

Quarterly Progress Report

(May 29, 2003 - August 31, 2003)



Control of Odors from Construction and Demolition Debris Landfills

**Principal investigator: Debra R. Reinhart, PhD, PE
Timothy G. Townsend, PhD, PE**

**Research Assistants: Sangho Eun (University of Central Florida)
Qiyong Xu (University of Florida)**

QUARTERLY PROGRESS REPORT
May 29, 2003 - August 31, 2003

PROJECT TITLE: Control of Odors from Construction and Demolition Debris Landfills

PRINCIPAL INVESTIGATORS: Debra R. Reinhart, PhD, PE
Timothy G. Townsend, PhD, PE

AFFILIATION: University of Central Florida (PI)

1.0 Introduction

Odors are common complaints from residents living near landfills. The deposited wastes can be sources of odor under certain conditions. Household hazardous wastes, illegally disposed wastes, and other aromatic wastes are good examples of odor sources. Gypsum, a component of dry wall, produces hydrogen sulfide during reduction which is most common source of odor related to C & D waste. This research will quantify the H₂S emission rates at several landfill sites and evaluate different cover soils to reduce odor.

2.0 Work Completed This Quarter

The five test sites were confirmed and the applicability of the flux chamber method was verified. Table 1 shows C & D Landfill sites selected and the number of measurement completed to date.

Table 1: C & D Landfill Sites and the Number of Measurement

Name of Landfill Site	Number of Measurement
C.R. 545 Landfill	20
Pine Ridge Landfill	20
Keene Road Landfill	17
Deland Landfill	20
Gel Corp. Landfill	19

2.1 Description of the Landfill

2.1.1 C.R. 545 Landfill

The C.R. 545 C&D Landfill is located in Winter Garden, Florida. The landfill began operations in 1991. The landfill site is 80 acres and a design capacity of 4 million yd³. About 240 to 250 trucks per day arrive at the landfill each week. The landfill receives 240,000 tons per year. Chakrabarti (2002) reported that drywall (gypsum) is, on average, 4 % of the volume of waste at the C.R. 545 C&D Landfill.

2.1.2 Pine Ridge Landfill

The Pine Ridge Landfill is a Class III facility located in Orange County, Florida. The landfill is 68.3 acres with an active waste area of about 10 acres. A preliminary H₂S monitoring was undertaken in 1995 in response to neighborhood complaints concerning

health and safety issues (Atwood and Tessitore, 1995). The average H₂S concentrations from three locations were 0.26 ppm, 0.25 ppm, and 0.48 ppm from August through September. The maximum 24-hour average H₂S concentrations were 0.58 ppm, 0.58 ppm, and 1.25 ppm.

2.1.3 Deland Landfill

The Deland Landfill is located in Deland, Florida. The landfill began operations in the early 1980s. The landfill is 80 acres with an active waste area of about 5 acres.

2.1.4 Keene Road Landfill

Keene Road Landfill is in Orange County, Florida. The landfill is 150 ft in depth with 2 ft of final cover. Cover soil (6 in) was applied weekly as an intermediate cover soil.

2.1.5 Gel Corp. Landfill

G.E.L. Corp. C&D Landfill is a C&D facility in Volusia County, FL. The landfill processes materials on-site, including wood and concrete. The recycled concrete is used as a road base, drain field and a concrete depending on the size. Also the landfill recycled the yard wastes as mulches. The landfill was a Class I landfill which closed in June of 1983. It was then permitted to accept C&D waste. Odor complaints started in 1997. The landfill has 60 ft high, the top area of approximately 5 to 6 acres.

2.2 Landfill Visits

Field trips have been made 18 times during this quarter. Frequently, adverse weather conditions have been encountered during the measurements due to rain and wind. Most flux measurements were conducted between 9 am to 4 pm. The weather and landfill visit dates are presented in Table 2.

Table 2: Landfill Visit Date and Weather Conditions

Landfill Visited	Visit Date	Weather
CR 545 Landfill	1-April-03	84 F, windy
	10-April-03	82 F, Windy
	17-April-03	87 F, windy
	25-April-03	87 F, windy
	9-June-03	85 F, scattered shower
Pine Ridge Landfill	29-May-03	90 F, windy
	10-June-03	92 F, no wind
	13-June-13	93 F, windy
	12-Aug-12	110 F, no wind
	13-Aug-13	118 F, no wind
Deland Landfill	11-Jul-03	98 F, no wind
	28-Jul-03	100 F, scattered shower
	29-Jul-03	100 F, no wind
	4-Aug-03	100 F, no wind
	Keene Road Landfill	24-Jun-03
25-Jun-03		100 F, no wind
20-Aug-03		105 F, scattered shower
21-Aug-03		93 F, scattered shower
Gel Corp. Landfill		5-Aug-03
	6-Aug-03	110 F, scattered shower
	7-Aug-03	110 F, scattered shower
	7-Aug-03	110 F, scattered shower

2.3 Survey of Ambient H₂S

An H₂S survey was conducted during every visit prior to taking the flux measurements. The survey area was limited to inactive areas due to safety concerns over active filling areas. The ambient concentrations were extremely variable with time, from site to site and within a site. All five C & D landfill sites had detectable ambient hydrogen sulfide concentrations ranging from below detection limit (0.003 ppm) to 50 ppm. Some area of the landfill could be potentially harmful to landfill workers who are exposed to undiluted C & D landfill gas. According to the National Institute for Occupational safety and Health (NOISH), a limit of 10 ppm over a ten minute period is a recommended guideline. Most ambient concentrations, however, ranged from 0.003 ppm to 0.200 ppm. Table 3 presents the results of the H₂S survey.

Table 3: Results of Hydrogen Sulfide Survey

Pine Ridge Landfill			
Visit Date	Cell 1 (ppb)	Cell 2 (ppb)	Cell 3 (ppb)
May 29	4 ~ 5	6 ~ 8	6 ~ 45
June 10	3 ~ 25	3 ~ 5	5 ~ 1500
June 13	3 ~ 25	3 ~ 140	3 ~ 11
August 12	4 ~ 10	3 ~ 6	3 ~ 74
August 13	3 ~ 16	3 ~ 4	7 ~ 1400
Deland Landfill			
Visit Date	Cell 1 (ppb)	Cell 2 (ppb)	Cell 3 (ppb)
July 11	3 ~ 15	3 ~ 6	3 ~ 5
July 28	7 ~ 220	3 ~ 7	3 ~ 5
July 29	3 ~ 12	3 ~ 4000	3 ~ 5
August 4	4 ~ 10	3 ~ 52	3 ~ 18
Gel Corp. Landfill			
Visit Date	Top Area (ppb)	Slope Area (ppb)	
August 5	3 ~ 8	6 ~ 1400	
August 6	3 ~ 10	50 ~ 50,000	
August 7	3 ~ 10	50 ~ 37,000	
August 8	3 ~ 8	9 ~ 32000	
Keene Road Landfill			
Visit Date	Cell 1 (ppb)	Cell 2 (ppb)	
June 24	5 ~ 28	-	
June 25	5 ~ 350	-	
August 20	3 ~ 5	3 ~ 110	
August 21	3 ~ 16	3 ~ 15	
C.R. 545 landfill (last Quarter)			
Visit Date	Covered Face	Working Face	
April 1	4 ~ 5	8 ~ 13	
April 10	3	5 ~ 13	
April 17	3	5 ~ 9	
April 25	1 ~ 4	5 ~ 9	
June 9	3	5 ~ 15	

2.4 Results of H₂S Flux Measurements

At the beginning of this research, both static and dynamic flux chamber modes were tested at the CR545 Landfill and the Pine Ridge Landfill. The dynamic flux method was determined to be the better application for hydrogen sulfide emission. The static mode concentrations over time were non-linear suggesting.

