ASSESSMENT OF COVER APPLICATION TO REDUCE AIR EMISSIONS FROM HAZARDOUS WASTE

LAIDLAW - CORUNNA FACILITY

SARNIA, ONTARIO

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1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained by Laidlaw Environmental Services Limited (Laidlaw) to undertake an assessment of Posi-Shell, a cover material, to reduce air emissions of volatile organic compounds (VOC's), aldehydes, ketones and alcohols from the exposed waste at Laidlaw's Corunna Facility. Posi-Shell is described by its supplier as an aggregate of (recycled) cementitious mineral binder, liquid (water), recycled plastic and cellulose fibres. After curing, the cover is considered to provide an non-permeable cover over the exposed waste, minimising any chemical emissions.

The objectives of this study was to provide an independent assessment of the cover's ability to surpress odourous emissions up to three weeks after application.

The basic tasks undertaken in this study are described below:

- select three sampling locations on the exposed waste at the pit face of the landfill;
- determine the emission rate of target compounds, prior to application, using an isolation flux chamber;
- determine the emission rates of the target compounds one day, two days, one week, two weeks and three weeks after application; and
- assess the emission reduction efficiency of the foam.

2. METHODOLOGY

2.1 Selected Target Compounds

Table 1 presents the list of selected target compounds. The list was based on sampling and headspace analysis conducted by Laidlaw at three Test-Bucket locations on the landfill pit face (Pit Cell #17) during July 11 and 14, 1997 [1]. Figure 1 shows a site map with the three sample locations. Shows a site plan of the facility including the three sample locations The list represents a cross-section of contaminants that are common to the waste stream at the Corunna facility.

Table 1: List of Target Compounds.

Acetone	o-Xylene
Benzene	p-,m-Xylene
Butanediol	Propanal
1-Butanol	Propanol
2-Butanol	Styrene
Butenal	Tetrachlorethylene
Chlorobenzene	1,3,5-Trimethyl Benzene
Cyclohexane	1,2,4-Trimethyl Benzene
Ethyl Benzene	1,2,3-Trimethyl Benzene
Heptane	Toluene
Methyl Ethyl Ketone	Acetaldehyde
2-Methyl Hexane	Difuro-Furan
3-Methyl Hexane	Dichloromethane
Methyl Isobutyl Ketone	Ethanol
Methyl Pentanone	Methyl Butanol

2.2 Sampling Protocol

In the original work plan submitted by RWDI to Laidlaw, it was proposed to conduct continuous VOC measurements over the surface of the pit face, using a PhotoVac Microfid Model MP 1001, in order to select locations with significant emissions which were also safely accessible. These measurements were conducted on July 22, 1997; however, they proved to be inconclusive in locating areas of peak emissions because of relatively low and uniform VOC concentrations above

the pit face. Therefore, it was decided to locate the sampling points in close proximity to the existing Laidlaw Test-Drum locations (see Section 2.1).

The flux chamber was then used to collect samples at these three locations. The flux chamber is shown schematically in Figure 2. It was constructed according to the designer's specifications [2]. The chamber is 71 cm in diameter and 31 cm high and is constructed of 14 gauge stainless steel. All interior and exterior fittings were stainless steel and all lines were made from Teflon tubing. The chamber was equipped with five exit ports (labelled A to E in Figure 2), air and waste temperature probes and a chamber differential pressure gauge. The flux chamber was placed on the surface of the waste and the bottom edge of the chamber was forced a short depth into the waste surface. The interface between the chamber and the surface was covered with common sand to provide the best seal possible. The flux chamber was operated under a slight positive pressure to further prevent outside air entering underneath and into the chamber.

The flux chamber was operated within parameters recommended by the designers [2]. The flux chamber was purged with ultra-high purity nitrogen gas for a minimum of 30 minutes at a rate of 17 l/min (2.83×10^{-4} m^3/s). This removed any residual outside air present in the chamber after it was placed on the surface of the waste. The purpose of diluting the chamber air was to establish an equilibrium between gas emissions from the sample surface and the sweep gas entering the chamber. The purge gas was introduced into the flux chamber using Teflon tubing equipped with fifteen, 0.635 mm diameter, downward-facing vent holes. The flow of purge gas (sweep rate) was regulated using a Matheson rotameter, which was calibrated using a Gilibrator automated bubble meter, which is a primary standard airflow calibrator. The total amount of purged gas introduced into the chamber was such that about 99% of the original air was purged from the flux chamber. Once the flux chamber had been purged, samples were drawn from the chamber through the exhaust port using a sample train consisting of a vacuum pump and a calibrated mass flow controller. The samples were collected by on a multi-phase carbon adsorbent TO1 tubes with Tenax provided by Laidlaw Environmental. The on-site Laidlaw laboratory conducted the analysis for the compounds shown in Table 1.

The concentration for each compound, C, was determined using Equation 1:

$$C = M/V \qquad (1)$$

where: C = *VOC concentration* (ng/m^3);
M = *mass on tube* (ng); *and*
V = *total volume of air sampled* (m^3).

The emission flux rate ($ng/m^2/s$) was determined using Equation 2:

$$E = \frac{C\,Q}{A} \qquad (2)$$

where: E = *VOC flux rate* ($ng/m^2/s$);
Q = *sweep rate of nitrogen into the flux chamber* = 2.83×10^{-4} m^3/s; *and*
A = *surface area enclosed by the flux chamber* = 0.40 m^2.

The flux chamber requires low wind speeds to sample properly. Strong winds may create a region of low pressure on the downwind side of the flux chamber. Winds were light during the flux chamber sampling and no provisions for wind breaks were required.

3. RESULTS

3.1 Sampling Results

The site selection and initial sampling, before cover application, was carried out on July 22, 1997. Covering of the pit face (approximately 90% of the exposed waste) was carried out by the supplier, Landfill Service Corporation, on July 23. After the cover was applied and the curing process was underway, sampling was repeated one day (July 24), two days (July 25), one week (July 31), two weeks (August 7) and three weeks (August 14) after covering. Sections 3.1.1 to 3.1.6 presents pertinent sampling information and the results. Sections 3.2 presents a summary of the results and emission reduction efficiency. All field note information taken during the study have been included in summary tables. All times are given in Eastern Daylight (Savings) Time (EDT).

3.1.1 Site Selection and Pre-Cover Application Sampling

Sample site selection and sampling prior to cover application was conducted on July 22. Table 2 presents a description of the sampling site locations.

Table 2: Sampling Locations.

Sample Number	Location
Site 1	Two metres west of Laidlaw Test-Bucket #3
Site 2	Two metres west of Laidlaw Test-Bucket #2
Site 3	½-metre south of Laidlaw Test-Bucket #1

The sampling parameters (start time, end time, etc.) are presented in Table 3.

Table 3: Sampling Parameters - July 22, 1997.

Parameter	Site 1	Site 2	Site 3
Purge Start (hours)	1355	1455	1552
Sweep Rate (l/min)	17.2	17.2	17.2
Sample Start (hours)	1436	1531	1629
Sample End (hours)	1451	1548	1644
Sample Flow Rate (ml/min)	300	300	300
Internal Pressure ("H_2O)	0.055	0.050	0.050
Waste Temperature (C)	31	31	36
Ambient Temperature (C)	25	25	27
Wind Speed (m/s)	2.0	2.8	3.0
Weather Conditions	Sunny/Clear	Sunny/Clear	Sunny/Clear
Sample Tube Number	D	B	E

Table 4 presents the pre-cover sampling results. The table shows the emission rate in $ng/m^2/s$ for the target compounds at each sampling location.

