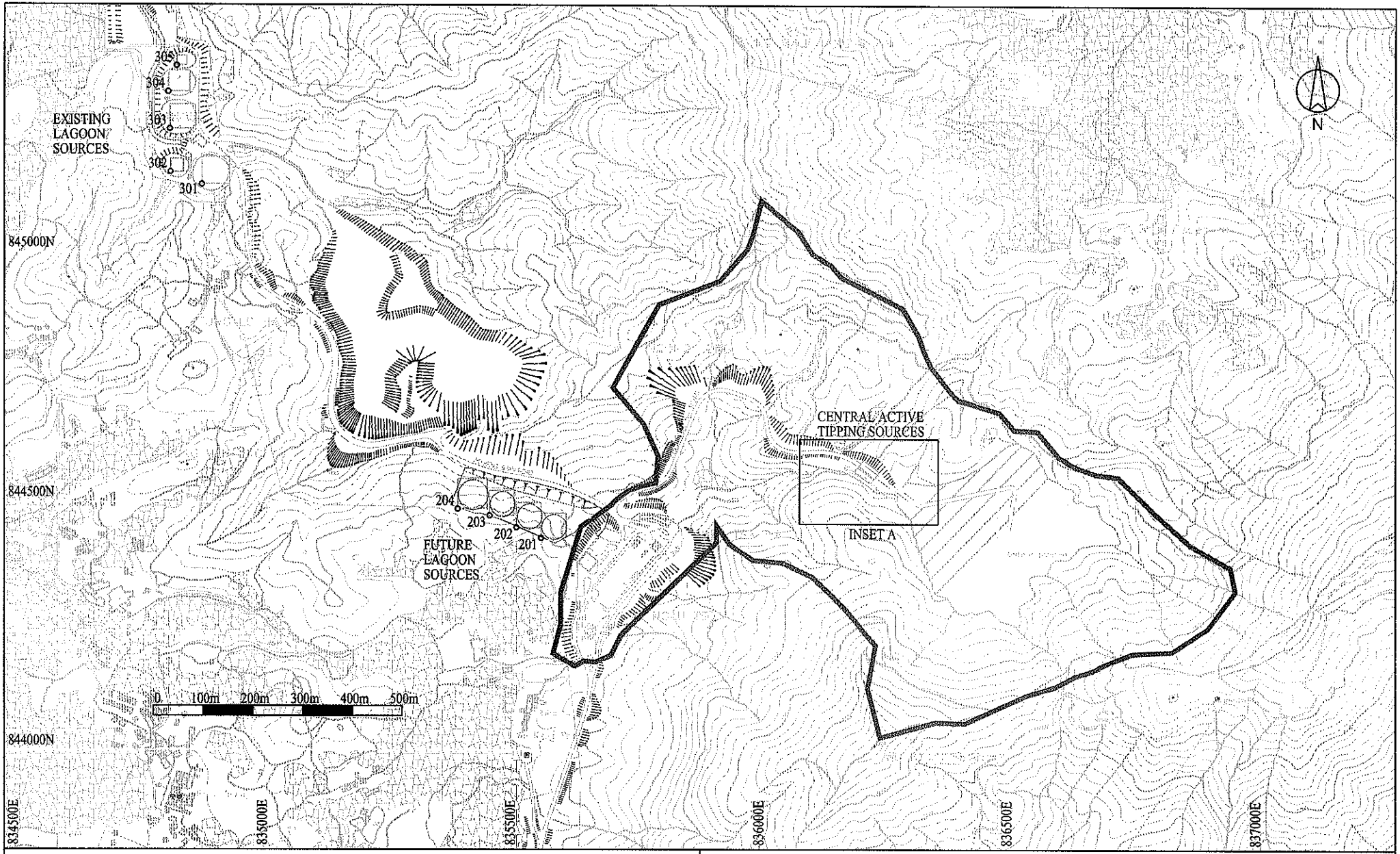
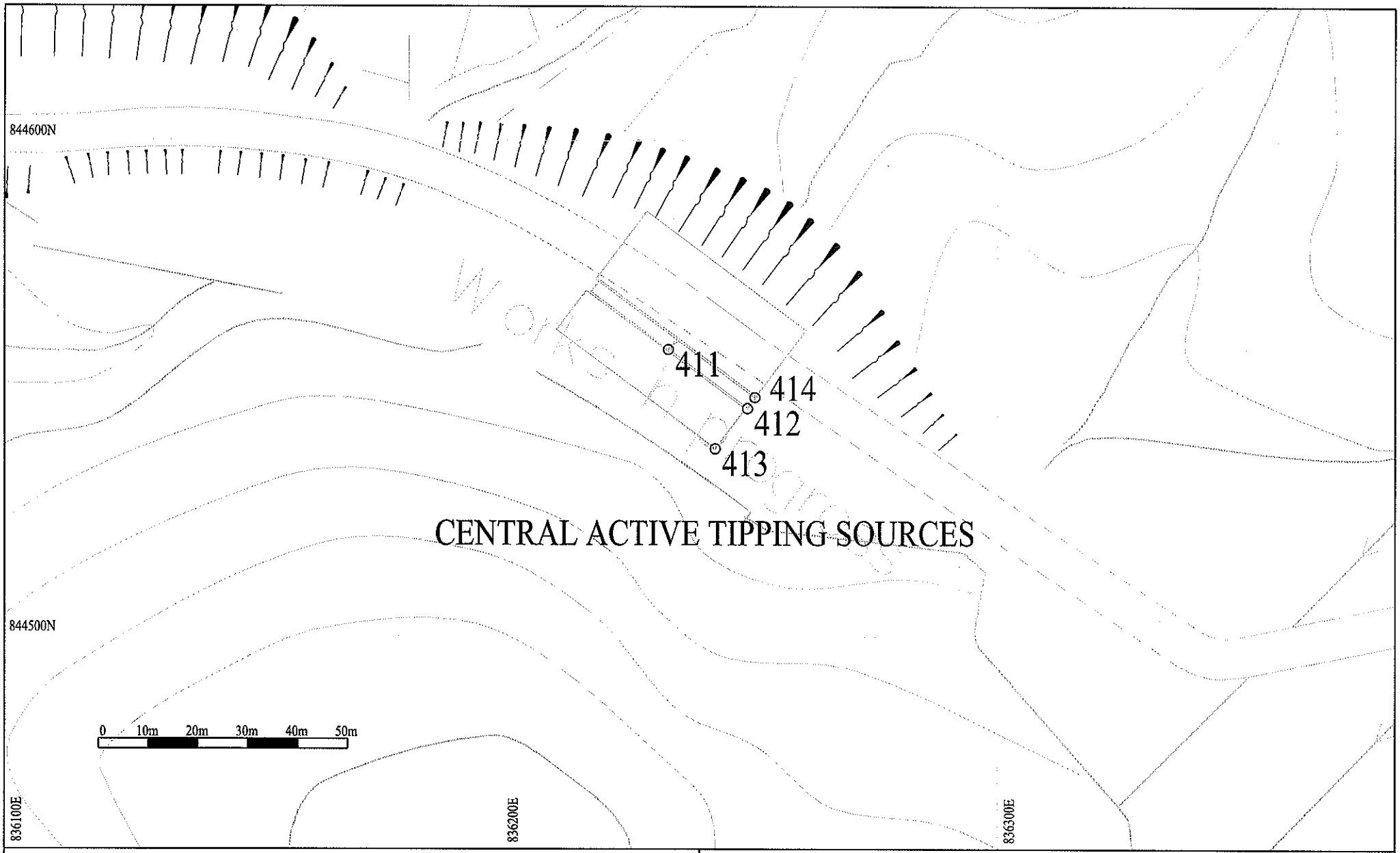
Appendix 3.3

