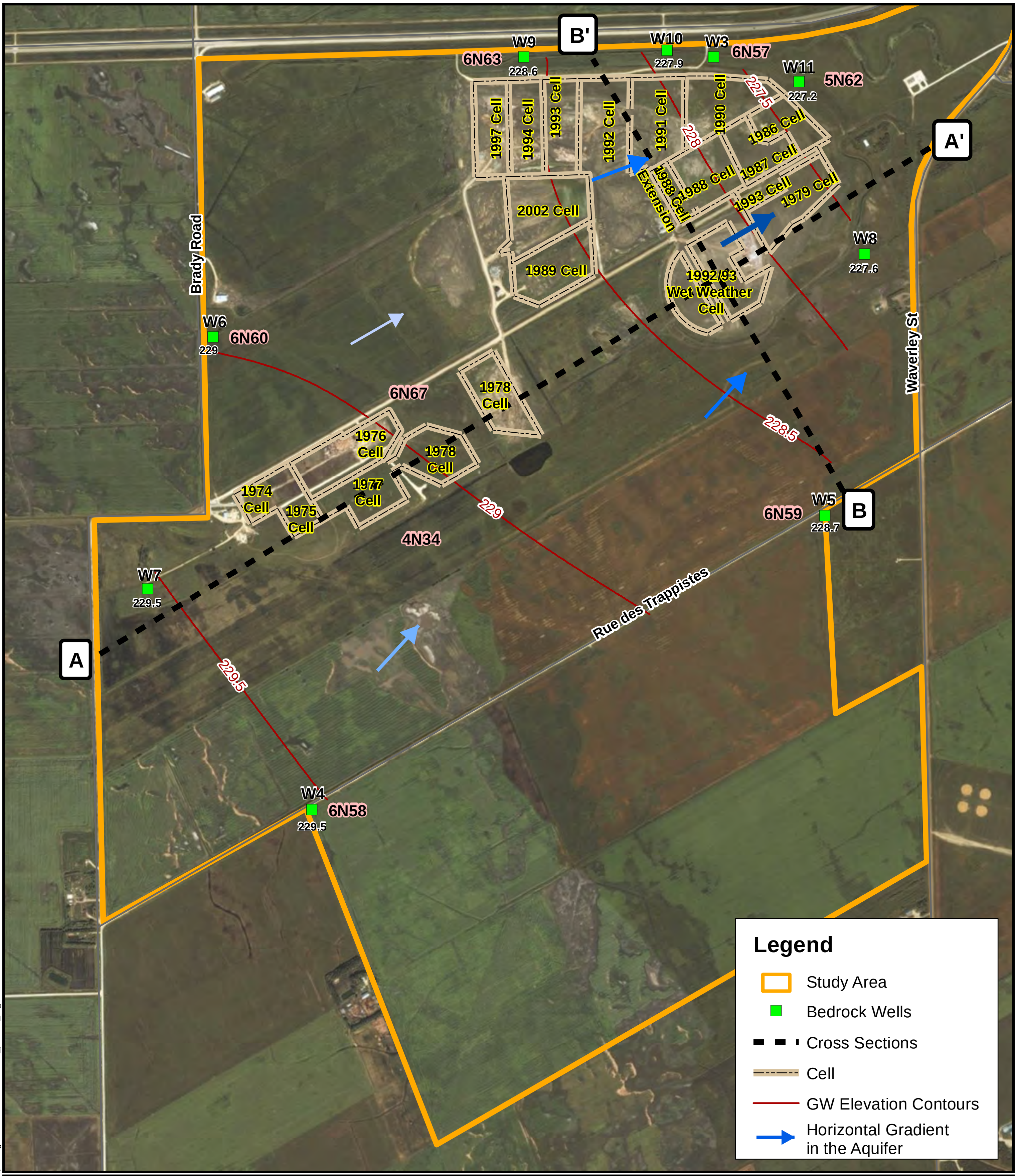
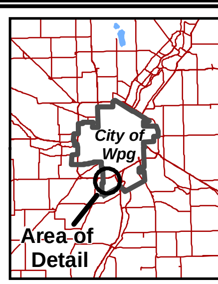


Average Groundwater Elevations in 2009 and Flow Direction in the Aquifer

Figure 5-6



NORTH

0 125 250 500

Metres

Acknowledgements:
Data provided by Government of Manitoba, ESRI, City of Winnipeg, Stantec Consulting Ltd.
Projection: NAD83 Zone 14N

PREPARED BY

Stantec

MAP SCALE	PROJECT
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DATE	
March 2, 2011	

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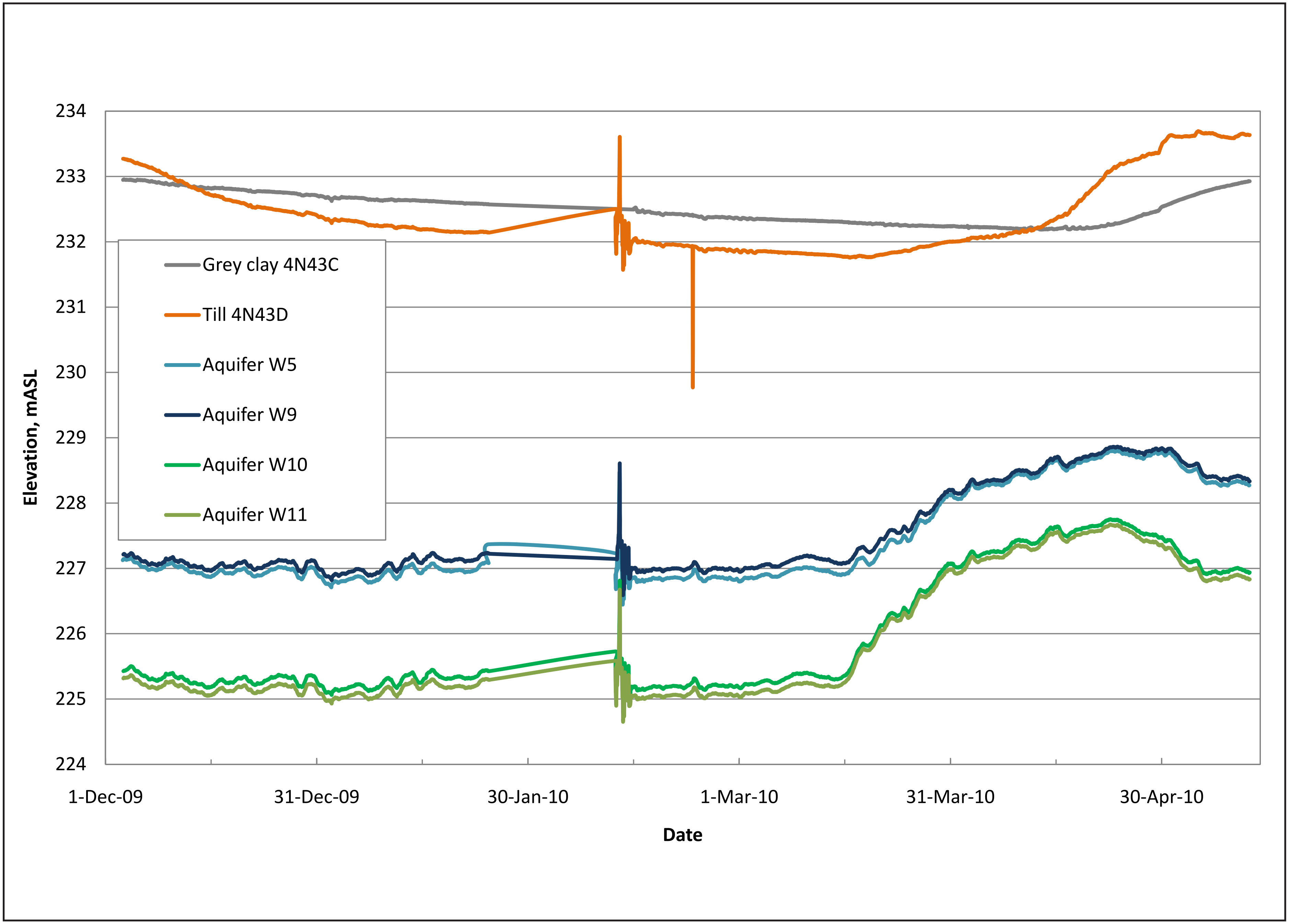
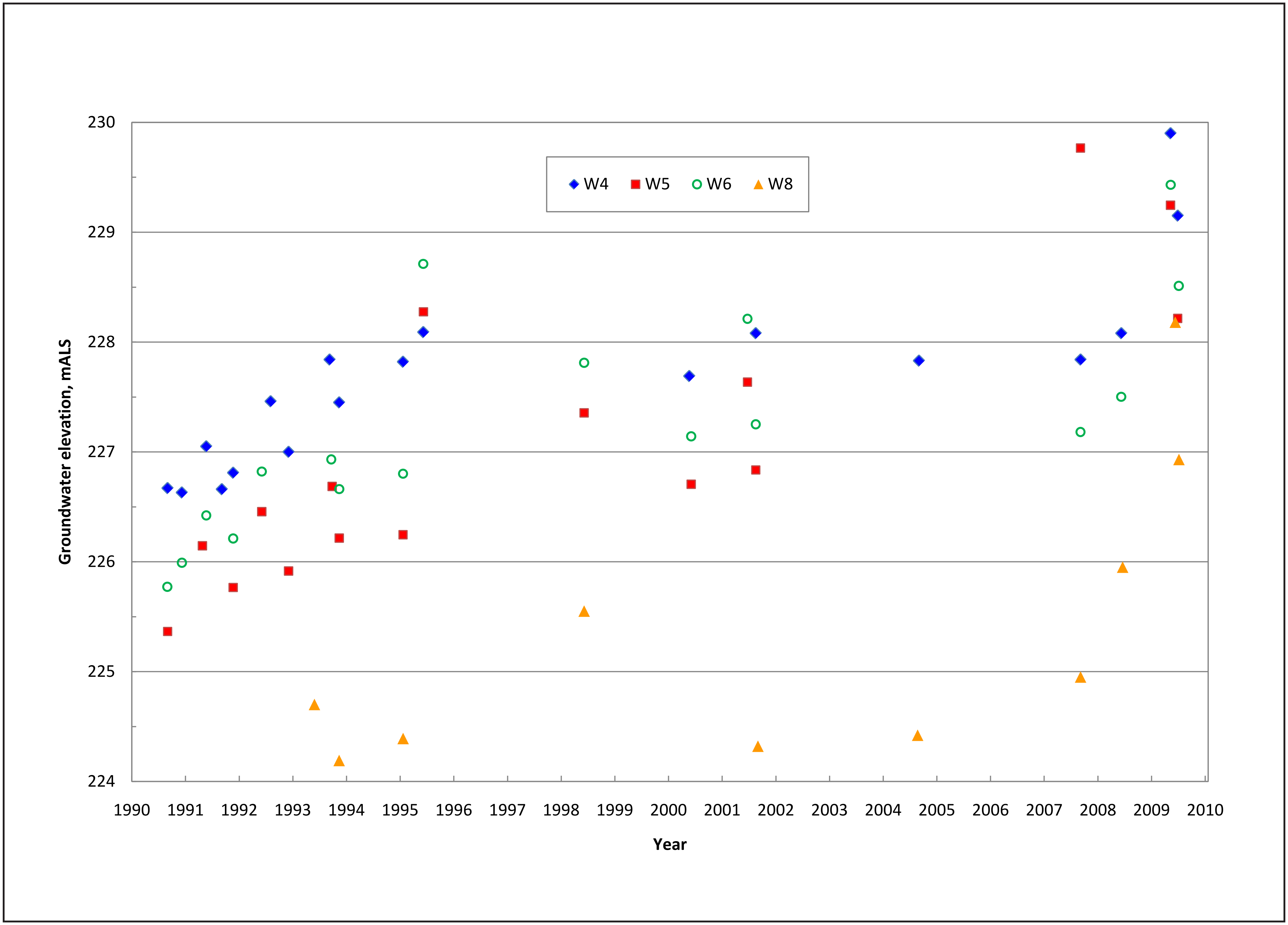


Piezometric Level Logs 2009/2010

Figure 5-7



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Piezometric groundwater elevations in bedrock monitoring wells

Figure 5-8

0.007 to 0.03 m/y. Pach (1994) estimated apparent groundwater velocities to be 0.04 m/y using chloride concentrations in pore water below the landfill. In 1986, UMA analyzed groundwater for tritium in order to determine if groundwater recharged and/or mixed with post-1953 titrated waters. Low concentrations of tritium in the overburden (≤2.5 TU) suggest that even the shallowest groundwater (3.6 m) likely recharged prior to 1953. These independent estimates show that vertical movement of solutions at the site is in the order several centimeters per year, which is in the range of estimates obtained for clays in the Winnipeg area (Tetr*ES,* 2010).

In the past, garbage that was received during wet weather and other wet waste were diverted into a special cell at the landfill, referred as the "Wet Weather Cell" (Figure 5-2). Leachate mounding has occurred within this cell, with elevations reaching 7-8 m above the original prairie level, while the undisturbed water table at the site is usually found within 1.5 m below ground surface (KGS, 2009). The City is currently reducing the mounding by improvement of the leachate-collection system at this cell. No significant mounding issues have been reported for any other parts of the Brady Landfill.

5.1.1.2.4 Groundwater Chemistry

Source and Quality of Data

The first site assessment of groundwater (and leachate) chemistry was done by UMA (1987). The study completed by Pach (1994) increased understanding of the site by adding analyses of pore water squeezed from the clay cores collected near and under the landfill. Since then, the City of Winnipeg has been occasionally monitored the chemistry of the leachate and groundwater, but no systematic analysis of these accumulated data has been completed until this EIA.

The dataset that supports this analysis includes samples collected by City of Winnipeg personnel between 2009 and 2011 (Appendix I). Historical data collected prior to 2009 show potential problems with the sampling methods, analytical protocols and reporting (Tetr*ES,* 2009c). For example, no field filtration was done for trace metal samples, and concentration units in the early reports were inconsistent. Therefore, samples taken prior to 2009 were not considered in this assessment, with the exception of nitrogen species, that have not been analyzed recently (Table 5-3).

In 2009 and 2010, samples of leachate were collected from pumping manholes, while groundwater samples were collected from piezometer nests and monitoring wells installed in the aquifer (Figure 5-9).The samples were analyzed by ALS Laboratory for a wide range of organic and inorganic contaminants, in accordance with the recommendations by Tetr*ES* Consultants (now Stantec; Tetr*ES* 2009c). Normal QA/QC protocols were followed by ALS Laboratory and all samples were approved. Multiple samples from the same locations/strata were also cross-checked. This check showed that some values of chloride and sulfate varied by an order of magnitude in the same groundwater-monitoring wells (Appendix I). Several of these values appeared to be anomalies and were therefore excluded from further analysis.

Table 5-3: Summary of Leachate and Groundwater Chemistry at the Brady Landfill (2009-2010)

Parameter	MOE	Leachate			Brown clay						Grey clay						Silty till						Carbonate aquifer					
	Guideline	n=8			Upstream n=4			Downstream, n=2			Upstream, n=19			Downstream, n=6			Upstream, n=4			Downstream, n=2			Upstream, n=8			Downstream, n=9		
	2004	minimum	median	maximum	minimum	median	maximum	minimum	median	maximum	minimum	median	maximum	minimum	median	maximum	minimum	median	maximum	minimum	median	maximum	minimum	median	maximum	minimum	median	maximum
Total Alkalinity, as mg/L $CaCO_3$	-	640	4860	6400	605	680	740	648	679	710	440	555	890	456	499	550	160	727.5	1460	310	312	2020	30	135	570	130	140	150
pH, pH units	-	6.71	7.155	7.43	6.66	6.98	7.11	6.88	6.97	7.06	6.68	6.91	7.69	6.93	6.97	7.02	7	7.27	7.91	7.26	7.34	7.57	7.37	7.61	10.7	7.44	8.05	11.5
Total Dissolved Solids	-	678	7121	9586	3240	3690	6140	3960	4445	4930	876	4665	5310	4830	5340	5610	1940	3990	4700	4860	5040	5380	508	4520	5990	3900	4755	10800
Total Organic Carbon, C mg/L	-	11	278	677	10	12	17	14	18	22	4	11.5	18	13	14.5	18	4	8.5	11	2	8	9	2	3	47	2	3	14
Total Kjeldahl Nitrogen, N mg/L	-	5.0	730	975	1.0	1.0	5.0	4.0	5.0	6.0	1.0	3.0	17.0	3.0	4.0	5.0	1.0	7.5	19	4.0	5.5	7.0	1.0	4.0	15.0	3.0	4.0	6.0
Nitrate + Nitrite Nitrogen, N mg/L	-	*0.06*	*0.06*	*0.06*	0.021	0.057	0.334	0.021	0.033	0.045	0.013	0.0335	0.9	0.014	0.0255	0.062	0.008	0.0715	0.129	0.013	0.019	0.192	0.008	0.015	0.025	0.009	0.013	0.02
Total Ammonia	-	*1.0*	*64*	*1625*	0.0015	0.185	0.288	0.69	0.7285	0.767	0.016	0.4865	1.23	0.683	0.842	1.05	0.0015	1.082	1.576	0.907	1	1.149	0.194	1.219	2.007	0.811	1.1645	1.434
Sulfate	-	30	95	1920	1550	2220	3060	244	2560	2640	67.9	1700	2780	238	1785	2550	311	1135	1540	77.9	995	1530	440	823	1120	442	716	974
Chloride	-	150	950	3300	173	384	496	112	496	512	117	476	1260	134	682	1210	328	1275	2000	156	1475	2500	1610	2335	2970	2050	2570	2910
Lithium (Li)	-	na	na	na	na	na	na	na	na	na	0.208	0.5225	0.667	0.443	0.5515	0.78	0.342	0.391	0.865	0.312	0.368	0.38	0.208	0.212	0.313	0.318	0.3195	0.321
Thorium (Th)	-	na	na	na	0.00005	0.00005	0.00005	na	na	na	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Phosphorus (P)	-	0.01	1.56	8.3	0.01	0.01	0.021	0.01	0.025	0.039	0.01	0.01	0.13	0.01	0.034	0.05	0.01	0.0285	0.05	0.01	0.036	0.05	0.01	0.01	0.05	0.01	0.01	0.05
Rubidium (Rb)	-	0.0038	0.1092	0.2140	0.0008	0.0012	0.0033	0.0036	0.0038	0.0040	0.0009	0.0058	0.0073	0.0058	0.0066	0.0094	0.0005	0.0047	0.0078	0.0048	0.0079	0.0145	0.0121	0.0141	0.0240	0.0126	0.0167	0.0286
Tin (Sn)	-	0.0002	0.0085	0.0208	0.0002	0.0002	0.0002	0.0002	0.0022	0.0043	0.0001	0.0002	0.0005	0.0001	0.0002	0.0055	0.0002	0.0002	0.0002	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002	0.0001	0.0002	0.0002
Tungsten (W)	-	0.0001	0.0044	0.0073	0.0001	0.0001	0.0001	0.0001	0.0002	0.0003	0.0001	0.0001	0.0005	0.0001	0.0001	0.0005	0.0001	0.0004	0.0007	0.0001	0.0003	0.0005	0.0001	0.0003	0.0030	0.0001	0.0005	0.0026
Potassium (K)	-	13.5	370.5	803	9.0	9.9	14.6	10.7	12.7	14.6	1.5	10.1	12.0	10.5	11.7	14.1	9.7	11.7	21.2	10.6	13.4	32.3	24.4	30.2	44.6	29.9	34.7	37.7
Barium (Ba)	23	0.105	0.420	0.586	0.009	0.012	0.014	0.009	0.012	0.015	0.007	0.010	0.142	0.008	0.013	0.020	0.010	0.014	0.018	0.012	0.018	0.022	0.009	0.011	0.012	0.010	0.014	0.071
Boron (B)	50	0.15	4.3	6.6	0.08	0.13	0.15	0.20	0.20	0.20	0.09	0.23	0.40	0.26	0.32	0.55	0.16	0.31	0.45	0.27	0.53	0.99	0.33	0.72	1.05	0.23	0.78	1.24
Iron (Fe)	-	0.54	4.4	18.9	0.001	0.15	0.26	0.001	0.14	0.28	0.001	0.03	4.4	0.001	0.005	0.31	0.001	0.34	2.5	0.001	0.005	0.61	0.50	0.99	3.2	0.001	0.46	0.82
Zirconium (Zr)	-	0.0007	0.0186	0.0473	0.0006	0.0011	0.0013	0.0010	0.0014	0.0018	0.0002	0.0005	0.0016	0.0002	0.0009	0.0016	0.0002	0.0002	0.0008	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0002	0.0002	0.0002
Chromium (Cr)	2	0.0051	0.0614	0.2230	0.0031	0.0055	0.0137	0.0005	0.0039	0.0072	0.0001	0.0025	0.0155	0.0001	0.0005	0.0065	0.0001	0.0012	0.0147	0.0001	0.0004	0.0040	0.0004	0.0005	0.0014	0.0001	0.0005	0.0102
Aluminum (Al)	-	0.006	0.042	0.095	0.001	0.005	0.042	0.001	0.002	0.003	0.001	0.003	0.222	0.001	0.002	0.007	0.001	0.003	0.093	0.001	0.005	0.034	0.001	0.001	0.265	0.001	0.004	0.016
Selenium (Se)	0.05	0.001	0.010	0.020	0.002	0.002	0.006	0.003	0.018	0.033	0.001	0.003	0.006	0.003	0.014	0.041	0.001	0.004	0.010	0.002	0.004	0.014	0.001	0.004	0.010	0.001	0.005	0.013
Cesium (Cs)	-	0.00005	0.00021	0.00036	0.00005	0.00005	0.00005	0.00005	0.00008	0.00011	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00011	0.00005	0.00005	0.00035
Cobalt (Co)	0.1	0.0012	0.0231	0.0397	0.0056	0.0063	0.0101	0.0044	0.0082	0.0120	0.0005	0.0095	0.0292	0.0036	0.0081	0.0177	0.0003	0.0017	0.0057	0.0010	0.0025	0.0037	0.0003	0.0006	0.0010	0.0001	0.0007	0.0009
Nickel (Ni)	1.6	0.006	0.116	0.244	0.030	0.033	0.042	0.021	0.028	0.036	0.005	0.019	0.049	0.009	0.016	0.031	0.005	0.012	0.019	0.004	0.007	0.020	0.000	0.004	0.007	0.000	0.003	0.006
Arsenic (As)	0.48	0.0029	0.0154	0.0193	0.0024	0.0050	0.0060	0.0084	0.0092	0.0099	0.0027	0.0068	0.0166	0.0040	0.0115	0.0196	0.0038	0.0117	0.0199	0.0045	0.0135	0.0202	0.0072	0.0166	0.0282	0.0105	0.0168	0.0270
Sodium (Na)	-	40	1070	1510	222	375	525	476	737	998	124	338	521	436	585	1300	465	566	1050	310	840	1300	955	1330	1670	1100	1380	1820
Titanium (Ti)	-	0.001	0.018	0.047	0.005	0.006	0.016	0.006	0.014	0.023	0.002	0.007	0.024	0.005	0.016	0.032	0.005	0.009	0.046	0.005	0.009	0.013	0.000	0.004	0.012	0.001	0.006	0.008
Silver (Ag)	0.0012	0.00005	0.00012	0.00032	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Silicon (Si)	-	6.2	18.9	23.0	9.5	11.2	11.7	11.9	12.0	12.1	5.9	11.5	12.2	9.4	10.3	11.1	8.0	10.2	15.9	3.3	8.3	10.9	2.0	4.2	5.3	2.3	4.2	7.3
Molybdenum (Mo)	7.3	0.0003	0.0032	0.0053	0.0011	0.0021	0.0043	0.0026	0.0028	0.0030	0.0008	0.0028	0.0077	0.0011	0.0026	0.0196	0.0017	0.0064	0.0755	0.0013	0.0033	0.0037	0.0022	0.0039	0.0067	0.0022	0.0034	0.0206
Vanadium (V)	0.2	0.0013	0.0098	0.0541	0.0066	0.0074	0.0122	0.0073	0.0110	0.0147	0.0023	0.0062	0.0125	0.0026	0.0062	0.0136	0.0013	0.0030	0.0133	0.0001	0.0037	0.0082	0.0005	0.0005	0.0006	0.0001	0.0005	0.0026
Magnesium (Mg)	-	58	421	491	269	385	535	303	395	487	151	228	347	215	256	395	137	283	781	137	210	289	84	122	152	37	145	173
Beryllium (Be)	0.053	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0001	0.0005	0.0001	0.0005	0.0005	0.0001	0.0005	0.0005	0.0001	0.0003	0.0005	0.0001	0.0005	0.0005	0.0002	0.0005	0.0005
Bismuth (Bi)	-	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.0001	0.00015	0.00015	0.0001	0.00015	0.00015	0.0001	0.00015	0.00015	0.0001	0.000125	0.00015	0.0001	0.00015	0.00015	0.0001	0.00015	0.00015
Chromium (VI)	-	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Thallium (Tl)	0.4	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00016	0.00026	0.00005	0.00014	0.00094	0.00005	0.00005	0.00037	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00010
Strontium (Sr)	-	0.489	3.8	6.2	2.8	4.0	5.4	4.3	4.9	5.5	0.9	3.7	4.6	3.5	4.4	6.6	1.8	3.2	4.9	2.8	3.6	3.8	2.3	3.0	5.0	2.7	3.9	4.4
Lead (Pb)	0.032	0.00005	0.00028	0.00128	0.00010	0.00036	0.00081	0.00013	0.00028	0.00043	0.00005	0.00017	0.00196	0.00005	0.00012	0.00064	0.00005	0.00013	0.00555	0.00005	0.00009	0.00057	0.00005	0.00007	0.00035	0.00005	0.00005	0.00043
Antimony (Sb)	16	0.0005	0.0019	0.0029	0.0016	0.0025	0.0029	0.0005	0.0032	0.0059	0.0001	0.0013	0.0061	0.0004	0.0005	0.0042	0.0001	0.0005	0.0015	0.0003	0.0005	0.0037	0.0001	0.0005	0.0044	0.0001	0.0005	0.0028
Zinc (Zn)	1.1	0.007	0.009	0.108	0.013	0.017	0.037	0.011	0.036	0.062	0.003	0.034	0.179	0.007	0.020	0.079	0.007	0.012	0.020	0.003	0.008	0.041	0.003	0.004	0.018	0.003	0.003	0.032
Calcium (Ca)	-	97	154	224	403	531	556	681	713	745	85	613	714	564	703	890	141	364	644	279	412	538	153	264	340	243	288	340
Copper (Cu)	0.023	0.002	0.002	0.003	0.004	0.014	0.020	0.007	0.007	0.008	0.001	0.009	0.040	0.003	0.005	0.027	0.001	0.002	0.051	0.001	0.002	0.005	0.000	0.001	0.005	0.001	0.001	0.005
Manganese (Mn)	-	0.16	0.34	0.90	2.53	2.94	6.38	4.69	5.32	5.9	0.05	1.89	6.7	1.3	2.3	6.1	0.00	0.16	1.5	0.06	0.30	0.72	0.01	0.03	0.09	0.00	0.02	0.03
Mercury (Hg)	0.000012	0.000025	0.000025	0.000169	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025
Tellurium (Te)	-	0.00025	0.00025	0.00025	0.0001	0.0025	0.0025	0.0025	0.0025	0.0025	0.0001	0.0025	0.0025	0.0001	0.0025	0.0025	0.0001	0.0025	0.0025	0.0001	0.00136	0.0025	0.0001	0.0025	0.0025	0.0001	0.0025	0.0025
Cadmium (Cd)	0.011	0.0000	0.0000	0.0000	0.0002	0.0026	0.0049	0.0004	0.0025	0.0047	0.0001	0.0021	0.0104	0.0002	0.0005	0.0032	0.0000	0.0002	0.0065	0.0000	0.0003	0.0051	0.0000	0.0000	0.0001	0.0000	0.0001	0.0003
Uranium (U)	-	0.0001	0.0006	0.006	0.035	0.21	0.33	0.14	0.16	0.18	0.02	0.06	0.33	0.03	0.07	0.24	0.01	0.02	0.26	0.003	0.020	0.043	0.00005	0.00029	0.00089	0.00005	0.00097	0.00141

