ASSESSMENT OF LFG VERTICAL MIGRATION

OTTAWA LANDFILL

WASTE MANAGEMENT

TECHNICAL REPORT – SURVEY AUGUST 2010

PROJECT Nº Q122482

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Quebec, August 31th, 2010

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1. INTRODUCTION

Waste Management of Canada Corp. has given a mandate to GENIVAR S.E.C. 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 and the air sparging system with the FID-GPS technology developed by the firm GENIVAR ;

- Measurement on a continuous basis of the methane concentrations in the ambient air above the ground along four (4) extra lines, located on the north and south sides 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. Dave Veilleux and Mr. Alain L'italien of GENIVAR on August 18th, 2010.

2. METHODOLOGY

2.1 Location of measurements

Assessment of vertical migration of LFG was performed above the entire landfill and above the ground along four (4) extra lines located on the north and south sides of the landfill site. 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 on each side 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 gases 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.

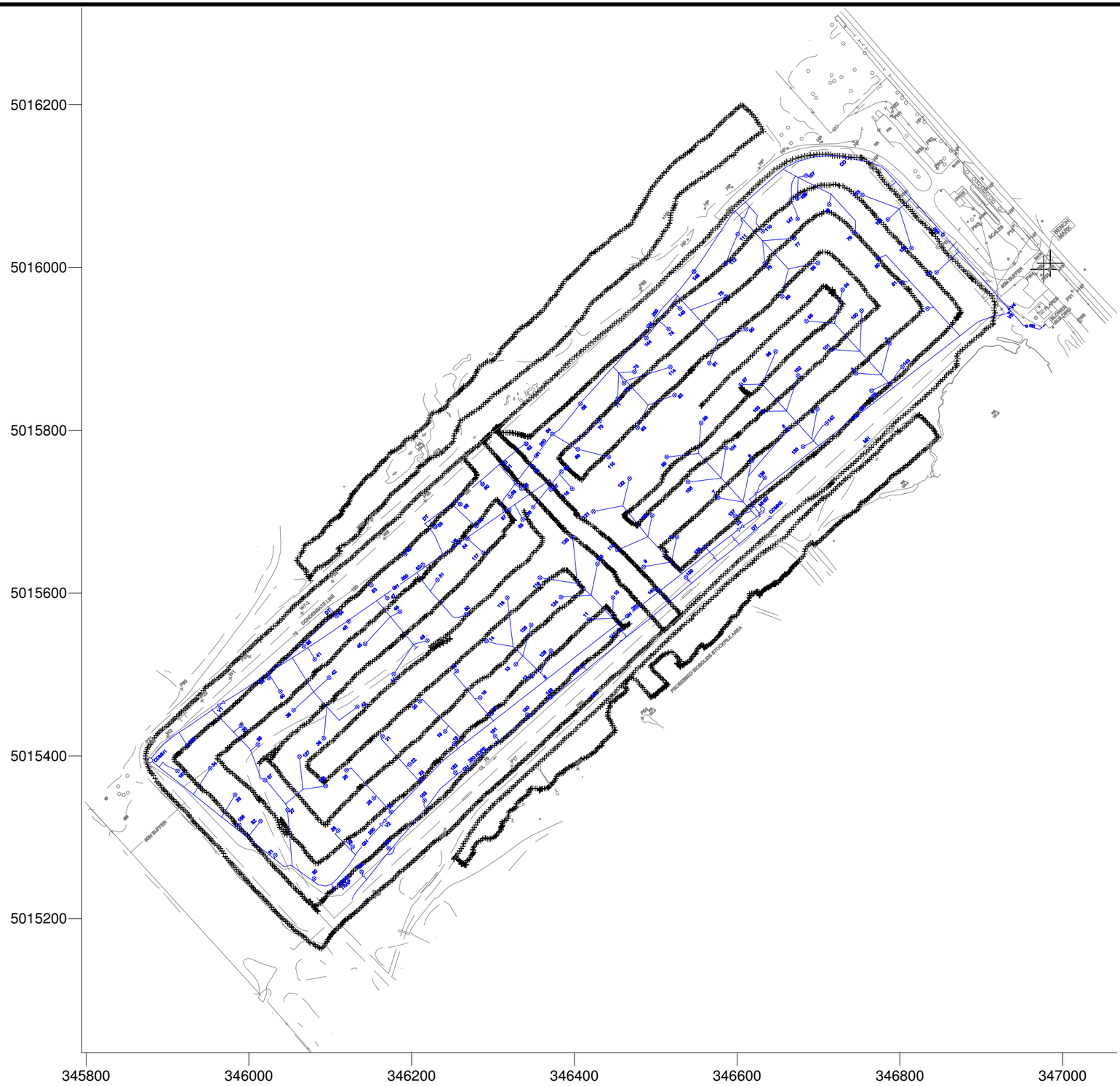
2.2.2 Instrument calibration

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 CH_4 in air ;
- 10 000 ppmv of CH_4 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

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GENIVAR

LEGEND

- MEASUREMENT POINTS
- GAS EXTRACTION WELL

FIGURE 2-1

LOCATION OF MEASUREMENT POINTS

AUGUST, 2010

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+ MEASUREMENT POINTS

EXISTING FENCE

FIGURE 2-2

LOCATION OF MEASUREMENT POINTS

AUGUST, 2010

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, October and December 2010. 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 only 3 points (0.05%) having a methane concentration above 500 ppmv compared to 0.85% 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 June 2010 survey.

