

ASSESSMENT OF LFG VERTICAL MIGRATION

OTTAWA LANDFILL

WASTE MANAGEMENT

TECHNICAL REPORT – SURVEY JUNE 2008

PROJECT N° Q111931

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Quebec, July 14, 2008

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1. INTRODUCTION

Waste Management of Canada Corp. has given a mandate to GENIVAR for the assessment of methane emission at the surface of Ottawa landfill.

According to the offer for professional services, the following tasks were performed:

- Measurement on a continuous basis of the methane concentrations in the ambient air above the surface of the landfill site with the FID-GPS technology developed by the firm GENIVAR ;
- Data processing and mapping of results ;
- Technical report editing.

Field work was performed by Mr. Alexandre Monette and Mr. Mathieu Plante of GENIVAR on June 26 & 27 2008.

2. METHODOLOGY

2.1 Location of measurements

Assessment of vertical migration of LFG was performed above the entire landfill. Location of the measurement points is shown on Figure 2-1.

This assessment was also performed above the LFG air sparging system trench (2 lines of 1 km long at a height of approximately 6 inches above ground). Location of the measurement points is shown on figure 2-2.

2.2 Methodology

Methane concentrations above ground are measured and recorded on a continuous basis with a portable Flame Ionisation Detector (FID). Spatial location of the measurement points are defined and recorded by a Global Positioning System (GPS).

According to the EPA procedure, the sampling is done along the periphery of the waste cells and along a serpentine pattern spaced about 30 meters apart, at a height of approximately 6 inches above ground.

Methane concentrations are then processed and spatial coordinates are transformed from the degree, minute, second format to the NAD83MTM Zone 9 system. A map showing iso-contours of methane concentration is prepared. The iso-contours are overlaid on a map showing the landfill gas collection system general arrangement in order to be able to evaluate its efficiency and to identify areas where modifications are required to reduce emissions to the atmosphere.

2.2.1 Instrumentation

Methane concentrations are determined with a Thermo Environmental Instruments TVA 1000B portable analyser by the flame ionisation method. This instrument is used for the measurements into ambient air of small concentrations of total volatile organic compounds, expressed as methane. The analytical range of the analyser is 0 to 50 000 ppmv with a lower detection limit at 0.5 ppmv.

Since the concentration of methane in landfill gas is more than 100 times higher than non methane organic compounds and that the measured concentrations are low, the result given by the instrument is interpreted as methane alone.

Spatial co-ordinates are measured by a Garmin GPS which in DGPS mode has an accuracy of less than 1 meter.

Wind speed is checked regularly during sampling with a portable anemometer.

2.2.2 Instrument calibration

Accuracy of the analytical instrument is verified on a regular basis with calibration gas having a known composition. Adjustments are made if required. For the TVA 1000B, the calibration gases are composed of:

- 100 ppmv of CH₄ in air;
- 10 000 ppmv of CH₄ in air.

2.2.3 Meteorological constraints

Average wind speed during sampling shouldn't exceed 8 km/hr with maximum peak speed at 20 km/hr.