Odour Emission Assessment

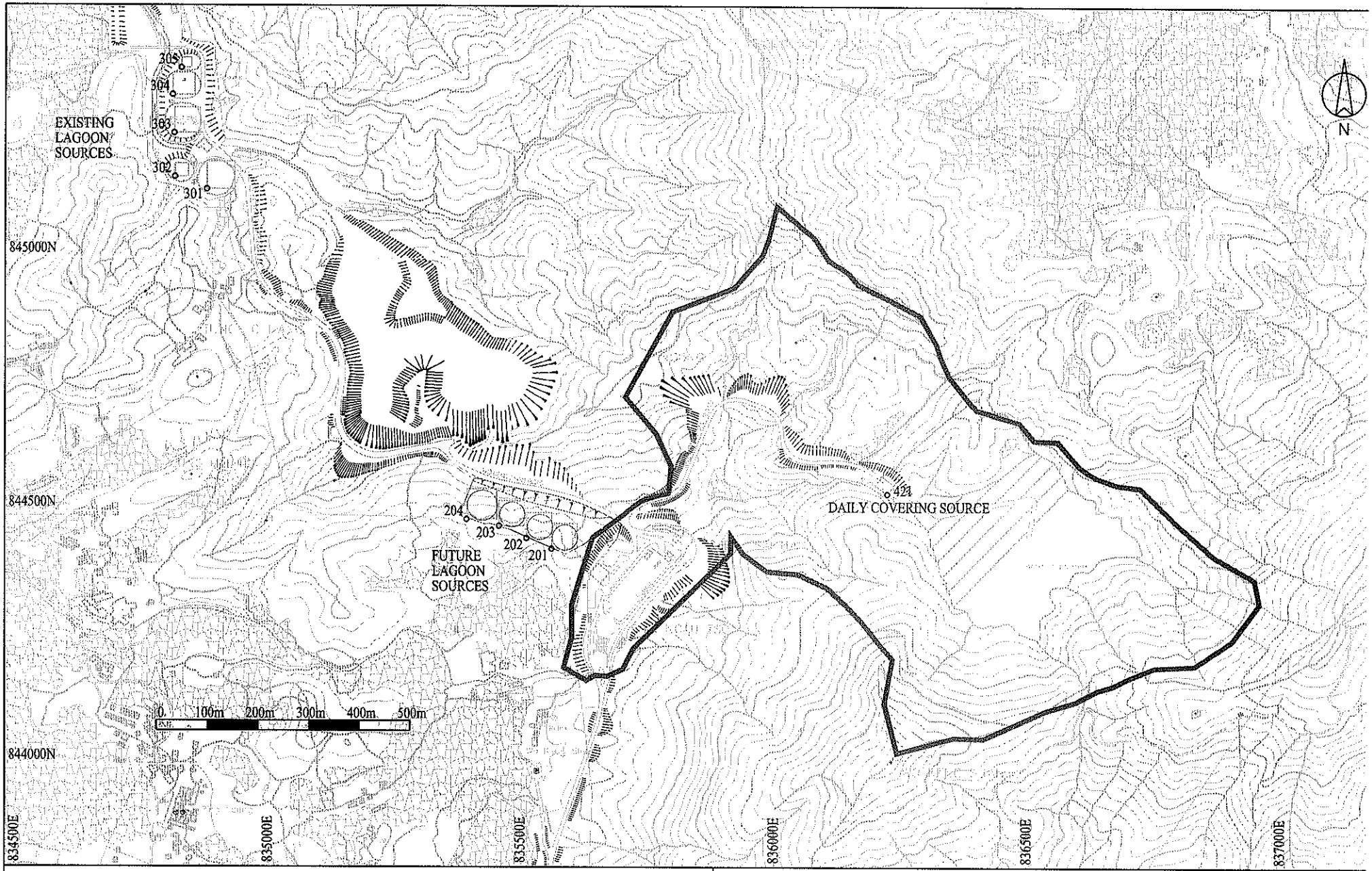


Appendix 3.3
Odour Emission Assessment
Figure 1

Location of Central Tipping & Lagoons
Odour Emission Sources (Day Time)