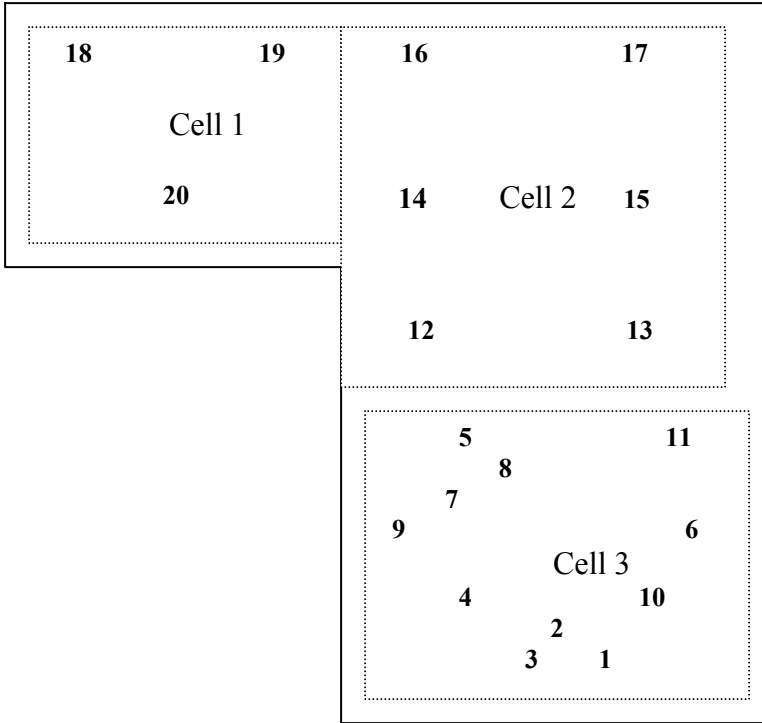
However, the dynamic mode is more complicated and inconvenient than the static mode. The dynamic mode needs a lot of peripheral equipments such as an air cylinder, a flow meter and a regulator. The sweep air flow rate of 6 L/min and retention time of 40 min were applied for a dynamic mode. If the air flow rate is over 6 L/min it tends to dilute H₂S too much, and the resulting concentration is below the detection limit. However, a flow rate of 10 L/min was used when high ambient concentrations of H₂S were found (i.e. > 1 ppm).

A beach umbrella was used to protect the chamber from sunlight which can cause a build-up of the pressure and moisture production inside the chamber. Bentonite slurry was applied around the chamber and the soil to prevent leaks. The burial depth of skirt was 60mm as recommended by Liao et al. (1998) to provide acceptable air tightness.

The detection limit of the flux chamber is estimated to be 0.158 mg/m²-day. Figures 5 and 7 show the change in concentration before reaching the retention time. The concentrations have a sharp initial increase within 10 minutes and then decrease until the retention time is reached. Theoretically, concentration should increase linearly until it reaches a steady state (Walker 1991; Gowing et al. 1997).

2.4.1 Pine Ridge Landfill

Data from monitoring of the Pine Ridge Landfill are presented in Figures 1 – 3 and Table 4 and 5. Locations 1 to 8 shown in Figure 1 were measured using the static mode where no sweep air was applied while measuring the accumulated hydrogen sulfide as a function of time. Most results of static mode were either below detection limit or non-linear response. The reasons for non-linear response could be the increased pressure inside chamber, which caused negative biasing, and moisture production as well as windy weather condition. Table 4 shows H₂S flux results of the static mode. The remaining data points were collected using the dynamic mode which applies sweep air to the chamber. Table 5 shows results of the dynamic mode testing and Figure 3 depicts the results as a chart.



Number (1-20) = Locations of Flux Measurements

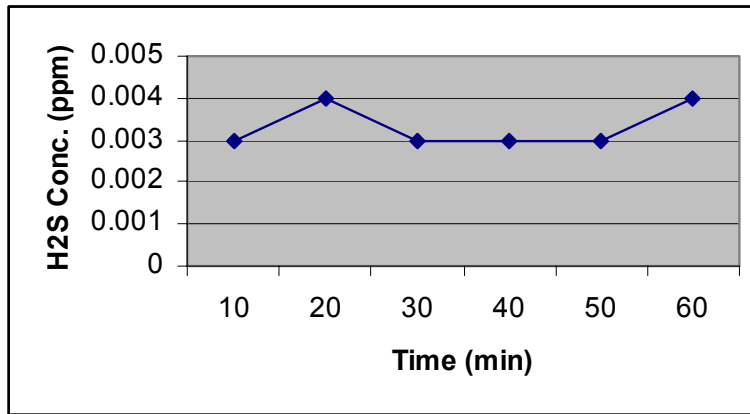
Figure 1: Site layout of Pine Ridge Landfill and Location of Flux Measurements

Table 4: H₂S Flux Results of Static Mode (Pine Ridge Landfill)

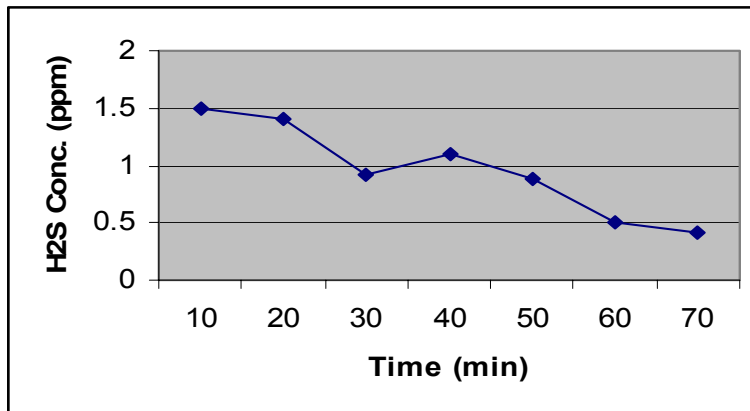
LOCATION #	DATE	TIME (MIN)	H ₂ S CONC. (PPB)	H ₂ S FLUX (MG/M ² -DAY)
1	10-Jun-03	10	0.003	Non-linear Response
		20	0.004	
		30	0.003	
		40	0.003	
		50	0.003	
		60	0.004	
2	10-Jun-03	10	1.500	Non-linear Response
		20	1.400	
		30	0.910	
		40	1.100	
		50	0.890	
		60	0.510	
		70	0.410	
3	29-May-03	-	BDL	N/A
4	29-May-03	-	BDL	N/A
5	29-May-03	10	0.019	Non-Linear Response
		20	0.007	
		30	0.120	
		40	0.110	
		50	0.110	
		60	0.120	
6	10-Jun-03	10	0.150	Non-linear Response
		20	0.120	

		30	0.110	
		40	0.100	
		50	0.090	
		60	0.120	
7	29-May-03	-	^a BDL	N/A
8	29-May-03	-	BDL	N/A