LANDFILL GAS EMISSION
WASTE MANAGEMENT

OTTAWA LANDFILL

GPS/FID MEASUREMENT



LEGEND

- + MEASUREMENT POINTS
- ⊕ GAS EXTRACTION WELL

FIGURE 2-1

LOCATION OF
MEASUREMENT POINTS

JUNE, 2008

5016200

5016000

5015800

5015600

5015400

5015200

345800

346000

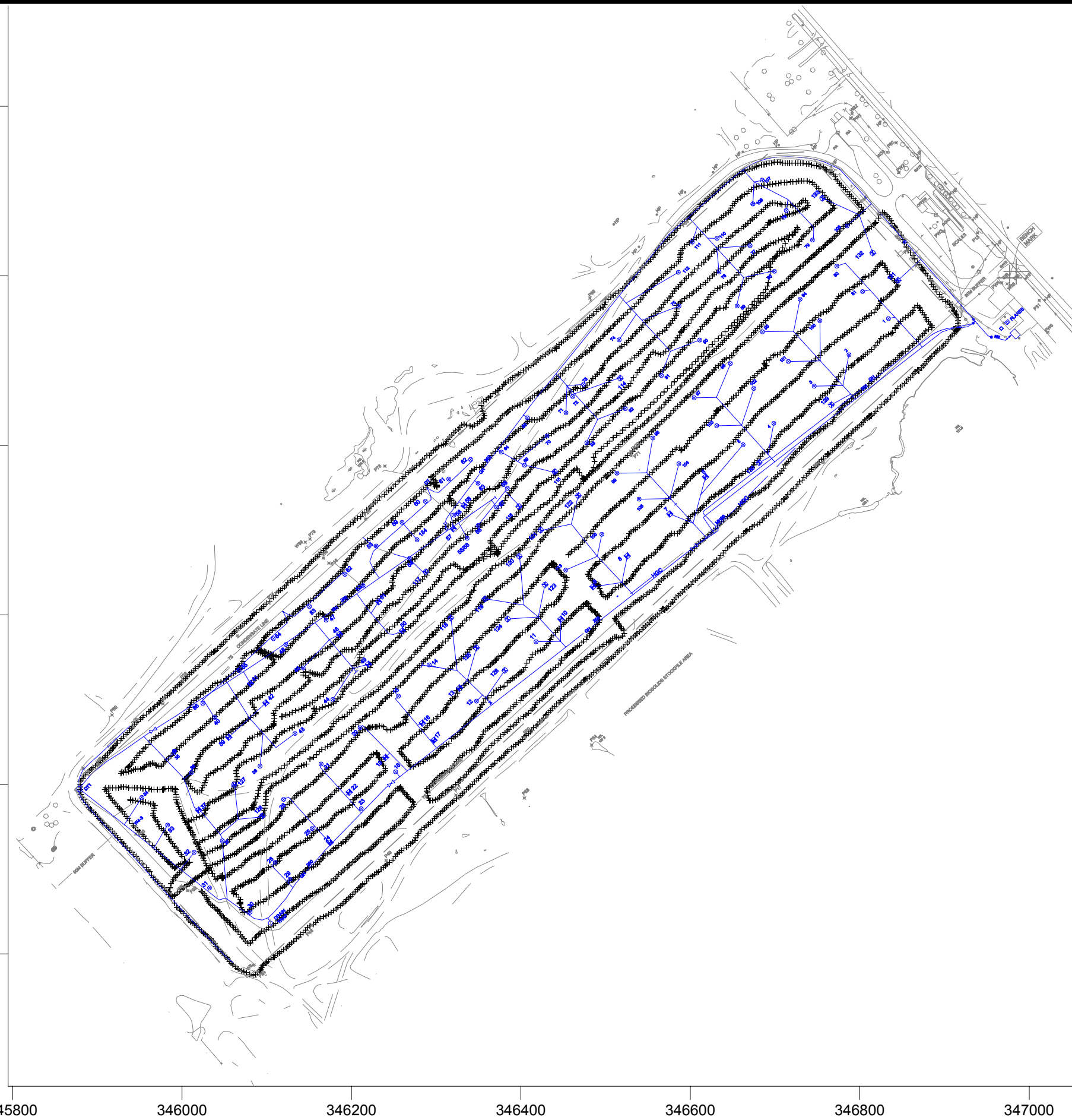
346200

346400

346600

346800

347000



LANDFILL GAS EMISSION
WASTE MANAGEMENT
OTTAWA LANDFILL

GPS/FID MEASUREMENT



LEGEND

- + MEASUREMENT POINTS
- EXISTING FENCE

FIGURE 2-2

LOCATION OF MEASUREMENT
POINTS

JUNE, 2008



3. RESULTS

3.1 Regulations

In Ontario, owners of landfill sites need an approval if their facilities “may discharge or from which may be discharged a contaminant into any part of the natural environment other than water» (Environmental Protection Act, R.S.O. 1990, CHAPTER E.19, part II General Provisions, section 9 Approval of Director, plant or production process). However, no specific maximum acceptable concentration of methane above the surface is defined.

Under item No. 4 of Provincial Officer’s Order No. 5830-6Z2PPW, WM is required to perform landfill gas emission surveys at the Ottawa landfill site in April, June, August and October 2008. Each report shall include also the survey results of the previous campaign and describe any actions related to the LFG collection and flaring system taken since the last survey.

US EPA has enacted operational standards in "Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills", into effect since March 12th, 1996 (40 CFR Parts 51, 52 and 60). This rule stipulates that methane concentrations measured at the surface of the landfill shall be less than 500 ppmv. EPA methodology and standard will be used for the assessment of methane emissions to the atmosphere at the Ottawa landfill.

3.2 Surface sampling results

Results show that there are 148 points (2.69%) having a methane concentration above 500 ppmv compared to 0.44% of the points for the previous survey. Table 3-1 presents the location of those points together with their concentration and table 3-2 presents the results of April 2008 survey.

Figure 3-1 presents the detailed results for this survey and figure 3-2 for April 2008. Iso-contour map of methane concentrations is shown on figure 3-3 for this sampling campaign and figure 3-4 for April 2008. The highest concentration recorded in the

Landfill gas emission surface sampling

Ottawa Landfill

present survey is 6 410 ppmv at (346 663, 5 016 035) which is located near of well 77.

Figure 3-5 presents the methane concentrations obtained above the LFG air sparging system located along Carp Road for this survey and figure 3-6 for April 2008. No methane concentration higher than 500 ppmv was measured in June 2008.

**Table 3-1 : Points having a methane concentration higher than 500 ppmv
June 2008**

X	Y	CH₄ (ppmv)
346663	5016035	6410
346046	5015487	5233
346398	5015787	4992
346047	5015455	3589
346358	5015501	3238
346283	5015463	3206
346361	5015502	3182
346516	5015948	2832
346570	5015645	2707
346511	5015943	2621
346400	5015789	2516
346166	5015313	2387
346545	5015622	2379
346267	5015629	2313
346575	5015649	2251
346235	5015663	2249
346447	5015853	2245
346159	5015273	2009
346157	5015272	1889
346349	5015739	1861
346384	5015520	1764
346071	5015366	1758
346796	5016043	1751
346429	5015866	1748
346366	5015470	1711
346605	5015720	1691
346233	5015661	1658
346264	5015627	1651
346181	5015569	1642
346156	5015530	1629
346280	5015462	1627
346261	5015472	1514
346064	5015319	1487
346288	5015750	1463
346381	5015516	1446
346349	5015449	1439
346275	5015738	1436
346661	5016033	1414
346589	5015700	1358
346167	5015316	1354
346576	5015694	1320
346493	5015594	1308
346365	5015446	1293
346392	5015784	1264
346262	5015726	1256
346052	5015524	1247
346162	5015347	1219
346701	5016109	1178
346683	5015787	1154
346591	5015703	1145