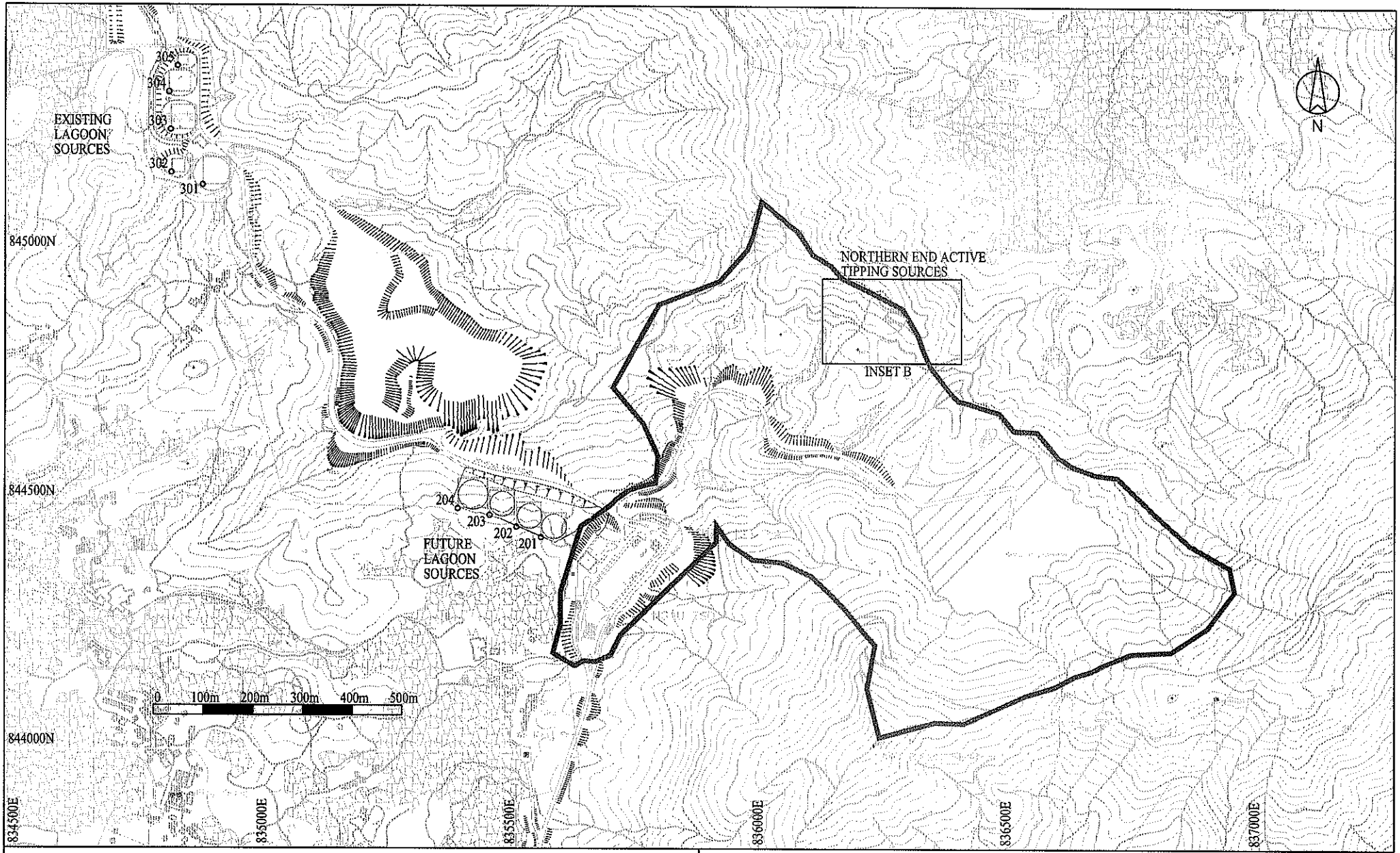


Appendix 3.3 Odour Emission Assessment Figure 2	Location of Central Tipping & Lagoons Odour Emission Sources (Day Time) -- INSET A