Notes: All parameters are in mg/L unless posted
Original data are presented in the Attachments, exept for leachate parameters in the italics
Parameters in italics were taken from historical data prior 2009
Values below detection limit were assumed to be a half detection limit in order to calculate medians, eg. Hg concentration below detection limit (0.00005 mg/L) assumed to be 0.000025 mg/L.
Lachate TDS were calculated from conductivity values presented in attachments

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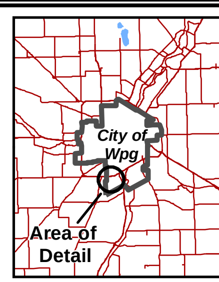
Groundwater and Leachate Sampling Locations at Brady Road Landfill

Figure 5-9



NORTH

220 110 0 220 440

Metres

Acknowledgements:
Data provided by Government of Manitoba, ESRI, City of Winnipeg, Stantec Consulting Ltd.
Projection: NAD83 Zone 14N

PREPARED BY Stantec

MAP SCALE 1:17,000	DATA SCALE N/A
DATE January 26, 2011	PROJECT 1114 10000

Definition of "Background" Values

In this assessment, the "baseline" groundwater chemistry is defined as an envelope of values observed for selected parameters in wells upstream of the refuse cells. These background concentrations integrate both natural and anthropogenic processes unrelated to the operation of the landfill.

Selected Guidelines for Assessing Quality

According to historical records (UMA, 1987), the Brady Landfill is located above a carbonate aquifer bearing non-potable groundwater. Neither federal nor Manitoba provincial governments regulate non-potable groundwater quality. Therefore, the Ontario Ministry of Environment guidelines for non-potable groundwater quality were used as the regulatory reference for this assessment (MOE, 2004). These guidelines are more focused on trace elements and organic contaminants and do not consider major ions and nutrients (Table 5-3). The MOE guidelines were updated in 2011, after the analysis of the data had been completed. Therefore, the assessment refers to the 2004 version of the MOE guidelines. In addition, some parameters were also compared with the Guidelines for Canadian Drinking Water Quality (Health Canada, 2008).

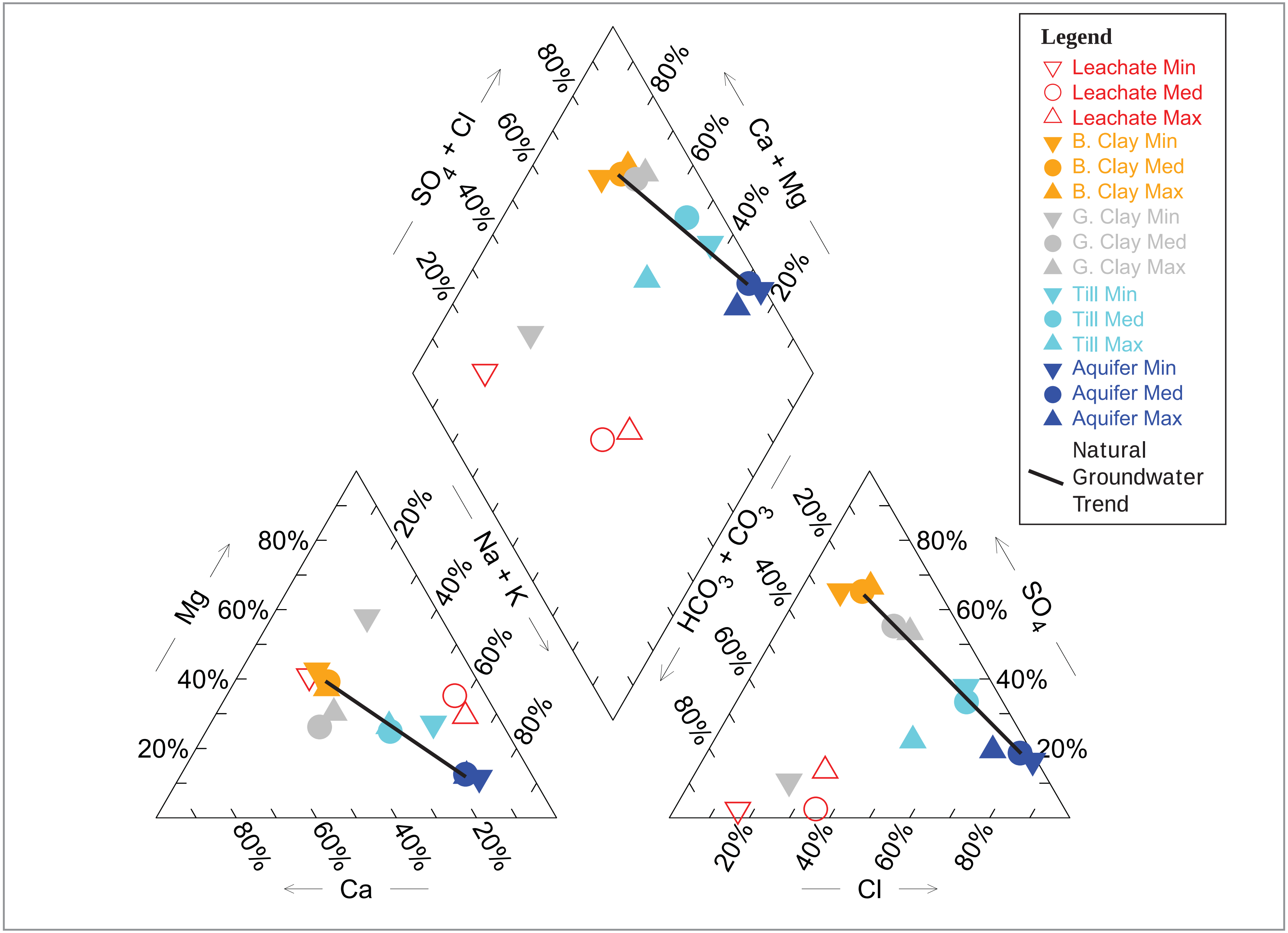
Quality

All strata, including the bedrock aquifer, contain non-potable groundwater due to elevated concentrations of Total Dissolved Solids (4000-5000 mg/L). High salinity restricts use of groundwater for industrial purposes and limits future aquifer use. On this basis, the groundwater is classified as brackish and is considered as "non-potable" (Hem, 1985; UMA, 1987).

The composition of major ions in the top (brown clay) and lower (carbonate aquifer) strata are different and represent two "end members" (Figure 5-10). In the brown clay, calcium, magnesium and sulfate are the major ions, while sodium and chloride dominate in the aquifer. Groundwater in the middle strata (grey clay and till) has intermediate composition between these end members (Figure 5-10). Median pH values (6.9-7.0) in the two upper clay layers are slightly lower than pH in the till and the carbonate aquifer (7.3-7.6), respectively.

The concentration of trace elements shows a strong vertical gradient. Groundwater within shallower clay layers has the higher median concentration for most trace metals, compared with the deeper carbonate aquifer (Table 5-3). The opposite pattern was observed for iron and arsenic concentrations, gradually increasing with depth, likely indicating reducing conditions. Median concentrations of boron, rubidium and tungsten were also higher the aquifer than in the overburden.

The median baseline concentrations of metals and metalloids in all strata are below the MOE guidelines for non-potable groundwater (MOE, 2004). Maximal concentrations of trace elements are also below the MOE guideline for non-potable groundwater, except for copper. Copper



Piper plot showing range of groundwater chemistry in different strata at the Brady landfill

Figure 5-10

concentrations exceeded the stipulated guidelines (0.023 mg/L) in four groundwater samples taken from the grey clay and silty till strata upstream of the landfill (Attachment I-A). The highest copper concentration upstream of the landfill was 0.05 mg/L. This exceedance is unlikely to be a cause for concern because the concentrations are less than the federal aesthetic objective for drinking water (1 mg/L; Health Canada, 2008), and in any event, this groundwater is not used as a potable water supply.

The stipulated MOE guideline for mercury is 0.000025 mg/L. Groundwater concentrations are an order of magnitude less than the Maximum Acceptable Concentration in Drinking Water (0.001 mg/L; Health Canada, 2008). (This discrepancy suggests that there is unnecessary conservatism within the MOE guideline for some trace elements.)

No organic contaminants were detected in the aquifer. However, several Polycyclic Aromatic Hydrocarbons (PAH) have been detected in the till at concentrations just above the detection limits:

- Benzo(b)fluoranthene, Benzo(b&j)fluoranthene, Benzo(ghi)perylene, Chrysene, Fluoranthene, Indeno(1,2,3 cd)pyrene, Phenanthrene and Pyrene in piezometer 4N34D and 4N34C located upstream of the old cells (Figure 5-9).
- Benzo(a)anthracene, Fluoranthene, Naphthalene, Phenanthrene and Pyrene in piezometer 6N57E located near the Perimeter Highway.

Concentrations of these compounds were an order of magnitude lower than the MOE guidelines for non-portable groundwater (Appendix I-A).

5.1.1.2.5 Leachate Chemistry

Major Parameters

The concentration of TDS in leachate has a wider range in comparison to groundwater, but the median TDS value is similar (Table 5-3). Considering the major ions, leachate can be classified as a sodium-bicarbonate solution with elevated concentrations of magnesium and chloride. This combination of anions separates leachate from the main groundwater trend lines (Figure 5-10). In contrast, median pH values (6.9) in leachate are close to the pH found in natural groundwater associated with clay.

Trace Elements and Radioactivity

The trace element concentrations in leachate comply with the MOE standards for non-potable groundwater, with the exception of mercury, boron, copper, selenium and lead. Elevated concentrations of boron (58.2 mg/L), copper (0.34 mg/L) and selenium (0.08 mg/L) have been detected in one of 12 manholes (Appendix I-B). Single exceedances for lead (0.05 mg/L) and mercury (0.00017 mg/L) in leachate were not consistent with other samples taken from the same manholes, indicating that these anomalies are likely the result of analytical error. Alfa radioactivity of leachate was below 5 Bq/L and beta radioactivity did not exceed 24 Bq/L. There is no MOE radioactivity guideline for non-potable groundwater.

Organic Compounds

Leachate was analyzed for the following groups of organic contaminant packages:

- Volatile Organic Compounds (VOC)
- Polychlorinated Biphenils (PCBs)
- Polycyclic Aromatic Hydrocarbons (PAH)
- EPA 8270 screening package
    - Pesticides and Herbicides
    - Dioxins and Furans
    - Nonylphenols and associated ethoxylates

Among 34 VOCs regulated by the MOE guideline, only vinyl chloride and acetone exceeded the guideline in six and three samples, respectively (Table 5-4). Several other VOC were detected in a single sample by EPA 8270 screening, but levels of these contaminants were not confirmed by more precise VOC analysis (Attachment I-B).

The PCB compound Aroclor 1242 was detected in 10 samples in concentrations over the stipulated guideline value. Other PCBs were not detected in leachate (Attachment I-B).

Several PAHs were detected by the EPA 8270 screening package. However, only benzo(ghi)perylene and indeno(1,2,3 cd)pyrene exceeded the MOE standards. These exceedances were found in only one sample taken in 2010, which was not confirmed in 2011 (Attachment I-B, Figure 5-9).

Concentrations of pesticides and herbicides in the leachate were generally below the detection limits. However, the detection limits for six of eight regulated contaminants were above the MOE guideline for non-potable groundwater. The detection limits for these parameters were probably high due to the high concentration of dissolved organics, which may have caused a matrix effect or high background noise during the analysis. In the groundwater samples containing little dissolved organic carbon, the detection limits of pesticides and herbicides were below or at the guidelines.

The Toxicity Equivalent (TEQ) for dioxins and furans did not exceed the stipulated guideline in the leachate samples.

Table 5-4: Results of Leachate and Groundwater Screening for Potential Contaminants (2009-2011)							
Analytical Group	**Media**	**Number of Parameters**			**Number of Samples**		**Comments**
		Measured	**Regulated***	**Exceeded***	**Analyzed**	**Exceeded***	
Trace elements and radioactivity	Leachate	38	19	5	28	3	Mercury, Boron, Copper, Lead and Selenium above the guideline
	Groundwater	38	19	1	96	5	Copper background above the guideline
Volatile organic carbohydrates (VOC)	Leachate	45	34	1	19	7	Vinyl Chloride and acetone above the guideline
	Groundwater	45	34	0	35	0	
PAH	Leachate	21	19	2	16	1	Benzo(ghi)perylene and Indeno(1,2,3)pyrene above the guideline
	Groundwater	21	19	0	36	0	
Pesticides and Herbicides	Leachate	26	8	1?	16	7?	Aldrin's detection limit above the guideline
	Groundwater	18	8	0	36	0	
PCBs	Leachate	9	1	1	19	10	Aroclor 1242 above the guideline
	Groundwater	9	1	0	26	0	
Dioxins and Furans	Leachate	17	1	0	8	0	
	Groundwater	17	1	0	4	0	
Nonylphenols and its ethoxylates	Leachate	8	0	0	8	0	
	Groundwater	8	0	0	4	0	

*Note: exceedances of parameters regulated by 2004 MOE Guidelines for Non-Potable groundwater (MOE, 2004).

Nonylphenols and ethoxylates are not regulated by the MOE guideline nor by the Canadian Drinking Water Quality Guidelines. They have been assessed as emerging contaminants (e.g., "Endocrine-Disrupting Compounds"), which might be included in groundwater-protection guidelines in the future. Comparison of values generally shows that leachate collected from older cells has a lower concentration than recent ones. This suggests decomposition of nonylphenols and ethoxylates with time, consistent with findings reported in the professional literature.

In summary, organic contaminants in leachate exceed the MOE standards more often than the trace elements. Among organic contaminants, the groups of greatest interest are VOCs and PAHs; while pesticides and herbicides, dioxins, furans, nonylphenols and ethoxylates are of less interest.

Indicator Parameters

Comparison of background water quality to leachate chemistry was taken to define parameters that can determine whether contamination in the groundwater originated from the landfill (Section 8.1.1.4.1). Indicator parameters were determined by dividing the median concentration in the leachate by the median background concentration in the groundwater. If the resulting ratio is over 10, the parameter is considered to be an indicator of groundwater contamination (Table 5-5). The suites of indicator parameters differ slightly between strata because the median groundwater concentration in each unit is not the same. Indicator parameters, for which ranges of concentrations in leachate and in groundwater do not overlap, were selected for further statistical comparison of median values (Table 5-4). Movement of indicator components is not conservative and depends on chemical reactions occurring during movement of the solutes. As an example, the movement of most trace and major elements/components can be retarded by adsorption to soil and chemical precipitation. Organic contaminants and nitrogen species can be decomposed as they migrate. Therefore, several indicator parameters were used simultaneously in the assessment of groundwater quality (Section 8.1.1.4.1).

5.1.2 Physiography and Soils

The Project site is located within the Winnipeg Ecodistrict of the Lake Manitoba Plain Ecoregion of the greater Prairies Ecozone. Historically this region's geology, surface and subsurface hydrology was predetermined by the glacial ice sheets which covered the region more than 12,000 years ago and more recently by glacial Lake Agassiz. The broad region in the Red River Valley is the accumulation of fine sediment deposit with distinct stratification.

The region occurs over an area with underlying geologic deposits of the Stony Mountain Formation – Ordovician (Upper) of the Paleozoic period. The thickness of the unconsolidated sediment which was deposited by Lake Agassiz at the site is measured at approximately 48.15 m.

Table 5-5: Indicator Parameters in Decreasing Order of Ratio of Median Concentration in Leachate to Median Background Concentration in the Strata

Brown Clay	Ratio	Grey Clay	Ratio	Silty Till		Carbonate Aquifer	Ratio
Total Ammonia	**328**	Phosphorus (P)	156	Total Kjeldahl Nitrogen	182	Total Kjeldahl Nitrogen	182
Total Kjeldahl Nitrogen	182	Iron (Fe)	137	Zirconium (Zr)	93	Phosphorus (P)	156
Phosphorus (P)	156	Total Kjeldahl Nitrogen	97	Total Ammonia	59	**Chromium (Cr)**	**123**
Rubidium (Rb)	94	**Total Ammonia**	**91**	Tin (Sn)	57	Total Organic Carbon	93
Tin (Sn)	57	Tin (Sn)	57	Phosphorus (P)	55	**Zirconium (Zr)**	**93**
Tungsten (W)	44	Tungsten (W)	44	Chromium (Cr)	53	Tin (Sn)	57
Potassium (K)	37	Barium (Ba)	44	Potassium (K)	32	Total Ammonia	45
Barium (Ba)	**35**	**Potassium (K)**	**37**	**Barium (Ba)**	**30**	Aluminum (Al)	42
Boron (B)	32	Zirconium (Zr)	36	Rubidium (Rb)	23	**Barium (Ba)**	**38**
Iron (Fe)	30	Chromium (Cr)	25	**Total Organic Carbon**	**23**	**Cobalt (Co)**	**36**
Total Organic Carbon	**23**	**Total Organic Carbon**	**23**	Aluminum (Al)	17	**Total Alkalinity**	**36**
Zirconium (Zr)	17	Rubidium (Rb)	19	Total Alkalinity	15	Nickel (Ni)	30
Chromium (Cr)	11	Boron (B)	19	Boron (B)	14	Vanadium (V)	20
		Aluminum (Al)	15	Cobalt (Co)	14	Tungsten (W)	15
				Iron (Fe)	13	Potassium (K)	12
				Tungsten (W)	12	Manganese (Mn)	11

Note: Bolded parameters show different ranges of their concentrations in leachate and in groundwater (i.e., no overlap)

The level to very gently sloping plain (0-2%) has a mean elevation of approximately 236 masl (Smith *et al.,* 1998). Landfill surface elevations as measured in 2007 and 2009 reach 258.5 masl on the south part of the site (1992/93 cell), 262 masl on the east part of the site (1986 and 1987 cells) and 251 masl on the north part of the site (1991 and 1992 cells). These elevations correspond to refuse placed between 18 m to 29 m (59 ft to 95 ft) above the surrounding prairie level. The side slopes of the landfill range from approximately 5H:1V to 7.5H:1V.