Figure 3-1 presents the detailed results for this survey and figure 3-2 for June 2010. Iso-contour map of methane concentrations is shown on figure 3-3 for this sampling campaign and figure 3-4 for June 2010.

Points having a methane concentration greater than 500 ppmv are located at three different places, which are:

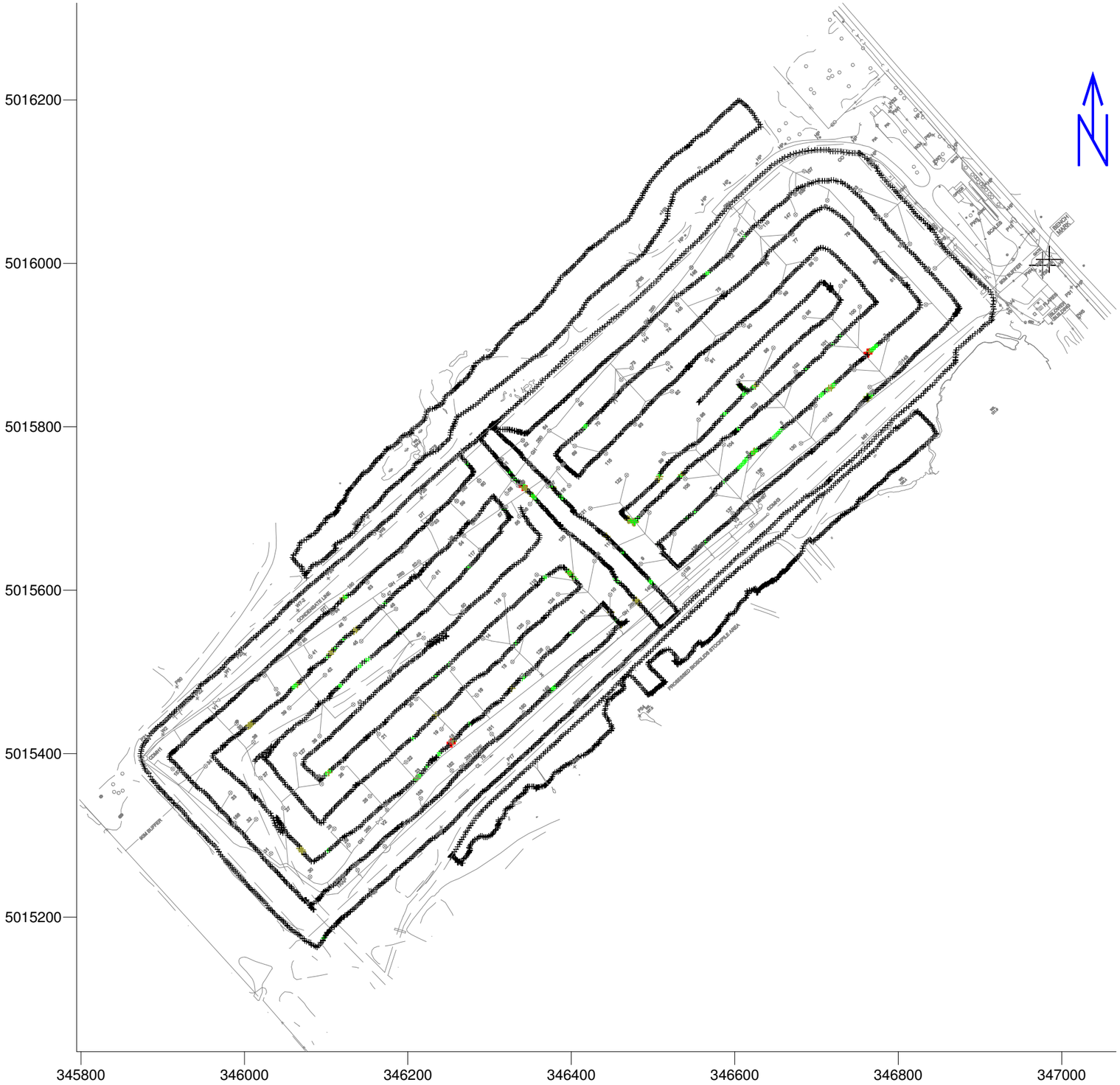
- On the east part of the site, between wells #2 & 3 ;
- On the west part of the site, near well #18 ;
- In the middle of the site, near well #56.

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 June 2010. As usual, no methane concentration higher than 500 ppmv was measured in August 2010.

Table 3-1 : Points having a methane concentration higher than 500 ppmv August 2010		
X	***Y***	***CH_4 (ppmv)***
346763	5015890	590
346341	5015727	584
346253	5015413	557