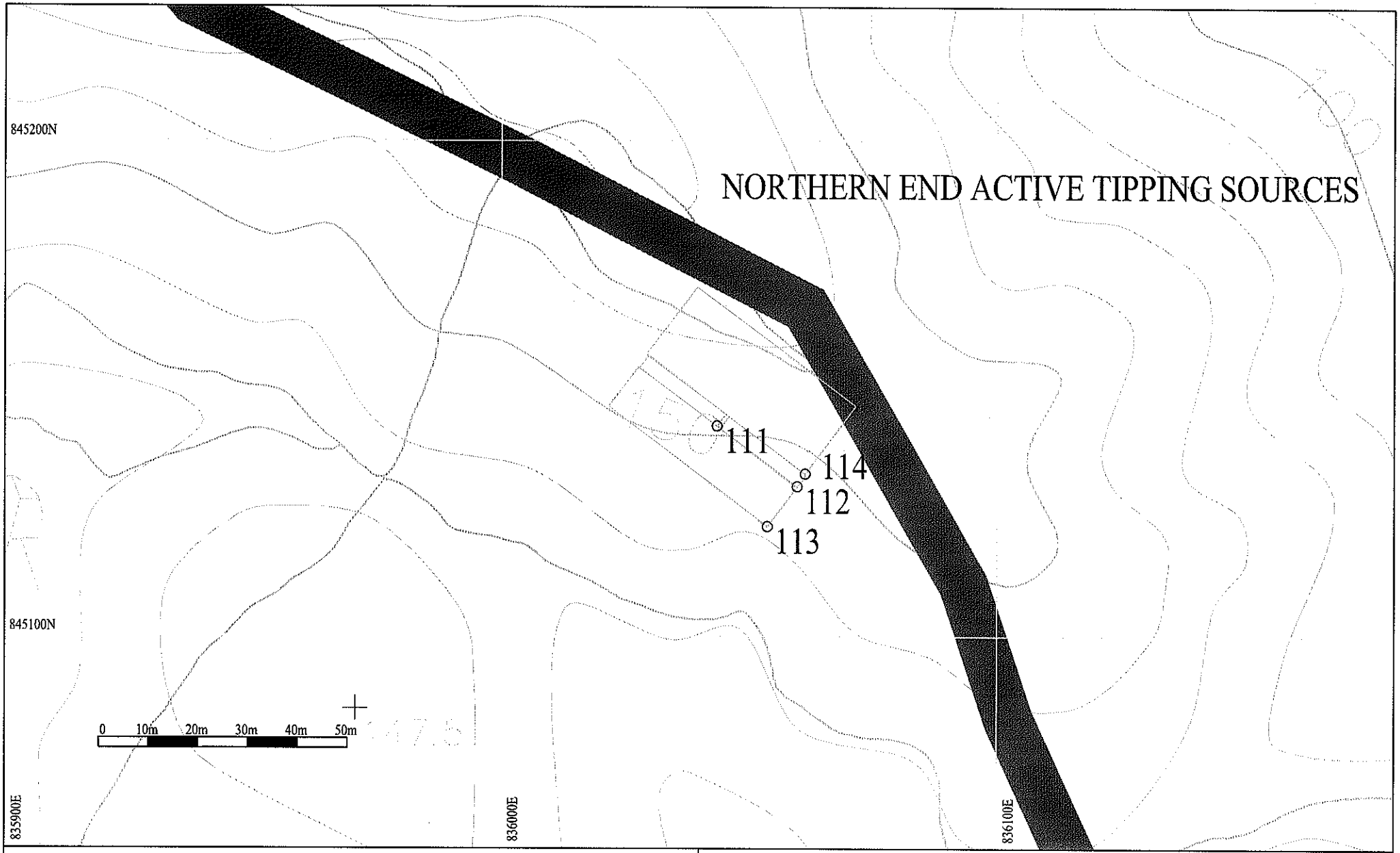
Appendix 3.3
Odour Emission Assessment
Figure 3

Location of Central Daily Cover & Lagoons
Odour Emission Sources (Night Time)