Soils typical of the region include primarily imperfectly to poorly drained, fine-textured lacustrine soils of the Dencross, Red River and Osborne soil associations. These blackearth soils range from 0.1 m to 0.15 m in thickness (KGS, 1991). Regional soils primarily have an Agricultural Capability Rating of Class 2 or 3, indicating that they have minor to moderate limitations to sustained agricultural production, and are therefore considered productive.

Regional baseline soil quality is characterized as having elevated concentrations of naturally occurring elements, including selenium (≥0.5 ug/g in soil; CCME, 2009) and barium (120-430 ug/g in soil; CCME, 1999a). Soil sampling activities undertaken at nearby sites are in agreement with these elevated background conditions.

5.1.3 Air Quality

Winnipeg generally enjoys excellent air quality compared with other similar-sized Canadian cities. In 2004 and 2005, the air quality index as measured in downtown Winnipeg was “Good” (best rating) more than 95% of the time (Krawchuck and Snitowski, 2008). Impairments to air quality are generally localized in nature, as a result of an activity impacting the local airshed (Manitoba Conservation, 1999).

5.1.4 Local Climate

Winnipeg lies in the middle of the North American continent on a low-lying, flat plain. It experiences an extreme range in temperatures, and is correspondingly classified as a ‘humid continental’ climate under the Koppen Climate Classification. Winnipeg is located within the most humid subdivision of the Grassland Transition Ecoclimatic Region (Smith *et al.,* 1998). Short, warm summers and long, cold winters are characteristic of the region. Due to its location in a flat open prairie, Winnipeg lies exposed to numerous weather systems, including cold Arctic high-pressure systems. Climate data recorded at a weather monitoring station in Starbuck, Manitoba (Climate ID: 5022770), approximately 20 km west of the site, indicates an annual mean temperature of 2.5°C, with extreme maximum and minimum temperatures of 41.5 and -43°C recorded. The area receives approximately 558 mm of precipitation per annum, 77% (434 mm) of which falls as rain. An extreme daily rainfall of 86.6 mm was recorded in 1973 (Environment Canada, 2010). The average growing season is approximately 183 days.

From December through February, the maximum daily temperature exceeds 0°C, on average, for only 10 days, and the minimum daily temperature falls below -20°C on 49 days through this period. Cold weather and snow can occasionally extend into April, however winter weather generally moderates in late February or early March. Environment Canada has proclaimed Winnipeg the coldest city with a population of over 600,000 in the world.

Summer conditions are typically warm and humid. Occasionally, humidex readings surpass 40°C. On average, the maximum daily temperature exceeds 30°C 14 days per year, however the humidex readings reach temperatures above 30°C approximately 45 times per year. The highest temperature ever recorded in Winnipeg (since commencement of record-keeping in 1873) was 42.2°C (108°F) on July 11, 1936. The hottest temperature recorded in the past 25 years was 38.7°C (101.7°F) on August 6, 1988, and again on August 1, 1989. The highest humidex reading was 48°C (118.4°F) on July 25, 2007. The city averages 514 mm (20 inches) of precipitation per year, although this can vary greatly from year to year.

Spring and fall tend to be rather contracted seasons, each averaging little over six weeks. In general the weather during these seasons is highly variable, and rapidly changing. For example, temperatures in Winnipeg in April have ranged from -26.3°C to 34.3°C, and in October from -20.6°C to 30.5°C. Winnipeg is one of Canada's sunniest cities, and the weather in all seasons is characterized by an abundance of sunshine. The city has 317 days of bright sunshine. July is the sunniest month, and November the least sunny. Winnipeg, like Chicago, is also known as a windy city. The average annual wind speed is 16.9 km/h (10.5 mph), predominantly from the south. The city has experienced wind gusts of up to 129 km/h (80 mph). April is the windiest month, and July the least windy. Tornadoes are not uncommon in the area, particularly in the spring and summer months. In 2007, Winnipeg registered the first confirmed “F4” tornado (on the Fujita scale) observed in Canada. Climate information is summarized in Figure 5-11.

5.1.4.1 Meteorological Data

Meteorological data obtained from Environment Canada for the period 2003-2007 (inclusive), provide a full five-year record of hourly observations for Winnipeg, Canada. Hourly observations for surface meteorological data were obtained from Environment Canada’s Atmospheric Environment Service (AES) for the station located at the Winnipeg International Airport. A wind rose is provided for this five-year record of hourly observations in Figure 5-12. Upper air data are not measured by Environment Canada for available Winnipeg weather stations. Consequently, Manitoba Conservation has previously authorized the use of upper air data from Bismarck, North Dakota for use in detailed dispersion modelling assessments for locations within southern Manitoba.

The full meteorological data set of hourly observations for both upper air (Bismarck) and surface monitoring (Winnipeg) stations were combined and processed using the AERMET data processor by Trinity Consultants of Dallas, Texas, for the dispersion modelling described in Section 7.

Weather averages for Winnipeg James Armstrong Richardson International Airport since 1938													[hide]
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	7.8 (46)	11.7 (53)	23.3 (74)	34.3 (94)	37.0 (99)	37.8 (100)	37.8 (100)	40.6 (105)	38.8 (102)	30.5 (87)	23.9 (75)	11.7 (53)	40.6 (105)
Average high °C (°F)	-12.7 (9)	-8.5 (17)	-1.1 (30)	10.3 (51)	19.2 (67)	23.3 (74)	25.8 (78)	25.0 (77)	18.6 (65)	10.8 (51)	-0.9 (30)	-9.7 (15)	8.3 (47)
Average low °C (°F)	-22.8 (-9)	-18.7 (-2)	-11.0 (12)	-2.4 (28)	4.8 (41)	10.7 (51)	13.3 (56)	11.9 (53)	6.0 (43)	-0.3 (31)	-9.6 (15)	-19.1 (-2)	-3.1 (26)
Record low °C (°F)	-42.2 (-44)	-45.0 (-49)	-37.8 (-36)	-26.3 (-15)	-11.1 (12)	-3.3 (26)	1.1 (34)	0.6 (33)	-7.2 (19)	-17.2 (1)	-34.0 (-29)	-37.8 (-36)	-45.0 (-49)
Precipitation mm (inches)	19.7 (0.78)	14.9 (0.59)	21.5 (0.85)	31.9 (1.26)	58.8 (2.31)	89.5 (3.52)	70.6 (2.78)	75.1 (2.96)	52.3 (2.06)	36.0 (1.42)	25.0 (0.98)	18.5 (0.73)	513.7 (20.22)
Rain Fall mm (inches)	0.2 (0.01)	2.5 (0.1)	7.5 (0.3)	21.5 (0.85)	58.0 (2.28)	89.5 (3.52)	70.6 (2.78)	75.1 (2.96)	51.9 (2.04)	31.0 (1.22)	6.1 (0.24)	1.6 (0.06)	415.6 (16.36)
Snow Fall cm (inches)	23.1 (9.1)	14.2 (5.6)	15.8 (6.2)	10.1 (4)	0.8 (0.3)	0.0 (0)	0.0 (0)	0.0 (0)	0.4 (0.2)	5.0 (2)	21.4 (8.4)	19.8 (7.8)	110.6 (43.5)

Source: Environment Canada[6] 2008-08-04

Summary Climate Data for Winnipeg, Canada
Figure 5-11

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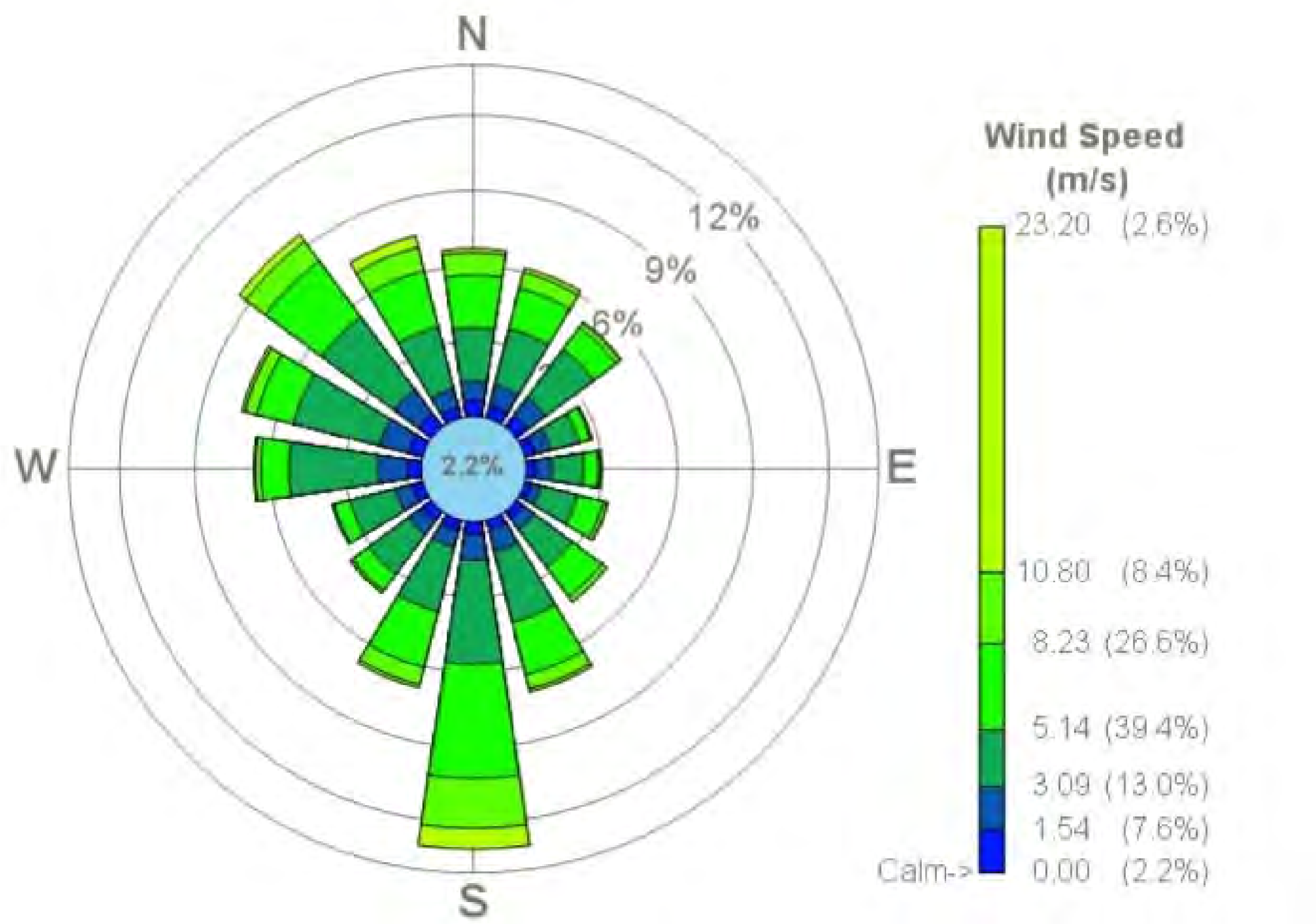

Wind Rose for Winnipeg, Environment Canada
Hourly Meteorological Record, 2003-2007
Figure 5-12

wind_rose
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5.1.5 Surface Water

5.1.5.1 Surface Water Hydrology

The region surrounding the site is primarily drained by the La Salle River, Westendorf Coulee and municipal roadside ditches. Drainage is generally to the east and south and is generally received by the La Salle River prior to entering the Red River (Figure 5-13).

5.1.5.1.1 Site Runoff to Westendorf Coulee

The Westendorf Coulee, also known as Grandmont Creek, is a tributary to the La Salle River that originates northeast of the facility and drains in an easterly to southeasterly direction. Flow is intermittent (Figure 5-13).

5.1.5.1.2 Municipal Ditches

The location and drainage direction of municipal ditches in the vicinity of Brady Road Landfill is also shown in Figure 5-13. Municipal ditches surrounding the site are primarily first-order drains, with the exception of the municipal ditch associated with Rue des Trappistes, which is a second order drain.

5.1.5.1.3 Site Runoff to La Salle River

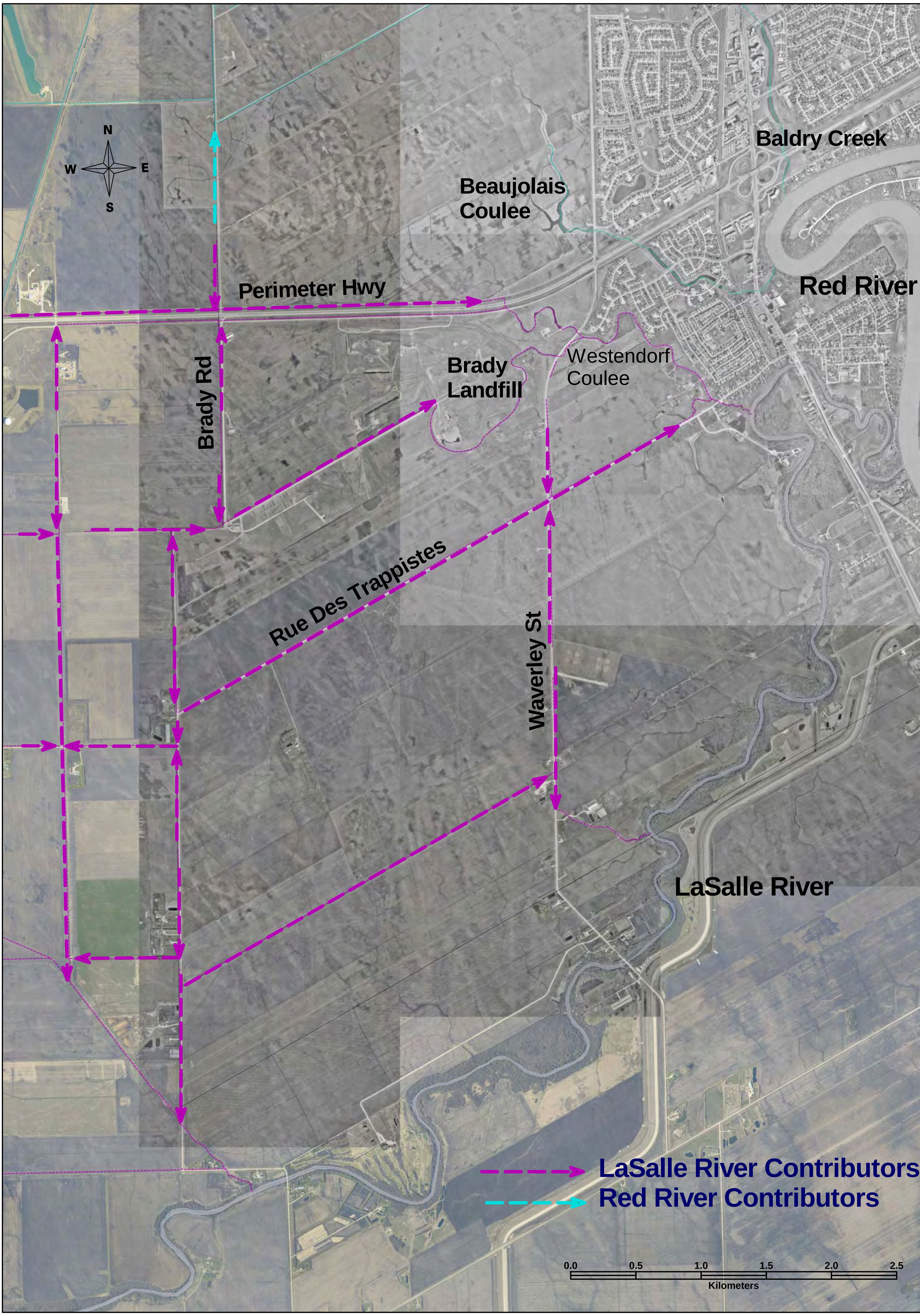
The La Salle River, at its nearest extent, is located approximately 1,500 m south and east of the Brady Road Landfill facility. The La Salle River watershed contains flat to rolling terrain, and drains in an easterly direction from its headwaters east of Portage La Prairie, Manitoba, to its outlet at the Red River, south of St. Norbert, Manitoba. The La Salle River has a gross drainage area of approximately 2400 km^2 at the point where it enters the Red River.

Analysis of the available streamflow data in the La Salle River (Table 5-6) indicates that streamflow varies considerably monthly (and from year to year); annual streamflow usually peaks in April during the spring freshet; on average, and 70 to 75% of the annual runoff volume occurs from the beginning of March to the end of May. The La Salle River experiences periods of zero flow, and as a result is classified as an intermittent stream.

Table 5-6: La Salle River Near Sanford (05OG001) Monthly Discharge (m^3/s)

Month	J	F	M	A	M	J	J	A	S	O	N	D	Annual (dam^3)
MIN	0	0	0	0	0	0	0	0	0	0	0	0	4,980
MEAN	0	0	1	16	6	1	2	1	0	0	0	0	79,980
MAX	0	0	14	55	49	12	54	15	3	11	3	1	291,470

Source: LSRCD 2007



Map of LaSalle River Contributing Drains in the St Norbert Area

1998 City Aerial
2009 Rural Aerial
Created January 26 2011
O:\Land Drainage\minor creeks and drains\La Salle
G:\Geoworkspaces\AD_LaSalle_DrainsMap2011_01_26.gws

Figure 5-13

5.1.5.2 Surface Water Quality

5.1.5.2.1 Site Runoff to Westendorf Coulee

Surface-water chemistry and surface-water flow at the Brady Landfill have not been fully characterized to date. Historically, there were few attempts to collect either chemistry data or flow rates from the site. Starting in 2010, a focused effort was implemented to remedy these gaps in understanding.

Samples have been collected from two sites (Figure 5-14) on several separate occasions (Tables 5-7 and 5-8). Not all identified variables were measured for each set of samples, so there are data gaps throughout the set of data. Variables included basic water chemistry, nutrients, a number of cations, major anions, and coliform bacteria (not all shown). The cations during some sample events were reported only as Totals. (This is a problem when describing surface water chemistry, because even a small amount of particulate matter can significantly alter the analytical results.)

The surface water at the landfill site is typical of water found in the region. The water is hard to very hard, with an alkaline pH and the majority of alkalinity in the form of bicarbonate (Tables 5-7 and 5-8). The nutrient status of the surface water is uncertain. For nitrogen, only TKN was analyzed (data not shown), so there is no information on nitrate. Phosphate was also not analyzed, and the phosphorus analysis was measured to only one decimal place.

Major constituents are highly variable, both temporally and spatially. Sodium varies from 4.5 to 121 ppm, calcium from 34 to 179 ppm, and magnesium from 14 to 108 ppm (Tables 5-7 and 5-8). Downstream concentrations are consistently greater than upstream concentrations, with median ratios recorded between 1.0 and 2.0X. This suggests that at least part of the variability in the data is caused by dissolution of ionic and organic constituents as the water moves across the site.

Despite the limited amount of data, chemistry of the surface water discharged from the Brady Road Landfill is generally typical of waters found in the Red River basin. Site runoff does not contain elevated concentrations of common inorganic contaminants of concern. The chemical characteristics of the surface runoff is generally within the overall baseline conditions found downstream in the La Salle River (see Section 5.1.5.2.2 below).

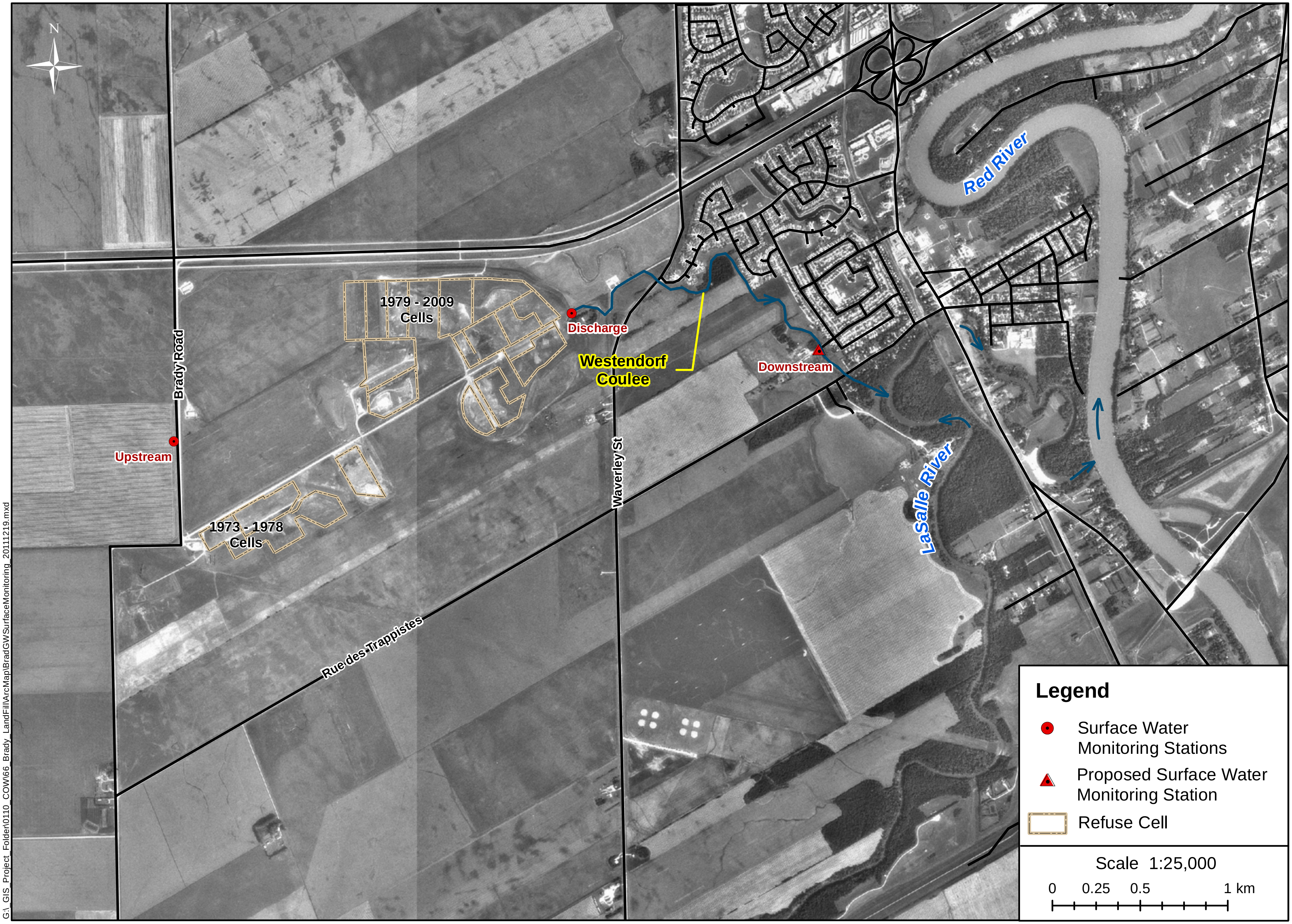


Figure 5-14. Surface Water Monitoring Network at Brady Road Landfill

Table 5-7: 2010 Surface-Water Chemistry for the Brady Landfill

Analyte	SW-25-1 (upstream)		SW-25-2 (downstream)		Downstream/ upstream Ratio	
	28-Apr	3-Jun	28-Apr	3-Jun	28-Apr	3-Jun
Alkalinity, HCO3 (mg/L CaCO3)	272	92	370	128	1.4	1.4
Hardness, Total (mg/L CaCO3)	290	102	566	135	2.0	1.3
pH	7.7	7.5	7.7	7.6	1.0	1.0
TOC (mg/L)	17	19	29	17	1.7	0.9
Turbidity (NTU)	0.76	210	12	148	15.7	0.7
Conductivity (µS/cm)	584	256	1360	335	2.3	1.3
Arsenic (As) - Total (mg/L)	0.004	0.005	0.006	0.005	1.5	1.0
Calcium (Ca) - Total (mg/L)	60	34	82	34	1.4	1.0
Chromium (Cr) - Total (mg/L)	0.002	0.002	0.003	0.002	1.5	1.0
Iron (Fe) - Total (mg/L)	0.03	0.49	0.28	0.3	9.3	0.6
Potassium (K) - Total (mg/L)	12	17	21	13	1.8	0.8
Magnesium (Mg) - Total (mg/L)	39	14	108	16	2.8	1.2
Manganese (Mn) - Total (mg/L)	0.031	0.027	0.516	0.023	16.6	0.9
Sodium (Na) - Total (mg/L)	21	4.5	102	7.3	5.0	1.6
Nickel (Ni) - Total (mg/L)	0.003	0.006	0.012	0.005	4.0	0.8
Median					**2.0**	**1.0**

Table 5-8: 2008 Surface-Water Chemistry for the Brady Landfill

Analyte	SW-25-1 (upstream)		SW-25-2 (downstream)		Downstream/ upstream Ratio	
	28-Apr	3-Jun	28-Apr	3-Jun	28-Apr	3-Jun
Alkalinity, HCO3 (mg/L CaCO3)	124	252	137	376	1.1	1.5
Hardness, Total (mg/L CaCO3)	133	288	166	502	1.2	1.7
pH	7.8	7.6	8.0	7.5	1.0	1.0
Turbidity (NTU)	23	2	27	5.4	1.2	2.7
Conductivity (µS/cm)	323	712	393	1440	1.2	2.0
Calcium (Ca) - Total (mg/L)	68	126	82	179	1.2	1.4
Chromium (Cr) - Total (mg/L)	0.003	0.001	0.005	0.004	1.7	4.0
Sodium (Na) - Total (mg/L)	14	36	19	121	1.4	3.4
Median					**1.2**	**1.9**

5.1.5.2.2 La Salle River

Considerable amounts of water-chemistry data have been collected for the La Salle River by the Province of Manitoba from a variety of locations. At least since 1984, water samples have been collected at the La Barriere Park Dam, just west of St. Norbert. The data indicate that water chemistry within the La Salle River is highly variable from year to year, but also seasonally, as the flow within the river changes (Table 5-9). During the spring freshet, the various analytes found within the river are at relatively low concentration (Table 5-9) due to excessive dilution. As the flow decreases, concentrations of most analytes increases, such that for many analytes there is an approximately three-fold difference in concentration between the spring and winter periods (Table 5-9).