Table 3-2 : Points having a methane concentration higher than 500 ppmv
June 2010

X	*Y*	*CH_4 (ppmv)*
346373	5015784	50000
346373	5015783	34100
346727	5015894	6052
346407	5015801	3615
346682	5015869	3265
346449	5015657	3149
346447	5015659	2824
346683	5015868	2519
346681	5015871	2255
346774	5015850	2152
346683	5015869	2117
346725	5015892	1895
346681	5015870	1735
346682	5015870	1644
346441	5015666	1572
346557	5015985	1499
346405	5015800	1251
346666	5015829	1104
346668	5015831	1078
346680	5015872	1064
346704	5015824	1031
346605	5016000	965
346727	5016027	931
346753	5015923	899
346765	5015891	892
346635	5015756	813
346638	5015760	758
346524	5015647	747
346556	5015982	741
346653	5015774	733
346636	5015758	719
346772	5015848	681
346594	5015755	677
346400	5015797	670
346482	5015957	669
346726	5016028	663
346788	5015863	662
346766	5015843	657
346764	5015842	633
346537	5015630	624
346671	5015792	623
346723	5015890	602
346620	5015781	591
346724	5015751	586
346785	5015861	584
346762	5015840	584
346728	5015755	562
346622	5015783	559
346402	5015798	549
346680	5015874	546
346695	5016038	523
346559	5015987	515
346709	5015830	514
346453	5015932	502
346461	5015851	501



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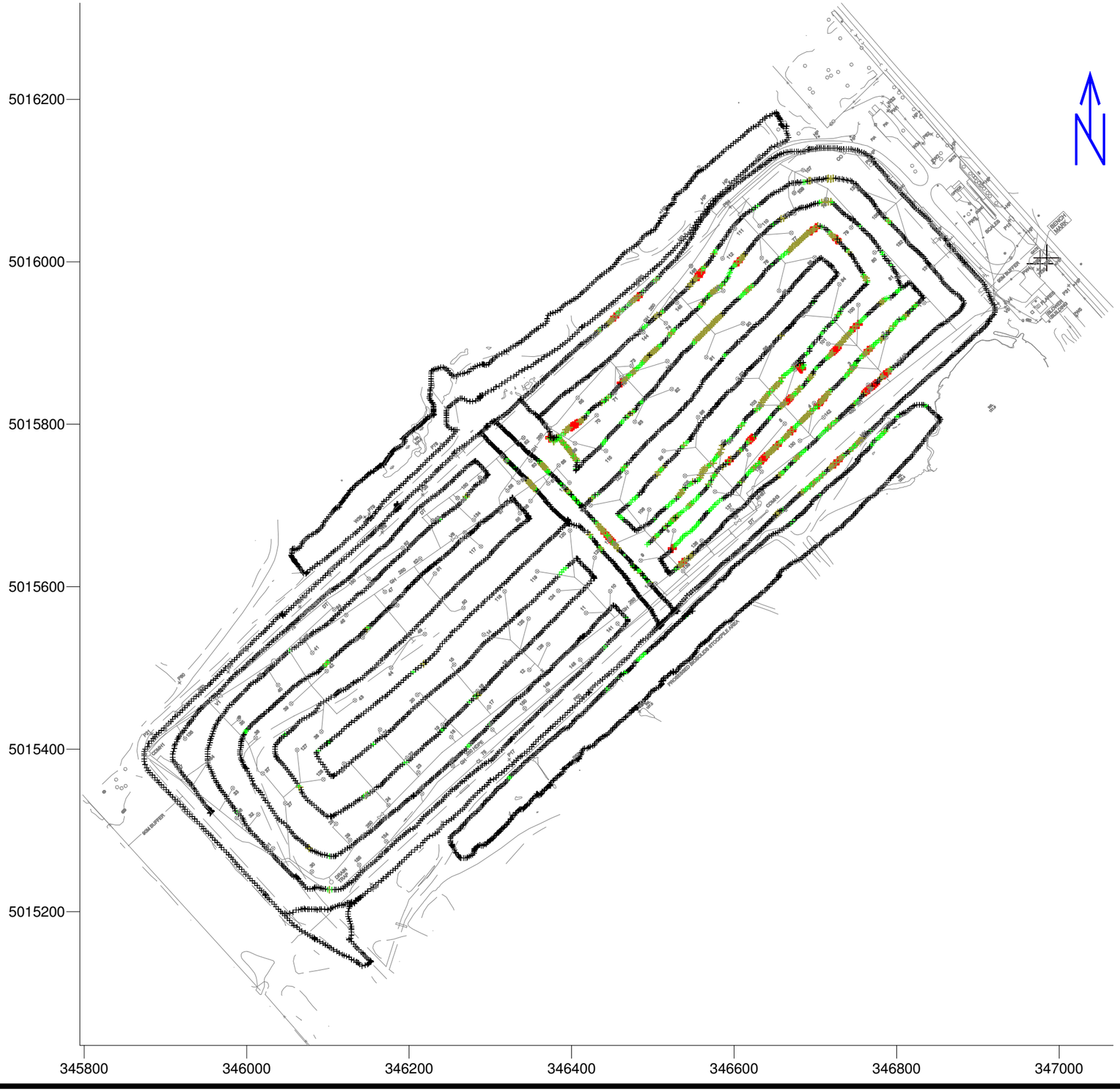
LEGEND