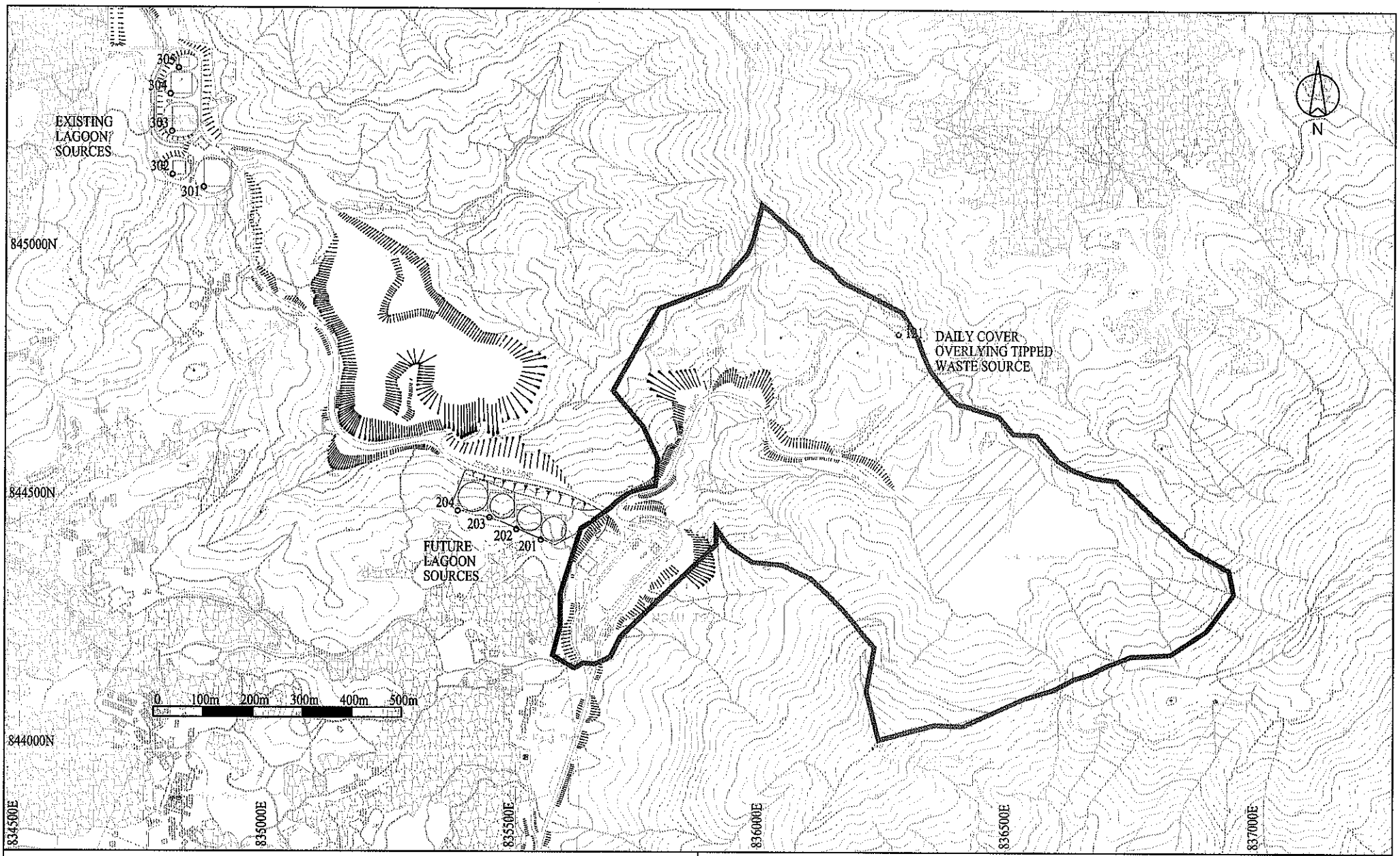
Appendix 3.3
Odour Emission Assessment
Figure 4

Location of Northern Tipping & Lagoons
Odour Emission Sources (Day Time)



Appendix 3.3
Odour Emission Assessment
Figure 5

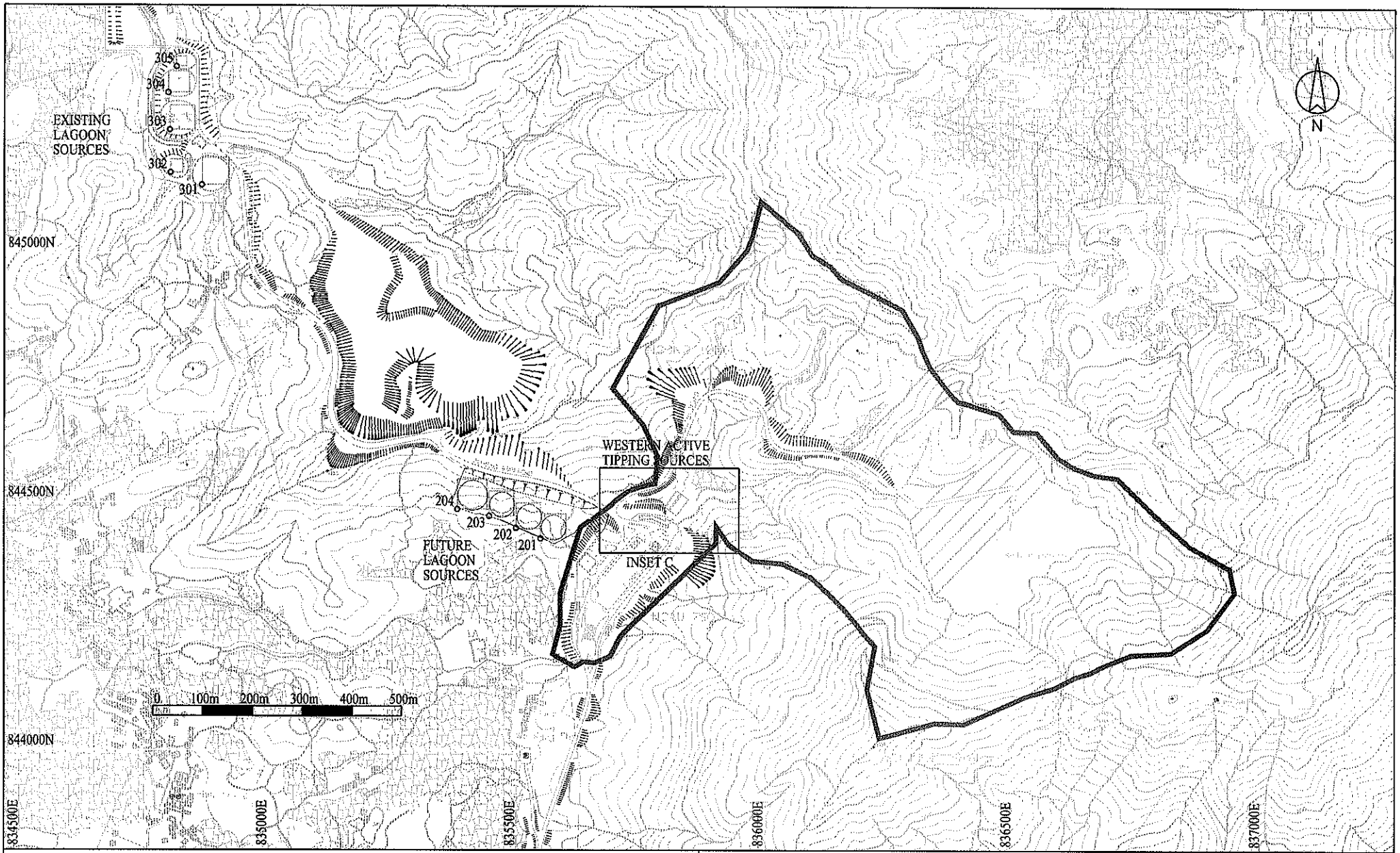
Location of Northern Tipping & Lagoons
Odour Emission Sources (Day Time) -- INSET B