Table 5-9: La Salle River Water Chemistry at La Barrier Park (1984-2010)

Analyte (mg/L)	Category	Yearly	Spring	Summer	Fall/Winter
Calcium	MAX	131	85	90	131
	MED	57	33	42	84
	MIN	13	13	29	40
Magnesium	MAX	72	40	41	72
	MED	30	16	22	43
	MIN	7	7	11	18
Hardness	MAX	699	185	434	625
	MED	267	128	183	386
	MIN	60	60	119	172
Alkalinity	MAX	530	237	407	517
	MED	232	99	173	299
	MIN	49	49	110	178
pH	MAX	9.0	8.7	9.2	8.4
	MED	7.8	7.7	7.9	7.7
	MIN	7.1	7.1	7.4	7.2
Sodium	MAX	162	45	45	162
	MED	44	16	30	81
	MIN	5	5	5	33
Potassium	MAX	18	22	14	17
	MED	12	10	11	14
	MIN	7	7	8	10
Sulfate	MAX	256	80	107	256
	MED	71	40	51	134

Table 5-9: La Salle River Water Chemistry at La Barrier Park (1984-2010)					
Analyte (mg/L)	**Category**	**Yearly**	**Spring**	**Summer**	**Fall/Winter**
	MIN	8	8	11	32
Chloride	MAX	288	232	219	288
	MED	64	22	46	144
	MIN	6	6	6	45

The seasonal difference can be summarized through examination of electrical conductivity, which is a general measure of the total ionic concentration in a water body. During the spring freshet, median conductivity was measured at 390 uS/cm (Figure 5-15). This increased to approximately 1270 in the fall/winter period (Figure 5-15). The cause of this seasonal variability may be infiltration of groundwater into the river. As the relative proportion of groundwater to total flow increases, the overall ionic strength of the water within the river also increases.

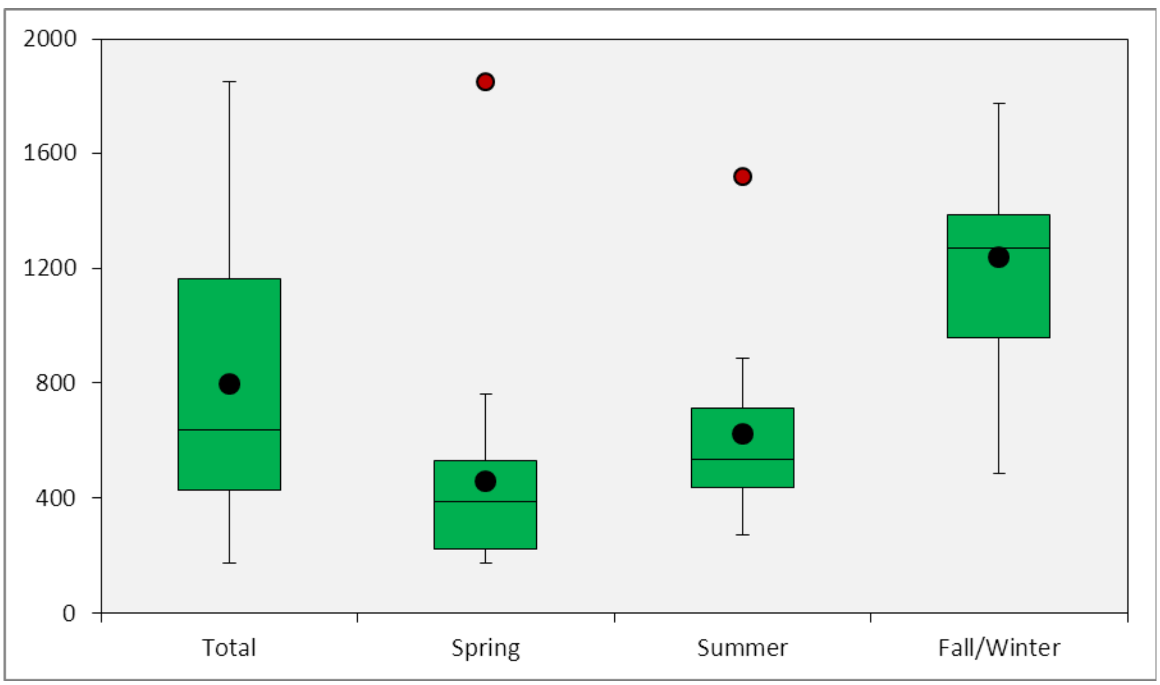


Figure 5-15: Electrical Conductivity (uS/cm)

The La Salle River is a highly buffered, alkaline river, with a median total alkalinity of 232 mg/L $CaCO_3$, and a median pH of 7.8 (Table 5-9). The river contains hard, to very hard water, with median total hardness estimated at 267 mg/L $CaCO_3$ (Table 5-9). Substantial amounts of sodium, and potassium are also present, such that the chemistry is dominated by neither divalent (Ca, Mg) nor monovalent (Na, K) cations. The anions sulfate and chloride are both present in high and variable amounts (Table 5-9). It is of interest to note that both chloride and sulfate concentrations at times exceed water-quality guideline limits.

The La Salle River watershed is heavily influenced by agricultural activity (Smith *et al.*, 1998). This watershed activity potentially releases both pesticides and nutrients into the river. A recent report (LSRCD, 2007) has indicated that concentrations of Dicamba and MCPA exceed guideline limits when detected. Both Dicamba and MCPA are herbicides commonly used to control broadleaf weeds on agricultural land or road and utility right of ways. Dicamba can enter surface waters through spills, aerial drift, improper disposal methods, and direct overspray of water bodies during application. Dicamba is very soluble in water and run-off from adjacent cropland is another pathway into the aquatic environment. The recent report, written by the La Salle Redboine Conservation District, found that Dicamba was detected in 36% of samples, while MCPA was detected in 16% of samples (LSRCD, 2007).

The La Salle River contains high and elevated concentrations of both phosphorus and nitrogen, and is classified as a eutrophic to hypereutrophic river. The data collected from the site at La Barrier Park Dam indicated a median concentration of Total Phosphorus greater than 400 ug P/L. In comparison, lakes are considered hypereutrophic at a mean concentration of approximately 100 ug P/L. In addition, both nutrients have been increasing in the La Salle River at least since the early 1970's. Jones and Armstrong (2001) demonstrated that total phosphorous concentrations have increased by over 194%, while total nitrogen concentrations have increased by 146% over the time period from 1973 to 2000.

In the La Salle River, oxygen consumption during the winter greatly exceeds production and anaerobic conditions can occur (LSCRD, 2007). Oxygen concentrations may also decrease in summer. While summer dissolved oxygen concentrations throughout the La Salle River are generally above the Manitoba Surface Water Quality Objective for the protection of aquatic life, oxygen depletion does occasionally occur (LSCRD, 2007).

5.2 BIOPHYSICAL ENVIRONMENT

5.2.1 Aquatic Environment

5.2.1.1 Fish and Fish Habitat

In areas immediately adjacent to the facility, including municipal roadside ditches and the Westendorf Coulee headwaters, fish habitat is considered suboptimal. These surface waterbodies are considered to provide indirect or "Type E" fish habitat, that is incapable of directly supporting fish life stages, such as spawning or rearing (DFO, 2007; Schwartz, *pers. comm.*, 2011).

Similar to the La Salle and Red rivers, the reach of Westendorf Coulee east of Waverley Street towards its outlet at the La Salle River, provides optimal “Type A” fish habitat that is considered complex and capable of supporting indicator sport fish species, such as pike, walleye and suckers (Schwartz, *pers. comm.,* 2011).

An inventory of fish species known or anticipated to occur within nearby surface waters is presented in Table 5-10. A total of 52 species have been identified as potentially occurring within nearby surface waters. Species common to all three surface water bodies are the common carp, northern pike and white sucker. A total of four species at risk may occur within nearby surface water bodies – bigmouth buffalo (Special Concern, Schedule 1; Red River), chestnut lamprey (Special Concern, Schedule 3; Red River), lake sturgeon (Endangered - COSEWIC; Red River), and silver chub (Special Concern, Schedule 1; Red River).

Table 5-10: Fish Species Known or Anticipated to Use Nearby Surface Waters, Brady Road Landfill

Fish Species		Status	Waterbody		
Common Name	**Scientific Name**		**Red River[1]**	**La Salle River[2]**	**Westen-dorf Coulee[3]**
Bigmouth buffalo	*Ictiobus cyprinellus*	SC	X	?	
Black bullhead	*Ameiururs melas*		X		
Black crappie	*Promoxis nigromaculatus*		X	X	
Blackside darter	*Percina maculate*		X		
Brook stickleback	*Culaea inconstans*		X		X
Brook trout	*Salvelinus fontinalis*		X		
Brown bullhead	*Ameiurus nebulosus*		X		
Brown trout	*Salmo trutta*		X		
Burbot	*Lota lota*		X		
Central mudminnow	*Umbra limi*		X	X	
Channel catfish	*Ictalurus punctatus*		X		X
Chestnut lamprey	*Icthyomyzon castaneus*	SC	X	?	
Cisco	*Coregonus artedi*		X		
Common carp	*Cyprinus carpio*		X	X	X
Creek chub	*Smotilus atromaculatus*		X		
Emerald shiner	*Notropis atherinoides*		X	X	
Golden redhorse	*Moxostoma erythrurum*		X		
Golden shiner	*Notemigonus crysoleucas*		X		

Table 5-10: Fish Species Known or Anticipated to Use Nearby Surface Waters, Brady Road Landfill

Fish Species		Status	Waterbody		
Common Name	**Scientific Name**		**Red River[1]**	**La Salle River[2]**	**Westen-dorf Coulee[3]**
Goldeye	*Hiodon alosoides*		x		X
Goldfish	*Carassius auratus*		X		
Johnny darter	*Etheostoma nigrum*		X		
Lake sturgeon	*Acipenser fulvescens*	End.	X		
Lake whitefish	*Croegonus clupeaformis*		X		
Largemouth bass	*Micropterus salmoides*		X		
Logperch	*Percina carpodes*		X		
Longnose dace	*Rhinichthys cataractae*		X		
Mooneye	*Hiodon tergisus*		X		
Northern pike*	*Esox lucius*		X	X	X
Quillback	*Sarpiodes cyprinus*		X		
Rainbow trout	*Oncorhynchus mykiss*		X		
River darter	*Percina shumardi*		X		
River shiner	*Notropis blennius*		x	X	
Rock bass	*Ampbloplites rupestris*		X	X	
Sauger	*Sander canadensis*		X		
Shorthead redhorse	*Moxostoma macrolepidotum*		X		X
Silver chub	*Macrhybopsis storeiana*	SC	X	?	
Silver lamprey	*Ichthyomyzon unicuspis*		x		
Silver redhorse	*Moxostoma anisurum*		X	X	
Smallmouth bass	*Micropterus dolomieu*		X		
Spotfin shiner	*Cyprinella spiloptera*		X	X	
Spottail shiner	*Notropis hudsonis*		X		
Stonecat	*noturus flavus*		X		
Tadpole madtom	*Noturus gyrinus*		X	X	
Troutperch	*Percopsis omiscomaycus*		X		
Walleye	*Sander vitreus*		X	X	
Western blacknose dace	*Rhinyichthys obtusus*		X		
White bass	*Morone chrysops*		X	X	
White bass	*Morone chyrsops*		X		

Table 5-10: Fish Species Known or Anticipated to Use Nearby Surface Waters, Brady Road Landfill

Fish Species		Status	Waterbody		
Common Name	Scientific Name		Red River[1]	La Salle River[2]	Westen-dorf Coulee[3]
White crappie	*Pomoxis annularis*		X		
White sucker	*Catostomus commersoni*		X	X	X
Yellow perch	*Perca flacescens*		X		

[1]Source: Stewart and Watkinson, 2007
[2]Source: Graveline and Larter, 2006
[3]Source: City of Winnipeg, 2005
SC - Special Concern (*Species at Risk Act* – SARA)
End. –Endangered (Committee on the Status of Endangered Wildlife in Canada – COSEWIC)

5.2.2 Terrestrial Environment

The Brady Road Landfill is located within the Winnipeg Ecodistrict of the Lake Manitoba Plain Ecoregion. Wildlife characteristic of this ecoregion include white-tailed deer, coyote, rabbits, ground squirrels and waterfowl (Smith *et al.,* 1998).

White tailed deer are common in the vicinity of the facility and in general in southern Manitoba. Despite the presence of a 2.5-m fence around the facility perimeter, deer are known to jump fences from 8-10 ft (2.4-3.1 m) in height (Palmer *et al.*,1985; Hall, 1999). Although potential forage vegetation is scarce within the facility, white-tailed deer have been observed in the area are likely to be transitorily present through the year.

Waterfowl including ringbilled gulls, Franklin gulls, Canada geese, mallards, blue-wing teal and gadwall have been observed throughout various areas of the facility on a seasonal basis. Gulls, particularly ringbilled gulls, will scavenge organic material in areas where refuse is readily available. Canada geese have been noted using seasonally ponded water in the north-western grassy areas. A small pond near the southern boundary of the facility has minimal edge vegetation and is therefore unsuitable breeding habitat for many species of waterfowl. However, mallard, blue-winged teal and gadwall ducks could potentially raise broods near this pond or along the associated ditch that runs southwest of the waterbody, with less predation risk due to the fence around the facility perimeter.

In grassy areas of the facility that are not currently part of the active landfill, small mammals such as mice, voles, squirrels and rabbits and birds including sparrows, horned and meadow larks, killdeer and wrens are likely to find forage and/or find cover within the grasslands. These herbivores and their young are potential prey for raptors, snakes and weasels that can cross the fence bordering the facility.

5.2.2.1 Ponds

With the exception of seasonal standing water in basins and grassy areas, the site supports three small ponds south of the landfilling area. One waterbody is shallow, has minimal reeds and cattails around its edge and is, during periods of high water, linked to a municipal ditch to the southwest. There are no fish populations resident in these ponds. Two additional ponds have recently been constructed of sufficient depth to collect non-contaminated surface water from the site to provide a fire-water source. These ponds may also be used in the future to wash sand reclaimed from City streets for reuse in sanding (Section 9.3). All ponds on-site will drain to the municipal ditch flowing to the La Salle River through a new engineered wetland (Section 9.6).

5.2.2.2 Endangered Habitat

According to the Manitoba Conservation Data Centre, no records for recent detections of endangered plant or animal species exist for the City-owned lands that constitute the facility (Friesen *pers. comm.,* 2011).

5.3 SOCIOECONOMIC ENVIRONMENT

5.3.1 Zoning

The Brady Road Landfill is designated as a “Rural and Agricultural Area” in Complete Communities, an OurWinnipeg Direction Strategy (Figure 1-3). The lands are zoned ‘A’ Agricultural in the City of Winnipeg Zoning By-Law 200/06, which allows landfills as a conditional use. The landfill will be rezoned with a Plan Development Overlay to more appropriately reflect the land uses of this site.

Lands south and east of the landfill are designated “Rural and Agricultural Area” and zoned Agricultural except for the lands designated Recent Communities southeast of the Waverley/P.T.H. 100 intersection as shown on the Urban Structure in Complete Communities (Figure 1-4). These Recent Communities lands are zoned ‘R1-M’ Residential-Single Family. The area east of Waverly, north of Rue de Trappistes is designated as a New Community and is currently zoned ‘A’ Agricultural.

Lands northeast of the Waverley/P.T.H. 100 intersection are designated Recent Communities and zoned ‘RR5’ Rural Residential and ‘R1-M’ Residential-Single Family.

The lands northwest of the Waverley/P.T.H. 100 intersection are designated Recent Communities and are zoned as an “R1-M” Residential Single-Family (Medium) District, an “RMF-S” Residential Multi-Family (Small) District, an “RMF-M” Residential Multi-Family (Medium) District, a “PR1” Parks and Recreation 1 (Neighbourhood) District, a “C2” Commercial Community District and a “C3” Commercial Corridor District respectively (BY-LAW NO. 82/200 amended 137/2009). A significant portion of lands NW of Waverley & the Perimeter are zoned

"A" Agricultural, but are part of the Waverley West development. They will be developed in future phases as a mix of residential, commercial and employment uses.

Lands to the west of the landfill are in the R.M. of Macdonald. Lands are zoned Agricultural General Zone in By-Law 15/95. In the Macdonald Ritchot Planning District Development Plan, the lands are designated Rural "Green Zone."

5.3.2 Surrounding Land Use

An overview of surrounding land uses within a 1500 m radius of the facility is presented in Table 5-11. Open land is the primary land use within the large future storage capacity area located within City-owned land associated with the facility along Rue des Trappistes. Recently, additional adjacent land uses have been expanded to include the Waverley West Subdivision north of the facility and the relocation of the Southwood Golf Course east-southeast of the facility.

Table 5-11: Land Use Within 1,500 m of Brady Road Landfill

Receptor	Approximate Distance from Landfilled Material	Direction
Richmond Lakes Residential Subdivision	700 m	E / NE
CBC Communication Tower (and associated small building)	900 m	SE
Parc La Salle Residential Subdivision	1,000 m	E / NE
Richmond West Subdivision	1,200 m	NE
Rural Residences	>1,200 m	W / S / SW
Baseball Diamond (8) Complex	1,600 m	S / SE

5.3.3 Populations and Demographics

The facility is located within the City of Winnipeg, the largest urban area in the Province of Manitoba. Based on the Canadian Census, the City's population in 2006 was 633,451, with 48.3% male and 51.7% female residents. Just over 24% of residents were 19 years old or younger, 27.4% were between 20 and 39 years old, and 29.5.0% were between 40 and 59 years old, 22.6% were between 50 and 79 years old and 5.5% were 80 years and older. The average age of residents of the City in May 2006 was 38.7, compared to an average of 38.1 years in Manitoba. The population density of the City averaged 1,365.2 individuals per square kilometer compared with an average of 2.1 for the Province of Manitoba. In 2009, the population of the City was estimated at 672,000 (City of Winnipeg, 2011a).

Over the last 10 years, the City's population has grown by over 44,000 people; 9,200 in 2009 alone (Statistics Canada, 2010). This growth is driven primarily by increased levels of immigration and a combination of fewer people leaving and more people coming from other parts of the country. The Conference Board of Canada is projecting even stronger population growth for the City in the coming years, increasing to over 10,000 people per year over the period of this plan. Approximately 180,000 new people are anticipated to make the City their home by 2031, increasing the population to an estimated 837,000.

The most proximal rural municipality (RM) is the RM of Macdonald, located west of Brady Road. Between 2001 and 2006, the RM of Macdonald experienced a 1.9% growth in population (Statistics Canada, 2006). Based on the Canadian Census, the 2006 population within the RM was 5,655, with 48.8% female and 51.1% male residents. Just over 32% of residents were 19 years old or younger, 22.5% were between 20 and 39 years old, and 32.0% were between 40 and 59 years old, 11.5% were between 50 and 79 years old and 1.7% are 80 years and older. The average age of residents of the RM of Macdonald in May 2006 was 36.7, compared to an average of 38.1 years in Manitoba. The population density of the RM of Macdonald averaged 4.9 individuals per square kilometer compared with an average of 2.1 for the Province of Manitoba.

5.3.4 Infrastructure

An overview of area infrastructure and its associated setback distance from the facility property line is provided in Table 5-12.

Table 5-12: Non-facility Infrastructure Located Within and Adjacent to the Brady Road Landfill

Infrastructure	Approximate Setback	Comments
PTH 100 (Perimeter Highway)	60 m	
PTH 100 Service Road	20 m	
Waverley Street	20 m	
Rue des Trappistes	15 m	
Brady Road	20 m	
Transcanada Pipeline	0 m	
Manitoba Hydro Substation	240 m	Located across southern half of facility, in open area.
Communication Towers	115 m	Located at the southwest corner of the Rue des Trappistes and Waverley Street intersection.
PTH 75	1.8 km	

Table 5-12: Non-facility Infrastructure Located Within and Adjacent to the Brady Road Landfill		
Infrastructure	**Approximate Setback**	**Comments**
Provincial Road (PR) 330	1.3 km	
Railway	1.6 km	Located west of PTH 75 and PR 330

5.3.5 Protected Areas

Three Provincial Parks lie within 10 km of the facility. Duff Roblin Provincial Park is approximately 5 km southeast and commemorates the establishment of a City flood control system. Our Abby or Our lady of the Prairies Provincial Wayside Park and the St. Norbert Provincial Heritage Park lie 2.5 and 3 km respectively east of the project site boundary. Our Abby or Our lady of the Prairies was a Trappist Monastery established in 1892. The St. Norbert Provincial Heritage Park commemorates Métis family life as it was during the late 1800s.