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

FIGURE 3-1

METHANE CONCENTRATIONS
LANDFILL

AUGUST, 2010



LANDFILL GAS EMISSION
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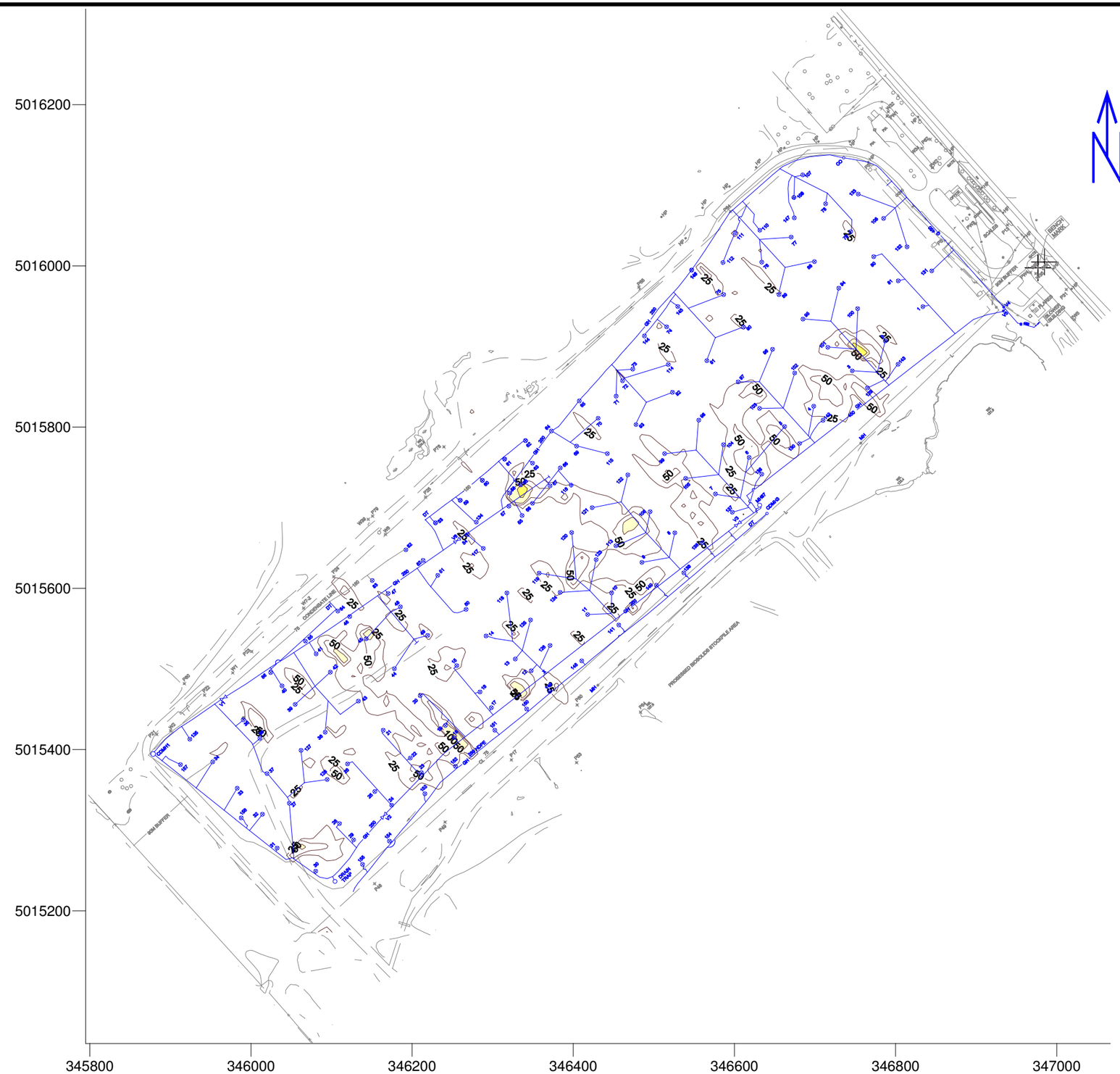
LEGEND