Appendix 3.3
Odour Emission Assessment
Figure 6

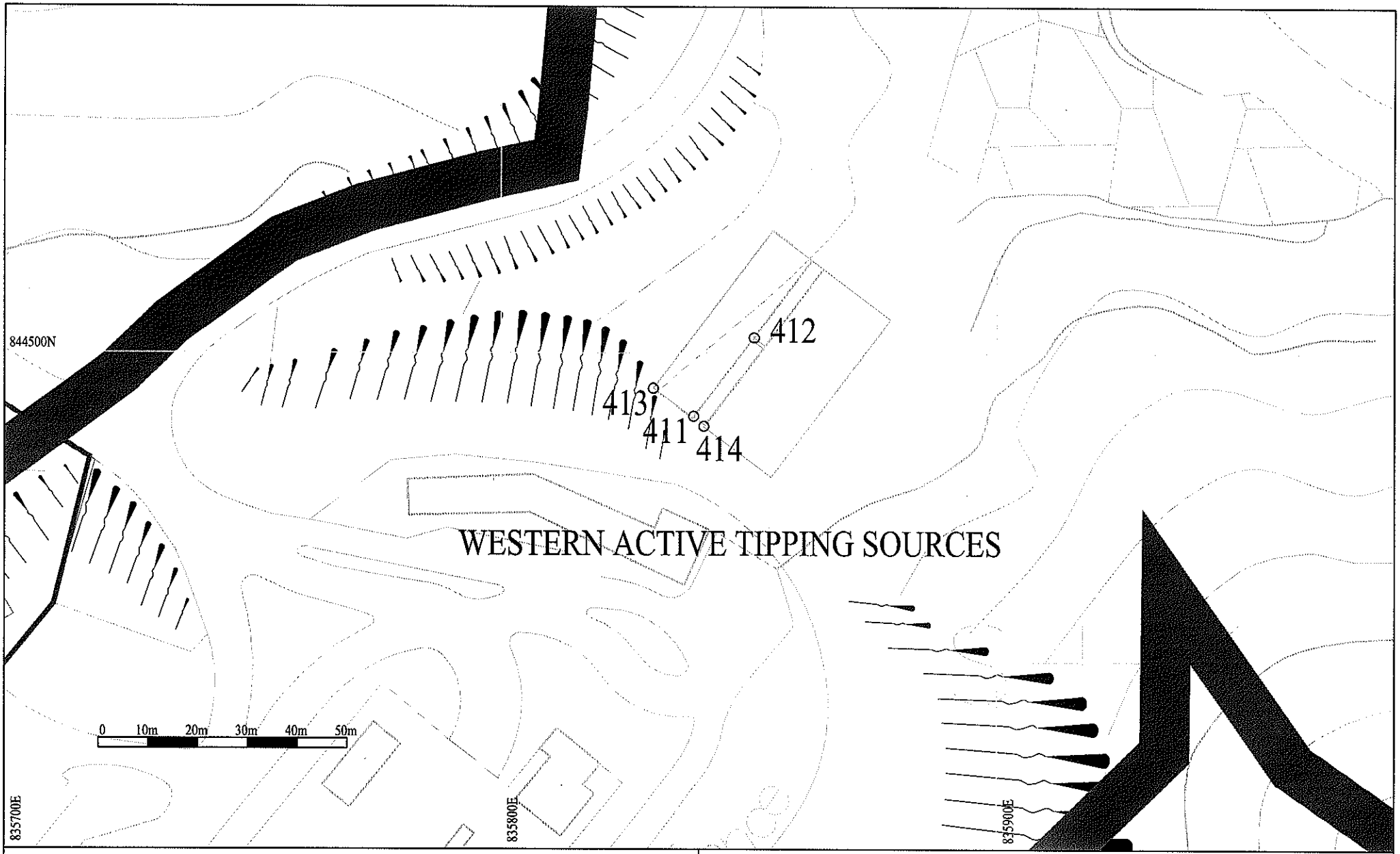
Location of Northern Tipping (Daily Cover overlying tipped waste) & Lagoons

Odour Emission Sources (Night Time)