**Table 3-1 : Points having a methane concentration higher than 500 ppmv
June 2008**

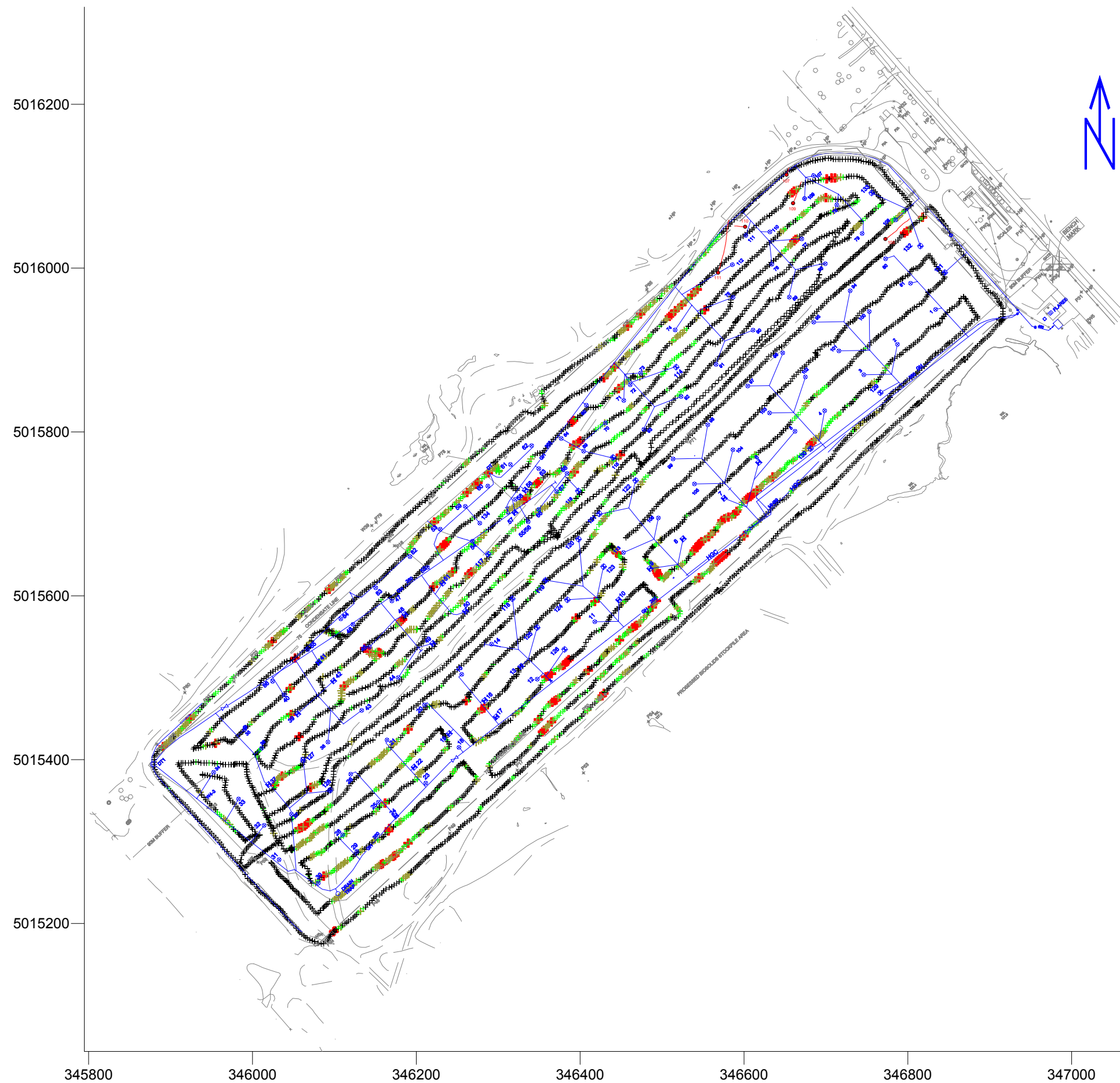
X	Y	CH₄ (ppmv)
346392	5015814	1124
346393	5015751	1118
346557	5015672	1114
346183	5015571	1098
346467	5015563	1093
346347	5015737	1074
346659	5016092	1065
346386	5015522	1035
346469	5015564	1035
346143	5015532	991
346600	5015673	981
346444	5015653	978
346365	5015505	962
346273	5015736	950
346608	5015721	939
346573	5015692	933
346087	5015258	927
346390	5015812	922
346379	5015515	919
346545	5015663	915
346564	5015679	912
346635	5015745	900
346356	5015436	877
346495	5015626	869
346603	5015718	869
346568	5015643	862
346354	5015434	850
346057	5015428	848
346094	5015608	845
346244	5015629	831
346496	5015624	830
346237	5015666	828
346066	5015321	819
346395	5015573	809
346154	5015531	784
346458	5015929	782
346707	5016110	781
346546	5015663	776
346410	5015509	772
346661	5016094	741
346610	5015723	737
346539	5015655	734
346057	5015316	726
346573	5015647	725
346112	5015490	716
346681	5015785	716
346578	5015651	703
346036	5015380	698
346100	5015191	698
346493	5015631	697

**Table 3-1 : Points having a methane concentration higher than 500 ppmv
June 2008**

X	Y	CH₄ (ppmv)
346612	5015725	691
346230	5015659	685
346494	5015628	685
346068	5015323	683
346448	5015546	683
346566	5015641	682
346543	5015974	677
346024	5015544	676
346488	5015586	676
346799	5016045	674
346581	5015696	673
345955	5015420	671
346190	5015298	667
346099	5015190	663
346222	5015690	662
346548	5015666	660
346552	5015949	657
346027	5015369	653
346546	5015664	647
346369	5015472	629
346334	5015719	622
346331	5015717	620
346818	5016062	604
346371	5015473	602
346445	5015652	601
346509	5015941	592
346172	5015282	590
346543	5015660	588
346524	5015955	585
346616	5015729	585
346221	5015611	580
346474	5015944	577
346174	5015283	570
345924	5015450	569
346190	5015437	564
346137	5015536	554
346060	5015317	553
346449	5015772	546
346442	5015879	543
346536	5015967	541
346427	5015478	538
346418	5015593	527
346541	5015658	522
346700	5016086	521
346429	5015481	520
346711	5016110	510
345891	5015416	507
346464	5015561	505

**Table 3-2 : Points having a methane concentration higher than 500 ppmv
April 2008**

X	Y	CH₄ (ppmv)
346709	5015785	951
346593	5015729	787
346591	5015728	737
346062	5015340	703
346264	5015538	613
346426	5015764	613
346052	5015332	603
346244	5015603	603
346596	5015731	599
346435	5015919	588
346293	5015478	562
346530	5015622	553
346514	5015919	553
346055	5015334	542
346244	5015604	542
346056	5015336	538
346043	5015575	523
346043	5015575	520
346776	5015849	519