Table 4: Pre-Cover Initial Sampling Results - July 22,1997.

Target Compound	Emission Rate ($ng/m^2/s$)		
	Site 1	Site 2	Site 3
Acetone	11.8	2.61	14.5
Benzene	0.80	0.58	0.96
1-Butanol	0.64	0.00	1.44
Butanediol	5.58	0.00	18.8
2-Butanol	0.00	0.00	1.91
Butenal	0.48	0.00	0.48
Chlorobenzene	0.16	0.00	0.48
Cyclohexane	0.48	0.00	0.48
Ethyl Benzene	4.62	0.73	3.99
Heptane	0.00	0.00	0.80
Methyl Ethyl Ketone	0.48	1.31	4.15
2-Methyl Hexane	0.00	0.00	0.32
3-Methyl Hexane	0.16	0.00	0.64
Methyl Isobutyl Ketone	2.55	1.31	3.20
Methyl Pentanone	2.55	0.00	0.00
o-Xylene	0.96	0.00	0.00
p,m-Xylene	7.81	1.74	14.8
Propanal	0.00	0.00	7.81
Propanol	0.00	0.00	0.00
Styrene	6.86	1.31	5.74
Tetrachlorethylene	0.48	0.00	10.7
1,3,5-Trimethyl Benzene	0.48	0.00	3.51
1,2,4-Trimethyl Benzene	1.12	0.00	1.43
1,2,3-Trimethyl Benzene	1.12	0.00	2.39
Toluene	13.6	5.51	15.6
Acetaldehyde	0.00	0.00	0.00
Difuro-Furan	0.00	0.00	0.00
Dichloromethane	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00
Methyl Butanol	0.00	0.00	0.00

The table shows that there is some variability between sample sites. This is especially noticeable at sampling Site 2, which generally shows much lower emission rates than the other two sites. Some species predominate in the emissions, for example, acetone, butandiol, ethyl benzene, methyl ethyl ketone, methyl isobutyl ketone, xylene, styrene, tetrachloroethylene and toluene.

3.1.2 One Day After Cover Application - July 24

Cover was applied to the waste material on July 23. Approximately 90% of the pit face was covered. The cover had "cured" to a stable surface by July 24, but it was still wet in spots and the cover appeared to be thin in various locations. It also had a distinct odour. Table 5 presents a description of the cover at the three sampling locations.

Table 5: Description of Sampling Locations on July 24.

Sampling Location	Description
Site 1	- Even grey colour - No surface cracks - Approximately 2 cm. thick
Site 2	- 10% grey, 90% lime green colour - Approximately 5% of surface cracked - Approximately 1.5 cm. thick
Site 3	- 90% grey, 5% green colour - No surface cracks - Approximately 1.5 cm. thick

Table 6 presents the sampling parameters on July 24.

Table 6: Sampling Parameters - July 24

Parameter	Site 1	Site 2	Site 3
Purge Start (hours)	0850	1027	1203
Sweep Rate (l/min)	17.2	17.2	17.2
Sample Start (hours)	0924	1057	1235
Sample End (hours)	1024	1200	1335
Sample Flow Rate (ml/min)	300	300	300
Internal Pressure ("H_2O)	0.050	0.045	0.040
Waste Temperature (C)	20	23	23
Ambient Temperature (C)	20	21	23
Wind Speed (m/s)	1.8	2.6	1.8
Weather Conditions	Overcast	Overcast	Overcast
Sample Tube Number	F	B	E

Table 7 presents the sampling results for July 24, 1997, one day after cover application. The table shows the emission rate in ng/m^2/s for the target compounds at each sampling location.

Table 7: Sampling Results - July 24, 1997.

Target Compound	Emission Rate (ng/m^2/s)		
	Site 1	Site 2	Site 3
Acetone	1.28	4.32	6.20
Benzene	0.20	0.36	0.00
1-Butanol	0.20	0.24	0.84
Butanediol	1.48	3.56	0.12
2-Butanol	0.44	0.00	0.40
Butenal	0.00	0.00	0.00
Chlorobenzene	0.00	0.08	0.08
Cyclohexane	0.00	0.00	0.00
Ethyl Benzene	0.20	1.56	0.24
Heptane	0.00	0.00	0.00
Methyl Ethyl Ketone	0.64	1.40	1.92
2-Methyl Hexane	0.00	0.00	0.00
3-Methyl Hexane	0.00	0.00	0.00
Methyl Isobutyl Ketone	0.24	1.76	0.36
Methyl Pentanone	0.00	0.00	0.00
o-Xylene	0.00	0.00	0.00
p-,m-Xylene	0.16	3.96	0.40
Propanal	0.00	0.00	0.00
Propanol	0.00	0.00	0.40
Styrene	0.20	4.44	0.24
Tetrachlorethylene	0.00	0.24	0.28
1,3,5-Trimethyl Benzene	0.00	0.40	0.16
1,2,4-Trimethyl Benzene	0.00	0.12	0.72
1,2,3-Trimethyl Benzene	0.00	0.24	0.20
Toluene	0.60	8.44	0.84
Acetaldehyde	1.08	0.00	0.00
Difuro-Furan	0.00	1.16	0.00
Dichloromethane	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00
Methyl Butanol	0.00	0.00	8.88

The table shows that, similar to the results on July 22, emissions of some species predominate; however, in general, the emissions rates are greatly reduced. Table 8 shows the percent reduction in the emission rates from July 22 to July 24.

Table 8: Percent Reduction In Emission Rates from July 22 to July 24.

Target Compound	Emission Rate Reduction (%)		
	Site 1	Site 2	Site 3
Acetone	89.2	-65.6	57.3
Benzene	74.9	37.9	100.0
1-Butanol	68.6	NA	41.5
Butanediol	73.5	NA	99.4
2-Butanol	NA	NA	79.1
Butenal	100.0	NA	100.0
Chlorobenzene	100.0	NA	83.3
Cyclohexane	100.0	NA	100.0
Ethyl Benzene	95.7	-115.2	94.0
Heptane	NA	NA	100.0
Methyl Ethyl Ketone	-33.8	-7.3	53.7
2-Methyl Hexane	NA	NA	100.0
3-Methyl Hexane	100.0	NA	100.0
Methyl Isobutyl Ketone	90.6	-34.9	88.7
Methyl Pentanone	100.0	NA	NA
o-Xylene	100.0	NA	NA
p-,m-Xylene	98.0	-127.7	97.3
Propanal	NA	NA	100.0
Propanol	NA	NA	NA
Styrene	97.1	-240.3	95.8
Tetrachloroethylene	100.0	NA	88.6
1,3,5-Trimethyl Benzene	100.0	NA	95.4
1,2,4-Trimethyl Benzene	100.0	NA	49.8
1,2,3-Trimethyl Benzene	100.0	NA	91.6
Toluene	95.6	-53.2	94.6
Acetaldehyde	NA	NA	NA
Difuro-Furan	NA	NA	NA
Dichloromethane	NA	NA	OA
Ethanol	NA	NA	NA
Methyl Butanol	NA	NA	NA
Average	**87.5**	**-75.8**	**86.8**
NA: Emission Rate Below Detection Level			

The table shows that, on average, the emission rates are reduced by 87.5% at Site 1 and 86.8% at Site 3. However, Site 2 shows some anomalous results, where the emission rates actually increased by 75.8%. The reason for this is unclear, but the surface at Site 2 was found to be different in appearance than at Sites 1 or 3 (i.e., large surface cracks and lime green in colour as opposed to grey at the other locations). It may also be due to the low initial sampling results, which may have been a sampling anomaly.

