+00 2.329E+00

NOTICE

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APPENDIX C

Service Life

Horizontal Collector Service Life Calculation

W12A Landfill, London, Ontario

Job No: 1648176

Prepared by: F. Barone

Date: September 18, 2020

Reviewed by: T. Edmond

This calculation sheet is for the service life of the proposed dual purpose gas/leachate horizontal collector trenches installed at 30 m spacing and to a depth of 3 m into the existing waste fill surface over the Phase 1 area prior to the vertical expansion. The service life calculation is with respect to bio-chemical clogging of the 50 mm clear stone backfill to the extent that the trenches no longer convey leachate to the perimeter leachate collector system.

The service life calculation uses the methodology described in the document "Evaluation of Service Life of the Engineered Components of Landfills" prepared for the Ontario Interim Waste Authority (IWA) by R. Kerry Rowe Inc, Golder Associates, Fenco MacLaren and Dillon, dated October 1994, with the assumptions that:

- i) all dissolved calcium in leachate entering the horizontal collector trenches precipitates to form bio-chemical clog matter that occupies the pore spaces between the clear stone particles, and,
- ii) as shown in Figure 1, the height of the clog zone in the collector trench relative to the base of the trench varies linearly from 0 m at the uphill (north) end of the trench (i.e., crest of the Phase 1 north slope crest) to the full 3 m height of the clear stone backfill over a distance of 725 m to the crest of the Phase 1 south slope.

The width of the horizontal collector trenches is 1m.

For these conditions, the total volume of clogged clear stone backfill at the end of the service life is 1,088 m³ (i.e., 0.5 x 725 m x 3 m x 1 m). The porosity reduction at any given point in the clogged zone of the clear stone at the end of the service life is 0.45 (i.e. a reduction in porosity from an initial value of 0.48 to a final value of 0.03). Therefore, the total volume of clog material (V_{CLOG}) at the end of the service life is approximately 490 m³ (i.e., 1,088 m³ x 0.45). The time frame to generate this volume of clog corresponds to the service life of the horizontal collector with respect to leachate drainage, and can be conservatively estimated using the equation:

$$T = \frac{V_{CLOG} \times P_{CLOG} \times f_{Ca}}{q_o \times L \times S \times C_{Ca}}$$

where,

T = service life of the horizontal leachate collector with respect to bio-chemical clogging (years),

V_{CLOG} = total volume of clog material in the collector drain at the end of its service life (m³)

= 490 m³

P_{CLOG} = dry density of the clog material = 1,500 kg/m³

f_{Ca} = fraction of calcium in the clog material

= 0.26

Horizontal Collector Service Life Calculation**W12A Landfill, London, Ontario**

Job No: 1648176

Prepared by: F. Barone

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q_o = annual average leachate generation rate via moisture percolation through the final cover
= 0.235 m/y

L = length of the horizontal collector installed from the south to north end of the existing
Phase 1 top surface
= 725 m

S = spacing of the horizontal collectors
= 30 m

C_{ca} = average calcium concentration in leachate entering the horizontal collectors
= 250 mg/L (from leachate monitoring wells installed in Phase 1, refer to Figure 2)
= 0.25 kg/m³

Substituting the above values into the equation gives a service life of approximately 150 years for the horizontal collectors with respect to biochemical clogging and leachate drainage. Allowing for additional conservatism, a service life of 100 years is recommended for the POLLUTE modelling.

Horizontal Collector Service Life Calculation

W12A Landfill, London, Ontario

Job No: 1648176

Prepared by: F. Barone

Date: September 18, 2020

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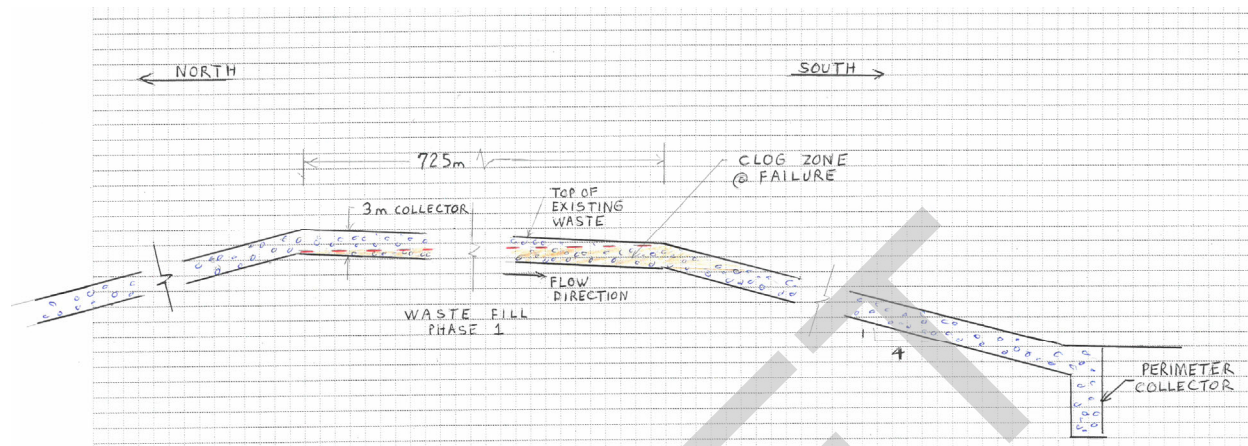


Figure 1: Cross-Section of Horizontal Collector

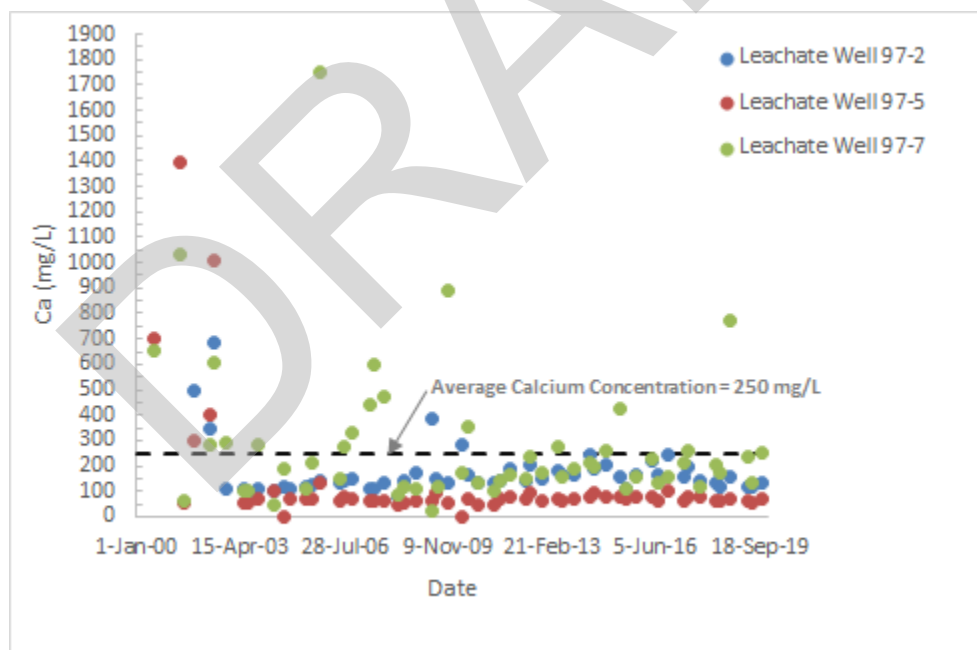


Figure 2: Historical Calcium Concentrations from the Leachate Monitoring Wells in Phase 1.