**LANDFILL GAS EMISSION
WASTE MANAGEMENT**

OTTAWA LANDFILL

GPS/FID MEASUREMENT



LEGEND

- ⊕ 0 à 50 ppmv
- ⊕ 50 à 100 ppmv
- ⊕ 100 à 500 ppmv
- ⊕ 500 à 50000 ppmv

FIGURE 3-1

**METHANE CONCENTRATIONS
LANDFILL**

JUNE, 2008

5016200

5016000

5015800

5015600

5015400

5015200

345800

346000

346200

346400

346600

346800

347000

LANDFILL GAS EMISSION
WASTE MANAGEMENT

OTTAWA LANDFILL

GPS/FID MEASUREMENT



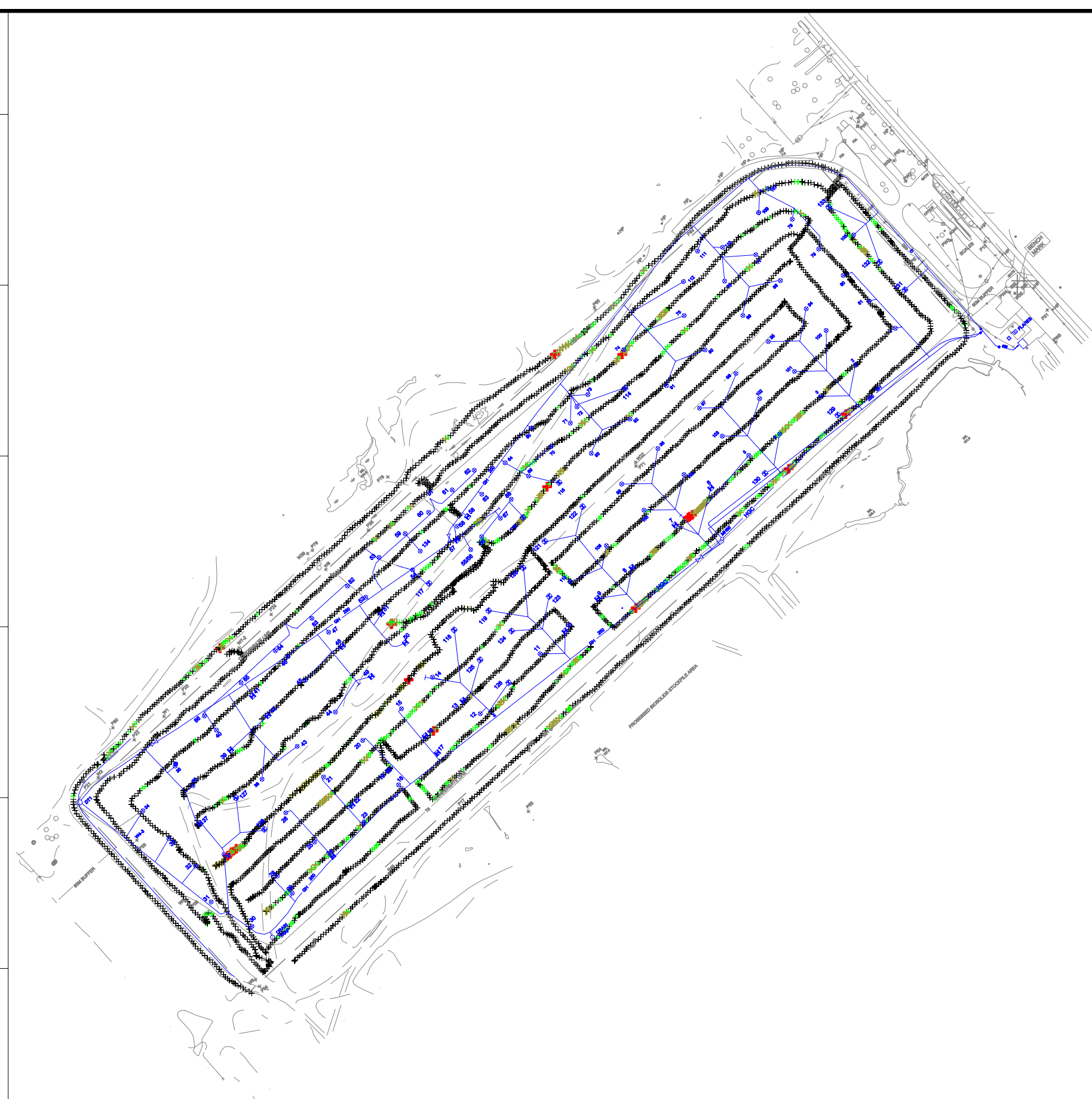
LEGEND

- + 0 à 50 ppmv
- + 50 à 100 ppmv
- + 100 à 500 ppmv
- + 500 à 50000 ppmv

FIGURE 3-2

METHANE CONCENTRATIONS
LANDFILL

APRIL, 2008



LANDFILL GAS EMISSION
WASTE MANAGEMENT

OTTAWA LANDFILL

GPS/FID MEASUREMENT



2500, rue Jean-Perrin, bur. 204 Québec (QC) G2C 1X1
Tél.: (418) 845-8885 Téléc.: (418) 845-5559