- 0 à 50 ppmv
- 50 à 100 ppmv
- 100 à 500 ppmv
- 500 à 50001 ppmv

FIGURE 3-2

METHANE CONCENTRATIONS
LANDFILL

JUNE, 2010



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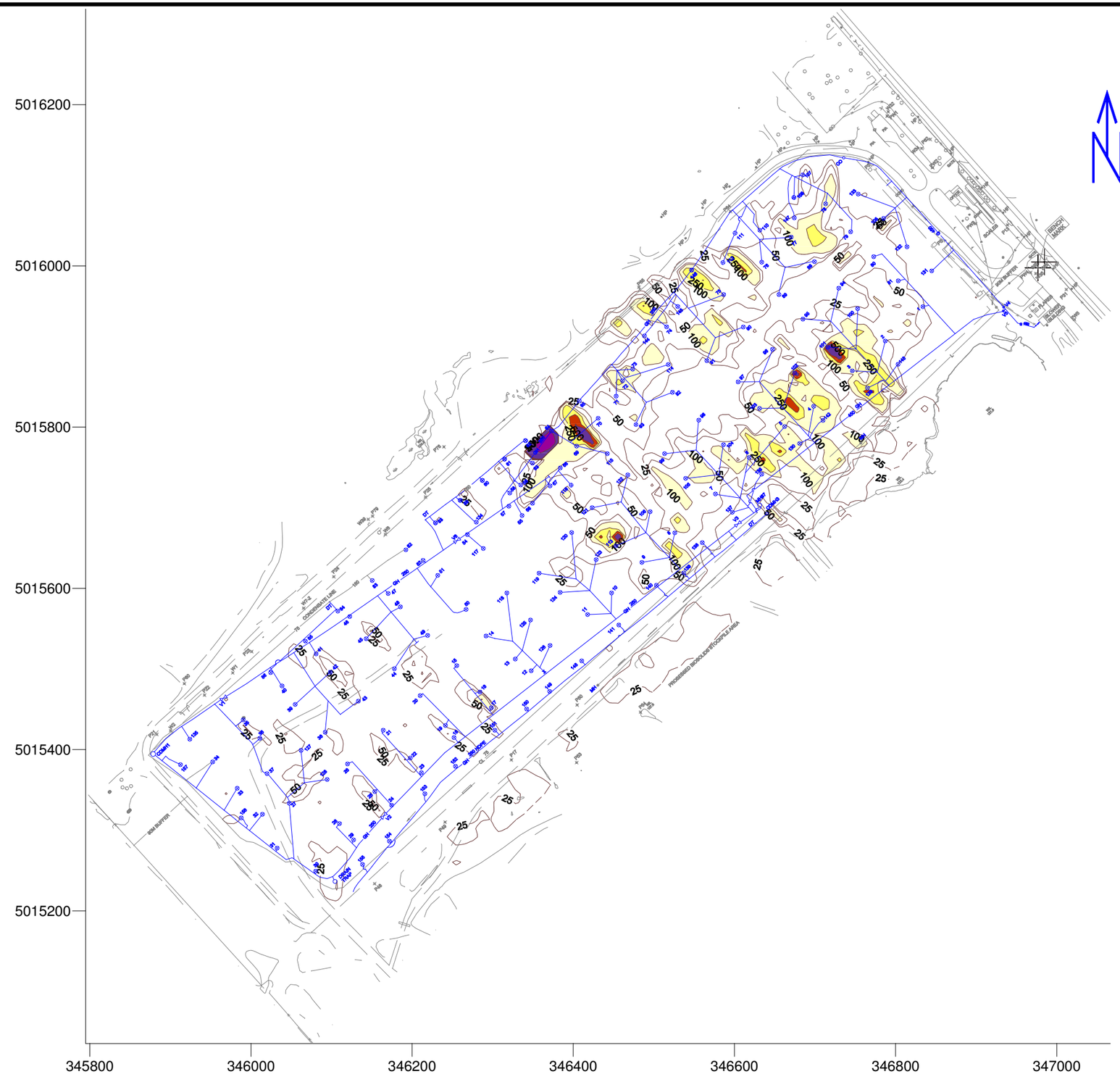
- 10000 ppmv
- 1000 ppmv
- 500 ppmv
- 250 ppmv
- 100 ppmv
- 50 ppmv
- 25 ppmv
- 0 ppmv

FIGURE 3-3

ISO-CONTOURS OF METHANE CONCENTRATIONS

AUGUST, 2010



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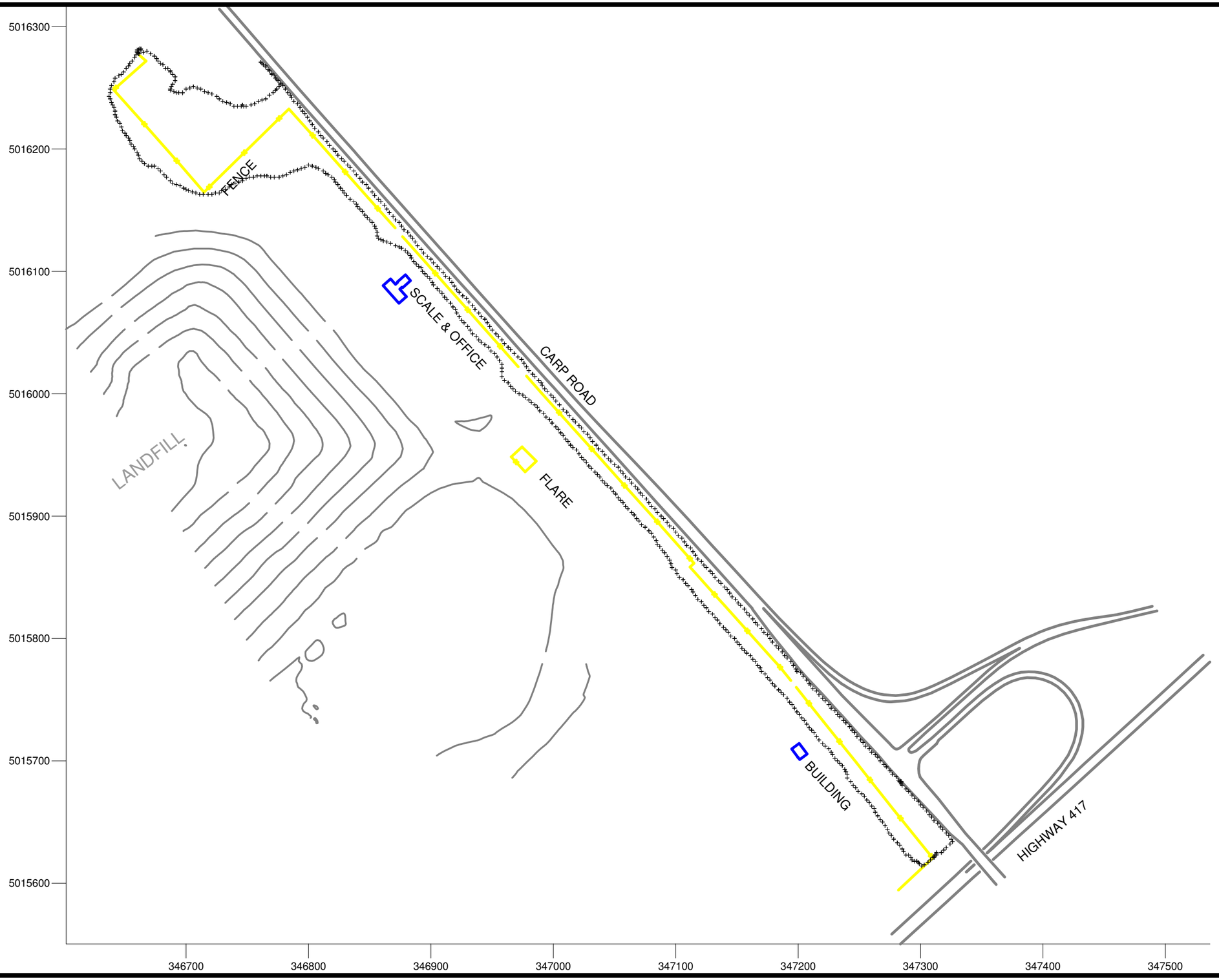
LEGEND