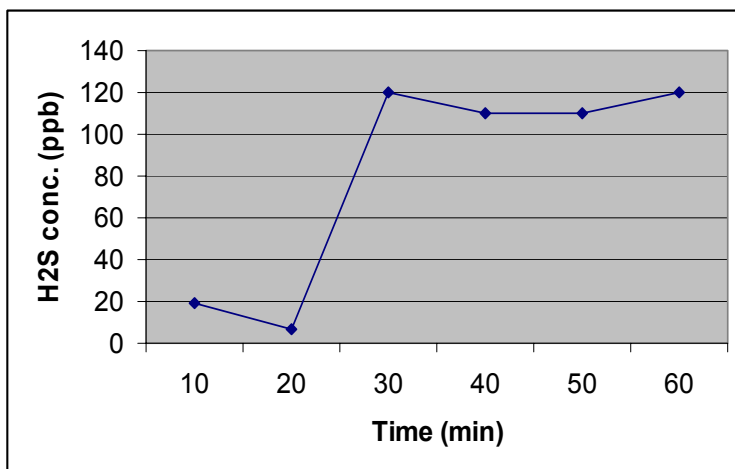
a: Below Detection Limit



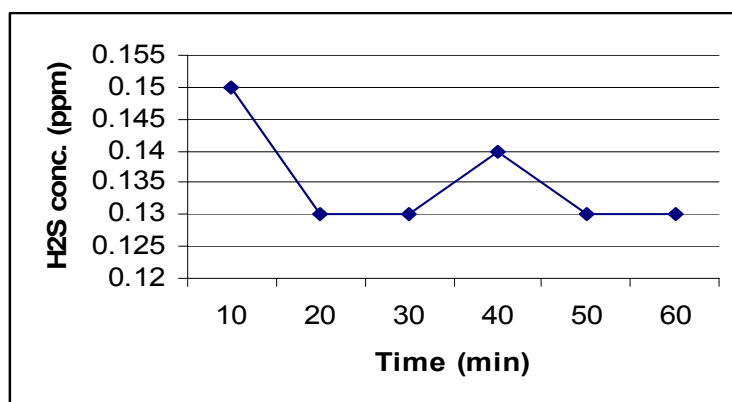
a) Location 1



b) Location 2



c) Location 5



d) Location 6

Figure 2: H₂S Concentration vs. Time for Static Mode Measurements at the Pine Ridge Landfill

Table 5: H₂S Flux Results of Dynamic Mode (Pine Ridge Landfill)

LOCATION	DATE	AIR FLOW RATE (L/MIN)	RETENTION TIME (MIN)	H ₂ S CONC. (PPM)	H ₂ S FLUX (MG/M ² -DAY)
9	13-Jun-03	5	45	0.006	0.368
10	13-Jun-03	5	45	0.110	6.752
11	13-Jun-03	5	45	0.006	0.368
12	13-Jun-03	5	45	0.170	10.434
13	12-Aug-03	6	40	BDL	N/A
14	12-Aug-03	6	40	0.007	0.416
15	12-Aug-03	6	40	0.028	1.664
16	12-Aug-03	6	40	0.045	2.675

17	13-Aug-03	6	40	BDL	N/A
18	13-Aug-03	6	40	BDL	N/A
19	13-Aug-03	6	40	BDL	N/A
20	13-Aug-03	6	40	BDL	N/A

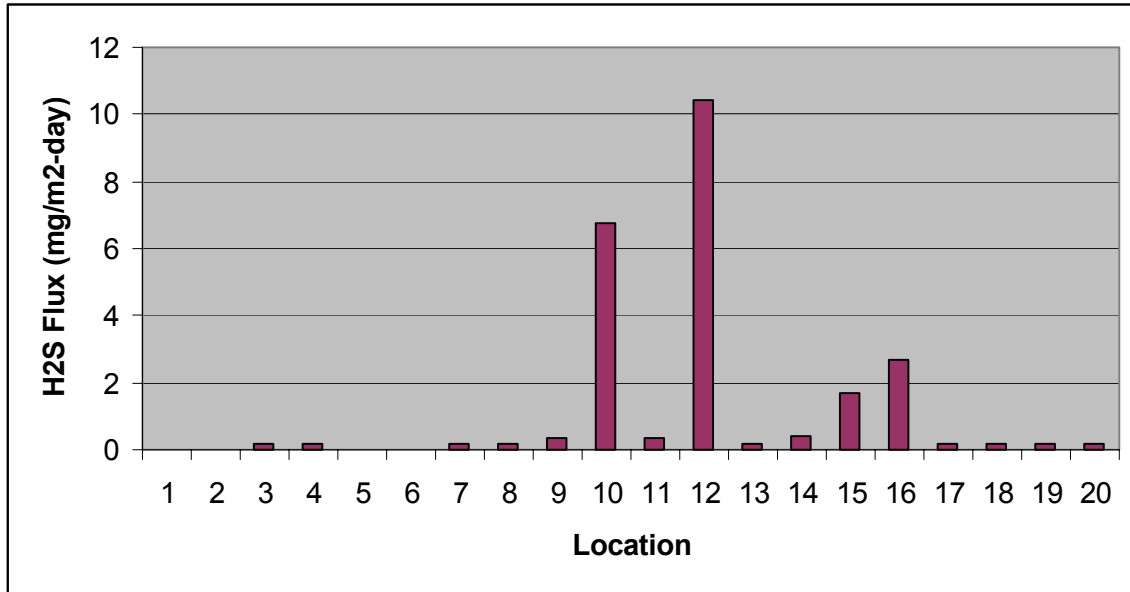


Figure 3: Flux Results of Pine Ridge Landfill

2.4.2 Deland Landfill

Data from monitoring of the Deland Landfill are presented in Figures 4 – 6 and Table 6 and 5.

Table 6: Results of Flux Measurement (Deland Landfill)

Location #	Air Flow Rate (L/min)	Retention Time (min)	H2S Conc. (ppm)	H2S Flux Rate (mg/m ² -day)
1	6	40	BDL	N/A
2	6	40	BDL	N/A
3	6	40	BDL	N/A
4	6	40	0.004	0.248
5	6	40	0.032	1.990
6	10	20	0.210	21.767
7	6	40	BDL	N/A
8	6	40	0.013	0.809
9	6	40	0.013	0.809
10	6	40	0.004	0.248
11	6	40	BDL	N/A
12	6	40	BDL	N/A
13	6	40	BDL	N/A
14	6	40	BDL	N/A
15	6	40	BDL	N/A