LEGEND

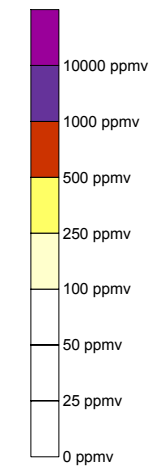


FIGURE 3-3

ISO-CONTOURS OF
METHANE CONCENTRATIONS

JUNE, 2008

5016200

5016000

5015800

5015600

5015400

5015200

345800

346000

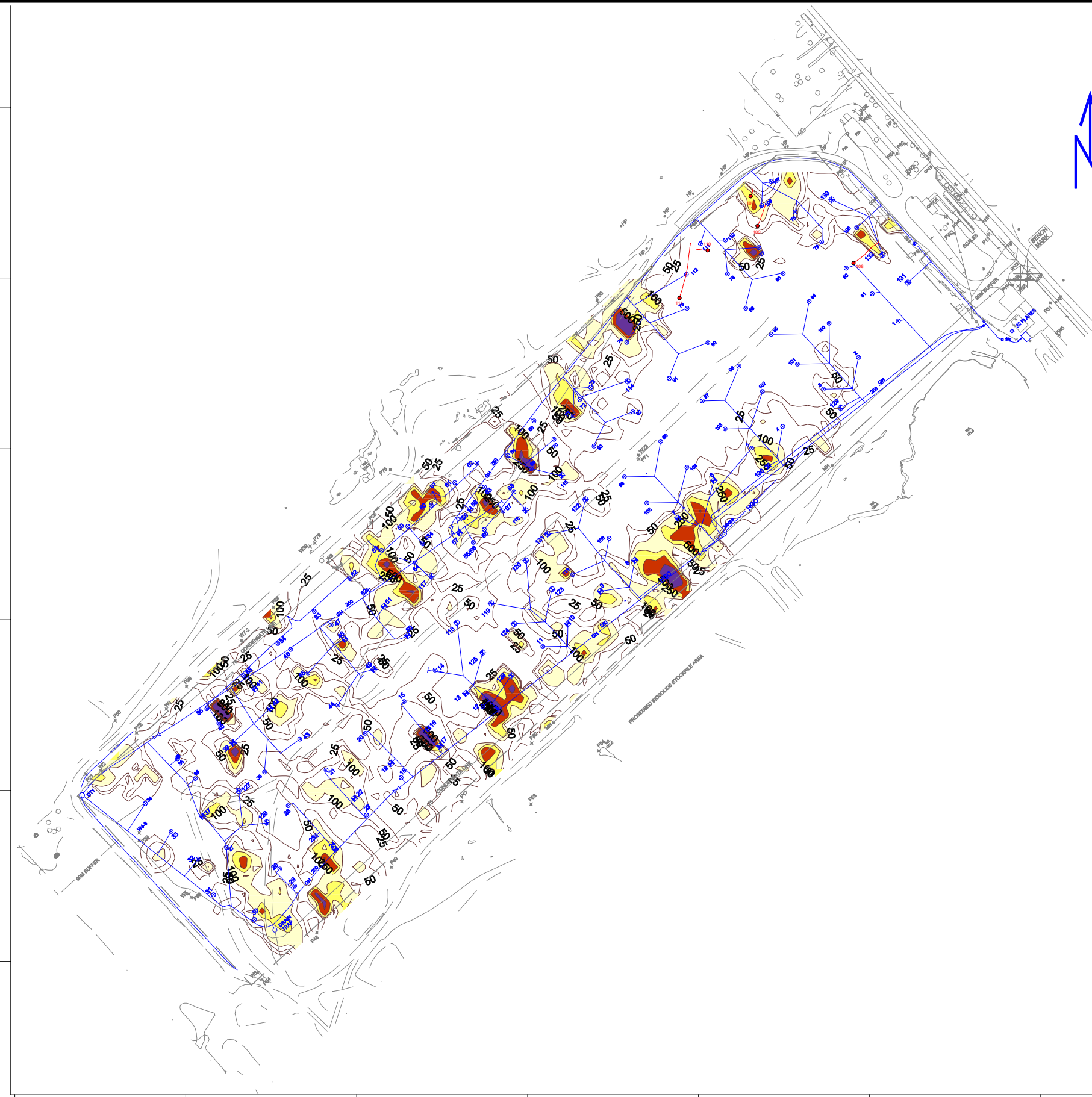
346200

346400

346600

346800

347000



5016200

5016000

5015800

5015600

5015400

5015200

345800

346000

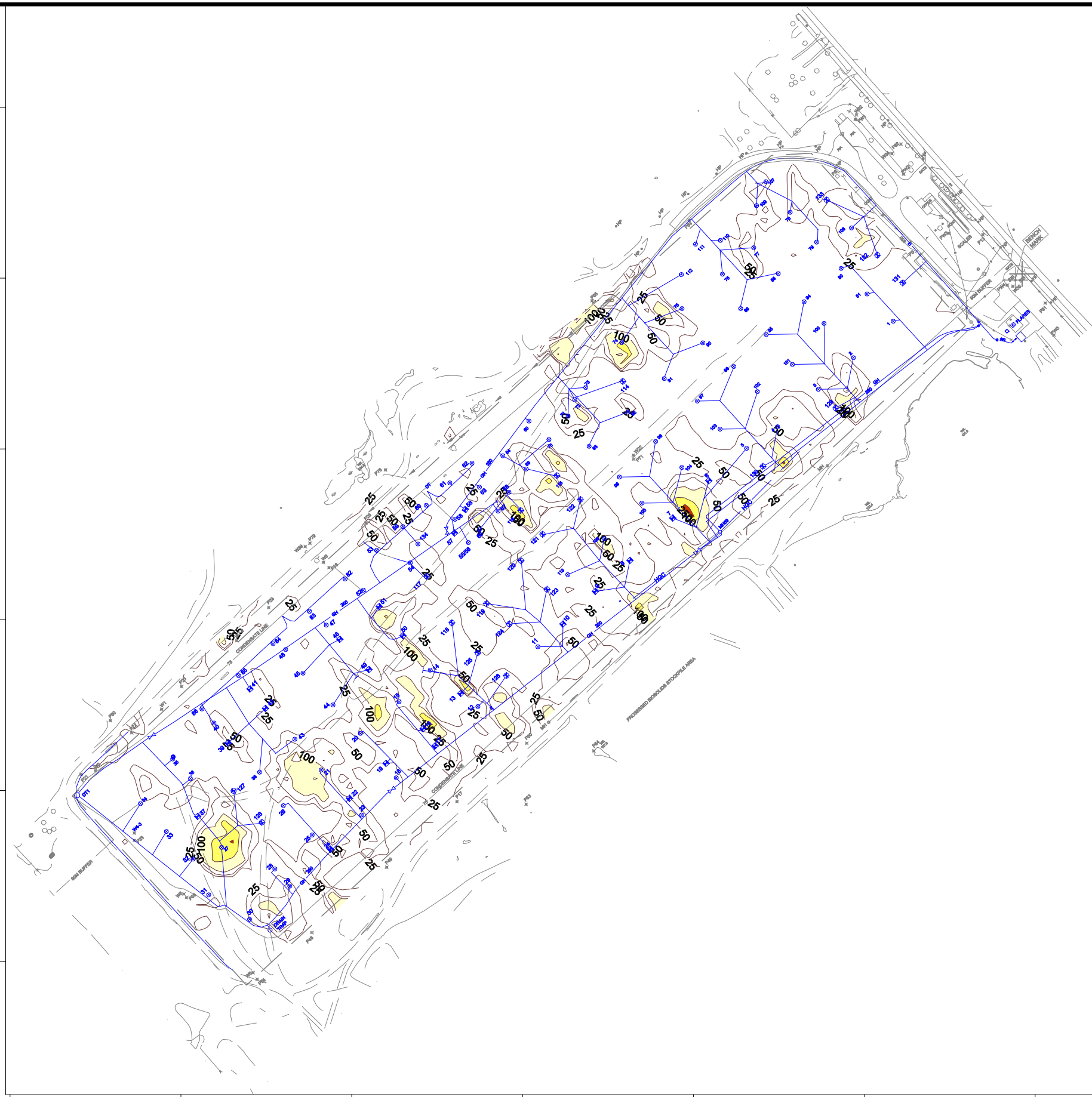
346200

346400

346600

346800

347000



**LANDFILL GAS EMISSION
WASTE MANAGEMENT**

OTTAWA LANDFILL

GPS/FID MEASUREMENT



2500, rue Jean-Perrin, bur. 204 Québec (QC) G2C 1X1
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LEGEND