A Centennial Farm is located 2.4 km west of the facility.

5.3.6 First Nation Communities

There are currently no First Nation communities, lands or interests in the immediate vicinity of the Project Site.

5.3.7 Heritage Resources

A search of the Department of Manitoba Culture, Heritage and Tourism, Historic Resources Branch, Provincial Heritage Registry yielded no previously recorded archaeological sites within the City-owned lands comprising the Brady Road Landfill Facility (Docking, *pers. comm.,* 2011).

6.0 Public Consultation

The following is a description of landfill-specific public consultation activities undertaken as part of the Environmental Impact Assessment (EIA) process. There were a number of public-consultation activities undertaken as part of the CIWMP development process (Appendices E1-E3) which preceded the landfill-EIA-related-consultation process. This prior consultation helped scope the EIA, especially in defining relative priorities of public concerns needing attention.

Additional information regarding landfill-related public-consultation activities and outcomes is contained in the Moderator's Report (Appendix F), from which much of s. 6.1.1. is drawn, and the City's Brady Road Landfill Licensing Public Participation Report (Appendix E-4).

6.1 PUBLIC MEETING

The City and Stantec hosted a public meeting on October 27, 2011 at the St. Norbert Community Centre. Advertisements for the meeting were placed in the *Winnipeg Free Press* and the *Sou'wester* in advance (Appendix E-4). In addition, 6,200 direct invitations were sent to neighbouring residents as well as direct invitations to stakeholders, including the RM of Macdonald.

The meeting format consisted of presentations by the City and Stantec, followed by a question and answer period. In addition, input was sought at the meeting through a feedback form, with input also sought online for the same form on the City's "Speak Up on Garbage" webpage.

The City presented information on the past and current character of the landfill. Stantec outlined findings about the type and significance of environmental effects evident after almost 40 years of landfill operation, and the effects expected from future landfill configuration and operations (i.e., the results of the EIA). The City concluded the formal presentation providing further detail about the implications of the new Master Plan and draft Operating Plan (Appendix G) on the landfill's future layout and activities.

It is estimated that more than 140 people attended, most of them living in proximity to the facility. When asked, the majority had visited the Brady site. The audience was attentive to the presentations and participated in a Question and Answer period in a very orderly manner. Various television, radio and print media also attended.

6.1.1 Question and Answer Period

The following topics were raised by meeting attendees:

- Concerns were identified respecting unpleasant odours that nearby residents experienced in the warmer months, especially "more recently," that have interfered with their enjoyment of the outdoors (Questions 1-5, Appendix E-4). Measures to address the problem, and an explanation of the causes, appeared to be understood and well received (Photo 7).

- The need for convenient public drop-off and recycling centres across the City was noted to address the concern about illegal dumping (Question 9, Appendix E-4). The audience appeared pleased that such facilities were part of the new CIWMP Master Plan (Photo 1-7).
- A question was asked concerning the treatment of the collected leachate (Question 7, Appendix E-4). Concern about leachate implications for groundwater quality was raised. The option of on-site treatment, to reduce or preclude haulage to the City's North End Treatment Plant, was suggested. The discussion in reply appeared to be helpful to the questioner.
- The operating cost of the planned changes was questioned (Question 18, Appendix E-4). Several wanted to know how the site's planned improvements and enhanced operations were to be funded.
- A question was asked respecting the possible reduction of property values due to the operation of the site (Question 23, Appendix E-4). Information provided to explain the absence of such an impact (e.g., high market demand for new homes north of the landfill) seemed to be reassuring.
- The future size of the landfill, the possibility of "surplus lands" being sold, and the possible need for another landfill in future decades, was of interest (Questions 22 and 24, Appendix E-4). The direct answer indicating this would not happen was appreciated.
- The City's ability to conduct larger-scale composting without unpleasant odours was challenged (Question 3, Appendix E-4). The audience appeared to accept the City's assertion of two decades of nearly complaint-free composting at the landfill. The City noted its commitment to investigate any complaint, and urged use of its telephone "311" information number (e.g., to create documentation of the complaint).
- One individual offered the opinion that material from the site could be used for dyke construction to create further flood protection for the City of Winnipeg (Question 16, Appendix E-4). The City referred to the absence of flooding impact on the landfill even during the 1997 Flood. The City declined to commit use of the landfill for any form of floodproofing.
- Impact of long-term operations on groundwater quality was of interest (Questions 7 and 8, Appendix E-4). The finding of 'acceptable' concentrations of leachate residue in groundwater was challenged by one person.
- Interest was expressed in possible access changes to the site (Question 20, Appendix E-4). Reference was made by the City to the current study by Manitoba Infrastructure and

Transportation of new signalized intersections on the south Perimeter Highway, which could cause new access to the site.

- The handling of dead animal waste was raised. Routine management procedures were explained by the City.
- A concern respecting human health risk was identified (Questions 4, 5, 7 and 8, Appendix E-4). The response (about low rates of respiratory disease in the nearest community) seemed to be accepted by the audience.
- A concern about the City allowing continuing residential development in proximity to the landfill was noted (Question 4, Appendix E-4).
- Concern about the time needed to introduce kitchen-waste collection and composting was raised (Question 14, Appendix E-4).
- There was clear interest in the information on the recycling of wood into the building board and the description of providing bicycles to inner city children yielded a very positive reaction.

There was general acceptance of the responses offered. Challenge to the findings of the environmental assessment was modest. No fundamental criticism of either the Master Plan or the vision for the landfill was expressed. No concerns about landfill fires were expressed.

There appeared to be a clear understanding that change was needed and the City must move forward in its Brady plans. An interest in positive change seemed widely present in the room. The change to the pick-up carts for waste and recycle recently agreed to by the City was well handled by the City and did not receive any challenge.

Of note was the observation that no one proposed or demanded that the site be moved elsewhere. There was only one related question in regard to the current location (Question 9, Appendix E-4)

Management approaches elsewhere in Canada were identified by the City and Stantec illustrating how proposed changes at the landfill to reduce impacts would be consistent with Best Practice across the country.

6.1.2 Feedback

To solicit feedback on Brady Road Landfill and the findings of the environmental impact assessment, a form (Appendix A in Appendix E-4) was provided to public meeting attendees and made available to the general public online through the City's "Speak Up on Garbage" webpage. A total of 87 responses to the form were received, 68 from meeting attendees and 19 subsequently from online respondents.

With regard to proposed changes to the future operation of Brady Road Landfill, 94% of respondents indicated it would affect them in some way, with 54% of the total respondents indicating it would affect them a lot (Figure 6-1). The overall effect of these changes w indicated to be positive by the majority (80%) of respondents (Figure 6-1; City of Winnipeg 2011).

When asked about the satisfaction with the public meeting, the majority (90%) of respondents (n=68) were "satisfied" with the meeting, with "43%" of the total respondents "very satisfied".

Figure 6-2 illustrates the breakdown of open-ended responses received at the end of the feedback form. Odour concerns, followed by composting concerns and suggestions, followed by litter and illegal dumping concerns and support for the meeting or future initiatives, were the most prevalent responses received.

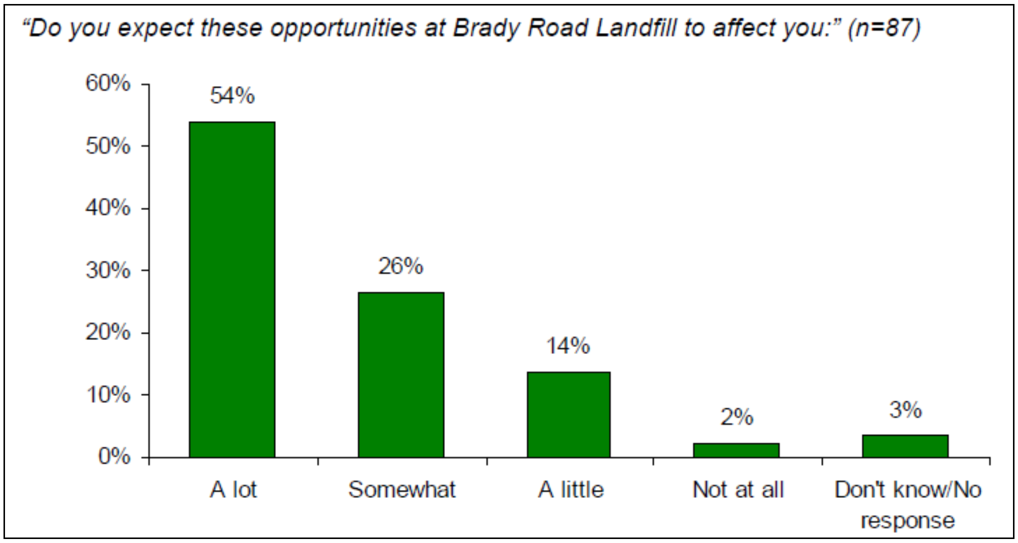
Review of the public feedback to the City during the CIWMP process that bears upon diversion targets, and implications on landfill operations, suggests either:

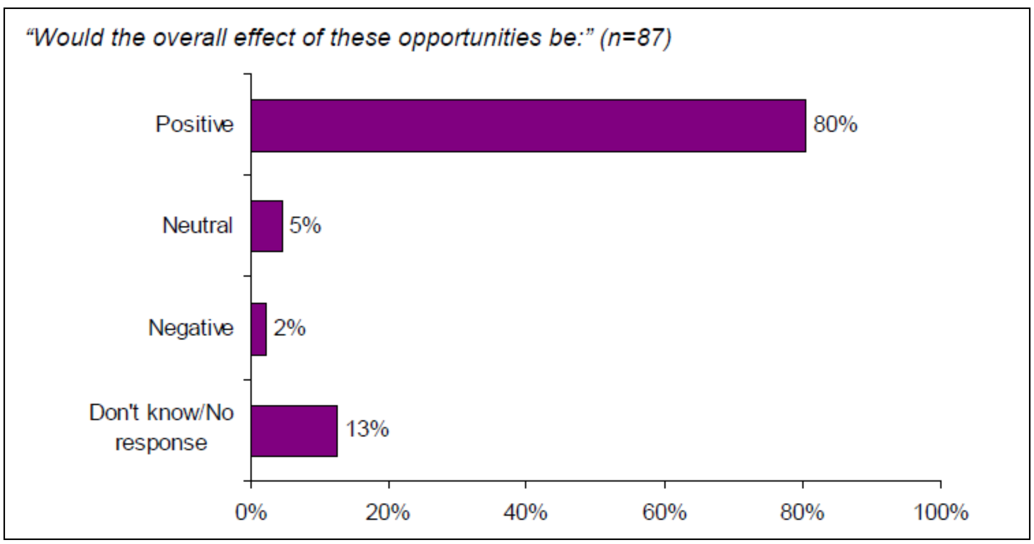
- A lack of public concern (e.g., 32% of 1,664 phone-survey respondents; p. 8 in Appendix E-4); or

- High levels of support for the City's focus on diversion to reduce recyclables being buried at the landfill (90% of 300 web-based survey responses; p. 8 in Appendix E-4).

Public concerns expressed about litter and odour totaled 12% and 7% of 1,664 phone-survey respondents, and 14% and 11% of 300 web-survey respondents. At the Public Meeting, response to litter and odour concerns was noted in 9% and 13% of the forms submitted. This appears to suggest that people living near to the site are more sensitive to odour, versus litter, than respondents from the entire City. Public support at the Public Meeting for all the measures planned to divert recyclables, reduce burial of organics, and manage litter and odour generation better totaled 88% (p. 14, Appendix E-4).

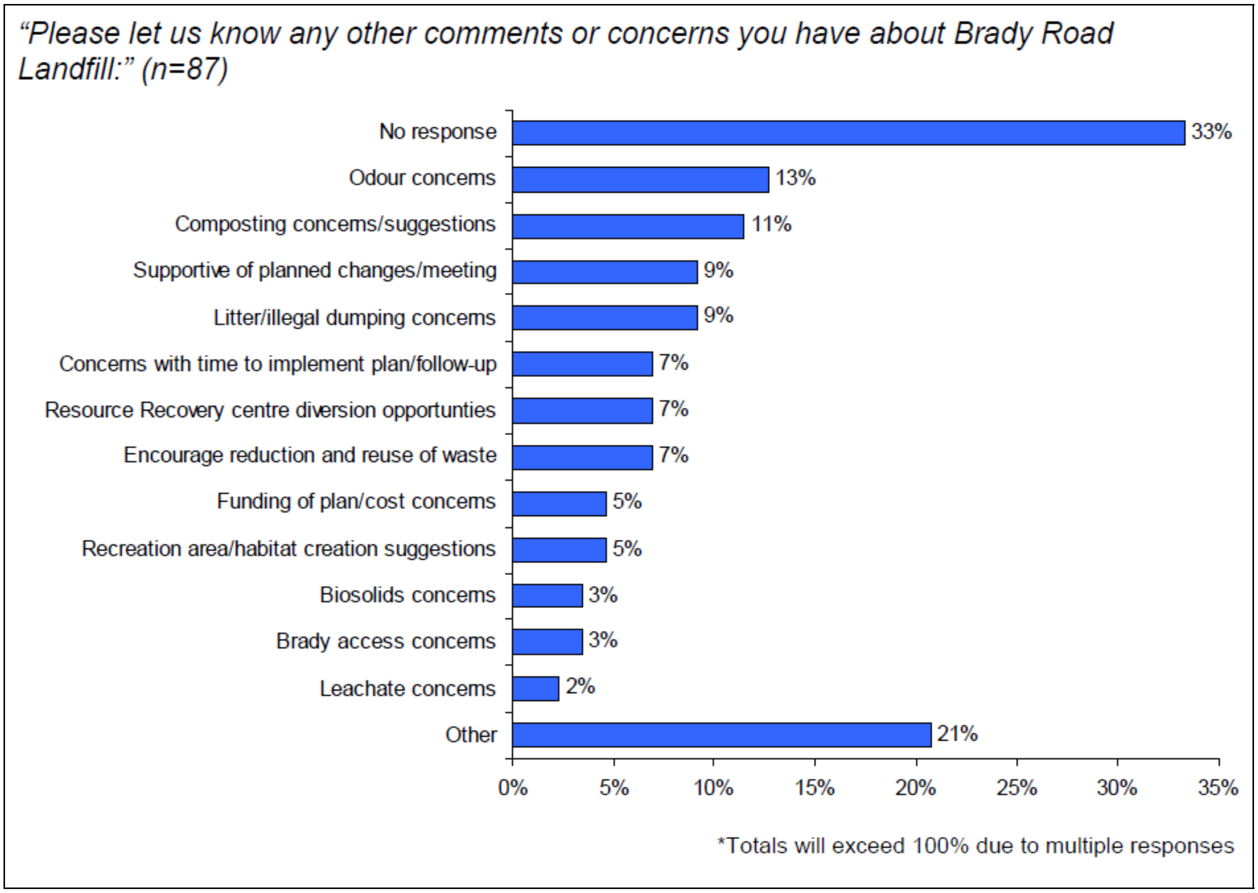
Figure 6-1: Public Responses Regarding Effects of Proposed Changes to Brady Road Landfill





(Source: City of Winnipeg, 2011b)

Figure 6-2: Open-ended Feedback from the Public, by Topic



(Source: City of Winnipeg, 2011b)

7.0 Approach to Environmental Impact Assessment

On the basis of the findings of the Phase 1 Environmental Licensing Plan (ELP; Stantec 2011d), and through dialogue with Manitoba Conservation, the following approach to the design and execution of the EIA was developed:

7.1 OBJECTIVES

The objective of the EIA was to complete an Environmental Impact Assessment (EIA) acceptable to Manitoba Conservation, City Council and stakeholders able to credibly support the City's application for an *Environment Act* licence.

7.2 GUIDING PRINCIPLES OF THE EIA

In response to the findings of the Phase 1 ELP, and guidance received from Manitoba Conservation, a suite of 'guiding principles' were developed to set out how the objectives could be met. These principles follow below:

- Definition of "the development" will include the landfill as it is, and as it will be, given the implementation of the Comprehensive Integrated Waste-Management Plan (CIWMP).
- Definition of "the development" will include the site, current and future Standard Operating Procedures (SOPs) in the new draft Operating Plan (Appendix G), future collateral developments on the site (e.g., possible "Industrial Park"), current and future site-specific monitoring, any ongoing Research and Development (R&D) program(s), and the City's commitment to public disclosure and accountability.
- The EIA will be comprehensive and technically sound.
- The EIA will satisfy requirements of the statute, and regulations and (as applicable), be consistent with regulatory precedents.
- The EIA will examine consequences of both typical and upset operating conditions, as guided by Manitoba Conservation.
- The assessment team will include recognized external authorities (e.g., Mr. Chris Neville of S.A. Papadopulos & Associates [Waterloo] regarding hydrogeology, and Dr. Tony Sperling of Sperling Hansen Associates [North Vancouver] regarding landfill design and emergency response planning, etc.).
- The EIA process will include provisions for meaningful public engagement.
- As appropriate, predictive tools will be used to simulate future operating conditions and associated impacts.

- The assessment of future impacts will emphasize the projected increments over, or decreases from, those apparent under the current (i.e., “baseline”) condition:
  - The assessment will seek to determine whether the ‘envelope’ of current permitted effects expands, remain unchanged, or contracts because of projected (i.e., CIWMP-related changes in waste composition and mass, and projected landfill configuration, operations and impact-prevent or -mitigation measures.
- A detailed Human Health Risk Assessment consistent with standard practice in the EIA industry is unnecessary for this case, given the absence of human-health concerns after more than three decades of landfill operations.
  - Review of the potential for future human-health impacts will occur by means of statistical analysis of health records and retention of independent expertise (Manitoba CancerCare) to explore the potential for longer-term impacts of past operations on health indices in census districts immediately adjacent to, and further away from, the landfill.

7.3 ASSESSMENT FOCUS

Consideration of the Table of Contents of this EIA indicates that a comprehensive range of subjects has been addressed. The reader will note, however, that different potential effects of current or future landfill operations have been addressed with different degrees of focus. Such differences of focus arise from a combination of:

- Stantec’s professional opinions about the relative importance of some potential landfill effects versus others, based on extensive relevant prior experience.
- Guidance received from Manitoba Conservation by the City of Winnipeg regarding assessment of the Brady Road Landfill.
- Public commentary received by the City during its consultation programming for development of the CIWMP.
- Comments received at the October 27, 2011 Public Meeting regarding the future Brady Road Landfill.
- The fact that some sources of potential impact at the landfill are being addressed by parallel processes having potential to preclude or minimize such potential impact sources:
  - For instance, the odour-related impacts of the City’s recent policy change to bury biosolids with waste at the landfill may be reduced or obviated by the City’s parallel process of evaluating and prioritizing biosolids-management options (Tetr*ES*

Consultants, 2009a), especially in consideration of their greenhouse-gas-emissions potential (Stantec, 2011b).

The potential impacts examined with greatest focus during the EIA study process have been:

- Potential impacts to groundwater quality (notwithstanding that groundwater is saline and non-potable), arising after more than three decades of operations.
- Potential concerns for human health arising from past and future operations of the Brady Road Landfill.
- Potential for reduction in odour sources at the landfill, given historic and projected future waste deliveries to the site.

This prioritization reflects a reduction in interest in one subject identified as being of concern during the Phase 1 ELP process undertaken by Stantec in 2010. The Phase 1 ELP process identified concerns about fire risk at the landfill, and suggested that this would be a major focus for the subsequent EIA.

The relative brevity of attention to this potential issue in the EIA arises from a combination of timely actions by the City since completion of the Phase 1 ELP study. These include:

- The solicitation of a fire-prevention and -management workshop hosted by Dr. Tony Sperling of Sperling-Hansen Associates (SHA) of North Vancouver on February 25-26, 2010, and actions, decisions and changes in landfill practices arising from this “lessons learned” workshop, e.g.,:
  - Communication of concerns about auto-shredder residue (ASR) to the current supplier (General Scrap Partnership) on March 10, 2011.
  - Review of information about ASR flammability received from General Scrap dated March 21, 2011.
  - Solicitation of independent professional reviews of the General Scrap binder of information from Dr. Tony Sperling (SHA), a North American authority on landfill fires (USFEMA 2002), and Dr. David Huebert (Stantec), a toxicologist, provided to the City on May 26, 2011 (Appendix J), and May 24, 2011, respectively.
  - Reconsideration of the historic policy allowing acceptance of auto-shredder residue (ASR) and storage of this material for use as daily cover at the landfill, notwithstanding the provisions of Manitoba Regulation (MR) 113/2003.
  - A decision by the Waste Management Services Division to dramatically reduce acceptance of ASR deliveries.

  - A decision by the Solid Waste Services Division to stop use of ASR as daily cover.
  - The decision to utilize all accumulated ASR at the landfill by burial of the ASR comingled with municipal solid waste as quickly as possible.
  - The commitment for improved use of fire-risk-monitoring tools at the landfill.
  - The commitment for use of enhanced staff-protective equipment for firefighting at the landfill.
- The City's commitment to the development of a comprehensive documented and upgraded Emergency Response Plan, based (in part) on the insights gained from this fire-risk-management workshop.
- The articulation of a wide variety of fire-risk-prevention, -minimization and -management procedures set out in the new draft Operating Plan jointly developed by Stantec and the City (Appendix G).
- The commitment to create ponds in which accumulated runoff would be stored, creating the first on-site water storage for firefighting purposes; this water could also be used for a sand-washing facility at the landfill, if proven feasible.
- Council's adoption of the CIWMP on October 19, 2011, including its staged commitments to the removal of organic materials:
  - It is the organic materials delivered to the site (e.g., paper, cardboard, selected plastic, wood, fibre, yard waste, kitchen waste) that create the combustible solid material, or the derived gases, needed to sustain landfill fires.
- The City's previous commitment to retrofit select waste cells with a landfill-gas recovery system, and its current commitment to design such systems into all future cells, for greatly enhanced capture and controlled combustion of malodourous and combustible landfill gases (especially methane).
- The commitment to improved design standards which, among other things, ensure that the design of all future cells will be highly resistant to the spread of subsurface fires and to the entry of oxygen to sustain such fires.