16	6	40	BDL	N/A
17	6	40	0.004	0.248
18	6	40	BDL	N/A
19	6	40	BDL	N/A
20	6	40	0.037	2.301

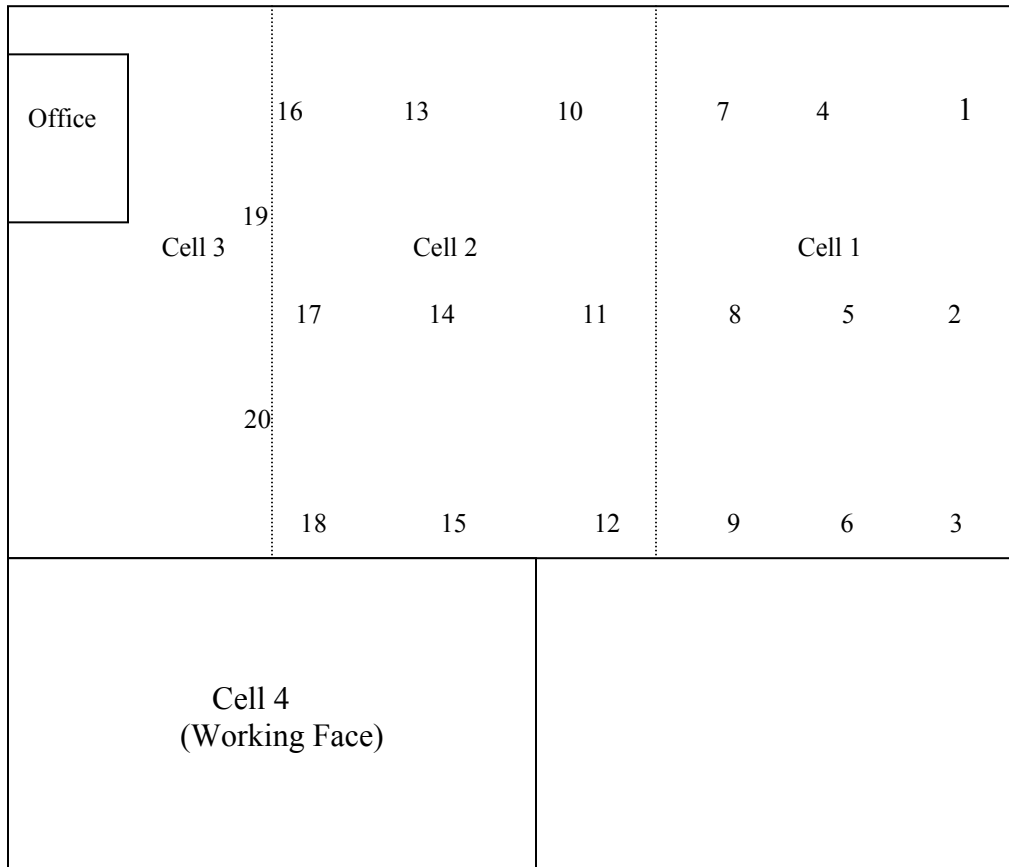
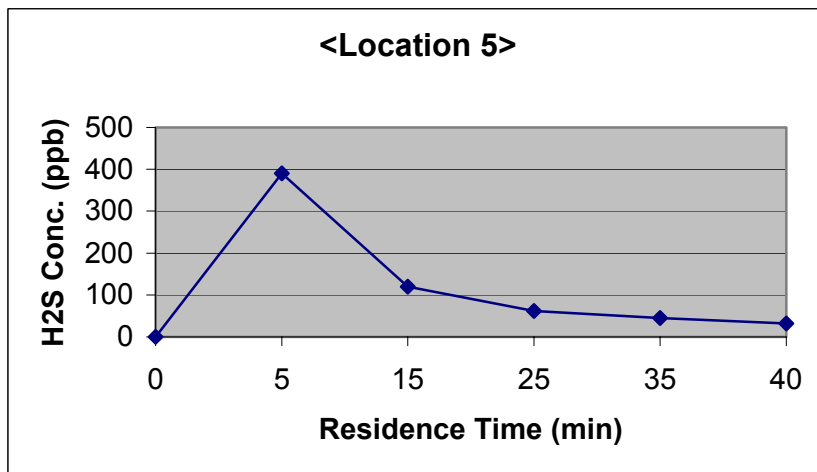
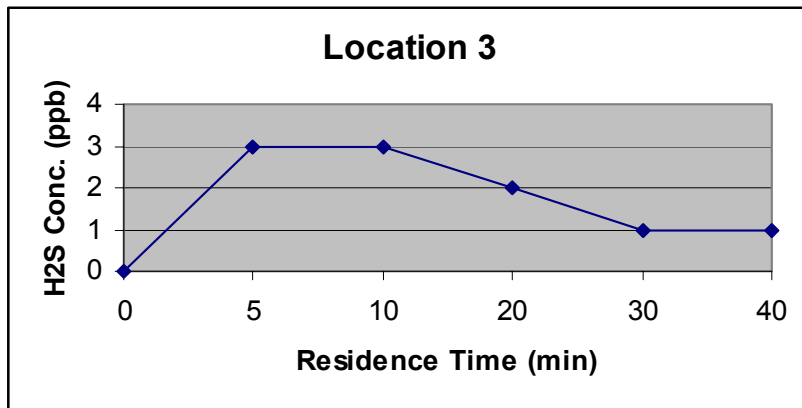