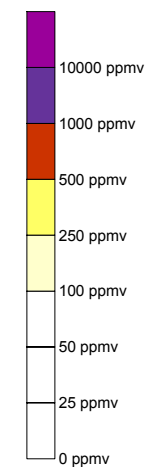


FIGURE 3-4

**ISO-CONTOURS OF
METHANE CONCENTRATIONS**

APRIL, 2008

**LANDFILL GAS EMISSION
WASTE MANAGEMENT
OTTAWA LANDFILL**

GPS/FID MEASUREMENT



LEGEND

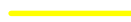




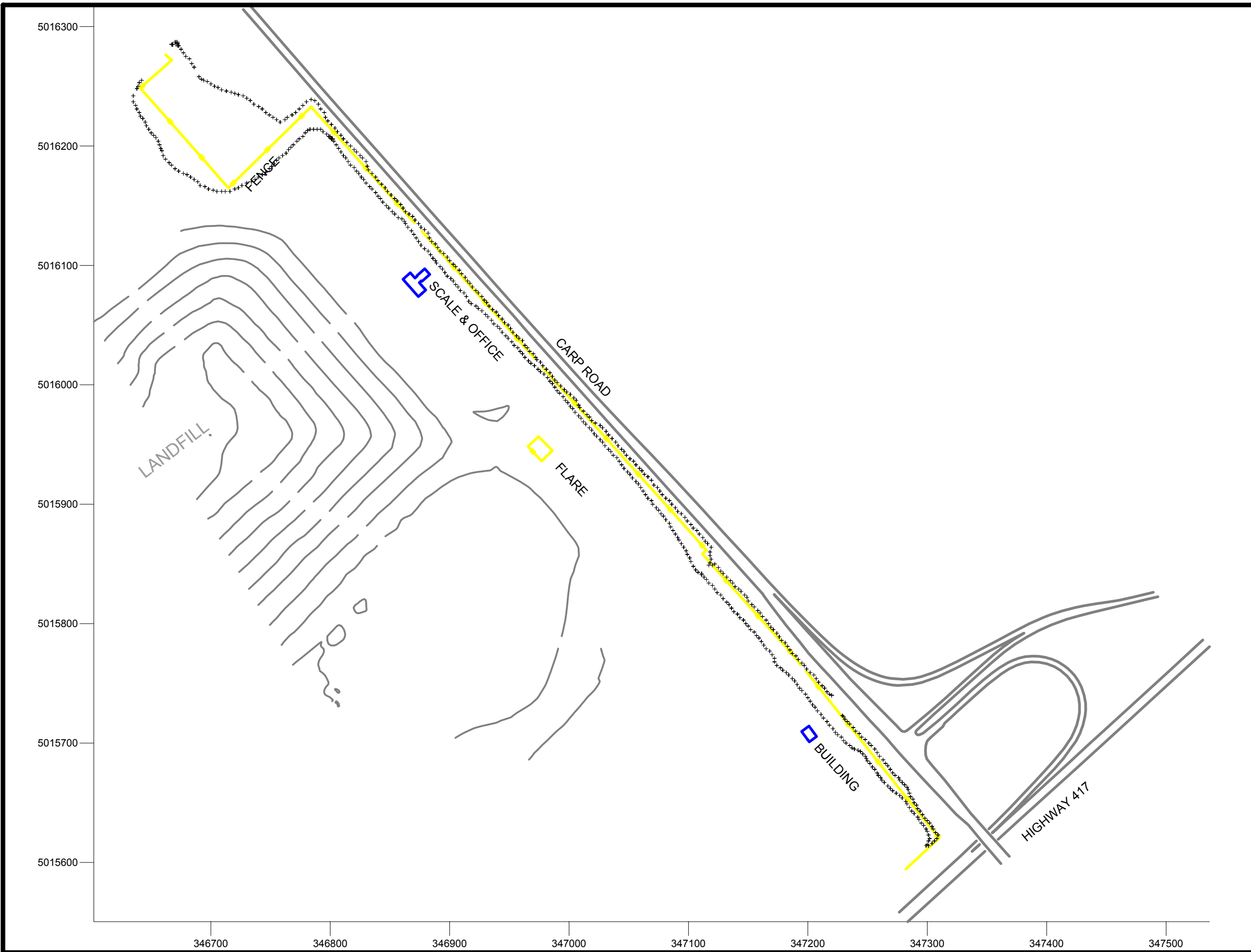
-  EXISTING FENCE
-  0 to 50 ppmv
-  50 to 100 ppmv
-  100 to 500 ppmv
-  500 to 50000 ppmv

FIGURE 3-5

**METHANE CONCENTRATIONS
CARP ROAD
JUNE, 2008**



**LANDFILL GAS EMISSION
WASTE MANAGEMENT
OTTAWA LANDFILL**

GPS/FID MEASUREMENT



LEGEND

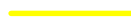




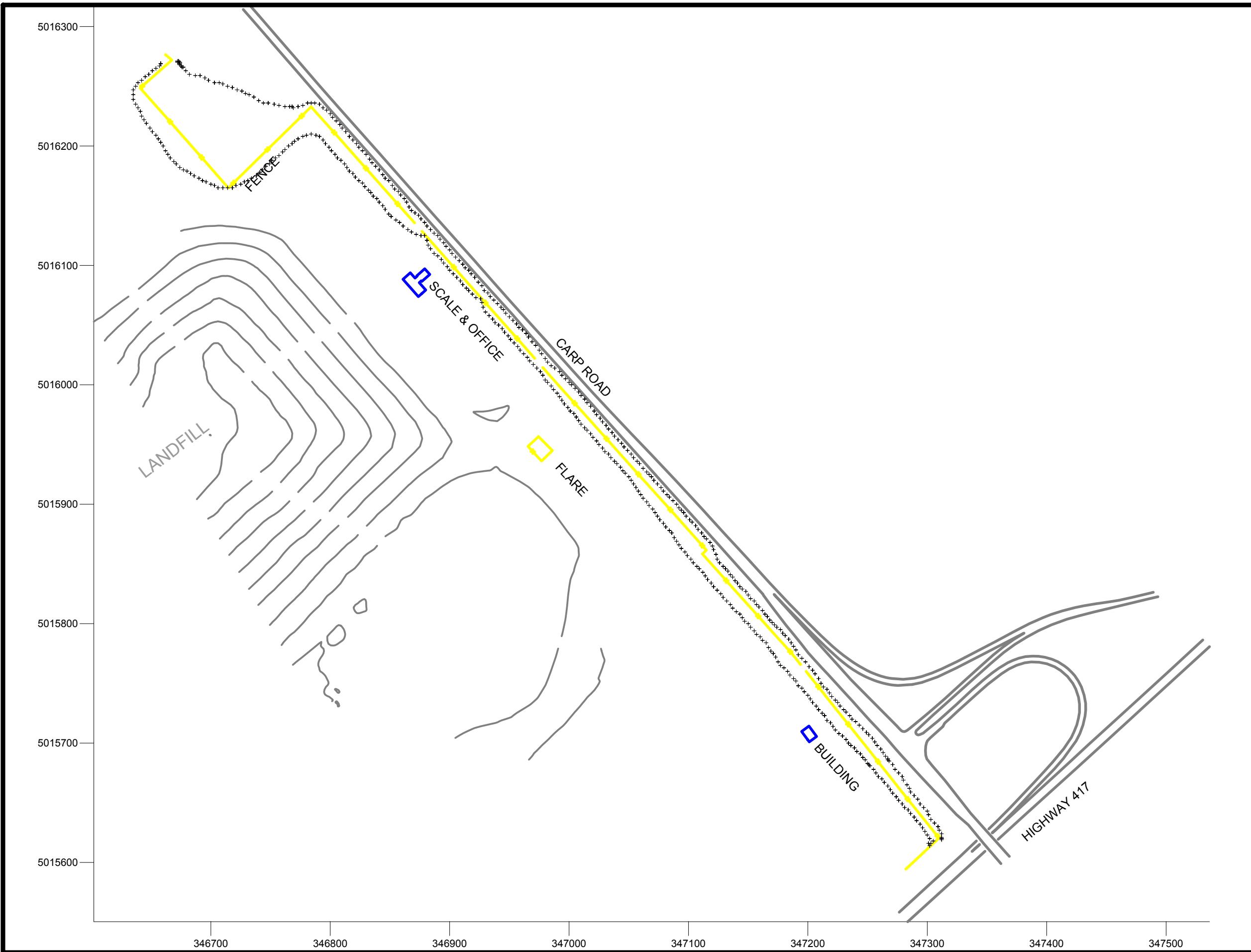
-  EXISTING FENCE
-  0 to 50 ppmv
-  50 to 100 ppmv
-  100 to 500 ppmv
-  500 to 50000 ppmv