3.1.3 Two Days After Cover Application - July 25

Table 9 presents the sampling parameters on July 25.

Table 9: Sampling Parameters - July 25.

Parameter	Site 1	Site 2	Site 3
Purge Start (hours)	1015	1150	1327
Sweep Rate (l/min)	17.2	17.2	17.2
Sample Start (hours)	1048	1223	1403
Sample End (hours)	1148	1324	1508
Sample Flow Rate (ml/min)	300	300	300
Internal Pressure ($"H_2O$)	0.08	0.06	0.09
Waste Temperature (C)	24	31	36
Ambient Temperature (C)	24	25	28
Wind Speed (m/s)	0.5	1.7	1.6
Weather Conditions	Foggy	Sunny/Hot	Sunny/Hot
Sample Tube Number	E	D	F

The cover cover appeared to be slightly harder and exhibited less odour. Table 10 presents the sampling results for July 25, 1997, two days after cover application. The table shows the emission rate in $ng/m^2/s$ for the target compounds at each sampling location. The internal chamber pressures were found to be higher than recommended by the designer. Correction factors, supplied by the designers, were applied to the emission rates to account for this slight overpressure condition.

Table 10: Sampling Results - July 25, 1997.

Target Compound	Emission Rate ($ng/m^2/s$)		
	Site 1	Site 2	Site 3
Acetone	7.91	4.41	10.03
Benzene	0.70	0.32	0.55
1-Butanol	0.61	0.00	0.99
Butanediol	0.00	1.81	26.12
2-Butanol	0.00	0.00	0.22
Butenal	0.17	0.24	0.00
Chlorobenzene	0.17	0.08	0.33
Cyclohexane	0.00	0.00	0.00
Ethyl Benzene	0.35	1.38	0.55
Heptane	0.00	0.24	0.00
Methyl Ethyl Ketone	0.17	0.20	0.11
2-Methyl Hexane	0.00	0.12	0.00
3-Methyl Hexane	0.00	0.00	0.00
Methyl Isobutyl Ketone	0.87	1.50	1.21
Methyl Pentanone	0.26	1.14	4.96
o-Xylene	0.00	0.00	0.55
p-,m-Xylene	0.44	3.11	1.43
Propanal	0.00	0.00	0.00
Propanol	0.00	0.00	5.29
Styrene	0.44	4.68	0.00
Tetrachlorethylene	0.00	0.51	1.43
1,3,5-Trimethyl Benzene	0.00	0.32	0.00
1,2,4-Trimethyl Benzene	0.00	0.71	0.00
1,2,3-Trimethyl Benzene	0.00	0.39	0.00
Toluene	1.30	7.79	2.75
Acetaldehyde	5.13	0.00	6.50
Difuro-Furan	0.00	0.00	0.00
Dichloromethane	0.00	0.63	0.00
Ethanol	0.00	0.00	7.72
Methyl Butanol	0.00	0.00	0.00

Similar to the previous days sampling results, the emission rates are still greatly reduced compared to the pre-covering results on July 22. Table 11 shows the percent reduction in the emission rates from July 22 to July 25.

Table 11: Percent Reduction In Emission Rates from July 22 to July 25.

Target Compound	Emission Rate Reduction (%)		
	Site 1	Site 2	Site 3
Acetone	32.9	-68.9	76.8
Benzene	12.7	45.7	80.7
1-Butanol	4.6	NA	76.8
Butanediol	99.9	NA	53.5
2-Butanol	NA	NA	96.1
Butenal	63.6	NA	99.9
Chlorobenzene	NA	NA	76.8
Cyclohexane	99.9	NA	99.9
Ethyl Benzene	92.5	-90.0	95.4
Heptane	NA	NA	99.9
Methyl Ethyl Ketone	63.6	84.9	99.1
2-Methyl Hexane	NA	NA	99.9
3-Methyl Hexane	99.9	NA	99.9
Methyl Isobutyl Ketone	65.9	-14.6	87.3
Methyl Pentanone	89.8	NA	NA
o-Xylene	99.9	NA	NA
p-,m-Xylene	94.4	-78.7	96.8
Propanal	NA	NA	99.9
Propanol	NA	NA	NA
Styrene	93.7	-258.9	99.9
Tetrachlorethylene	99.9	NA	95.5
1,3,5-Trimethyl Benzene	99.9	NA	99.9
1,2,4-Trimethyl Benzene	99.9	NA	99.9
1,2,3-Trimethyl Benzene	99.9	NA	99.9
Toluene	95.6	-41.4	94.1
Acetaldehyde	NA	NA	NA
Difuro-Furan	NA	NA	NA
Dichloromethane	NA	NA	NA
Ethanol	NA	NA	NA
Methyl Butanol	NA	NA	NA
Average	**75.3**	**-52.7**	**82.3**

NA: Emission Rate Below Detection Level

The table shows that at Sites 1 and 2, the average reduction in the emission rates has decreased slightly (i.e., 87.5% to 75.3% at Site 1 and 86.8% to 82.3.8% at Site 2. This slight decrease may be due to the fact that any suppression of emissions due to moisture is absent as the waste and cover dries out and the fact that the cover has not yet completely cured, statistical variations in the analysis, or because of additional curing of the cover producing a more impervious surface. Site 2 still shows anomalous results with an increase in the average emission rate; however, the increase was slightly smaller (i.e., 52.7% , down from 75.8%) then was found after first day

(post-cover).

3.1.4 One Week After Cover Application - July 31

Table 12 presents the sampling parameters on July 31.

Table 12: Sampling Parameters - July 31.

Parameter	Site 1	Site 2	Site 3
Purge Start (hours)	1020	1155	1328
Sweep Rate (l/min)	17.2	17.2	17.2
Sample Start (hours)	1040	1225	1353
Sample End (hours)	1140	1325	1453
Sample Flow Rate (ml/min)	300	300	300
Internal Pressure ("H_2O)	0.04	0.06	0.06
Waste Temperature (C)	31	40	42
Ambient Temperature (C)	23	26	28
Wind Speed (m/s)	1.0	1.7	2.0
Weather Conditions	Sunny	Sunny/Hot	Sunny/Hot
Sample Tube Number	C	D	E

The cover surface was noticeably harder, with very little odour. Also no additional cracking of the surface was evident. Table 13 presents the sampling results for July 31, 1997, one week after cover application. The table shows the emission rate in $ng/m^2/s$ for the target compounds at each sampling location.

Table 13: Sampling Results - July 31, 1997.