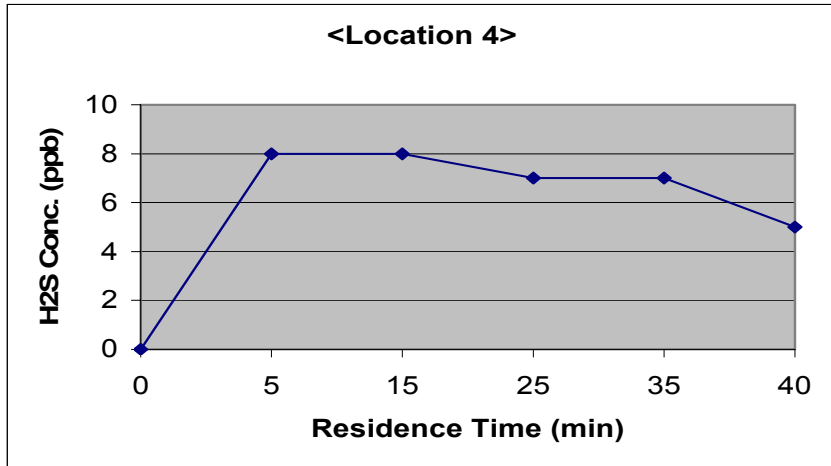
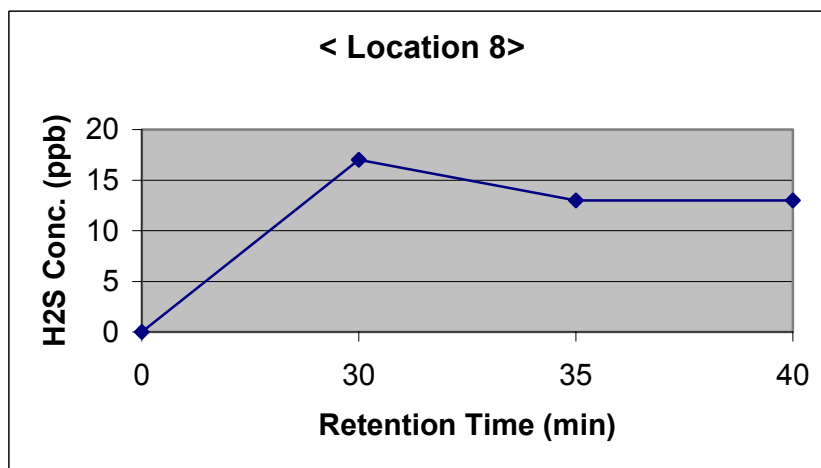
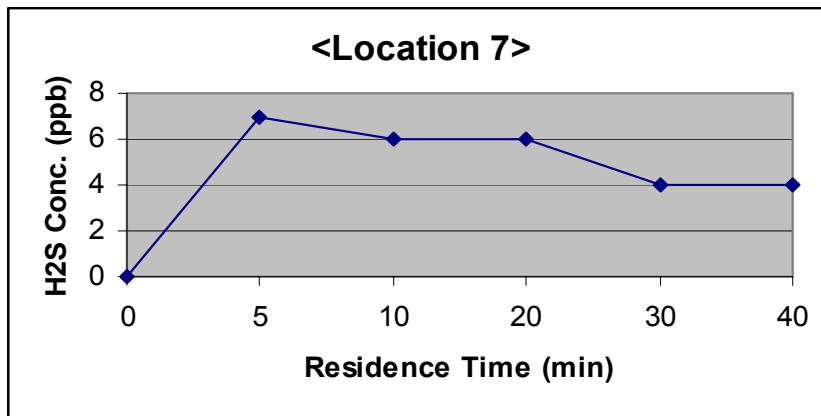
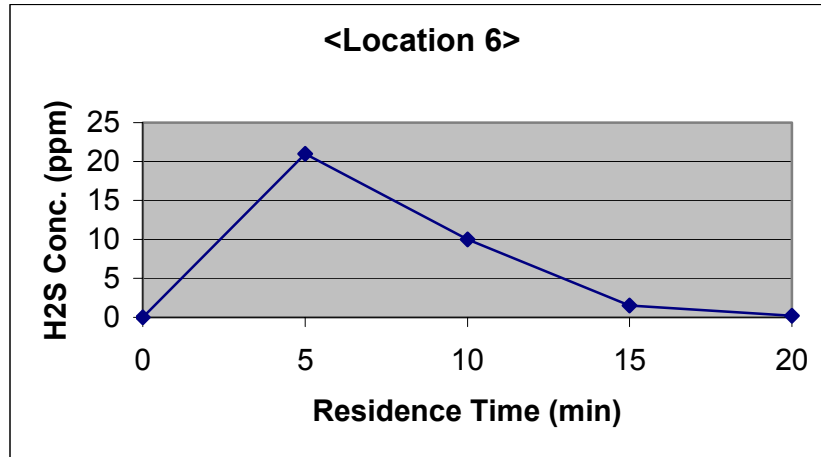
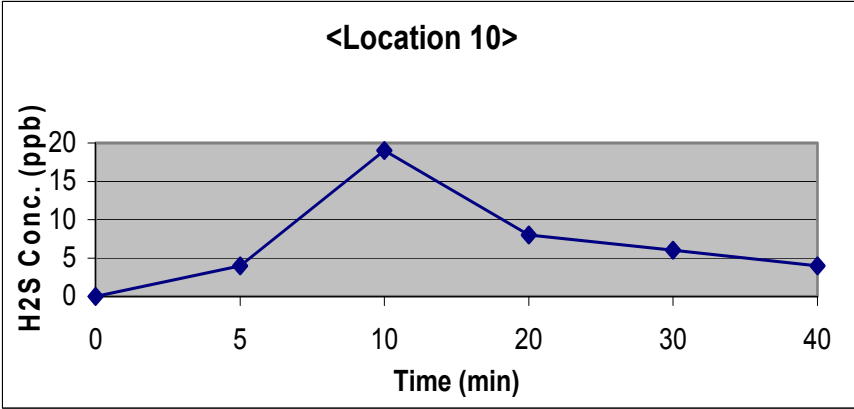
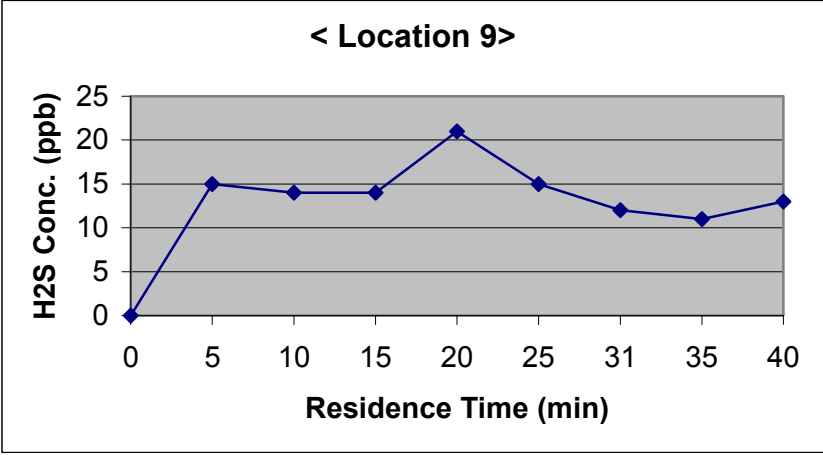