FIGURE 3-6

**METHANE CONCENTRATIONS
CARP ROAD
APRIL, 2008**



3.3 Site configuration and well performance

As of July 2008, the landfill gas collection system at the Ottawa landfill is composed of 137 vertical extraction wells. All of these wells are connected to two (2) pumping and flaring stations via a 450 mm header located at the bottom of the slopes.

3.4 Improvements since the previous assessment

A total of 28 wells were installed by Waste Management between May 2008 and July 2008. 12 new wells were installed and 16 wells were redrilled.

3.5 Wind speed

Sampling was done when the winds were under specifications described at 2.2.3. Effectively, the wind velocity during the sampling campaign was between 5.5 and 8.0 km/hr on Thursday (June, 26) and between 1.0 and 6.0 km/hr on Friday (June, 27).

4. INTERPRETATION OF RESULTS

The results show that high emissions are disseminated all along the northern and southern slopes. No high value is however recorded over the top and the southeast corner of the landfill.

No high value was recorded above the air purging system near Carp road.

The integrity of the soil cover should be checked and modified if required and the vacuum increased at the wells located in the area of the high spots.

APPENDIX I

STATISTICAL REPORT

Gridding Report

Wed Jul 02 09:05:06 2008

Elapsed time for gridding: 0.18 seconds

Data Source

Source Data File Name: R:\GENIVAR\Q111931 (Biogaz-Relevé surface West Carleton)\Relevés de surface\Rapport 2008\Juin 2008\Données terrain\Site_juin08_rev.xls

X Column: A

Y Column: B

Z Column: C

Data Counts

Active Data: 5500

Original Data: 5942

Excluded Data: 0

Deleted Duplicates: 442

Retained Duplicates: 124

Artificial Data: 0

Superseded Data: 0

Univariate Statistics

	X	Y	Z
Minimum:	345880	5015175	0
25%-tile:	346164	5015454	6.74
Median:	346373	5015643	19.13
75%-tile:	346586	5015852	49.97
Maximum:	346916	5016134	6410
Midrange:	346398	5015654.5	3205
Range:	1036	959	6410
Interquartile Range:	422	398	43.23
Median Abs. Deviation:	211	199	15.07
Mean:	346378.97018182	5015654.0172727	73.054767272727
Trim Mean (10%):	346376.99373737	5015652.6440404	36.022519191919
Standard Deviation:	254.59319819159	240.02001104419	247.1218172581
Variance:	64817.696565421	57609.605701651	61069.192564946
Coef. of Variation:			3.3826925535954
Coef. of Skewness:			11.173907727521

Inter-Variable Correlation

	X	Y	Z
X:	1.000	0.849	-0.030
Y:		1.000	-0.033
Z:			1.000

Inter-Variable Covariance

	X	Y	Z
X:	64817.696565421	51899.762878678	-1903.314292394
Y:		57609.605701651	-1950.3677332529
Z:			61069.192564946

Planar Regression: $Z = AX + BY + C$

Fitted Parameters

	A	B	C
Parameter Value:	-0.010135296970963	-0.033178013000602	169993.14409998
Standard Error:	0.027699829311119	0.029381672842947	139311.48833701

Inter-Parameter Correlations

	A	B	C
A:	1.000	0.849	0.830
B:		1.000	0.999
C:			1.000

ANOVA Table

Source	df	Sum of Squares	Mean Square	F
Regression:	2	462567.9745366	231283.9872683	3.7904
Residual:	5497	335417991.13267	61018.372045237	
Total:	5499	335880559.1072		

Coefficient of Multiple Determination (R^2): 0.0013771799587512

Nearest Neighbor Statistics

	Separation	Delta Z
Minimum:	1	0
25%-tile:	2.8284271247462	0.86
Median:	2.8284271247462	4.32
75%-tile:	3.1622776601684	20.8
Maximum:	6.0827625302982	6284
Midrange:	3.5413812651491	3142
Range:	5.0827625302982	6284
Interquartile Range:	0.33385053542219	19.94
Median Abs. Deviation:	0.33385053542219	4.11
Mean:	2.8241040528066	59.465287272727
Trim Mean (10%):	2.8546860436403	19.159270707071
Standard Deviation:	0.69653684155902	272.57017393953
Variance:	0.48516357164902	74294.499721427
Coef. of Variation:	0.24663993554586	4.5836854817406
Coef. of Skewness:	-0.43116934993465	12.15100865233
Root Mean Square:	2.9087329325202	278.98139742975
Mean Square:	8.4607272727273	77830.620111855

Complete Spatial Randomness

Lambda:	0.0055358501656729
Clark and Evans:	0.42024528854445
Skellam:	1618.5815319646