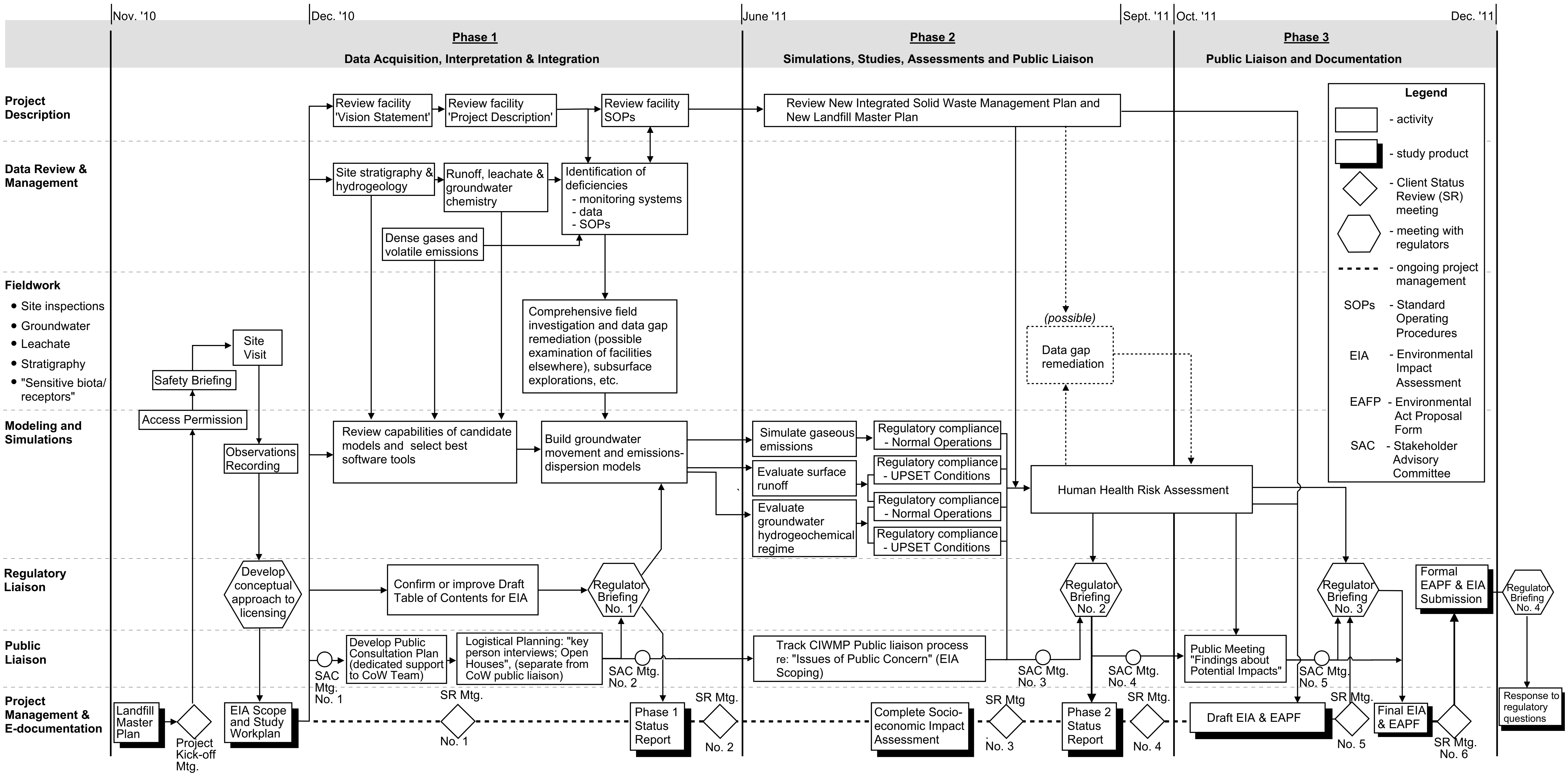
These 15 measures, commitments and decisions, taken together, represent a comprehensive and effective response to the fire-risk-management challenge identified in the Phase 1 ELP. This combination of design, operating and contingency-response measures means that the residual risk requiring attention in the EIA is of modest magnitude.

It is important to understand that in the absence of all of these design and operating measures, landfill fires have indeed been experienced at the Brady Road facility. These fires, however, have been of small scale, of short duration and were consistently amenable to complete eradication. It may be that more than three decades of the landfill's operations can be considered to be somewhat less than current "Best Practice," yet no landfill fire has ever occurred sufficient to alarm the adjoining community, or to cause the City to engage its fire department in fire suppression at the landfill. Accordingly, adoption of the CIWMP, and its emphasis on upstream diversion of organic (i.e., burnable) materials, can only result in a significant reduction in the already-low risk posed by landfill fires.

7.4 ACTIVITIES

A series of parallel and interlocking workstreams (Figure 7-1) were designed to give effect to these principles. Specific activities are key to ensuring an appropriate scope of assessment, and to thoroughness of analysis. These include:

- Development of a thorough Project Description (both current and future), based on public domain information, existing Standard Operating Procedures (SOPs), site visits, and input from the City's landfill-management team.
  - Description of the 'future landfill' will be based on projected future SOPs (i.e., the new draft landfill 'Operating Plan'), the results of the Phase 1 ELP's 'Best Practices Review', the public input to the development of the CIWMP, the public input to the EIA process, and Council's decisions regarding the recommended Plan.
- Design and execution of a Public Consultation Process, embedded in the public-engagement process for the CIWMP, including one landfill-specific public meeting.
- Evaluation of the present state of environmental impacts, to define Baseline Conditions in respect of the future landfill configuration and operations.
- Evaluation of the potential for incremental increases (or decreases) in Future Environmental Impacts, based on the projection of the future landfill configuration and operations, using simulation tools accepted for such use by local and international regulatory authorities:
  - Future impacts on ***Air*** will be simulated with an appropriate tool (e.g., the SCREEN3 model) for normal conditions, for all landfill-gas emissions now regulated by Manitoba Conservation (or Ontario MoE).
  - Future impacts on ***Surface Water*** will be assessed in consideration of runoff patterns, the surface-water containment and drainage (ditching) system, the measured water quality in the site runoff and in the receiving watercourse (La Salle River), the volumes of runoff versus volumes of river water, and the extent of public contact with or use of the surface-water runoff.



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Conceptual Process for Scope 2, Stage 2 Environmental Impact Assessment of Brady Road Landfill

Figure 7-1

- Future impacts on ***Groundwater*** will be assessed in consideration of leachate and groundwater movement patterns, measured leachate and groundwater quality, the chemistry of the receiving watercourse (La Salle River), the magnitude of chemical loadings to the river, and the extent of public dependence on the groundwater.

- Future impacts on ***Soils*** will be assessed in consideration of runoff patterns, the surface-water containment and drainage (ditching) system, the measured water quality in the site runoff and site stratigraphy and pedology (i.e., soil classification).

- Future impacts on ***Human Health*** will be assessed in consideration of the maximum ground-level emissions concentrations predicted by an emissions-dispersion model at critical receptors within a 5-km radial distance of the landfill, for normal operating conditions, in relation to reported air quality guidelines protective of human health.

8.0 Environmental Assessment

8.1 NORMAL OPERATIONS

8.1.1 Physical Environment

8.1.1.1 Air Quality

8.1.1.1.1 Ground Level Emission Concentrations

Stantec completed a screening-level air-quality dispersion-modeling assessment to determine the maximum predicted ground-level concentrations of regulated emissions under normal operating conditions at the Brady Road Landfill (Appendix K). This assessment was performed using the U.S. EPA SCREEN3 dispersion model based on data available from existing data (KGS and CH2MHILL 2005), plus U.S. EPA AP-42 emission factors (U.S. EPA 1998). The emission factors used in the modelling predate the recent City of Winnipeg policy change providing for acceptance of biosolids at the landfill for burial (Sections 4.4.4.2, 4.8.3).

As noted in Section 7.3, modeling of emissions from upset conditions (e.g., a landfill fire) was not undertaken due to the high uncertainty around substances emitted from such events and the lack of available data describing their release rates. Mutual agreement was obtained from Manitoba Conservation in March 2011 that new standard operating procedures and emergency response planning are adequate means of mitigating upset conditions at Brady Road Landfill, and that dispersion modelling of normal emissions would be appropriate and sufficient for the EIA (Braun *pers. comm.* 2011).

The modelling ignores the effect of implementing the CIWMP (i.e., ignores the reduced amounts of organics to be buried in the future) in deriving its predictions. Ignoring the benefits of CIWMP implementation is one of many sources of conservatism in the model, causing over prediction of ground-level values.

The assessment for normal operating conditions showed that the maximum predicted concentrations of all modelled emissions for which there are regulatory objective are less than those objectives (Table 8-1). The highest predicted concentrations were for methane, carbon dioxide, and nitrogen: three species which are relatively inert and of little concern to human health in ambient air at the predicted concentrations. Methane and carbon dioxide have no deleterious effect on human health at low concentrations. Nitrogen makes up 78% of the atmosphere, and a small addition is of no concern. Hydrogen sulphide and other reduced sulphur compounds are of concern owing to their distinctive ‘rotten eggs’ odour. Because the predicted concentrations of these substances are below the objectives for all averaging intervals (Table 8-1), these malodorous emissions are unlikely to be detected or a concern under typical operating conditions.

Table 8-1: Summary of Compliance for Modeled Emissions Air-Quality Criteria or Guideline

Substance	Manitoba Guideline Exists (Y/N)?	Manitoba 1-hour Average Guideline	Manitoba 24-hour Average Guideline	Ontario 10-minute Average	Ontario 24-hour Average	Alberta AAQO 1-hour Average
Methane	N					
Carbon dioxide	N					
Nitrogen	N					
Hydrogen sulphide	Y	✓	✓	✓	✓	✓
Dimethyl sulphide	N			✓		
Methyl mercaptan	N					
Carbon monoxide	N			✓		✓
Benzene	N					✓
Butane	N					
Ethane	N					
Hexane	N				✓	✓
Pentane	N					
Propane	N					
Chloroethane	N				✓	
1,1-Dichloroethane	N				✓	
1,1-Dichloroethene	N					
1,2-Dichloroethene (cis)	N				✓	
1,2-Dichloroethene (trans)	N				✓	
Ethylbenzene	N			✓		✓
Methylene chloride	N				✓	
Styrene	Y	✓	✓		✓	✓
Tetrachloroethane	N					
Toluene	N				✓	✓
1,1,1-Tricholoroethane	N					
Tricholoroethane	N					
Vinyl chloride	N				✓	✓
Total Xylenes	N			✓		✓

[shaded] = Not Applicable ✓ = Compliance E = Exceedance

Other substances such as ethylbenzene, styrene, and toluene are substances of concern owing to potential human-health effects, but they are present in very low ambient concentrations, well below the regulatory objectives. The maximum predicted concentrations occur relatively close to the landfill (~970 m away), meaning their concentrations at more distant receptors are much reduced from the maximum predicted values presented.

The predicted ground-level concentrations of the substances modelled are all below the applicable Manitoba, Ontario and Alberta ambient air-quality objectives protective of human health and against nuisance. From this perspective it can be concluded that the effect of the landfill gas on ambient air quality under typical operating conditions is acceptable, and that normal landfill operations yield emissions causing no significant impact. Implementation of the CIWMP should logically be expected to reduce even the current low levels of air-quality impact as the years progress.

That said, complaints about odour nuisance have increased in recent years, apparently in relation to the termination of the City's "WinGro" program, and default deliveries of dewatered biosolids to the landfill (Section 4.4.4.2). These recent odour nuisances have not caused a significant number of complaints to the City's "311" line, but were reported at the October 27 Public Meeting as "significant" for some people living near the landfill (Appendices E and F).

The City has been proactively evaluating options for biosolids management since 2008 (Tetr*ES* 2009a, b). Evaluation of options continues with the City's long-term wastewater-treatment systems operator Veolia Water Canada (Stantec 2011b). The City's preferred option will reduce and can potentially eliminate these occasional impacts, especially as assisted by the City's landfill-gas project (Section 4.4.5).

8.1.1.1.2 Greenhouse Gases

The estimated reduction in GHG expressed in CO_2 equivalent terms from flaring of LFG from the LFG project (1,700 m^3 per hour) is 97,405 tonnes per year. This reduction represents a significant benefit in terms of reducing GHG emissions that contribute to global warming/climate change (Cheminfo Services Inc. 2002; City of Winnipeg 2009; Anonymous 2007).

The City's continuing investigations of biosolids-management options (Morrison Herschfield 2001; Best 2008; CH2MHILL 2008; Breslin 2009; Tetr*ES* 2009a, b; Stantec 2011b) should, once a preferred option is selected, further reduce GHG generation at the landfill. Since 2009, the City has been examining various options for managing this material (including composting some of the material at the landfill; Tetr*ES* Consultants, 2009a, b), pending a longer-term solution. These include discussions held in 2009 with the University of Manitoba about use of landfill "biogas" for heating buildings at the University of Manitoba campus, some 8 km away (Samyn 2009). This could create a reduction in the University's energy costs estimated in 2009 at $6 M (Welch 2009). The City is now retaining services for moving in a new direction for landfill-gas management. The Province committed to $2.55 M to assist with the City's planned LFG capture system in June 2011 (Government of Manitoba 2011). Current planning by the City (jointly with

Veolia Water Canada Inc.) includes consideration of the greenhouse-gas-emissions potential of biosolids-management options (Stantec, 2011b).

The significant reduction in concentrations of VOCs and other trace compounds in LFG by landfill-gas combustion is dealt with in a report to Environment Canada (Cheminfo 2002), an excerpt of which follows:

> *"The analysis of the Environment Canada landfill gas test data shows that landfill gas combustion is a highly effective means of reducing greenhouse gas emissions. It also significantly reduces emissions of all volatile organic compounds from raw landfill gas, many of which are hazardous or toxic substances. The only apparent disadvantage of landfill gas combustion is its production of Nitrous Oxides (NO_X) and Carbon Monoxide (CO) emissions, which are still very low compared to other national sources. Landfill gas combustion produces negligible levels of particulate matter and Sulphur Dioxide (SO_X) emissions. Landfill gas combustion does produce emissions of dioxins and furans, but the levels are so small relative to other known sources that they should be considered insignificant. Chlorides and fluorides are also produced, but their levels are very low compared to other national sources."*

Condensate will be collected within LFG system piping. The condensate strength is typically less than leachate, except that it is more acidic in nature. It will be collected and treated at an approved treatment facility (City of Winnipeg 2009) and therefore will present no impact.

8.1.1.1.3 Dust

By design, working landfills increase in elevation over time, and are covered with soil. Elevated soil-covered structures, particularly in windy environments like the prairies, cause entrainment of surface dust by wind moving in the boundary layer at the soil surface. Entrained dust can move for hundreds of metres in downwind directions.

These dusts can also transport gases from the landfill, when volatile organic compounds (VOCs) adsorb to these entrained particles.

The typical mechanisms for reduction of dust from landfills, all of which are included in the City's new draft Operating Plan (Appendix G), include:

- Botanical screens and barriers around landfill margins.
- Litter-control fences placed around the working face (especially once covered in captured plastic bags and other wind-blown debris).
- Use of chemical dust-suppressant compounds or water mists, for creation of surface crusts.
- Vegetation of all intermediate or final cover.

Also, glass separated in recycling is not sold to third parties, due to the high costs of its transportation to available (low-value) markets. The glass is recycled by on-site processing to create roadbed material, thereby obviating costs for the City's purchase of limestone rock as road subgrade. It is also used to armour the roads to the working face and other locations where vehicular motion has potential to destabilize the road surface and to encourage dust entrainment.

Taken together, these measures greatly reduce the potential for dust export from the landfill. Dust generation by landfill operations is not a significant impact on air quality and will not be in the future.

8.1.1.2 Soils

The landfilling of wastes and associated production of leachate as well as the generation of contaminated surface water run-off have the potential to degrade soil quality through the introduction of constituents (such as hydrocarbons, metals and volatile organic compounds) to underlying soils. In addition, these constituents have the potential to be introduced to off-site soils through surface-water drainage (Section 5.1.5.1).

As indicated in Section 5.1.1.2.3, the movement of solutions at the site is in the order of several centimeters per year due to the low permeability of clay-textured soils beneath the site. Data were opportunistically obtained from soil sampling during the recent and ongoing (Stage 3) excavation of an unlined, decommissioned, former municipal solid-waste landfill in south Winnipeg (Cadboro East) only ~2 km from the Brady Road site. Former Landfill No. 23 is being excavated by the developers in three stages to rehabilitate the land for development. Stage 3 removal will continue this winter pursuant to a recent specification (Stantec 2011e). The results of sampling activities are to be documented in a report to Manitoba Conservation at the end of next spring (Stantec 2012, in press), The data obtained to date indicate that the clay-textured soils of the region greatly limit the downward migration of contaminants beneath this site. The concentration of analytes in all samples collected to date from the excavation floor (within a depth of approximately 1 m or less of previously landfilled materials) did not meet or exceed the CCME Canadian Soil Quality Guidelines for residential/parkland land use (fine-grained soil; CCME, 1999b) or the Canada Wide Standards for Petroleum Hydrocarbons in Soil (CCME 2001). The only exceptions, barium and selenium, are considered to be naturally elevated in the regional soils (see Section 5.1.2).

There are a number of proposed future changes at the facility which will reduce the potential future impact of operations on soil quality, including:

- Incorporation of a geosynthetic liner beneath all future landfill cells;
- Development of an engineered wetland to provide polishing of surface water drainage prior to discharge from the site (Figure 1-2);

- Continued monitoring of surface-water quality at select locations on a semi-annual basis and monitoring of accumulated surface water prior to discharge;
- Reduction in the footprint of proposed burial areas.

These proposed changes will reduce the already low level of environmental effects of facility operations on soil quality beneath and adjacent to the site. Operation of the future facility is anticipated to result in no significant impact to the soil environment.

8.1.1.3 Surface Water

Potential effects to surface water quality as a result of facility operations were determined by assessing the water-quality "fingerprint," or chemical composition, of site surface water from (incomplete) monitoring records (Tables 5-7 and 5-8) in comparison with the chemical composition of water quality in the La Salle River (Table 5-9).

Despite the limited amount of data, chemistry of the surface water discharged from the Brady Road Landfill is generally typical of waters found in the Red River basin. Site runoff does not contain elevated concentrations of common inorganic contaminants of concern. The chemical characteristics of the surface runoff is generally within the overall baseline conditions found downstream in the La Salle River.

Runoff volumes from the site are a minor component of surface water volumes in the La Salle (and Red River) which reduces their potential for impact on receiving water quality. Further, minimal public use or contact with the surface water in the municipal ditches and Westendorf Coulee downstream of the site, if any, is expected, and the water quality in the La Salle is so impaired at present (Section 5.1.5.2) that incremental traces of landfill contaminants of any groundwater "daylighting" in the river will be virtually immeasurable and indistinguishable from natural background values.

As previously identified, there are a number of proposed changes to the facility which will further reduce the potential for impacts to the surface-water environment. These include the proposed establishment of an engineered wetland to polish surface water quality prior to discharge and surface-water monitoring programs, which include a downstream sampling location to monitor for off-site impacts.

Proposed adoption of Best Practices, coupled with the limited public use of waters immediately downstream of the site, further reduce the potential for environmental or public harm. Therefore, future operations of the facility are not anticipated to result in significant adverse effects to surface water.

8.1.1.4 Groundwater

8.1.1.4.1 Existing Effects of the Landfill on Aquifer Quality

The potential effects of leachate on groundwater quality in the carbonate aquifer were examined by comparison of values for selected indicator parameters upstream and downstream of the landfill (Section 5.1.1.2.4). Median concentrations for two-thirds of the indicator parameters are comparable or lower downstream of the landfill. Downstream median values are increased for aluminum (4x), tungsten (1.7x), barium (1.3x), potassium (1.2x), cobalt (1.1x) and alkalinity (1.1x). However, barium is significantly different downstream of the landfill (Appendix I-3). Other parameters did not show a significant difference, likely due to an insufficient number of samples, resulting in low power for the nonparametric tests (Motulsky 2003). The increase in barium can be caused by either landfilling activities or natural processes (such barite dissolution and barium leaching from the till to the aquifer). The median concentration of barium downstream of the landfill is 0.014 mg/L, which is several orders lower than the MOE guideline for non-potable groundwater (23 mg/L).

No organic contaminants were detected in the aquifer. Several PAHs have been detected in the till above the aquifer (mostly upstream of the landfill), but their concentrations are orders of magnitude lower than the MOE guideline for non-portable groundwater (Attachment I-A).

In terms of standard groundwater-quality parameters, the review can be summarized as follows:

- Groundwater in the overburden and carbonate aquifer is non-potable due to high TDS (4,000 to 5,000 mg/L). Major ions in the overburden are calcium, magnesium, sulfate and bicarbonate; while sodium and chloride dominate in the carbonate aquifer.
- Only copper exceeded the stipulated MOE guideline for non-potable groundwater. This exceedance is related to elevated background concentrations.
- No organic contaminants were detected in the aquifer. Several PAHs have been detected in the till upstream and downstream of the landfill. Concentrations of these PAHs were close to the detection limits and orders of magnitude lower than the MOE guidelines for non-portable groundwater.
- Leachate has pH and TDS similar to groundwater, but sodium-bicarbonate composition is distinct from natural waters at the site. In leachate, only single exceedances of the MOE guideline for non-potable groundwater were observed for copper,boron,selenium, lead and mercury. Exceedance of the stipulated MOE guidelines in leachate was observed for several organic contaminants:
  - VOC compound – vinyl chloride and acetone six and three samples of nineteen.
  - PCB compound – Aroclor 1242 in ten of nineteen samples.

  - PAHs – benzo(ghi)perylene, and indeno(1,2,3 cd)pyrene in one of sixteen samples.

- Median concentrations for six indicator parameters increased downstream of the landfill, but only the increase in barium was statistically significant. This increase can be caused by either landfilling activities or natural processes (e.g., barium leaching from the till due to barite dissolution). Regardless of the process, median concentrations of barium downstream of the landfill were still three orders of magnitude lower than the MOE guideline for non-potable groundwater.

Endocrine-Disrupting Compounds (EDCs)

A significant number of sources of endocrine-disrupting compounds (EDCs) exist in municipal solid waste. In many ways, these materials can be deposited at landfills, mostly in the wastestreams from homes (Slack, Gronow and Voulvoulis 2004). It is common for unused analgesics, pain relievers and antibiotics to be discarded in garbage and thus delivered to landfills (Holm *et al.* 1995). These materials cannot easily be removed from wastestreams delivered to landfills by pre-screening or other methods.

Because these materials are largely water soluble (i.e., are designed to be ingested), they can recruit to fluid streams within landfills (e.g., leachate) and accumulate in any leachate migrating vertically beneath a landfill. If leachate is discharged to a stream, effects on fish can include disrupted reproduction (e.g., Noaksson *et al.* 2003).

The presence of EDCs in landfill leachate has been confirmed in numerous studies. Their presence in the leachate recovered from sampling stations at the Brady Road Landfill was confirmed (Section 5.1.1.2.4; Table 5-4). The quantities recovered from leachate were, however, extremely low, and below action levels.

The environment within the landform, being damp, often acidic, and often without much oxygen, means that many pharmaceutical compounds will at least partially degrade biochemically over time.

Given the fact that such pharmaceutical residues typically move to the base of the landfill liner system, there are no significant mechanisms for these materials to be moved into the airshed, or to leave the landfill in any other way. There are no evident significant mechanisms for these compounds to create exposure to any parties living near a landfill.

The potential for risk of exposure to residual EDCs in the landfill is judged to be extremely low. The potential for EDC-contaminated leachate to percolate through the clay fill beneath the landfill, to be dispersed within the groundwater, and to eventually travel to the Red River or the La Salle River in any significant quantity, is infinitely small.

Metals from Electronic Waste ("e-waste")

"E-waste" represents the discarded digital technology that was previously popular, sometimes as little as six months ago. E-waste includes such materials as cell phones, TVs, computer monitors and keyboards.