- 10000 ppmv
- 1000 ppmv
- 500 ppmv
- 250 ppmv
- 100 ppmv
- 50 ppmv
- 25 ppmv
- 0 ppmv

FIGURE 3-4

ISO-CONTOURS OF METHANE CONCENTRATIONS

JUNE, 2010



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LEGEND

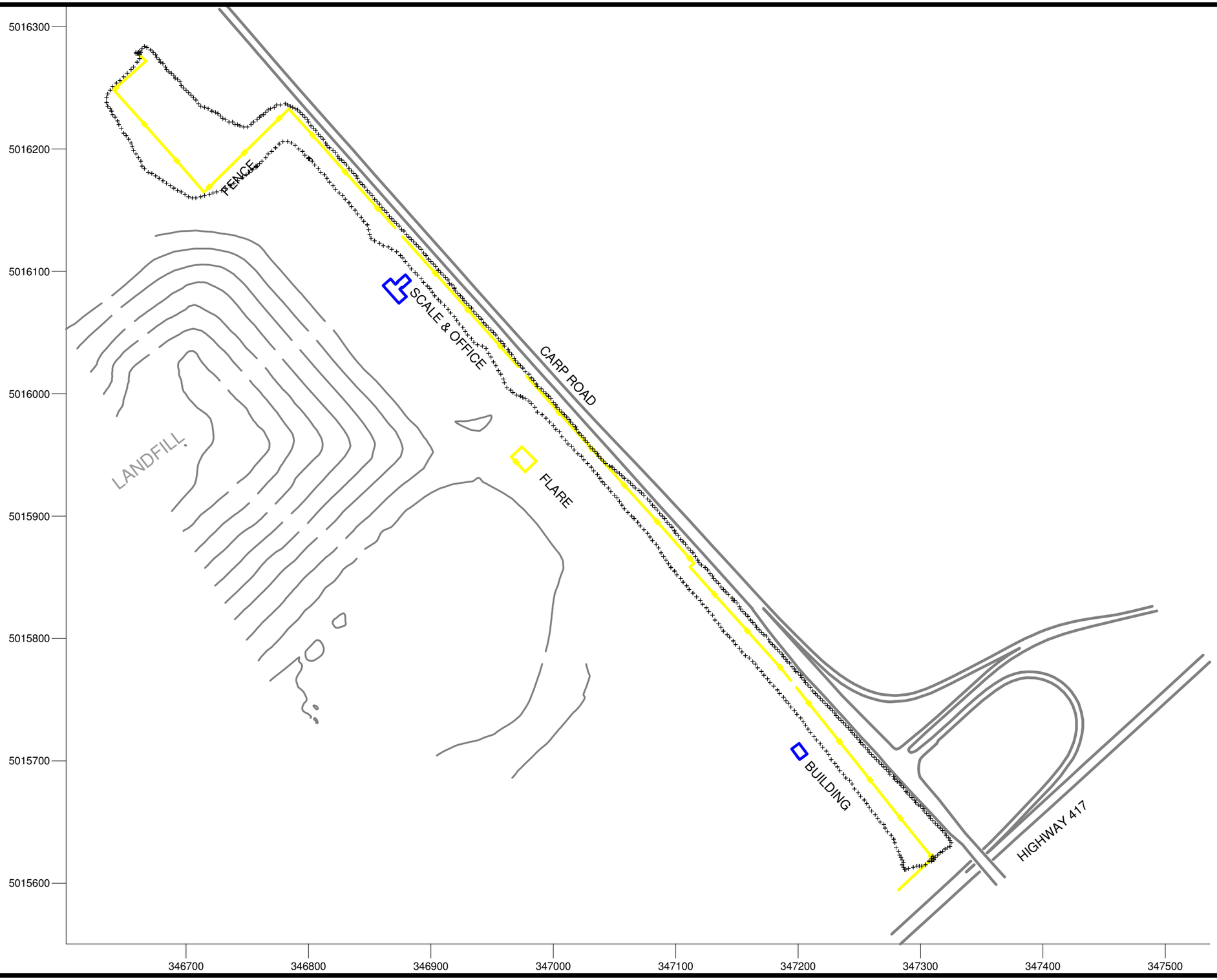
EXISTING FENCE

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

FIGURE 3-5

METHANE CONCENTRATIONS
CARP ROAD

AUGUST, 2010



LANDFILL GAS EMISSION
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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

JUNE, 2010

3.3 Site configuration and well performance

Since April 2009, the landfill gas collection system at the Ottawa landfill is composed of 177 vertical extraction wells and horizontal collectors installed at the bottom of North, West and South slopes. All of these wells are connected to three (3) flaring stations (2 enclosed flares with 3 blowers and 1 candlestick flare with 1 blower) via a 450 mm header located at the bottom of the slopes.