Exclusion Filtering

Exclusion Filter String: Not In Use

Duplicate Filtering

Duplicate Points to Keep:	Maximum Z
X Duplicate Tolerance:	0.00012
Y Duplicate Tolerance:	0.00011

Deleted Duplicates:	442
Retained Duplicates:	124
Artificial Data:	0

X	Y	Z	ID	Status
345937	5015421	17.15	3094	Retained

345937	5015421	2.22	5329	Deleted
345937	5015421	3.06	5087	Deleted
345939	5015382	2.3	5304	Retained
345939	5015382	0.61	5867	Deleted
345939	5015382	1.19	5650	Deleted
345939	5015382	1.69	5484	Deleted
345939	5015382	1.93	5411	Deleted
345977	5015394	6.7	4395	Retained
345977	5015394	6.32	4450	Deleted
345978	5015394	11.92	3617	Retained
345978	5015394	8.44	4117	Deleted
345978	5015394	7.83	4217	Deleted
345978	5015394	5.5	4604	Deleted
346004	5015407	69.42	1052	Retained
346004	5015407	47.26	1492	Deleted
346004	5015407	44.34	1570	Deleted
346004	5015407	35.71	1858	Deleted
346004	5015407	26.66	2304	Deleted
346004	5015407	24.89	2422	Deleted
346005	5015307	27.62	2259	Retained
346005	5015307	1.88	5429	Deleted
346005	5015307	2.35	5289	Deleted
346005	5015307	2.71	5180	Deleted
346005	5015307	2.83	5152	Deleted
346007	5015356	13.68	3420	Retained
346007	5015356	11.56	3662	Deleted
346007	5015356	11.24	3708	Deleted
346007	5015356	10.63	3792	Deleted
346009	5015308	71.07	1019	Retained
346009	5015308	16.84	3121	Deleted
346009	5015308	5.5	4602	Deleted
346013	5015341	59.39	1226	Retained
346013	5015341	37.27	1785	Deleted
346013	5015341	30.68	2078	Deleted
346013	5015341	13.3	3460	Deleted
346013	5015341	11.12	3723	Deleted
346013	5015341	6.77	4380	Deleted
346013	5015341	3.25	5052	Deleted
346017	5015330	14.88	3304	Retained
346017	5015330	11.37	3694	Deleted
346017	5015330	6.97	4346	Deleted
346022	5015319	8.9	4039	Retained
346022	5015319	2.17	5344	Deleted
346023	5015274	20.63	2754	Retained
346023	5015274	16	3193	Deleted

346023	5015274	15.58	3238	Deleted
346025	5015316	3.07	5085	Retained
346025	5015316	2.98	5114	Deleted
346025	5015316	3.02	5102	Deleted
346032	5015298	9.17	4003	Retained
346032	5015298	9.12	4012	Deleted
346032	5015298	6.85	4372	Deleted
346032	5015298	5.96	4523	Deleted
346032	5015298	3.19	5066	Deleted
346032	5015298	3.66	4956	Deleted
346038	5015557	361	205	Retained
346038	5015557	221	331	Deleted
346038	5015557	138	537	Deleted
346038	5015557	127	587	Deleted
346047	5015290	13.55	3430	Retained
346047	5015290	13.23	3470	Deleted
346047	5015290	12.53	3545	Deleted
346047	5015290	11.88	3623	Deleted
346047	5015290	10.13	3841	Deleted
346047	5015291	19.72	2840	Retained
346047	5015291	19.38	2878	Deleted
346047	5015291	19.2	2895	Deleted
346047	5015291	18.94	2921	Deleted
346047	5015291	18.36	2973	Deleted
346047	5015291	18.16	2988	Deleted
346047	5015291	16.89	3116	Deleted
346047	5015291	16.19	3177	Deleted
346047	5015292	49.21	1442	Retained
346047	5015292	42.35	1637	Deleted
346047	5015292	33.34	1960	Deleted
346047	5015292	21.02	2722	Deleted
346047	5015292	18.48	2963	Deleted
346047	5015292	16.17	3178	Deleted
346047	5015292	15.42	3248	Deleted
346048	5015290	23.75	2515	Retained
346048	5015290	21.72	2663	Deleted
346048	5015290	20.24	2783	Deleted
346048	5015290	19.91	2815	Deleted
346048	5015290	19.17	2898	Deleted
346048	5015290	18.25	2981	Deleted
346048	5015290	17.86	3015	Deleted
346048	5015290	17.8	3023	Deleted
346048	5015290	17.52	3052	Deleted
346048	5015290	17.26	3080	Deleted
346048	5015290	17	3105	Deleted
346048	5015290	16.58	3136	Deleted
346048	5015290	16.19	3176	Deleted
346048	5015290	15.83	3214	Deleted
346048	5015290	15.33	3260	Deleted

346048	5015290	14.93	3295	Deleted
346048	5015290	14.69	3319	Deleted
346048	5015290	14.23	3362	Deleted
346048	5015290	13.96	3393	Deleted
346048	5015290	13.73	3416	Deleted
More ...				

Breakline Filtering

Breakline Filtering: Not In Use

Gridding Rules

Gridding Method: Triangulation with Linear Interpolation
 Anisotropy Ratio: 1
 Anisotropy Angle: 0

Output Grid

Grid File Name: R:\GENIVAR\Q111931 (Biogaz-Relevé surface West Carleton)\Relevés de surface\Rapport 2008\Juin 2008\Données terrain\Site_juin08_rev.grd
 Grid Size: 93 rows x 100 columns
 Total Nodes: 9300
 Filled Nodes: 3405
 Blanked Nodes: 5895

Grid Geometry

X Minimum: 345880
 X Maximum: 346916
 X Spacing: 10.464646464646
 Y Minimum: 5015175
 Y Maximum: 5016134
 Y Spacing: 10.423913043478

Grid Statistics

Z Minimum: 0.35929664133932
 Z 25%-tile: 9.6614817883911
 Z Median: 24.323048207348
 Z 75%-tile: 62.592509374884
 Z Maximum: 2807.9395465566
 Z Midrange: 1404.149421599
 Z Range: 2807.5802499153
 Z Interquartile Range: 52.931027586493
 Z Median Abs. Deviation: 18.144475870755
 Z Mean: 76.132431010213
 Z Trim Mean (10%): 44.425640225385

Z Standard Deviation:	194.88630452805
Z Variance:	37980.671692602
Z Coef. of Variation:	2.5598329377123
Z Coef. of Skewness:	7.2468275732879
Z Root Mean Square:	209.22910587231
Z Mean Square:	43776.818744126