Figure 4: Site layout of Deland Landfill and Location of Flux Measurements







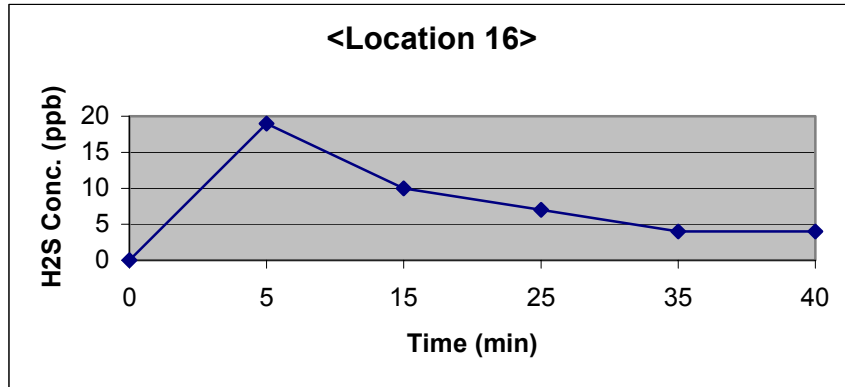
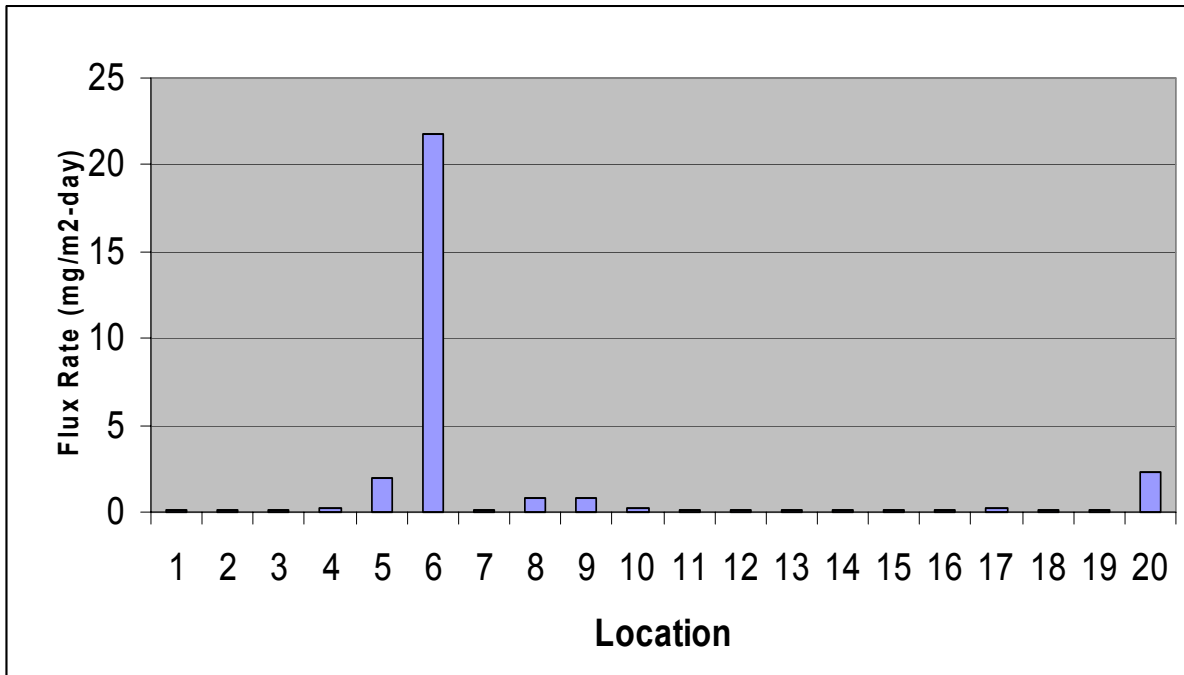
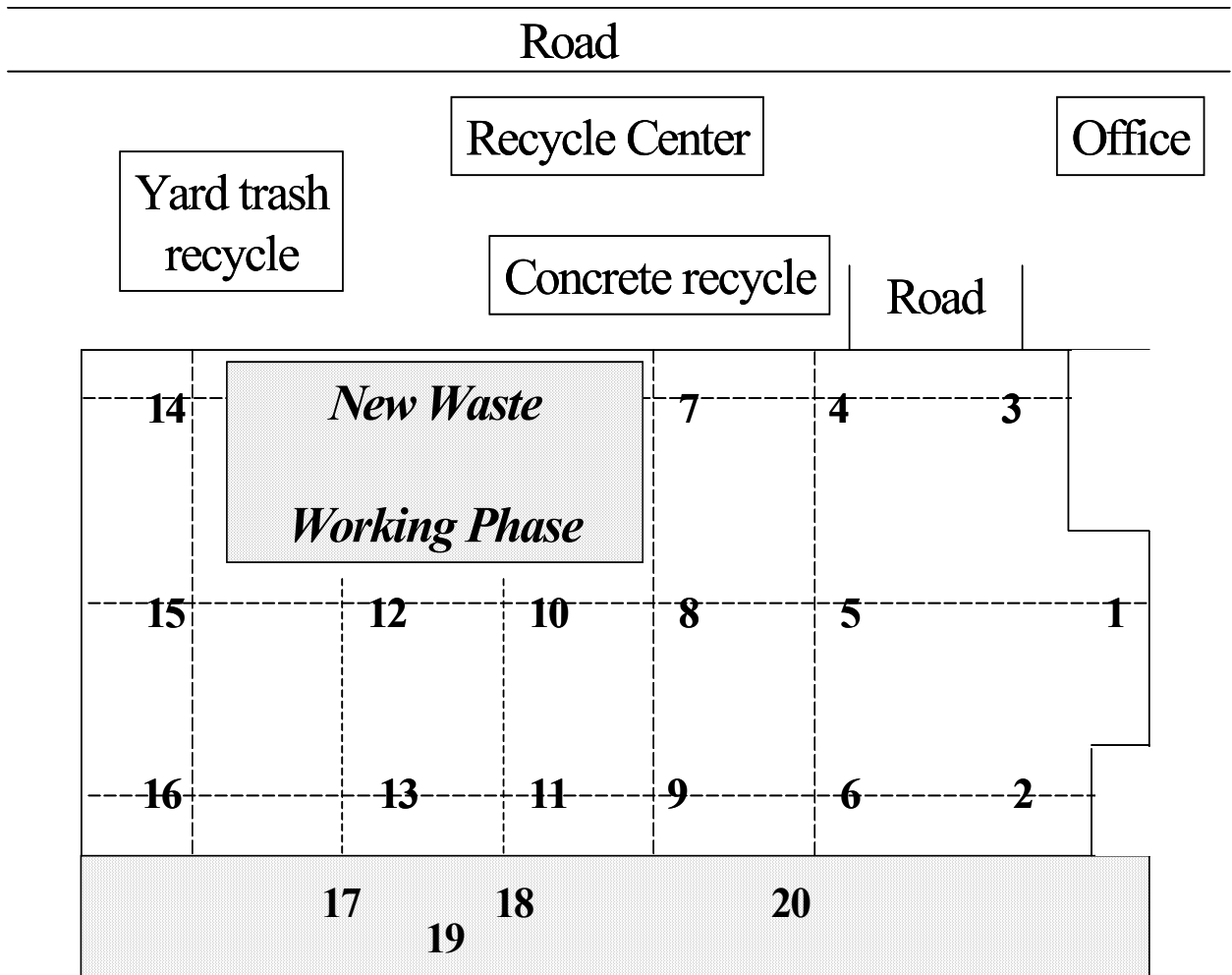


Figure 5: Change in Concentration over Time - Deland landfill



2.4.3. Gel Corp. Landfill

Data from monitoring of the Gel Corp. Landfill are presented in Figures 7 –9 and Table 7.



Number (1-20) = Locations of Flux Measurements

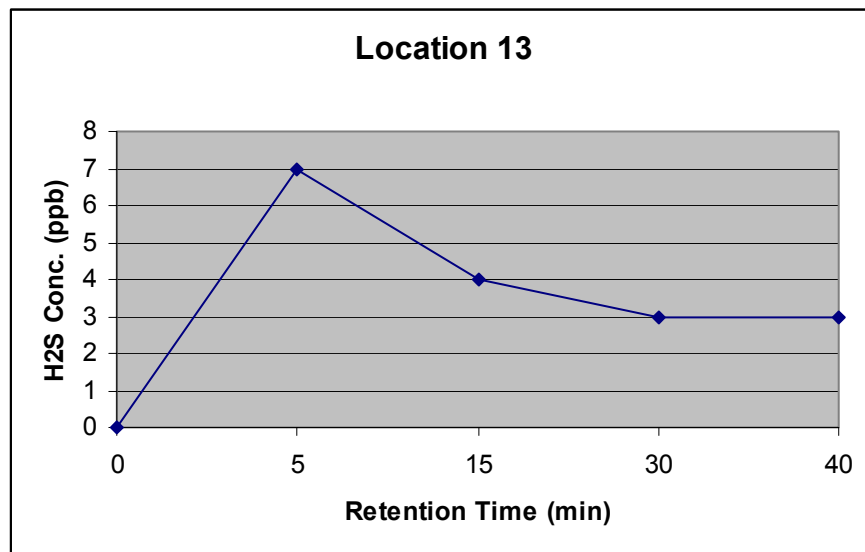
Figure 7: Site Layout of Gel Corp. Landfill and Locations of Flux Measurement

H₂S flux rates at the top of the Gel Corp. Landfill were all below detection limit. Flux rates around the slope area (location 17 to 20 in Figure 7) were significantly higher, no doubt attributable to the 2-foot soil cover layer at the top. Every morning white fumes are observed on the top and slope of the landfill, which was described as a “white dragon” by landfill workers. In some spots, H₂S concentrations were very low, however, in other spots, the H₂S concentrations were over the detection limit of the instrument, 50 ppm. Some big concrete particles or woods were observed in those spots, which made some “holes” for gas emission. The white fume is likely condensing water as a result of the temperature difference between landfill and ambient air. In those spots where high H₂S concentrations were detected, moist gypsum drywall may be the source of H₂S

emissions.