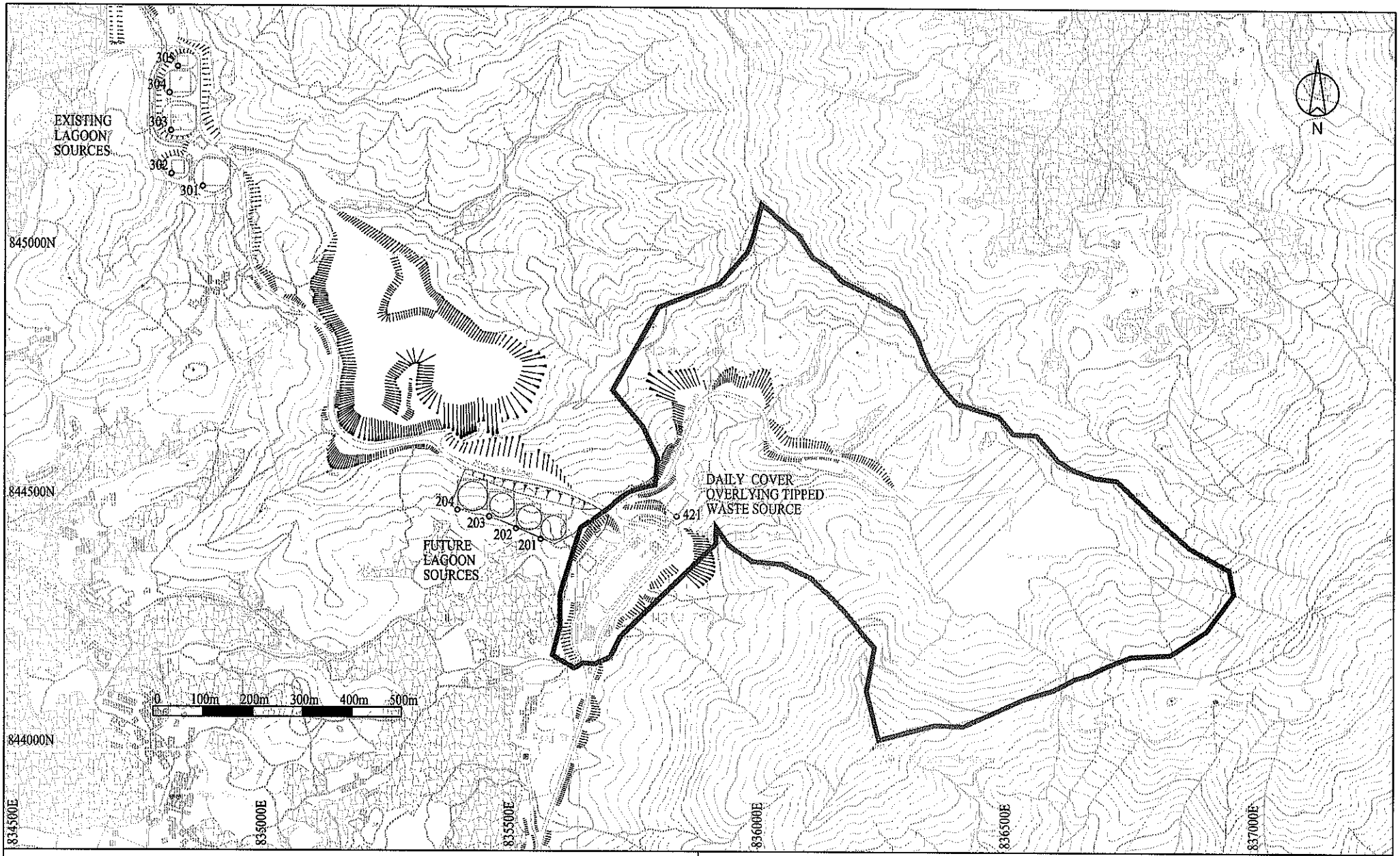
Appendix 3.3
Odour Emission Assessment
Figure 7

Location of Western Tipping & Lagoons
Odour Emission Sources (Day Time)



Appendix 3.3
Odour Emission Assessment
Figure 8

Location of Western Tipping & Lagoons
Odour Emission Sources (Day Time) -- INSET C



Appendix 3.3
Odour Emission Assessment
Figure 9

Location of Western Daily Cover Overlying Tipped Waste & Lagoons
Odour Emission Sources (Night Time)

Appendix 3.3: Establishment of Odour Emission Strength

In accordance with the recommendations from the Odour Research Laboratory of HKPU and the technical paper on "Comparison Study on Portable Wind Tunnel System and Isolation Chamber for Determination of VOCs from Areal Sources, Kaiyun Jiang & Ralph Kaye", researchers have demonstrated in the paper that portal wind tunnel have been successfully and widely applied for the determination of odour emission from liquid and solid areal sources since Yr 1990. There are other examples showing that the same wind tunnel hood sampling methodology and the associated wind equation below have been adopted in landfill in Italy and documented in a paper "Odour emission factors for assessment and prediction of Italian MSW landfills odour impact, by Selena Sironi et al, 25 May Year 2005".

The equation employed to establish odour source emission strength (SOER) is given as follows:

$$SOER = \frac{\text{Odour concentration (ou) x Wind Speed (m/s) x Cross section Area } (m^2)}{\text{Covered surface area } (m^2)}$$

As stated, this equation can also be applicable for both liquid and solid area sources for converting odour emission on various wind velocity. The actual hourly emission concentration is then calculated by the above equation.