Target Compound	Emission Rate (ng/m²/s)		
	Site 1	Site 2	Site 3
Acetone	4.92	5.08	10.92
Benzene	0.40	0.08	2.76
1-Butanol	0.28	0.00	1.96
Butanediol	0.00	0.00	0.00
2-Butanol	0.40	0.00	0.24
Butenal	0.00	0.00	0.52
Chlorobenzene	0.00	0.00	0.00
Cyclohexane	0.00	0.00	0.00
Ethyl Benzene	1.56	0.00	0.12
Heptane	0.00	0.00	0.00
Methyl Ethyl Ketone	2.44	0.00	0.12
2-Methyl Hexane	0.00	0.00	0.00
3-Methyl Hexane	0.00	0.00	0.00
Methyl Isobutyl Ketone	1.20	0.00	0.44
Methyl Pentanone	0.00	0.00	0.00
o-Xylene	0.00	0.00	0.12
p-,m-Xylene	1.56	0.00	0.36
Propanal	0.00	0.00	0.00
Propanol	0.00	0.00	0.00
Styrene	1.56	0.00	0.00
Tetrachlorethylene	0.28	0.08	0.40
1,3,5-Trimethyl Benzene	0.00	0.00	0.00
1,2,4-Trimethyl Benzene	0.00	0.00	0.00
1,2,3-Trimethyl Benzene	0.00	0.00	0.00
Toluene	4.04	0.08	0.84
Acetaldehyde	0.00	0.00	0.00
Difuro-Furan	0.00	0.00	0.00
Dichloromethane	0.76	2.52	0.00
Ethanol	0.00	0.00	0.00
Methyl Butanol	7.60	0.00	0.16

The results show that, although the cover surface had appeared to have undergone additional curing, the emission rates have increased for the majority of compounds compared to the measurements conducted a week ago on July 25. However, emissions from Site 2 have significantly decreased. This is also evident in Table 14, which shows the percent reduction in the emission rates from July 22 to July 31.

Table 14: Percent Reduction In Emission Rates from July 22 to July 31.

Target Compound	Emission Rate Reduction (%)		
	Site 1	Site 2	Site 3
Acetone	58.3	-94.7	24.7
Benzene	49.8	86.2	-188.5
1-Butanol	56.1	NA	-36.6
Butanediol	73.5	NA	99.9
2-Butanol	NA	NA	87.5
Butenal	99.9	NA	-8.7
Chlorobenzene	99.9	NA	99.9
Cyclohexane	99.9	NA	99.9
Ethyl Benzene	66.3	99.9	97.0
Heptane	NA	NA	99.9
Methyl Ethyl Ketone	-410.1	99.9	97.1
2-Methyl Hexane	NA	NA	99.9
3-Methyl Hexane	99.9	NA	99.9
Methyl Isobutyl Ketone	53.0	99.9	86.2
Methyl Pentanone	99.9	NA	NA
o-Xylene	99.9	NA	NA
p-,m-Xylene	80.0	99.9	97.6
Propanal	NA	NA	99.9
Propanol	NA	NA	NA
Styrene	77.2	99.9	99.9
Tetrachlorethylene	41.5	NA	96.3
1,3,5-Trimethyl Benzene	99.9	NA	99.9
1,2,4-Trimethyl Benzene	99.9	NA	99.9
1,2,3-Trimethyl Benzene	99.9	NA	99.9
Toluene	70.2	98.5	94.6
Acetaldehyde	NA	NA	NA
Difuro-Furan	NA	NA	NA
Dichloromethane	NA	NA	NA
Ethanol	NA	NA	NA
Methyl Butanol	NA	NA	NA
Average	**55.7**	**73.7**	**70.3**
NA: Emission Rate Below Detection Level			

The table shows that the average reduction in the emission rate has changed from 75.3% on July 25 to 55.7% on July 31 at Site 1. Similarly, at Site 3, the average emission rate has changed from 82.3% on July 25 to 70.3% on July 31. However, the emission rate at Site 2 is now comparable to the other sites with an emission rate reduction, compared to the initial measurements on July 22 of 73.7%. The reason for the slight increase in the emissions at Sites 2 and 3 is unclear. There was no indication from observation of the cover surface that deterioration had taken place. In fact, the surface was found to be harder and looked more likely to be less permeable. Therefore, the

difference may be due to just statistical variation in the analysis from sample to sample. There is also no explanation in the results from Site 2, as again there was no evidence of change in the cover surface at this location.

3.1.5 Two Weeks After Cover Application - August 7

Table 15 presents the sampling parameters on August 7.

Table 15: Sampling Parameters - August 7.

Parameter	Site 1	Site 2	Site 3
Purge Start (hours)	0910	1122	1303
Sweep Rate (l/min)	17.2	17.2	17.2
Sample Start (hours)	1020	1153	1344
Sample End (hours)	1120	1301	1444
Sample Flow Rate (ml/min)	300	300	300
Internal Pressure ($"H_2O$)	0.02	0.04	0.03
Waste Temperature (C)	22	30	30
Ambient Temperature (C)	24	26	26
Wind Speed (m/s)	1.5	2.5	2.0
Weather Conditions	Sunny	Sunny/Hot	Sunny/Hot
Sample Tube Number	B	D	F

There was little change in the cover surface from that observed on July 31. A few cracks had appeared, but they were relatively small. Table 16 presents the sampling results for August 7, two weeks after cover application. The table shows the emission rate in $ng/m^2/s$ for the target compounds at each sampling location.

Table 16: Sampling Results - August 7.

Target Compound	Emission Rate ($ng/m^2/s$)		
	Site 1	Site 2	Site 3
Acetone	1.84	6.60	6.04
Benzene	0.12	0.00	0.20
1-Butanol	0.12	0.00	0.20
Butanediol	0.00	0.00	0.00
2-Butanol	0.00	0.36	0.56
Butenal	0.00	0.00	0.00
Chlorobenzene	0.00	0.00	0.00
Cyclohexane	0.00	0.00	0.00
Ethyl Benzene	0.52	2.36	0.20
Heptane	0.00	0.32	0.00
Methyl Ethyl Ketone	0.76	0.00	2.32
2-Methyl Hexane	0.00	0.00	0.00
3-Methyl Hexane	0.00	0.00	0.00
Methyl Isobutyl Ketone	0.44	2.20	0.44
Methyl Pentanone	0.00	0.00	0.00
o-Xylene	0.00	0.00	0.20
p-,m-Xylene	0.60	5.32	0.68
Propanal	0.00	0.00	0.00
Propanol	0.00	0.00	0.00
Styrene	0.36	4.84	0.00
Tetrachlorethylene	0.16	0.68	0.64
1,3,5-Trimethyl Benzene	0.00	0.56	0.00
1,2,4-Trimethyl Benzene	0.00	0.48	0.00
1,2,3-Trimethyl Benzene	0.00	0.00	0.00
Toluene	2.40	10.12	1.68
Acetaldehyde	0.00	0.00	0.00
Difuro-Furan	0.00	0.00	0.00
Dichloromethane	0.32	1.36	0.00
Ethanol	0.00	0.00	0.00
Methyl Butanol	1.04	5.40	1.64

The emission rates in Table 16 are similar to the emission rates measured on July 24 and 25. Therefore it appears that the results on July 31 may have been an anomaly. This is evident in Table 17, which shows the percent reduction in the emission rates from July 22 to August 7.

Table 17: Percent Reduction In Emission Rates from July 22 to August 7.