Table 7: Results of Flux Measurement (Gel Corp. Landfill)

Location #	Date	Flow Air Rate (L/min)	Retention Time (min)	H ₂ S Con. (ppb)	H ₂ S Flux Rate (mg/m ² -day)
1	5-Aug-03	6	40	BDL	N/A
2	5-Aug-03	6	40	BDL	N/A
3	5-Aug-03	6	40	BDL	N/A
4	5-Aug-03	6	40	BDL	N/A
5	6-Aug-03	6	40	BDL	N/A
6	6-Aug-03	6	40	BDL	N/A
7	6-Aug-03	6	40	BDL	N/A
8	6-Aug-03	6	40	BDL	N/A
9	7-Aug-03	6	40	BDL	N/A
10	7-Aug-03	6	40	BDL	N/A
11	7-Aug-03	6	40	BDL	N/A
12	7-Aug-03	6	40	BDL	N/A
13	7-Aug-03	6	40	3	0.179
14	7-Aug-03	6	40	BDL	N/A
15	8-Aug-03	6	40	BDL	N/A
16	8-Aug-03	6	40	BDL	N/A
17	8-Aug-03	6	40	3	0.179
18	6-Aug-03	10	25	47,000	2799.19
19	8-Aug-03	10	25	170	10.124
20					



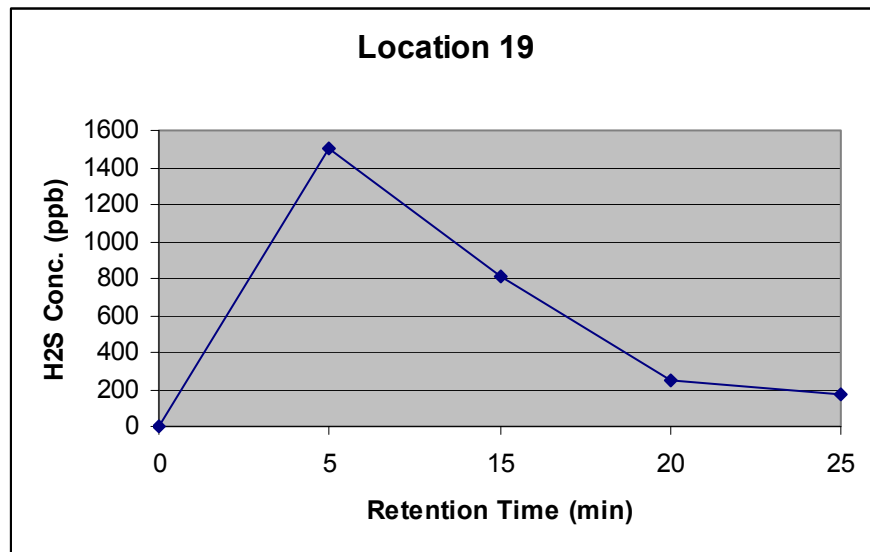
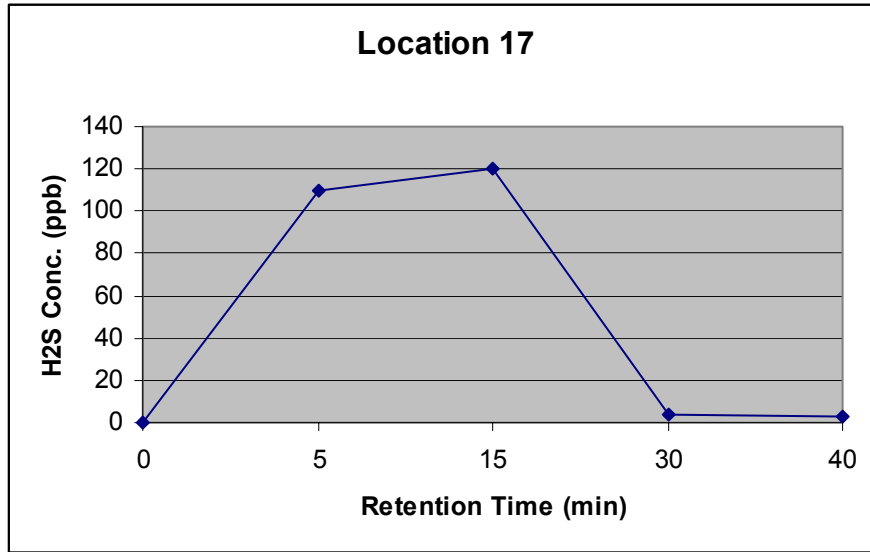


Figure 8: Change in Concentration with Time - Gel Corp. Landfill

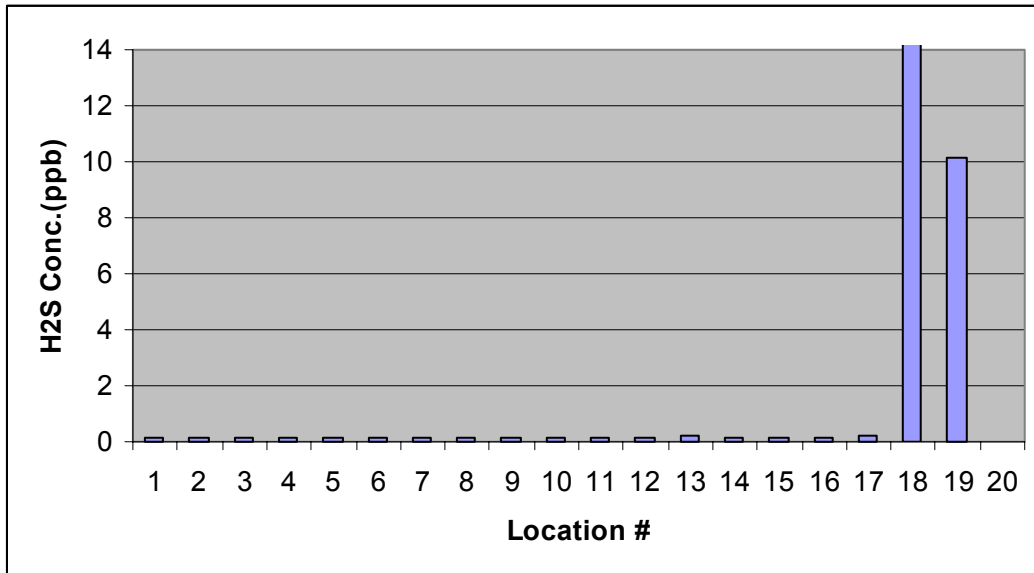
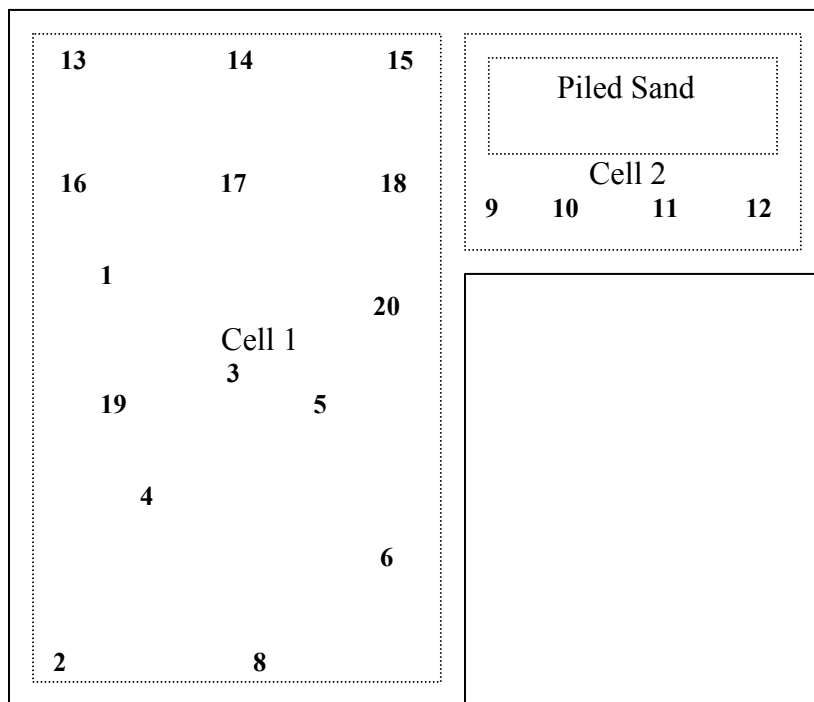