Buried e-waste is a source of metal pollution, because acidic fluids within landfills, created by decay of organic materials, can dissolve plastic and metals found in all forms of digital technology. Among the metals that would be liberated are mercury, copper, cobalt, chromium, etc.

Soluble metals derived from burial of electronic waste have been detected in leachate below the landfill (Table 5-4). As noted in Section 5.1.1.2.4, the concentration of all metals but copper (the copper exceedance is attributed to elevated background levels of copper in the aquifer) in groundwater is very low, well below promulgated action levels.

These same materials with capacity to create ecological or human-health risk, if released in quantities to an aquatic ecosystem, have innate economic value. Commodity prices in the last several years have created a significant growing industry in the recycling of metallic components of electronic waste. The rising price of energy has also contributed to technologies (including high-oxygen incineration or pyrolosis) of plastic cable and computer-housing materials within these digital products.

The market for e-waste is sufficient that all major modern landfills now routinely provide for their segregation, repackaging and shipment to potential recycling facilities. The Community Resources Recovery Centre planned for the landfill (Section 4.3.2.1), will, therefore, have these provision for such materials. This would be consistent with the Best Practices review the City undertook, where considerable commitment to such practices at, for example, the Hartland Landfill in Victoria, was evident. This commitment to e-waste capture, segregation and management for recycling has the potential to create revenue streams to defray landfill operating costs. More importantly, it captures materials for reuse which have the inherent potential to be toxic in aquatic environments.

After 35 years of Brady Road landfill operation, no significant effect of the landfill on the aquifer chemistry was detected, except for an increase in barium, which also can be caused by a natural process.

8.1.1.4.2 Future Potential for Aquifer Contamination

Method

Assessment of the potential for future contamination of the non-potable aquifer beneath the Brady Road landfill was undertaken to understand and predict the effects of implementing the

CIWMP. This assessment included identification of contaminants of concern and mass-balance calculations.

First, the contaminants of concern were defined as these elements or compounds, having concentrations in leachate exceeded stipulated MOE guideline for non-potable groundwater, and which therefore have some (presently unquantified) potential to exceed this guideline in the aquifer in the future (MOE, 1994). On this basis, potential contaminants of concern were selected as follows:

- Boron (trace element)
- Copper (trace element)
- Selenium (trace element)
- Lead (trace element)
- Mercury (trace element)
- Acetoen (VOC compound)
- Vinyl chloride (VOC compound)
- Aroclor 1242 (PCB compound)
- Benzo(ghi)perylene (PAH compound)
- Indeno(1,2,3 cd)pyrene (PAH compound)

Secondly, potential future impacts were calculated based on the present conceptual understanding of site hydrology. Leachate seeps slowly downwards along a vertical hydraulic gradient below the landfill through several metres of the grey clay to the underlying till and aquifer. The highest vertical hydraulic gradient found by previous City-sponsored studies was approximately 1 m/m. This gradient was found at the “wet cell,” where mounding of leachate occurs within the landfill mass (KGS 2008). This mounding condition creates a transient “worst-case” estimate because the City is taking steps to improve the leachate-collection system to reduce the mounding. When leachate reaches the aquifer, after additional decades of future vertical migration, the leachate will be diluted as it mixes with the groundwater. In order to account for the effects of dilution, horizontal flow in the aquifer and the maximum predicted future vertical seepage rate from the future area of the landfill (Figure 8-1) were calculated using input from Table 8-2 and the following formulas:

- Horizontal aquifer flow - QH=TiHW, m^3/s
- Leakage from landfill - QL=kiVA, m^3/s

Area of Landfill and Widths of Aquifer Perpendicular to Groundwater Flow for Theoretical Estimation of Leachate Loading to Underlying Groundwater

Figure 8-1

Acknowledgements:
Data provided by Government of Manitoba, ESRI, City of Winnipeg, Stantec Consulting Ltd.
Projection: NAD83 Zone 14N

PREPARED BY Stantec

MAP SCALE 1:17,000	DATA SCALE N/A
DATE March 15, 2011	PROJECT 1114 10000

G:_GIS_Project_Folder\0110_COW66_Brady_LandFill\ArcMap\BradyLechate_GWSamplingArea_20110314.mxd

Table 8-2: Input Parameters Used for Dilution of Leachate in the Aquifer

Parameter, units	Value	Source
T – Transmitivity, m^2/s	0.014	UMA, 1987
iH – Horizontal gradient in the aquifer, m/m	0.00075	City of Winnipeg, 2009
W – aquifer width across beneath the area (Line CC', Figure 8-1)	1280	Figure 8-1
k – Average hydraulic conductivity of grey clay, m/s	3.4E-10	UMA, 1987
iV – Maximum vertical hydraulic gradient across grey clay, m/m	1	KGS, 2008
A – proposed surface area of cells (Area A, Figure 6-1), m^2	2,900,000	Figure 8-1

The estimated horizontal flow in the aquifer (QH) and the leakage rate from the landfill (QL) are estimated as 1,160 m^3/d and 85 m^3/d, respectively. The leakage rate is 14x lower than the aquifer flow, which is consistent with the previous estimates done by UMA (1987).

Results

Dilution of leachate in the groundwater means that concentrations of the potential contaminants of concern decline below 2004 MOE guideline for non- potable groundwater (Table 8-3) once the mixing is complete.

Table 8-3: Concentrations of Potential Contaminants of Concern (ug/L)

Parameter	Maximum Leachate Concentration	Aquifer Background	Guideline*	Predicted Concentration in Aquifer
Boron	58,200	780	45,000	4,608
Copper	343	1	87	23.8
Selenium	80	5	63	10.0
Lead	50	0.05	25	3.4
Mercury	0.17	0.025	2.8	0.035
Vinyl Chloride (VOC)	9.8	0	1.7	0.19
Acetone	5,700	0	130,000	380
Aroclor 1242 (PCB)	0.90	0	15	0.062
Indeno(1,2,3 cd)pyrene (PAH)	0.37	0	0.20	0.024
Benzo(ghi)perylene (PAH)	0.24	0	0.20	0.016
*MOE 2009				

Conservatism of Analysis

The method presented above is a simple approach to evaluate the potential future contamination of the aquifer from the landfill at macroscopic scale and does not account for local features such as microfissures or fractures. Offsetting this is the highly conservative nature of the foregoing analysis, as explained below.

In the above-noted calculations, the area of landfill is considered as a source of constant-concentration contaminants, which is a conservative assumption because the concentrations will actually gradually decrease with time. The foregoing calculations assume NO reduction in loadings in leachate that will, in fact, occur as the CIWMP is introduced and as deliveries to the landfill diminish in relation to improved upstream diversion to recycling, and as future waste-composition changes (e.g., increased diversion of organics, plastics, drywall, metals, plastics, etc.). Also, the approach ignores the fact of natural attenuation during the migration of the leachate through the clay, which causes a retardation of contaminant movement. It also should be understood that the highest vertical gradient was conservatively applied to the entire area of the landfill, a very conservative assumption, because the average gradient across the area is two to three times lower than one used in the calculations.

In general, assumptions and inputs for calculations are conservative, which results in overestimation of the future potential for aquifer contamination presented in Table 8-3.

It can be concluded from the estimates above that the concentration of the potential future contaminants present in the leachate will be below MOE guideline for non- potable groundwater in the aquifer downstream of the Brady Road landfill property boundaries.

8.1.2 Biophysical Environment

8.1.2.1 Flora

8.1.2.1.1 Typical Vegetation

Due to the presence of productive soils, the majority of the land within the region has previously been converted to cropland. At the time of the expansion of land owned by the City of Winnipeg for the use as a waste disposal ground in the late 1980s, the surrounding land parcels were primarily under agricultural production (Hildermann Witty Crosby Hanna & Associaties and Keil and Associates Ltd., 1987). In addition, the site does not contain features associated with remnant native vegetation, such as riparian zones.

Accordingly, the continued operation of the Brady Road Landfill is not anticipated to result in significant effects to vegetative community. A net beneficial effect to vegetation is anticipated to result from tree and shrub planting efforts planned especially on the north, east and west side of the facility. Further, the final land use plan for Brady Road Landfill is anticipated to include additional tree and shrub planting efforts, which will increase the vegetative diversity of the site.

8.1.2.1.2 Rare Plants

There have been no recorded occurrences of rare plants within the vicinity of the facility. The current land use of the landfill site, as well as the active cultivation of the buffer zone by agricultural producers, is anticipated to limit the potential occurrence or colonization of rare plants within the site. No significant adverse effects to rare plants are anticipated.

8.1.2.2 Fauna

8.1.2.2.1 Wildlife

The professional literature indicates that there can be landfill-proximity effects in some wildlife, usually voles, mice or other microtines (e.g., Sanchez-Chardi *et al.* 2007). There is little literature documenting effects on larger fauna.

Potential effects to wildlife as a result of past and continued facility operation are judged to be minor to non-existent, due to standard operating procedures and site infrastructure (e.g., fencing) designed to limit the interaction of wildlife with the facility. Regular inspection of the integrity of perimeter fencing by landfill operations staff aids in continuing to limit interaction with large-bodied mammals such as white-tailed deer.

8.1.2.2.2 Birds

The landfill lies in alignment with a major runway at Winnipeg International Airport (WIA). The WIA, on numerous occasions in the past 20 years, has raised concerns about the possibility of ponds being developed within proximity to the airport, especially in proximity to the axis of this major runway. This is one reason that the City has abandoned its 1987 concept of a series of large ponds on the site (Figure 1-5).

The necessity for some on-site storage of water means, however, that some ponds are necessary (see Sections 1.2.3.2.3, 1.2.3.2.4 and 9.6 regarding need for on-site firefighting water and wash-water for sand-washing). Accordingly, the City has committed to reduce the potential number and types of bird attractants in the design of these ponds, including its proposed engineered wetland.

Regarding nuisance birds, particularly gulls attracted to the working face of the landfill (Section 4.8.2.1), the City undertook a Best Practices review in 2009/2010 (Section 4.6.2). In this Best Practices review, it observed the means by which the Vancouver (Delta) and Victoria (Hartland) landfills reduced the access of such birds to its working faces. This year, building upon these experiences in British Columbia, the Solid Waste Services Division embarked upon a field trial of falconry for inhibition of bird access to the working face. This trial is still underway. Its results will be considered, along with other approaches to minimizing bird attractants at the working face (e.g., use of soft straw blown onto the compacted waste for daily cover) to maintain its progress in reducing the presence of nuisance avifauna at the landfill.

8.1.2.2.3 Fish

Areas immediately adjacent to the site, including the Westendorf Coulee and municipal roadside drainage ditches, do not provide optimal fish habitat; however, some sub-optimal fish habitat is found near the confluence of surface drainage channels with the La Salle and Red rivers. An assessment of surface water quality in the La Salle River indicated the lack of any significant presence of any “fingerprints” of contamination from parameters commonly associated with leachate. This suggests that fish habitat in surface water receiving bodies located downgradient of the site is not affected by facility operations.

The planned establishment of an engineered wetland will provide additional polishing of site surface and storm-water runoff before it is discharged to the receiving environment. Routine surface water sampling will help to ensure that surface water discharges meet the City of Winnipeg Sewer Bylaw for discharge to the land-drainage system.

8.1.3 Socio-economic Environment

8.1.3.1 Transportation Networks and Other Infrastructure

Curbside waste collection, as well as disposal deliveries by residents and commercial operators, can result in heavy truck and vehicle traffic to the site. This traffic can result in high volumes on PTH 100, particularly during high-volume periods (e.g., first weeks of the new year).

The Province of Manitoba is currently undertaking a study to review access locations along PTH 100 between PR 330 and PTH 75 (Stantec 2012b). As part of this study, it is anticipated that the existing access point to Brady Road from PTH 100 will be closed, and alternate access will be provided. Ultimately, it is anticipated that unsignalized traffic movements, such as the westbound to southbound (i.e., left turn) movement from PTH 100 to Brady Road, will be eliminated in favor of movements through signalized intersections.

Additional infrastructure on or adjacent to the site includes the TransCanada pipeline, CBC communication towers and Manitoba Hydro substation. The facility has historically operated without considerable effect to these components. The Master Plan developed for the site (Figure 4-3) does not advocate activities that would affect these components.

With the proposed access changes under study by the Province and continued operation of the development in recognition of local infrastructure, the development has not and will not result in significant adverse effects to local infrastructure.

8.1.3.2 Heritage Resources

The past and future operation of the Brady Road Landfill facility are not anticipated to have any impacts on heritage resources due to the absence of previously recorded sites within the City-owned lands that comprise the facility.

In the event that heritage resources are discovered during future expansion of facility operations (e.g., excavation of new cells) within the footprint of existing owned lands, work in that area will cease and the Historic Resources Branch of the Manitoba Department of Culture, Heritage, Tourism and Sport will be contacted by the Landfill Supervisor for further guidance.

No significant impacts to heritage resources are anticipated as a result of the Brady Road Landfill.

8.1.3.3 First Nations

Existing and future operation of the facility is not anticipated to result in significant adverse effects to First Nations.

8.1.3.4 Nuisance and Aesthetics

8.1.3.4.1 Noise

Use of heavy equipment at the facility is the chief noise-producing activity heard at the landfill. Other local sources of noise may include traffic to and from the site and gulls at the working face.

Due to the distance of receptors, the incidence of nuisance noise generated at the site is considered infrequent. No noise concerns were raised by respondents to the public consultation program, which included direct invitations to and attendance by neighbouring residents.

Future development of adjacent lands is anticipated to result in receptors locating closer to the site; however, future material burial activities are anticipated to progress south and west, away from planned future development.

No significant adverse impacts have been associated with nuisance noise from almost four decades of operations. No noise nuisance is anticipated as a result of the evolution of the landfill in response to CIWMP implementation and application of the evolving Operating Plan.

8.1.3.4.2 Odours

Complaints to the City's "311" line about odour nuisance have increased in recent years, apparently in relation to the termination of the City's "WinGro" program, and default deliveries of dewatered biosolids to the landfill (Section 4.4.4.2). Only one complaint was received in 2009, whereas 10 complaints per year were received in 2010 and 2011 (Hawley *pers. comm.* 2011). These recent odour nuisances were also reported at the October 27 Public Meeting as being "significant" for some people living near the landfill (Appendices E and F).

The City has been proactively evaluating options for biosolids management since 2008 (Tetr*ES* 2009a, b). Evaluation of options continues with the City's long-term wastewater-treatment systems operator Veolia Water Canada (Stantec 2011b). The City's preferred option will reduce and, likely can eliminate these occasional impacts, especially as assisted by the City's landfill-gas project (Section 4.4.5).

8.1.3.4.3 Visual Impacts

The physical presence of the site, visibility of operating areas and generation of litter are aspects of the development which may contribute to visual impacts. The site is noted as being highly visible, particularly from the north by growing residential neighbourhoods and motorists travelling the south Perimeter highway. The progression of the landfill from east to west south of the Perimeter Highway, grading to a point aimed to the southwest (Figure 4-4) will be orderly and attentive to maintain the final intended grade of 25-30% (Figure 4-5) by careful cover grading relative to known site benchmarks (Figure 8-2).

The most frequent visual concern heard from respondents to the public consultation activities were typically related to visual impacts to off-site areas, due to windblown litter or illegal dumping of wastes on travel routes to the site. Procedures for litter control have been identified in the standard operating procedures developed for the site and include litter patrols, perimeter plantings and familiarization with best practices for litter control. In addition, the establishment of convenient Community Resource Recovery Centres (CRRCs) to provide closer depot locations for the four corners of the City is aimed at reducing illegal dumping.

As identified in Figure 4-4, the future development of landfill cells and burial of waste is planned to begin progressing south and south west away from residential areas within the next five years. Future operational practices will also include smaller operating areas. Landscaping of the finished slopes as well as additional tree planting and berming is planned to further screen the site from adjacent residents and motorists.

Operation of the facility has occurred for nearly 40 years without significant public complaint regarding visual impacts of the facility. The continued development of land within visual distance zones of the facility suggests that the physical presence of the facility is not perceived as intrusive to individuals associated with those developments. With on-going litter control activities, more convenient locations to dispose of wastes and final cover and landscaping of highly visible portions of the facility, the development is not anticipated to result in significant adverse visual impacts.

8.1.3.5 Human Health

8.1.3.5.1 Occupational Health and Safety

Potential effects to the health and safety of workers may result from the use of heavy equipment and large machinery, handling of special wastes (e.g., SRM, asbestos) and working near traffic. The City of Winnipeg has undertaken Job Hazard Analyses (JHA) for a number of higher risk tasks associated with operations and developed Safe Work Procedures (SWPs) for completing these tasks. The JHAs and SWPs have been included in the new draft Operating Plan (Appendix G).

In addition to the JHAs and SWPs, the City of Winnipeg has committed to developing a Health and Safety Manual for Operations as well as an Emergency Response Plan. The ERP is now being drafted. These documents will be updated on a regular basis (as "living documents") to provide long-term planning, guidance and prescriptions for operations and emergency response.

With the implementation of existing and planned health and safety and emergency response documentation, the development is not anticipated to result in significant adverse effects to human health and safety.

8.1.3.5.2 Community Health

As described in Section 5.3.1, air quality in the region is good. To understand the current potential for any effects of landfill gas emissions or dust entrainment on human health, the Manitoba Regional Health Authority (RHA) Indicator Atlas for 2009 was accessed to find summary statistics for mortalities from Total Respiratory Morbidity (TRM) (illness) in males and females in regions around the landfill, compared with other regions in Winnipeg and with the same mortalities across the entire province. Data in the 2009 RHA Indicator Atlas setting out the relative states of risk to men and women from all causes of respiratory illness are provided in Table 8-4.

Table 8-4: Mortality from Total Respiratory Morbidity (2001-02 to 2005/06) by Neighbourhood and Region*

Location	Males	Females
Fort Garry	9.22%	8.18%
St. Vital	11.26%	8.64%
Assinboine South	12.38%	10.35%
River Heights	13.51%	11.04%
Downtown	14.45%	11.34%
All Winnipeg	12.00%	9.43%
All Brandon	13.22%	8.41%
Interlake	13.92%	8.15%
Rural South	14.79%	8.93%
All Manitoba	13.09%	9.30%

*Source: Manitoba Centre for Health Policy, 2009

"Total Respiratory Morbidity" is defined as illness caused by asthma, acute bronchitis, chronic bronchitis, emphysema or chronic obstructive pulmonary disease (COPD).

The data indicate that the region of Winnipeg nearest the landfill (Fort Garry) has the lowest reported mortalities from TRM (Total Respiratory Morbidity). This suggests that there is no basis for conviction that respirable particulate exposure, and any exposure to extremely diluted landfill emissions, is impairing human health in its vicinity. On this basis, airborne dusts (and any sorbed gases) generated by the landfill do not create any significant health risk, even after almost three decades of operations.

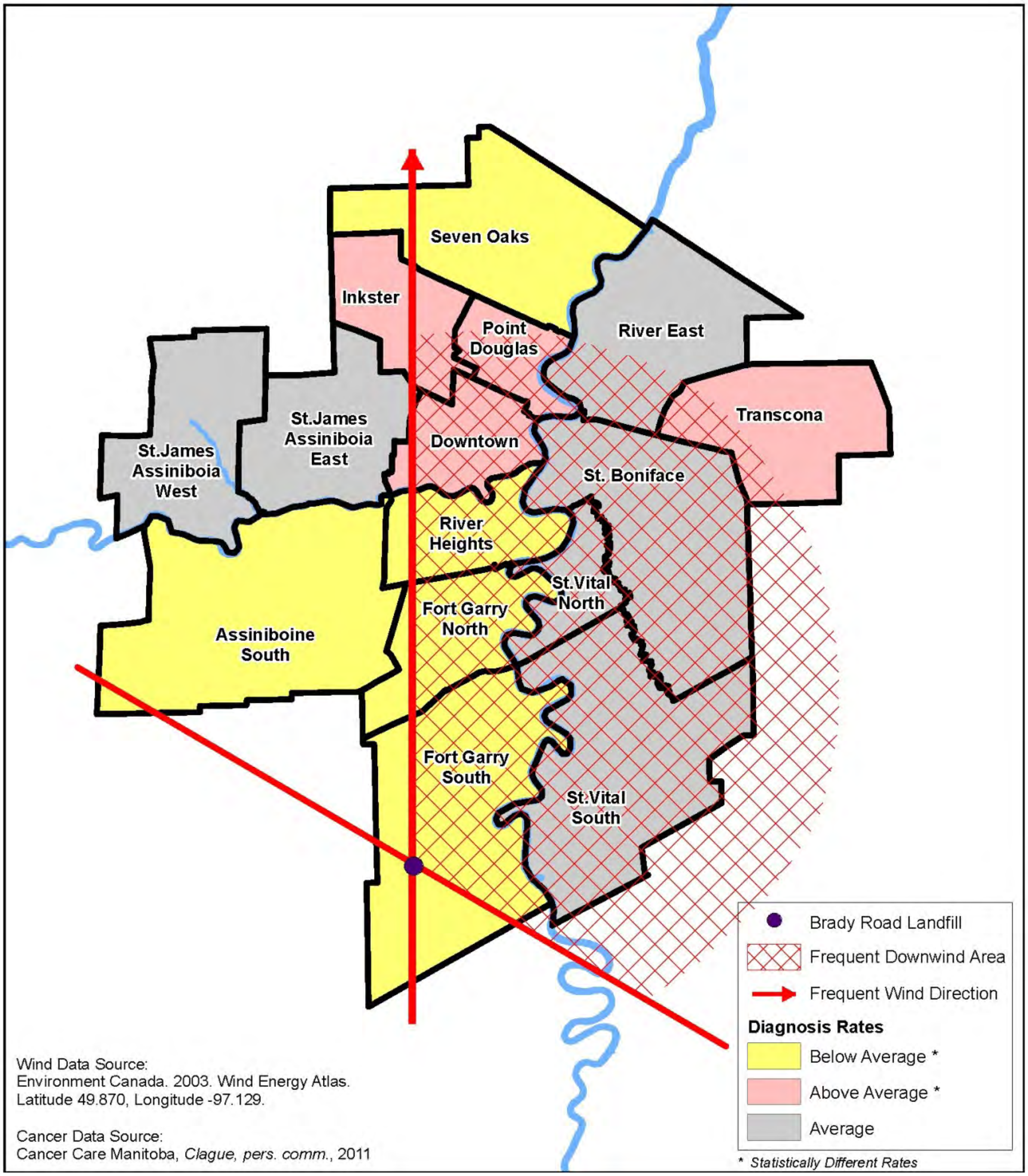
Concerns about health risks from long-term exposure to carcinogenetic gases emitted from landfills have been reported in the literature. The approach to accessing airborne-disease statistics for populations living within the census districts close to, and further from the facility involved retaining CancerCare Manitoba as a subconsultant to analyze data on lung-cancer incidence in the neighbourhoods. On the basis of the incidence rates determined by CancerCare Manitoba (Table 8-5), there is no evidence of any significant health risk to the nearest neighbours to the landfill for reportable respiration diseases after almost four decades of landfill operations. Indeed, the age-adjusted incidence rates for lung cancer, likely the most worrisome of respirable diseases, are the lowest in the census district surrounding the landfill (Clague *pers. comm.,* 2011; Table 8-5; Figure 8-2).