Target Compound	Emission Rate Reduction (%)		
	Site 1	Site 2	Site 3
Acetone	84.4	-122.0	58.4
Benzene	84.9	99.9	79.1
1-Butanol	81.2	NA	86.1
Butanediol	99.9	NA	99.9
2-Butanol	NA	NA	70.7
Butenal	99.9	NA	99.9
Chlorobenzene	99.9	NA	99.9
Cyclohexane	99.9	NA	99.9
Ethyl Benzene	88.8	-225.6	95.0
Heptane	NA	NA	99.9
Methyl Ethyl Ketone	-58.9	99.9	44.0
2-Methyl Hexane	NA	NA	99.9
3-Methyl Hexane	99.9	NA	99.9
Methyl Isobutyl Ketone	82.8	-68.6	86.2
Methyl Pentanone	99.9	NA	NA
o-Xylene	99.9	NA	NA
p-,m-Xylene	92.3	-205.9	95.4
Propanal	NA	NA	99.9
Propanol	NA	NA	NA
Styrene	94.7	-271.0	99.9
Tetrachlorethylene	66.6	NA	94.0
1,3,5-Trimethyl Benzene	99.9	NA	99.9
1,2,4-Trimethyl Benzene	99.9	NA	99.9
1,2,3-Trimethyl Benzene	99.9	NA	99.9
Toluene	82.3	-83.7	89.2
Acetaldehyde	NA	NA	NA
Difuro-Furan	NA	NA	NA
Dichloromethane	NA	NA	NA
Ethanol	NA	NA	NA
Methyl Butanol	NA	NA	NA
Average	**84.9**	**-101.0**	**90.8**

NA: Emission Rate Below Detection Level

The table shows that the average reduction in the emission rate is similar to the reductions measured on July 24 and 25. The average emission rate reduction at Site 1 was 84.9%, compared to 87.5% on July 24, 88.3% on July 25 and 55.7% on August 7. At Site 3, the average emission rate reduction was 90.8%, compared to 86.8% on July 24, 92.2% on July 25 and 70.3% on July 31. However, the average emission rate at Site 2 is again showing an increase compared to the original measurements on July 22. Therefore, it appears that the measurements conducted on July 31 were anomalous.

3.1.6 Three Weeks After Cover Application - August 14

Table 18 presents the sampling parameters on August 14.

Table 18: Sampling Parameters - August 14.

Parameter	Site 1	Site 2	Site 3
Purge Start (hours)	1030	1225	1400
Sweep Rate (l/min)	17.2	17.2	17.2
Sample Start (hours)	1122	1256	1344
Sample End (hours)	1222	1356	1444
Sample Flow Rate (ml/min)	300	300	300
Internal Pressure ("H_2O)	0.025	0.05	0.045
Waste Temperature (C)	24	29	30
Ambient Temperature (C)	25	25	26
Wind Speed (m/s)	2.5	2.7	2.5
Weather Conditions	Sunny	Sunny/Hot	Sunny/Hot
Sample Tube Number	D	E	F

Similar to the observations made on August 7, there was little change in the cover surface. Table 19 presents the sampling results for August 14, three weeks after cover application. The table shows the emission rate in ng/m^2/s for the target compounds at each sampling location.

Table 19: Sampling Results - August 14.

Target Compound	Emission Rate ($ng/m^2/s$)		
	Site 1	Site 2	Site 3
Acetone	0.36	3.12	4.76
Benzene	0.08	0.36	0.16
1-Butanol	0.00	0.00	0.28
Butanediol	0.00	0.00	0.00
2-Butanol	0.20	0.00	1.24
Butenal	0.00	0.68	0.20
Chlorobenzene	0.00	0.00	0.00
Cyclohexane	0.00	0.00	0.00
Ethyl Benzene	0.04	1.84	0.08
Heptane	0.00	0.00	0.00
Methyl Ethyl Ketone	0.20	0.96	2.16
2-Methyl Hexane	0.00	0.00	0.00
3-Methyl Hexane	0.00	0.00	0.00
Methyl Isobutyl Ketone	0.16	1.08	0.32
Methyl Pentanone	0.00	0.00	0.00
o-Xylene	0.00	0.00	0.00
p-,m-Xylene	0.08	3.16	0.16
Propanal	0.00	0.00	0.00
Propanol	0.00	0.00	0.00
Styrene	0.00	2.88	0.08
Tetrachlorethylene	0.00	0.28	0.00
1,3,5-Trimethyl Benzene	0.00	0.00	0.00
1,2,4-Trimethyl Benzene	0.00	0.00	0.00
1,2,3-Trimethyl Benzene	0.00	0.00	0.00
Toluene	0.20	7.20	0.48
Acetaldehyde	0.00	0.00	0.00
Difuro-Furan	*0.00*	*0.00*	*0.00*
Dichloromethane	0.00	1.12	0.00
Ethanol	0.00	0.00	0.00
Methyl Butanol	0.36	4.84	12.96

The emission rates in Table 19 are similar to the emission rates measured the previous week on August 7. In fact, with the exception of methyl butanol at Site 3, the emission rates are all slightly lower. This is also shown in Table 20, which presents the percent reduction in the emission rates from July 22 to August 17.

Table 20: Percent Reduction In Emission Rates from July 22 to August 14.

Target Compound	Emission Rate Reduction (%)		
	Site 1	Site 2	Site 3
Acetone	96.9	-19.6	67.2
Benzene	90.0	37.9	83.3
1-Butanol	99.9	NA	80.5
Butanediol	99.9	NA	99.9
2-Butanol	NA	NA	35.2
Butenal	99.9	NA	58.2
Chlorobenzene	99.9	NA	99.9
Cyclohexane	99.9	NA	99.9
Ethyl Benzene	99.1	-153.9	98.0
Heptane	NA	NA	99.9
Methyl Ethyl Ketone	58.2	26.4	47.9
2-Methyl Hexane	NA	NA	99.9
3-Methyl Hexane	99.9	NA	99.9
Methyl Isobutyl Ketone	93.7	17.2	90.0
Methyl Pentanone	99.9	NA	NA
o-Xylene	99.9	NA	NA
p-,m-Xylene	99.0	-81.7	98.9
Propanal	NA	NA	99.9
Propanol	NA	NA	NA
Styrene	99.9	-120.8	98.6
Tetrachlorethylene	99.9	NA	99.9
1,3,5-Trimethyl Benzene	99.9	NA	99.9
1,2,4-Trimethyl Benzene	99.9	NA	99.9
1,2,3-Trimethyl Benzene	99.9	NA	99.9
Toluene	98.5	-30.7	96.9
Acetaldehyde	NA	NA	NA
Difuro-Furan	NA	NA	NA
Dichloromethane	NA	NA	NA
Ethanol	NA	NA	NA
Methyl Butanol	NA	NA	NA
Average	96.7	-40.6	88.8
NA: Emission Rate Below Detection Level			

The table shows similar results to the previous weeks measurements at Sites 1 and 3. There was a slight improvement at Site 1 where the average reduction increased from 84.9% to 96.7%. At Site 2 the average reduction dropped from 90.8 % to 88.8%, primarily due to the increased emissions of methyl butanol. Site 2 showed the similar emissions increase compared to the initial measurements on July 22.