3.4 Improvements since the previous assessment

Since the last survey, the LFG system have been maintained and calibrated on a regular basis. No LFG wells have been installed since April 2009.

3.5 Wind speed

Sampling was done when the winds were under specifications described at 2.2.3. The average velocity of the wind was 6 km/hr and the gust of the wind was 14 km/h.

4. INTERPRETATION OF RESULTS

The results indicate that the methane emissions to the atmosphere are visibly lower than the last survey. The results shown on Figure 3-1 indicate that there are only three (3) points having a methane concentration higher than 500 ppmv.

The integrity of the soil cover should be checked and modified if required and the vacuum increased at the wells (#2, 3, 18 & 56) located in the area of the high spots, if possible.

No high value was recorded above the ground along the four (4) extra lines located on the north and south sides of the landfill site and above the air purging system near Carp road.

APPENDIX I

STATISTICAL REPORT

Gridding Report

Wed Aug 18 16:03:55 2010
Elasped time for gridding: 0.09 seconds

Data Source

Source Data File Name: R:\GENIVAR\Q122482 (Biogaz - WM Ottawa, Surface 2010)\Août 2010\Données brutes\Ottawa_18aout2010_BUTE.xls
X Column: A
Y Column: B
Z Column: C

Data Counts

Active Data: 6033

Original Data: 6690
Excluded Data: 0
Deleted Duplicates: 657
Retained Duplicates: 200
Artificial Data: 0
Superseded Data: 0

Univariate Statistics

	X	Y	Z
Minimum:	345873	5015163	0
25%-tile:	346205	5015477	2.45
Median:	346392	5015665	5.26
75%-tile:	346584	5015839	12.67
Maximum:	346917	5016199	590
Midrange:	346395	5015681	295
Range:	1044	1036	590
Interquartile Range:	379	362	10.22
Median Abs. Deviation:	189	181	3.61
Mean:	346394.47173877	5015662.7584949	11.550609978452
Trim Mean (10%):	346394.34616093	5015661.4717363	8.2288952310808
Standard Deviation:	243.13521043622	236.23899643992	25.201496834337
Variance:	59114.730553864	55808.863438942	635.11544269108

Coef. of Variation:	2.1818325509519
Coef. of Skewness:	11.505224268571

Inter-Variable Correlation

	X	Y	Z
X:	1.000	0.694	0.017
Y:		1.000	-0.030
Z:			1.000

Inter-Variable Covariance

	X	Y	Z
X:	59114.730553864	39862.283826187	102.07934095828
Y:		55808.863438942	-179.65092014941
Z:			635.11544269108

Planar Regression: Z = AX+BY+C

Fitted Parameters

	A	B	C
Parameter Value:	0.0060572635195268	-0.0069056635194323	32549.827406105
Standard Error:	0.0016599435084577	0.0017083995477648	8180.1884054761

Inter-Parameter Correlations

	A	B	C
A:	1.000	0.694	0.657
B:		1.000	0.999
C:			1.000

ANOVA Table

Source	df	Sum of Squares	Mean Square	F
Regression:	2	11218.831633476	5609.4158167378	8.8537
Residual:	6030	3820432.6341218	633.57091776481	
Total:	6032	3831651.4657553		

Coefficient of Multiple Determination (R^2): 0.0029279363568795

Nearest Neighbor Statistics

	Separation	|Delta Z|
Minimum:	1	0
25%-tile:	2	0.13
Median:	2.2360679774998	0.58
75%-tile:	2.8284271247462	3.1
Maximum:	4.4721359549996	577.84
Midrange:	2.7360679774998	288.92
Range:	3.4721359549996	577.84
Interquartile Range:	0.82842712474619	2.97
Median Abs. Deviation:	0.5923591472464	0.55
Mean:	2.3390072280267	5.1287303165921
Trim Mean (10%):	2.3398965570285	2.1114085803719
Standard Deviation:	0.72689900755415	23.854085700088
Variance:	0.52838216718321	569.01740458714
Coef. of Variation:	0.3107724503132	4.6510703873271
Coef. of Skewness:	-0.29824615826299	14.514920270576
Root Mean Square:	2.4493544006419	24.399206529055
Mean Square:	5.9993369799436	595.32127924747

Complete Spatial Randomness

Lambda:	0.0055779301468957
Clark and Evans:	0.34938004397736
Skellam:	1268.4972255004

Exclusion Filtering

Exclusion Filter String: Not In Use

Duplicate Filtering

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

Deleted Duplicates: 657
Retained Duplicates: 200
Artificial Data: 0

X	Y	Z	ID	Status
345957	5015441	11.34	1888	Retained
345957	5015441	9.26	2287	Deleted
345957	5015441	8.1	2559	Deleted
345957	5015441	4.06	3896	Deleted
345957	5015441	6	3122	Deleted
345957	5015441	6.3	3018	Deleted
345974	5015409	20.02	932	Retained
345974	5015409	12.52	1693	Deleted
345974	5015409	9.36	2263	Deleted
345974	5015409	7.37	2736	Deleted
345974	5015409	4.09	3882	Deleted
345974	5015409	4.19	3841	Deleted
345974	5015409	5.47	3350	Deleted
345974	5015409	5.61	3285	Deleted
345974	5015409	6.21	3048	Deleted
345974	5015410	11.34	1889	Retained
345974	5015410	11.32	1895	Deleted
345974	5015410	6.42	2985	Deleted
345974	5015410	6.81	2885	Deleted
346013	5015346	8.3	2510	Retained
346013	5015346	8.25	2521	Deleted
346027	5015396	8.14	2544	Retained
346027	5015396	8.02	2580	Deleted
346036	5015409	7.78	2642	Retained
346036	5015409	6.16	3064	Deleted
346039	5015321	8.84	2382	Retained
346039	5015321	7.59	2688	Deleted
346039	5015321	4.14	3861	Deleted
346039	5015321	4.91	3582	Deleted