Table A: Odour strength at different areas within NENT Landfill (under reasonably worst-case weather condition)

Sampling Location	Temp. at the time of samplings (°C)	Odour Conc. OU [1]	Wind velocity inside hood, V1 (m/s)	Odour Source Emission Strength (SOER), OU/m²-s [1,2,3,4]
Tipping (Day1-1) – Special-Waste + Sludge	21	64	0.2	4
Daily cover overlying tipped waste (Day 1)	21	41	0.2	2.6
Tipping (Day2-1) – Special-Waste + Sludge	21	61	0.2	3.8
Tipping (Day2-2) – MSW waste	21	36	0.2	2.3
Tipping (Day2-3) – Special-Waste + Sludge	21	99	0.2	6.2
Tipping (Day2-4) – Special-Waste + Sludge	21	69	0.2	4.3
Tipping (Day2-5) – compacted waste	21	21	0.2	1.3
Raw Leachate Lagoon – before ASP (ASP-1)	21	228	0.25	17.8
Leachate Lagoon – after ASP (ASP-2)	21	94	0.25	7.3
Effluent Lagoon	21	26	0.25	2
Raw Leachate Lagoon – before ASP (ASP-4)	21	276	0.25	21.6
Aeration Lagoon	21	36	0.25	2.8
Active Tipping (Day3-1) – MSW waste	28	60	0.1	1.88
Active Tipping (Day3-2) – MSW waste	28	53	0.1	1.66
Active Tipping (Day3-3) – MSW waste	28	55	0.1	1.72
Active Tipping (Day3-4) – Special-Waste + Sludge	28	154	0.1	4.81
Manoeuvring (at tipping area)	28	20	0.1	0.63

Remark:

[1] cross section area ($0.4*0.25\ m^2$) = $0.1m^2$

[2] covered surface area ($0.8*0.4m^2$) = $0.32m^2$

[3] It is impracticable to take meaningful odour samples for inactive / restored portions of the Landfill, due to inevitable distortion by the temporary-cover's own "smell" and nearby tipping (in the case of covered portions), or by plants' / fertilisers' smell (in the case of restored portions).

[4] It is a reasonable assumption that inactive tipping areas of landfill have no significant emission, in view of the following :

- The LFG management system creates a negative pressure condition in the landfilled area;
- Effective temporary covers (in the case of covered portioned) and permanent capping (in the case of restored portions), together with the LFG management system, provide double preventive measures against emission;
- For restored landfills in particular, site visits reveal that there is indeed no detectable odour.

The temperature effect was also investigated by comparing odour emission strengths at different temperatures. A comparison table is tabulated below (see Table B). Based on the best available monitoring data, the effects of OU per degree C between 21℃ and 28℃ have been estimated. This temperature adjustment factor will be used to normalise all emission rate to 28℃. It is observed that the change in odour strength is in the range of 0.08 to 0.14 OU/m² / s / ℃ (representing from less odorous to more odorous waste). For the worst-case scenario, the odour strength is assumed to increase by 0.14 OU/m^2/s for each ℃ increment (from 21℃ to 28℃). The temperature conversion factors are listed in Table C.

Table B: Odour Strength Varied with Temperature

Sample Type	Nature	Max Temp (℃)	Odour Conc OU	Wind velocity inside hood, V1, (m/s)	Odour Source Emission Strength (SOER1) normalised to Groundspeed of 0.5m/s, OU/m^2-s	Changes in OU/m^2-s per Degree Temp Increase
Tipping – MSW	Tipping – MSW	21	36	0.2	[2.3*(0.5/0.2)^0.5]=3.64	(4.2-3.64)/7= 0.08 OU/deg C
	Tipping – MSW (max)	28	60	0.1	[1.88*(0.5/0.1)^0.5]=4.20	
Tipping – Special-Waste + Sludge	Tipping – Special-Waste + Sludge	21	99	0.2	[6.2*(0.5/0.2)^0.5]=9.8	(10.76-9.8)/7= 0.14 OU/deg C
	Tipping – Special-Waste + Sludge	28	154	0.1	[4.81*(0.5/0.1)^0.5]=10.76	

Table C: Temperature Conversion Factors (with ground speed of 0.5m/s)

Sampling Location	From 21 deg C to 28 deg C
Tipping	7 * 0.14 = 0.98 OU/ m^2-s
Lagoon	No Change

For the ease of odour modelling, odour emission strength normalised at 0.5m/s is initially adopted in the ISCST3 model (Table D). The results is then converted to the actually odour concentration taken into account of the actually hourly ground wind speed.

Table D: Odour strength applied in the model (Temperature under reasonable worst case condition)

Sampling Location	Measured Odour Source Emission Strength normalised to 0.2m/s (SOER1), OU/m^2-s	Modelled Odour Source Emission Strength at 0.5m/s (SOER2), OU/m^2-s
Daily cover overlying tipped waste	2.6 (at 21deg C)	4.11+0.98= 5.09
Tipping – Special-Waste + Sludge	(4+3.8+4.3+6.2)/4= 4.58 (at 21deg C)	7.23+0.98=8.21
Tipping – MSW	[(1.88+1.66+1.72)/3]*(0.2/0.1)^0.5= 2.47 (at 28deg C)	3.91
Tipping – compacted waste	1.3 (at 21deg C)	2.06+0.98= 3.04
Tipping – aggregated (90% of MSW and 10% of Special-Waste + Sludge)	-	(8.21*0.1+3.91*0.9)=4.34
Manoeuvring (at tipping area)	0.89 (at 28 deg C)	1.41
Raw Leachate Lagoon – before ASP	17.62	27.86
Leachate Lagoon – after ASP	6.53	10.32
Aeration Lagoon	2.5	3.95
Effluent Lagoon	1.79	2.83

Appendix 3.3A

Identification of worst case scenario for odour assessment

Statistical Analysis of the Reasonably Worst-case Weather Condition for Odour Assessment