3.2 Summary of Results

Table 21 presents a summary of the percent reduction in emissions for selected compounds during all five sampling periods. Compounds that were not detected during any of the sampling periods (e.g., dichloromethane, ethanol, etc.) were omitted from the table. Summary results for Site 2 have not been presented due to the anomalous nature of the data. It is suspected that the anomalous results from Site 2 were due to either poor application of cover at this location (see Table 5, Section 3.1.2) or a chemical reaction between the cover and the waste.

Table 21: Summary of Percent Reduction in Emissions of Target Compounds After Cover Application.

Target Compound	Site 1	Site 3	Site 1	Site 3	Site 1	Site 3	Site 1	Site 3	Site 1	Site 3
	Period After Cover Application									
	1 Day (July 24)		2 Days (July 25)		1 Week (July 31)		2 Weeks (Aug. 7)		3 Weeks (Aug. 14)	
Acetone	89.2	57.3	69.1	76.8	58.3	24.7	84.4	58.4	96.9	67.2
Benzene	74.9	100	59.9	80.7	49.8	-188.5	84.9	79.1	90.0	83.3
1-Butanol	68.6	41.5	56.1	76.8	56.1	-36.6	81.2	86.1	99.9	80.5
Butanediol	73.5	99.4	99.9	53.5	73.5	99.9	99.9	99.9	99.9	99.9
2-Butanol	NA	79.1	NA	96.1	NA	87.5	NA	70.7	NA	35.2
Butanal	100	NA	83.3	99.9	99.9	-8.7	99.9	99.9	99.9	58.2
Chlorobenzene	100	NA	49.8	76.8	99.9	99.9	99.9	99.9	99.9	99.9
Cyclohexane	100	100	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9
Ethyl Benzene	95.7	94.0	96.5	95.4	66.3	97.0	88.8	95.0	99.1	98.0
Heptane	NA	100	NA	99.9	NA	99.9	NA	99.9	NA	99.9
Methyl Ethyl Ketone	-33.8	53.7	83.3	99.1	-410.1	97.1	-58.9	44.0	58.2	47.9
2-Methyl Hexane	NA	100	NA	99.9	NA	99.9	NA	99.9	NA	99.9
3-Methyl Hexane	100	100	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9
Methyl Isobutyl Ketone	90.6	88.7	84.3	87.3	53.0	82.2	82.8	86.2	93.7	90.0
Methyl Pentanone	99.9	NA	95.3	NA	99.9	NA	99.9	NA	99.9	NA
o-Xylene	100	NA	99.9	NA	99.9	NA	99.9	NA	99.9	NA
m & p-Xylene	98.0	97.3	97.4	96.8	80.0	97.6	92.3	95.4	99.9	98.9
Propanal	NA	99.9	NA	99.9	NA	99.9	NA	99.9	NA	99.9
Styrene	97.1	95.8	97.1	99.9	77.2	99.9	94.7	99.9	99.9	98.6
Tetrachlorethylene	100	97.4	99.9	95.5	41.5	96.3	66.6	94.0	99.9	99.9
1,3,5-Trimethyl Benzene	100	95.4	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9
1,2,4-Trimethyl Benzene	100	49.8	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9
1,2,3-Trimethyl Benzene	100	91.6	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9
Toluene	95.6	94.6	95.6	94.1	70.2	94.6	82.3	89.2	98.5	96.9
Maximum Reduction (%)	**100**	**100**	**99.9**	**99.9**	**99.9**	**99.9**	**99.9**	**99.9**	**99.9**	**99.9**
Minimum Reduction (%)	**-33.8**	**41.5**	**69.1**	**53.5**	**-410.1**	**-188.5**	**-58.9**	**44.0**	**58.2**	**35.2**
Average Reduction (%)	**87.5**	**86.8**	**84.9**	**92.2**	**55.7**	**70.3**	**84.9**	**90.8**	**96.7**	**88.8**

The summary table shows that, for the two sites considered, over the 21-day study period, the average emission reduction ranged from 88.8 and 96.7 %. The effectiveness is slightly less for some of the more volatile species (e.g., acetone), where the emission reduction was more variable. However, this may be due to sampling artifacts other than actual variations in the effectiveness of the cover. Figures 3 and 4 show the emission rates for four select compounds; acetone, m&p-xylene, styrene and toluene, at Sites 1 and 3, respectively, over the 21-day sampling period. The emission rates were lowest immediately after the Posi-Shell was applied. By Day 2, (post-cover),

the emissions had generally increased, but a steady reduction was found in emissions over the next 3 weeks at Site 1. The findings were similar at Site 3 however, there was slightly more variability for some of the select compounds. The figures clearly show an overall reduction in emission rates over the study period particularly after the cover material had the opportunity to cure. Therefore, it appears that, during the 21-day period of this study, the Posi-Shell cover material appeared to be an effective barrier, reducing airborne emissions from the stored waste.

4. CONCLUSIONS

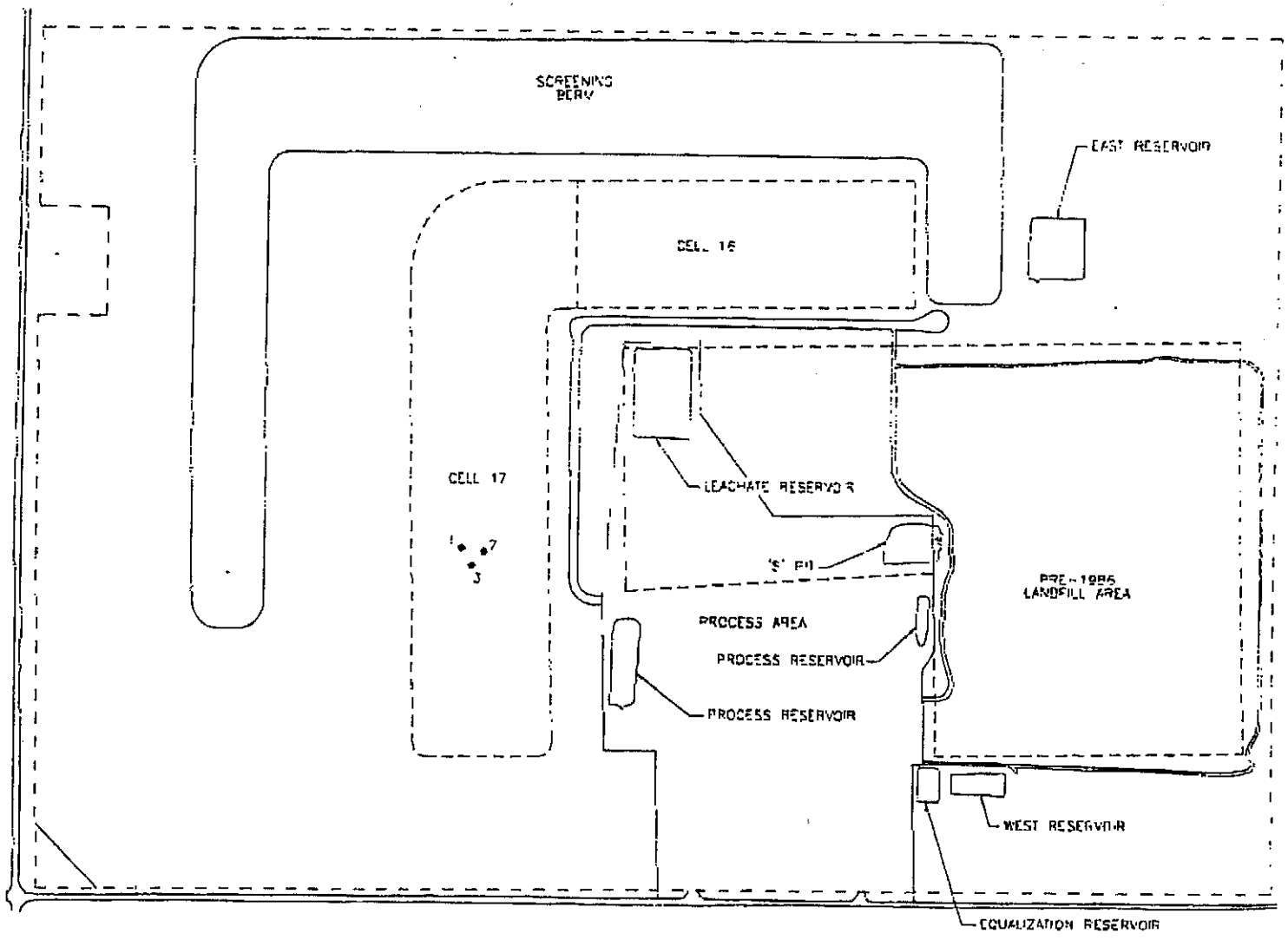
RWDI performed an assessment of a cover application material called Posi-Shell to reduce air emissions of volatile organic compounds, aldehydes, ketones and alcohols from the exposed waste at Laidlaw's Corunna Facility. The study involved sampling the emissions of target compounds from the pit face using an isolation flux chamber. Three sample positions were studied.