346043	5015316	10.58	2028	
	Retained			
346043	5015316	6.62	2942	Deleted
346074	5015220	4.71	3656	
	Retained			
346074	5015220	4.55	3712	Deleted
346074	5015221	4.68	3666	
	Retained			
346074	5015221	4.08	3885	Deleted
346075	5015221	4.55	3713	
	Retained			
346075	5015221	2.46	5069	Deleted
346075	5015221	2.68	4842	Deleted
346075	5015221	2.91	4560	Deleted
346075	5015221	3	4419	Deleted
346075	5015221	3.77	3981	Deleted
346075	5015221	4.07	3891	Deleted
346075	5015221	4.49	3735	Deleted
346075	5015620	0.91	6179	
	Retained			
346075	5015620	0.9	6186	Deleted
346080	5015214	3.86	3955	
	Retained			
346080	5015214	3.25	4190	Deleted
346080	5015214	3.32	4162	Deleted
346081	5015215	3.67	4013	
	Retained			
346081	5015215	3.47	4090	Deleted
346082	5015215	4.4	3770	
	Retained			
346082	5015215	4.28	3816	Deleted
346090	5015461	16.11	1263	
	Retained			
346090	5015461	15.03	1380	Deleted
346091	5015461	21.21	838	
	Retained			
346091	5015461	16.42	1232	Deleted
346092	5015224	4.06	3897	
	Retained			
346092	5015224	3.97	3925	Deleted
346101	5015572	1.93	5517	
	Retained			
346101	5015572	1.86	5572	Deleted
346101	5015572	1.93	5519	Deleted
346101	5015572	1.93	5518	Deleted

346104	5015183 Retained	4.25	3826	
346104	5015183	2.87	4610	Deleted
346106	5015474 Retained	5.59	3291	
346106	5015474	4.64	3681	Deleted
346112	5015192 Retained	3.65	4020	
346112	5015192	2.59	4944	Deleted
346112	5015192	2.77	4728	Deleted
346115	5015701 Retained	3.09	4316	
346115	5015701	3.01	4410	Deleted
346115	5015701	3.08	4334	Deleted
346124	5015395 Retained	32.95	417	
346124	5015395	30.56	470	Deleted
346124	5015395	23.69	710	Deleted
346124	5015395	20.38	899	Deleted
346124	5015395	14.1	1482	Deleted
346127	5015722 Retained	3.19	4240	
346127	5015722	3.13	4283	Deleted
346136	5015361 Retained	6.01	3119	
346136	5015361	4.42	3758	Deleted
346136	5015361	5.01	3543	Deleted
346137	5015361 Retained	8.01	2583	
346137	5015361	7.78	2643	Deleted
346149	5015420 Retained	9.39	2254	
346149	5015420	7.57	2694	Deleted
346172	5015439 Retained	20.26	911	
346172	5015439	17.83	1078	Deleted
346173	5015439 Retained	21.11	840	
346173	5015439	14.74	1412	Deleted
346173	5015439	13.2	1605	Deleted
346173	5015439	8.84	2383	Deleted
346174	5015772 Retained	3.16	4265	
346174	5015772	2.98	4460	Deleted

346174	5015772	3	4426	Deleted
346175	5015535	27.19	564	Retained
346175	5015535	18.65	1011	Deleted
346175	5015535	12.14	1751	Deleted
346187	5015309	20.02	931	Retained
346187	5015309	17.81	1080	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\Q122482 (Biogaz - WM Ottawa, Surface 2010)\Août 2010\Données brutes\Ottawa_18aout2010_BUTE.grd
Grid Size: 99 rows x 100 columns
Total Nodes: 9900
Filled Nodes: 4408
Blanked Nodes: 5492

Grid Geometry

X Minimum: 345873
X Maximum: 346917
X Spacing: 10.545454545455

Y Minimum: 5015163
Y Maximum: 5016199
Y Spacing: 10.571428571429

Grid Statistics

Z Minimum: 0.014972170676254
Z 25%-tile: 2.8350854978385
Z Median: 7.1834224601262
Z 75%-tile: 14.835615418908
Z Maximum: 488.50146899696

Z Midrange:	244.25822058382
Z Range:	488.48649682629
Z Interquartile Range:	12.000529921069
Z Median Abs. Deviation:	4.7893705120605
Z Mean:	12.214254978366
Z Trim Mean (10%):	9.6622806623313
Z Standard Deviation:	20.318440073723
Z Variance:	412.83900702948
Z Coef. of Variation:	1.6635022037538
Z Coef. of Skewness:	10.386038219772
Z Root Mean Square:	23.707109307253
Z Mean Square:	562.02703170603