Table 8-5: 25-year Mean Age-Standardized Rates for Lung Cancer Diagnosed in Winnipeg (1984-2009) by Census District

Years	Community Area	Female Std Rate	Male Std Rate	Total Male+Female Std Rate
1984-2009	St. James - Assiniboia	60.39	99.05	75.51
	Assiniboine South	54.25	69.79	59.60
	Fort Garry	46.54	70.92	56.89
	Fort Garry North	45.17	82.71	60.64
	Fort Garry South	48.59	58.37	**53.07**
	St. Vital	[illegible]	[illegible]	[illegible]
	St. Boniface	54.14	96.73	70.16
	Transcona	64.79	104.57	81.10
	River East	58.45	100.37	74.79
	Seven Oaks	45.77	83.40	60.99
	Inkster	63.93	124.05	88.75
	Point Douglas	68.87	139.60	98.52
	Downtown	54.74	112.36	78.71
	River Heights	48.32	92.31	64.62
	Winnipeg	**55.58**	**97.48**	**72.24**

(Source: Clague, *pers. comm.,* 2011)

Figure 8-2: Fort Garry South and Downwind Cancer Diagnosis Rates in Winnipeg, 1984-2009



8.1.3.5.3 Infectious Waste

There can be circumstances in which food products on supermarket shelves can be found to be contaminated, as has been discovered many times in the past decades, at meat-processing plants and elsewhere. When manufacturers recall contaminated foods, these materials are routinely directed by the Canada Food Inspection Agency (CFIA) to landfills for disposal. The Brady Road Landfill has the capacity to meet such needs. The local CFIA has accepted that the design and operation of the landfill is suitable for the disposition of such contaminated foods.

Domesticated animals can become infected by agents that can significantly constrain their viability. The resulting diseases are called “transmissible degenerative encephalopathies,” or “TDE’s” (Taylor, 2000). They include scapie in sheep, chronic wasting disease in domesticated elk and bovine spongiform encephalopathy (BSE) in cows. When large herds of domesticated animals are found to be infected, the infection most typically is by a small protein called a “prion” (Prusiner *et al.*, 1984; http://www.en.wikipedia.org/wiki/prion). Prions have been the cause of the mad cow disease epidemic in Britain in the 1990s, and are the causative agent of chronic wasting disease in wild and domestic elk across the northern United States (Nutsch and Spire, 2004). When domesticated herds are infected by prions, they must be euthanized and disposed of at a landfill.

To date, there have not been significant instances of disposal of contaminated food products or infected herds at the landfill.

A significant quantity of academic research has been undertaken to examine the survival of these infectious agents in landfills. After various studies (Nutsch and Spire 2004; Wisconsin undated; Gale *et al.* 1998; SSC, 2003) the consensus is that, other than dedicated, custom-purpose incinerators, landfill disposition is the safest and most cost-effective method available for disposal for such contaminated livestock. These studies indicate that the hostile environment within the landfill cells contribute to slowly diminished viability of infectious bacteria, viruses, fungi and prions over time (Gale *et al.* 1998).

On the basis of this information, there is no basis to expect that any past or future disposal of contaminated food products or infected animals at the facility will pose risk to ecosystems or adjoining communities.

8.2 UPSET CONDITIONS

It is typical practice that environmental impact assessments consider the consequences of both “normal” and “atypical” conditions. In the case of a landfill, the usual most probable “worst-case” scenarios are:

- Major breach of the liner system beneath a landfill cell and above a significant aquifer of potable water relied upon by a substantial number of users.

- A major landfill fire.
- A major spill on- or off-site.
- Flooding of the landfill.

8.2.1 Landfill Fires

As discussed in Section 7.3, the risk of a major landfill fire has been dramatically reduced by a combination of design and operational features, and the City's commitment to the development of improved emergency-response procedures and purchase of risk-indication (e.g., gas "sniffers") equipment. Small, short-lived and easily managed fires have broken out at the landfill over the years, caused almost exclusively by "hot loads" and lightning strikes (Hawley, *pers. comm.*, 2010b). They are routinely smothered and extinguished.

Landfill fires, if not extinguished quickly, can become dangerous because they can emit clouds of chemical-containing smoke and because they can be hard to fully extinguish (US FEMA, 2002; Sperling, 2001).

Landfill-fire-risk can and typically is managed through a combination of measures including those noted in Section 4 and in the draft Operating Plan. City's timely response to the fire-related Action Items identified in the Phase 1 ELP (Stantec, 2011c), its drafting of a comprehensive new draft Operating Plan (Appendix G), and its current actions to begin drafting a comprehensive ERP have had the combined effect of removing fire from the list of "most probable, worst-case scenarios."

8.2.2 Liner Breach

The potential for a "most-probable, worst-case scenario" involving a liner breach and loss of leachate to contaminate a potable groundwater does not apply to the current circumstance, because the underlying aquifer is saline, and there are no dependent users who consider this a resource and there is no synthetic liner that can be "breached."

8.2.3 Spills

Further, there is no probable scenario for some kind of "most-probable, worst-case" spill event at the landfill because the landfill is not a destination for waste fluids being delivered there. The landfill is, however, a source of malodourous hazardous leachate which is delivered by tanker truck daily to the North End Water Pollution Control Centre (NEWPCC) for treatment. Thus, a more likely "most-probable, worst-case" spill scenario would involve one of these delivery trucks somehow overturning and its load spilling on the site, or along its route to the NEWPCC.

8.2.3.1 On-Site

In the former case, involving a spill on-site, the deep layers of low-permeability clay which were the reasons causing the landfill to be developed at Brady Road more than three decades ago would provide the same protection of the saline aquifer as has been observed against leachate migration. The consequences of an on-site spill, therefore, must logically be predicted to be insignificant, both in the short and long term.

8.2.3.2 Off-Site

The consequences of a spill of leachate within the City would be substantial, short lived, negative but amenable to rapid management. A combination of the City's emergency-response procedures, and aggressive action by the Fire Department (to wash the material into storm or sewer drains), would mean that the leachate would be effectively diluted in storm sewers or sanitary sewers before they would discharge. They would discharge, in this scenario, to the Red River (untreated but diluted), or to the NEWPCC (where they were being delivered for treatment in any case), respectively. These consequences are insignificant in respect of potential impacts for ecosystems or adjoining human populations.

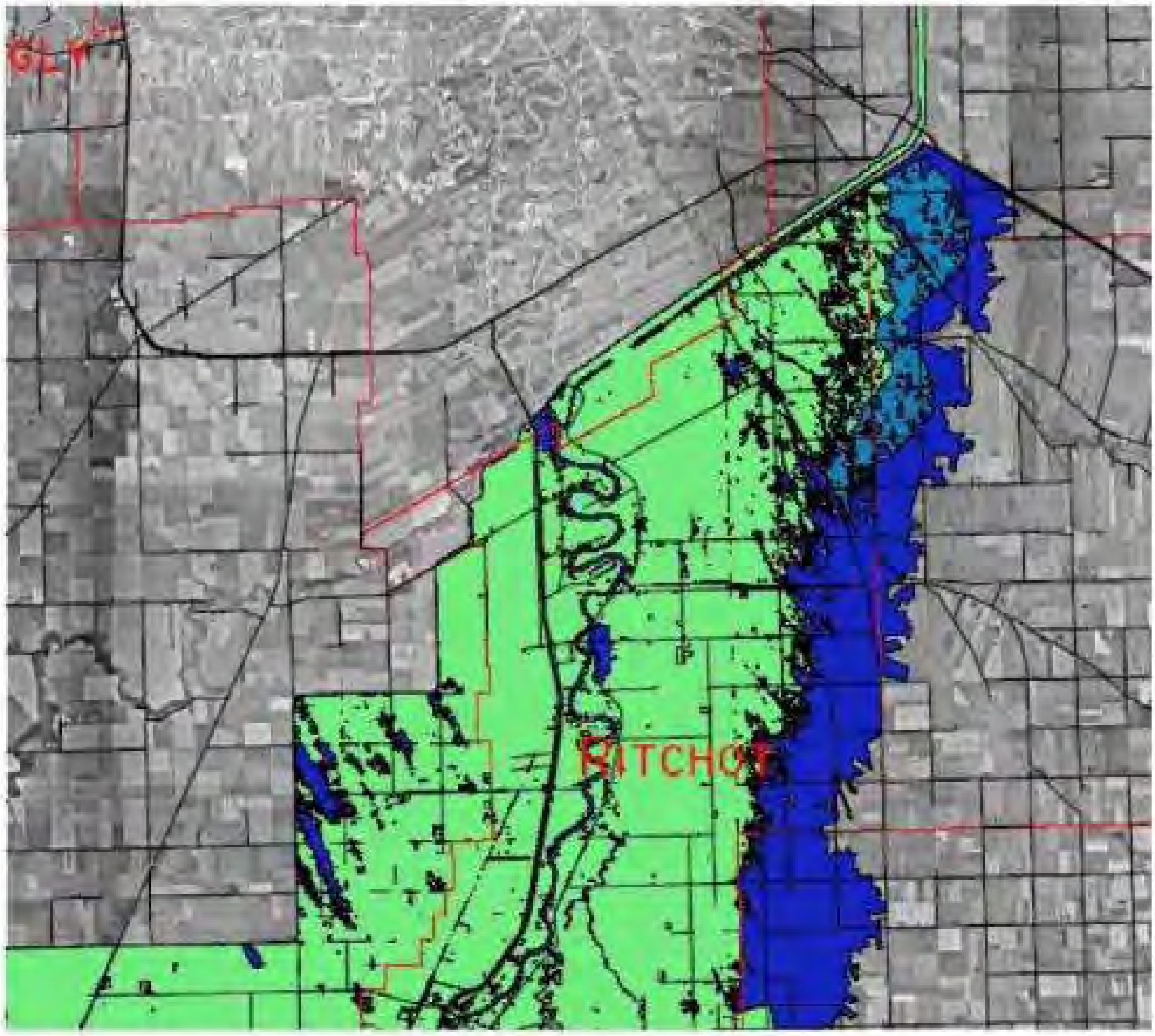
8.2.4 Flooding

One person in the October 27 Public Meeting regarding the landfill queried the vulnerability of the landfill's location to flooding (Question 16, Appendix E-4). (He also wondered aloud whether the landfill mass could be constructively part of the City's flood-control/barrier system, in which the City declined interest.)

The major flooding challenge faced to date by the landfill was the "Flood of the Century" in 1997 flood. In magnitude and potential for risk, it would certainly approximate a "most probable worse-case" flood risk to the landfill. The spring freshet that year, notwithstanding the title conferred on the event by media, was a 1:90-year flood event (Figure 8-3). The landfill was protected that year by the continuous barrier created by two components of the Winnipeg Floodway, the "West Dyke" and the "Z Dyke."

A more severe 1:100-year flood would create more flooding east of the Red River but would not flood the landfill (Figure 8-3). An extreme flood event with a return frequency of only 1:700 years (which the Floodway Expansion Project is designed to protect against) would still not cause flooding of the landfill (Figure 8-3; Tetr*ES* 2004).

The consequences of a "worst-case" flooding event must therefore be considered to be not significant.



Provincial Highways and Municipal Roads Manitoba
Rural Municipalities Manitoba
90 Year Event Flood Extent - EXPANDED Floodway
1997 Actual Flood Extent (90 Year Event, Pre-Gaps, Pre-Expansion)
700 Year Event Flood Extent (With or Without FW Expansion - EL-778')

Comparison of Flooding Events
90 Year (~1997) vs. 700 Year
Figure 8-3

flood_events; V\1114\actv\grfx\01\0110\66

8.3 CONCLUSIONS

Almost 40 years of landfill operations have occurred at the Brady Road site. On-site and related data have been accumulated to assist in determination of effects from these years of operations. Reference to Table 8-6 will indicate that no significant environmental impacts on air, soil, surface water or groundwater quality are evident over the past decades of operations. No significant impacts are evident on community health.

These findings are consistent with findings of similar, in some cases exhaustive, studies (Genivar *et. al.* 2007; Environment Canada 2003a, 2003b; City of Calgary 2005; MOE 1999.

There are few residual effects associated with landfill operations as they now occur. The only long-term measurable effect of landfill operations is a very slight increase in chemicals associated with waste in the groundwater directly beneath the areas where waste has been buried. As indicated in the EIA, the concentrations of these chemicals do not approach action levels (i.e., applicable water-quality guidelines). They should decline in future years in consequence of CIWMP implementation. The small quantities of these chemicals in the groundwater do not represent a public-health impact because the groundwater in question is saline (i.e., salty), and is not known to be used for domestic (i.e., drinking water or purchase water) purposes by any parties downstream.

The other significant residual vector from the landfill is landfill gas and associated occasional odour nuisance. As noted in the EIA and above, a landfill gas-recovery project is being implemented by the City. It will significantly reduce the volumes of gases, some of which are malodorous, released to the receiving airshed. Further, the City is planning for Best Practices in on-site Source-Separated Organic (SSO) management, and composting, which should also reduce odour generation. The long-term operation of the LFG project (and any future SSO process) will also be the subject of monitoring, by means of systems specifically designed and installed for this purpose.

Accordingly, these residual effects are judged to be infrequent, transient and mitigable, and therefore "not significant." The consequence of CIWMP implementation is that these vectors will be reduced in the future, due to the effects of reduced waste deliveries because of greater upstream diversion.

The City's commitments to Best Practices in landfill design and operations articulated in the new draft Operating Plan reduce all current foreseeable potential risk sources and constrain all foreseeable risk vectors. The conversion of the site from a "landfill" to a "perpetual care resources-recovery facility" means that the low level of measurable environmental risk from operations can only be reduced.

Table 8-6: Extent of Key Impacts from ~40 Years of Landfill Operations at Brady Road Site and Predicted Future Impacts

Receptor	Vector	Concern	Impacts from Past Operations	Evidence Source	Predicted Future Impacts	Basis of Judgment
Local airshed	Wind-entrained dusts and gases from working face	Respiratory illness in people in adjoining communities	None significant. Total respirable morbidity and respiration cancer rates lowest for both men and women over past 25 years in Fort Garry South.	CancerCare Manitoba statistics. Regional Health Authority Indicators Atlas 2009.	Few to none significant	Council adoption of and commitment to implement CIWMP, especially relating to upstream diversion of recyclables and organics, and to improved operating conditions and procedures at the facility. Solid Waste Services Division (SWSD) commitments to respond positively to all Table 2 Action Items in the Phase 1 ELP. SWSD commitments to finalize and progressively improve draft new Operating Plan, including new comprehensive ERP.
Local groundwater	Leachate migration into groundwater	Impacts on potability and domestic/ commercial use of groundwater	None significant. Groundwater is saline and not used for domestic or commercial potable purposes. Contaminants in fully mixing groundwater beneath site don't approach protective criteria. Groundwater "daylighting" in La Salle groundwater quality likely of higher quality than present in river.	Borehole logs detailing site stratigraphy. Long-term City data on leachate and groundwater quality. "Piper Plot" analyses showing leachate "fingerprint" different from groundwater "fingerprint." Estimate of groundwater dilution of leachate migrating to groundwater. Provincial water-chemistry and flow data for La Salle River.	Few to none significant	Groundwater has too much salinity for any future potable use. Measures in CIWMP will significantly divert recyclable metals, plastics, wood and other organics from wastestreams delivered for burial. Council adoption of and commitment to implement CIWMP, especially relating to upstream diversion of recyclables and organics, to improved operating conditions and procedures at the facility. Solid Waste Services Division (SWSD) commitments to respond positively to all Table 2 Action Items in the Phase 1 ELP. SWSD commitments to finalize and progressively improve draft new Operating Plan, including new comprehensive ERP.
Local surface water	Contaminated runoff management from site to La Salle River	Impaired water quality in La Salle River	None significant. Surface runoff enriched by alkalinity, nutrients and some metals in slight degree by passage through site. Modest human use of La Salle River. Groundwater quality likely of higher quality than present in river.	City grab-sample data from surface impoundments or sample stations. Provincial water-chemistry and flow data for La Salle River.	Few to none significant	New surface ditching designs and plans for creation of engineered wetland for polishing runoff before off-site discharge. Council adoption of and commitment to implement CIWMP, especially relating to upstream diversion of recyclables and organics, to improved operating conditions and procedures at the facility. Solid Waste Services Division (SWSD) commitments to respond positively to all Table 2 Action Items in the Phase 1 ELP. SWSD commitments to finalize and progressively improve draft new Operating Plan, including new comprehensive ERP.
Human health	Wind-entrained dusts and gases from working face	Respiratory illness in people in adjoining communities	None significant. Total respirable mortality and respiration cancer rates lowest for both men and women over past 25 years in Fort Garry South.	CancerCare Manitoba statistics. Regional Health Authority Indicators Atlas 2009.	Few to none significant	Council adoption of and commitment to implement CIWMP, especially relating to upstream diversion of recyclables and organics, and to improved operating conditions and procedures at the facility. Solid Waste Services Division (SWSD) commitments to respond positively to all Table 2 Action Items in the Phase 1 ELP. SWSD commitments to finalize and progressively improve draft new Operating Plan, including new comprehensive ERP.
	Exposure to contaminated smoke from major landfill fire		No major landfill fires; all fires small and easily extinguished.	Information received from Chief Norm Daly at February 25-26, 2010, Fire Management Workshop.		

9.0 Future Developments

Implementation of the CIWMP will give rise to three fundamental changes affecting the landfill's long-term site use:

- The site will become a perpetual-care facility, with more land available for cell development than will likely be needed for at least the next century. Land previously thought necessary for waste burial but now unlikely to be needed for that purpose will be dedicated to waste diversion and public recreation.
- The previous conception of a 90-m hill at the site to facilitate public recreation, along with the original conception of a series of larger on-site ponds (Figure 1-5), has been significantly adjusted. The maximum elevation of the landform created by buried waste will now not exceed 30 m above the prairie, and large ponds will no longer be contemplated except for small or "dry ponds" for runoff control or the sand-wash facility noted below. Because the facility is close to the southern approach to the Winnipeg International Airport, ponds will be discouraged on-site to reduce attraction to migratory birds, or will be designed and operated to minimize bird attraction and/or as "dry ponds."
- Finally, the site will landscaped, as portions of the site are completed, to encourage on-site public recreation and visual screening from adjoining lands. Vegetation of soil cover will occur in a portion of the current landfill being retrofitted for landfill-gas recovery. Starting initially with appropriate cultivars of fast-growing full-canopy trees (e.g., hybrid poplar), visual screening of the site will commence on the north, east and west sides, facing the growing subdivision development on these sides of the landfill. Slower-growing trees (e.g., willow and evergreens) will infill behind the poplars, to add to the visual screening and sound deadening, and to create year-round botanical screening and improved site aesthetics.

Specific additional new activities expected to occur in the immediately foreseeable future as part of the development to be licensed include the following:

9.1 GAS RECOVERY

The City is in the process of retaining professional engineering services to design and develop a landfill gas-(LFG) recovery system (e.g., Photo 1-9; Figures 1-2 and 4-7). The LFG project, has previously been reviewed and licensed by Manitoba Conservation. Initially, the recovered gas will be flared to reduce the greenhouse gas (GHG) content. As the evolution of deliveries to and burial at the facility occur during the implementation of the CIWMP, consideration will be given to alteration of the LFG facility. Depending on the proven amount and quality of the gas recovered, it may be possible that energy production can be achieved.

9.2 SITE RENAMING

The site will soon be renamed as the “Brady Road Resources Management Facility” to reflect the long-term vision of resource recovery and waste diversion. Signage at the site will soon acknowledge this new fundamental shift in and repurposing of the Brady Road Landfill. The “rebranding” of the site will emphasize the long-term materials-management and perpetual-care concepts that City Council adopted on October 19, 2011.

9.3 SAND-WASH FACILITY

The feasibility of recycling recovered sand from winter street sanding is currently being determined. With this concept, accumulated sand recovered from street-sanding operations after winter will be stockpiled on-site, and washed each summer using runoff stored in a new sand-wash pond facility. The washed sand would then be reused each winter on icy streets. The water accumulating in the sand-wash pond would be available for on-site firefighting.

9.4 RECYCLING CENTRE

On-site recycling of materials is currently limited to metal goods, appliances (Photo 1-4) and used tires (Photo 1-5). There is also an operation to recover usable wood from diseased elm for use as flooring (with the residue being chipped; Photo 1-6). Future development of the site to increase the frequency and extent of materials diverted includes the allocation of space for a comprehensive Community Resource Recovery Centre (CRRC; e.g., Photo 1-7; Figure 1-2). The CRRC will accommodate mechanisms for recycling a much broader range of materials than are stored and recycled now, likely including institutional, commercial and industrial waste, household hazardous wastes and electronic wastes (“e-waste”).

9.5 COMPOSTING FACILITY

Currently there is a windrow-type composting operation on-site that composts leaf and yard waste materials collected either at depots or curbside or delivered to the site (Photo 1-3). The composted product is used on-site for landscaping purposes. Under the CIWMP, this operation will be significantly expanded (Figure 1-2). Also under the CIWMP, a Source-Separated Organics (kitchen waste) program is to be implemented; however, the technology for composting this material has not yet been determined. Once determined, the SSO-management technology will be developed and housed on-site.

9.6 RUNOFF POLISHING

Whereas all surface runoff now flows naturally to the La Salle River without any on-site treatment, future alterations to the site will include provision of a new engineered wetland (e.g., Photo 8; Figures 1-2 and 4-3) for polishing of this runoff before it leaves the property.

10.0 Facility Decommissioning

The *Environment Act* requires that applications for licensing provide indication of the expected decommissioning concept for the development to be licensed. Whereas landfill planning some decades ago considered decommissioning as the final stage in the project life cycle, landfill planning around the world, fueled by an increased scarcity of resources and increased public desire for recycling, is moving towards concepts like “perpetual-care” and “materials-management.” The Brady Road Landfill is no exception, as exemplified by City Council’s approval of the CIWMP.

The original conception of the Brady Road Landfill imagined burial of wastes for at least another century when the last Management Plan was articulated in 1987 (Figure 5-1). City Council’s adoption of the CIWMP means that land uses on the site previously expected to be focused on waste burial can now include such other uses as public recreation (Figure 5-2). This means, therefore, that the life expectancy of the landfill land base will be more than a century. It also means, given the current tendency over the last two decades towards “landfill mining” around the developed world, that waste materials now buried will be mined for materials recovery (e.g., metals recovery, plastics recovery) in the future. It is contemplated that landfill mining could happen at the Brady Road facility in the decades to come. Indeed, the first landfill mining activities in the City occurred with the excavation of the long-decommissioned Cadboro East facility north of the south Perimeter Highway to facilitate site availability for the new “Bridgwater” subdivision.

In this context, the current vision for Brady Road does not contemplate a traditional “decommissioning” of the facility. Rather, adoption of the CIWMP means that future landfill cells will be designed for buried wastes to be recovered at some future date. A cycle of waste burial, waste decay, waste stabilization, rest, and then (possibly) selective cell mining is expected at the Brady Road facility in the decades to come.

Should there be any conception of traditional “decommissioning” of the site in the future, the City will advise the Director of Environmental Approvals to this effect. Upon receipt of any guidance or instruction from the Director to file a formal decommissioning plan consistent with that particular requirement, the City will develop a conceptual decommissioning plan for provincial review and approval.

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