The results indicated that, over the 21-day study period, emissions of the target compounds from the two sites at the pit face were reduced by about 89 to 97%. Anomalous findings were encountered at the second location which appeared to be related to a chemical reaction with the waste that may have changed the binding characteristics of the Posi-Shell. With minor exceptions, the cover appeared to form a resilient surface, free from major cracks, after curing. When properly applied, the cover application was demonstrated to be an effective cover material, capable of dramatically reducing emissions for the target compounds.

5. REFERENCES

1. Fax transmittal from Mr. Blake Nesbitt, Laidlaw Environmental Services, to Mr. David Chadder, RWDI on July 15, 1997.

2. Reinhart, D. R., D. C. Cooper and B. L. Walker. 1992. **"Flux Chamber Design and Operation for the Measurement of Solid Waste Landfill Gas Emission Rates".** Journal of Air and Waste Management Association. 42:1067-70.



Flux Chamber Sample Locations

Laidlaw Cover Application - Corunna, Ontario

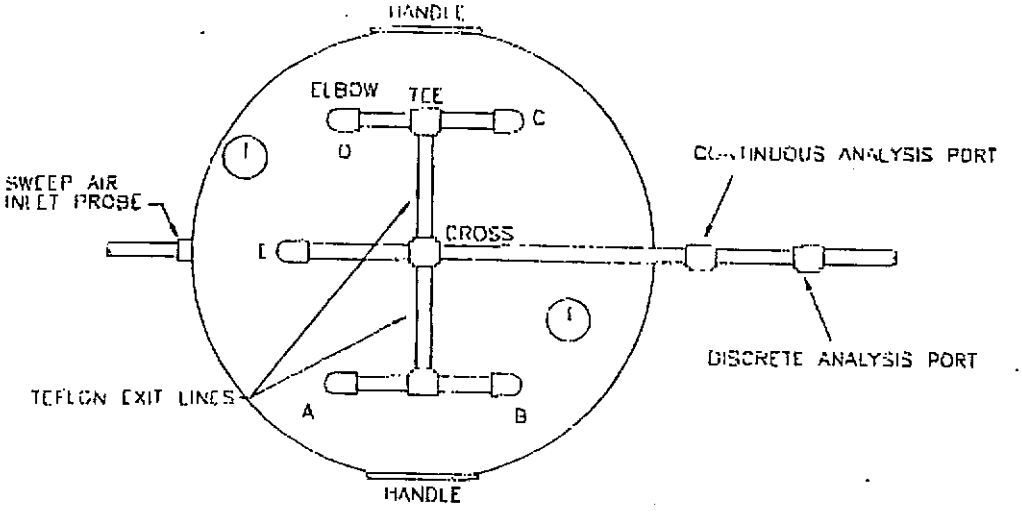
Job No. 97-411

Drawn by: SML | Figure: 1

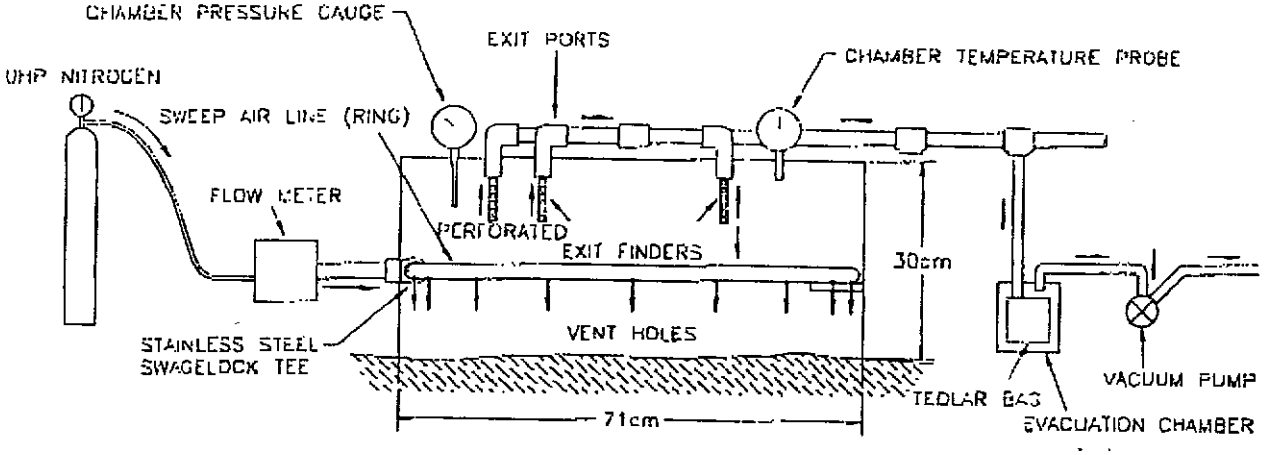
Scale: Approx. 1:7,000

Date: Oct. 30,1997

RWDI

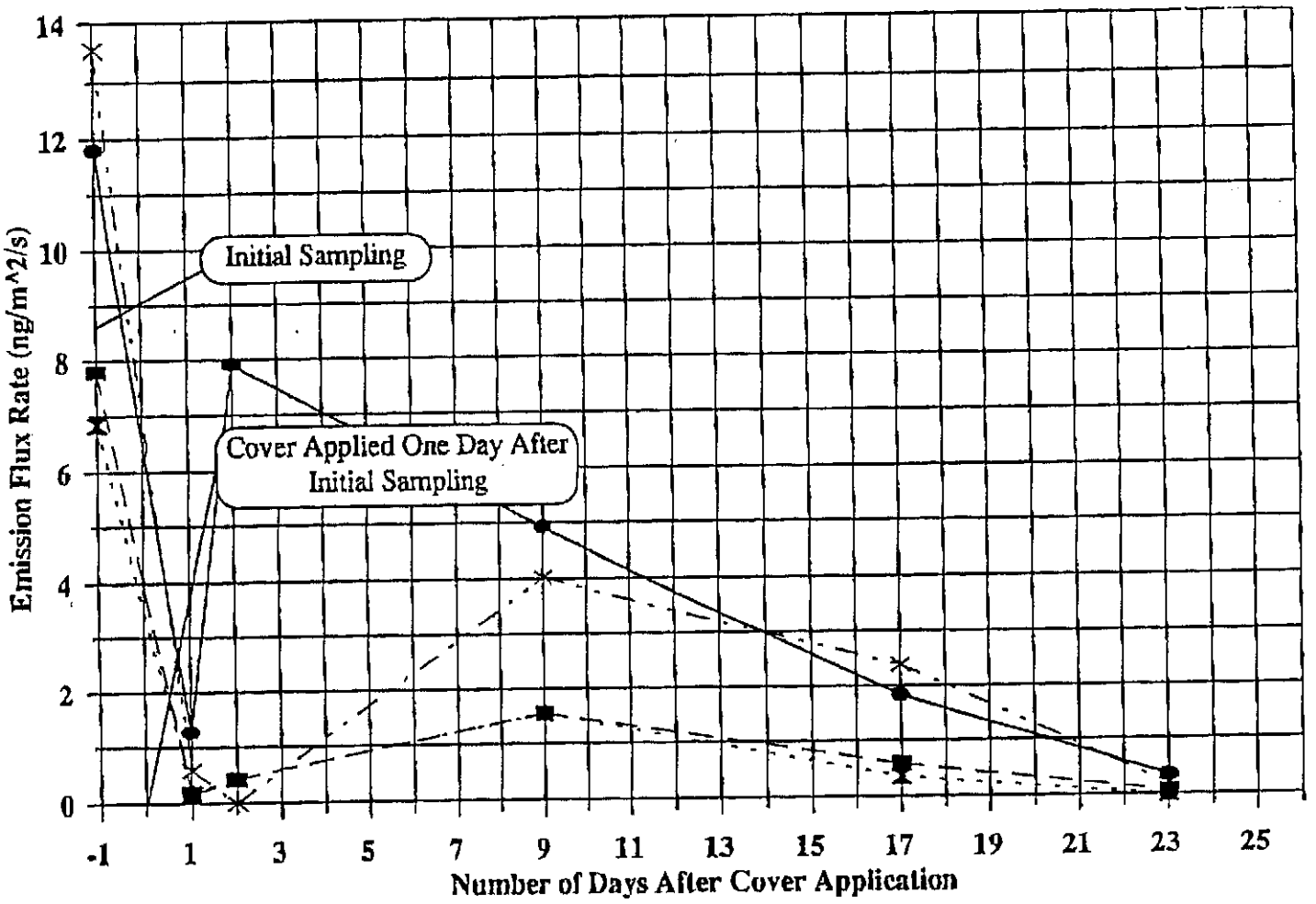


Top View

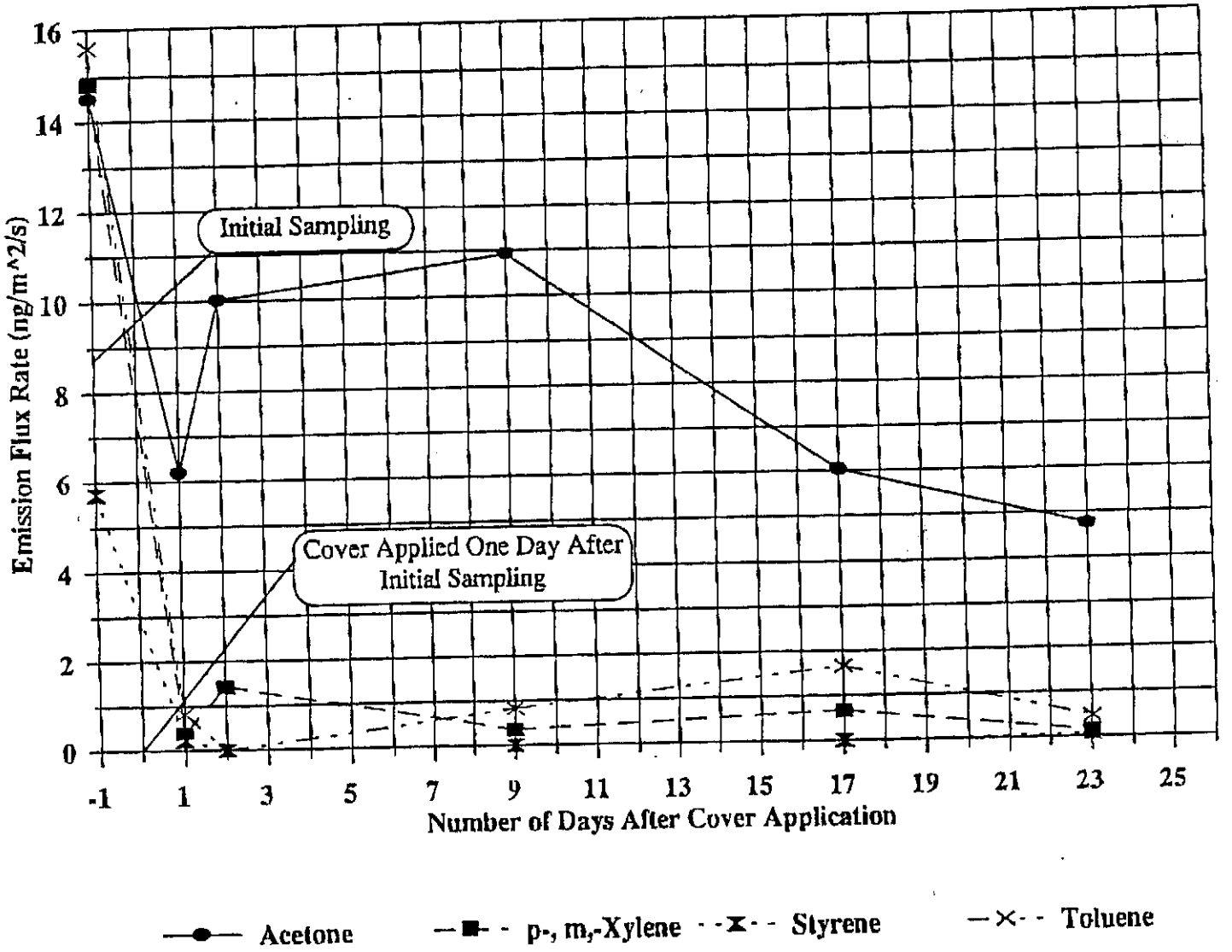


Side View

Schematic Drawing Flux Chamber Sampling Assembly Laidlaw Cover Application - Corunna, Ontario	Job No. 97-411	Drawn by: SML Figure: 2 Scale: N.T.S. Date: Oct. 29,1997	RWDI



Emission Flux Rates for Select Compounds - Site 1	Figure: 3	RWDI
Laidlaw Cover Application - Corunna, Ontario Job No. 97-411	Date: Oct. 30,1997	



Emission Flux Rates for Select Compounds - Site 3	Figure: 4	RWDI
Laidlaw Cover Application - Corunna, Ontario Job No. 97-411	Date: Oct. 30,1997	