Figure 9: H₂S Flux Rate - Gel Corp. Landfill

2.4.4. Keene Road Landfill

Data from monitoring of the Keene Road Landfill are presented in Figures 10 – 11 and Table 8.



Number (1-20) = Locations of Flux Measurements

Figure 10: Site layout of Keene Road Landfill and Location of Flux Measurements

Data were collected at the Keene Road Landfill in June and August. Considerable more rain has occurred in August as compared with June this year. The landfill surface was muddy and ponding was common. The water on the landfill surface has retarded hydrogen sulfide emission. As seen in Table 8, all of the measurements in August are below detection limit.

Table 8: Results of Flux Measurement (Keene Road Landfill)

Location #	Date	Air Flow Rate (L/min)	Retention Time (min)	H2S Conc. (ppm)	H2S Flux Rate (mg/m ² -day)
1	24-June-03	5	45	BDL	N/A
2	24-June-03	5	45	BDL	N/A
3	24-June-03	5	45	BDL	N/A
4	25-June-03	5	45	0.004	0.243
5	25-June-03	5	45	0.014	0.849
6	25-June-03	5	45	0.006	0.364
7	25-June-03	5	45	0.016	0.970
8	25-June-03	5	45	0.003	0.182
9	20-Aug-03	6	40	BDL	N/A
10	20-Aug-03	6	40	BDL	N/A
11	20-Aug-03	6	40	BDL	N/A
12	20-Aug-03	6	40	BDL	N/A
13	21-Aug-03	6	40	BDL	N/A
14	21-Aug-03	6	40	BDL	N/A
15	21-Aug-03	6	40	BDL	N/A
16	21-Aug-03	6	40	BDL	N/A
17		6	40		
18		6	40		
19		6	40		
20		6	40		

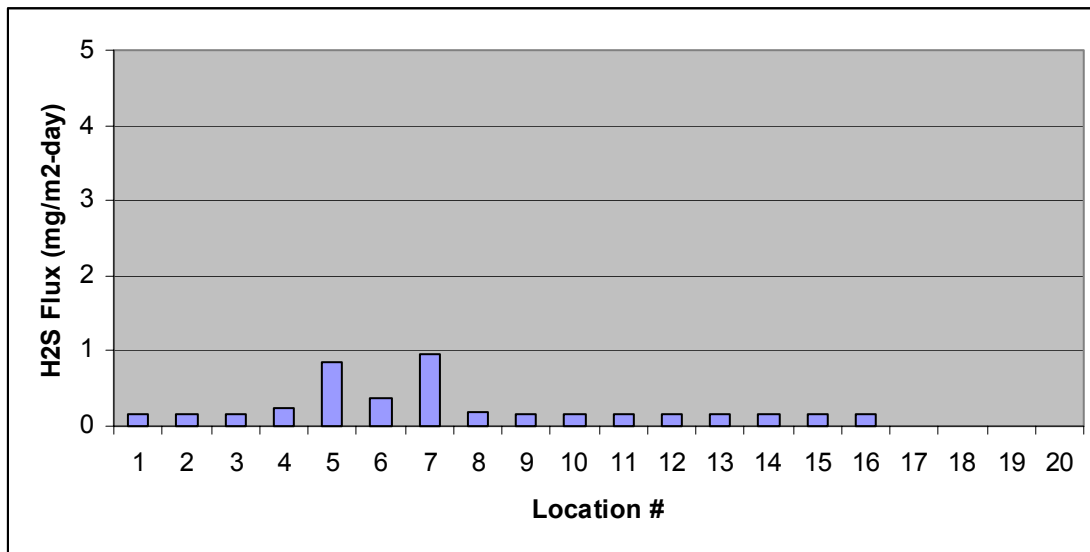
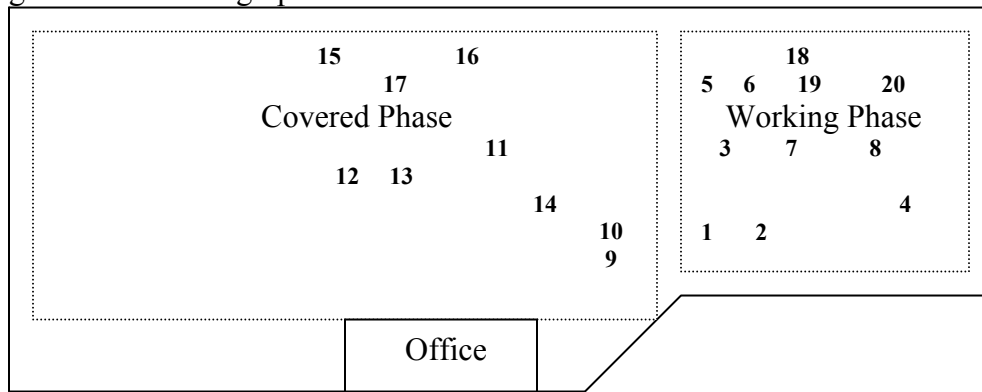


Figure 11: H₂S Flux Rates - Keene Road Landfill

2.4.5. CR 545 Landfill (Last quarter)

During the first and second landfill trips to the CR 5454 landfill, a dynamic flux chamber method was used with air flow introduced the chamber. The results, however, were all below the detection limit of the Jerome meter even though reduced air flow rates and detention times were used. For the rest of sampling events, the static flux chamber method was used with no air flow while measuring the increase in concentration as a function of time. Figure 12 depicts the locations of the flux measurement and Tables 9 and 10 present the dynamic and static flux results. Some locations had unstable readings ranging from 0.003 to 0.100 ppm. The identified reasons for variable data were unstable Jerome meter readings due to low concentration and the long length of tubing. After regenerating the Jerome meter and making the tubing shorter, readings became stable. Finally two flux data sets were obtained. One of them, however, gave nonlinear response data. Figure 13 show the graphs for locations 1 and 4.



Number 1 - 20 = Locations of Flux Measurements

Figure 12: Site Layout of CR 545 Landfill and Location of Flux Measurements

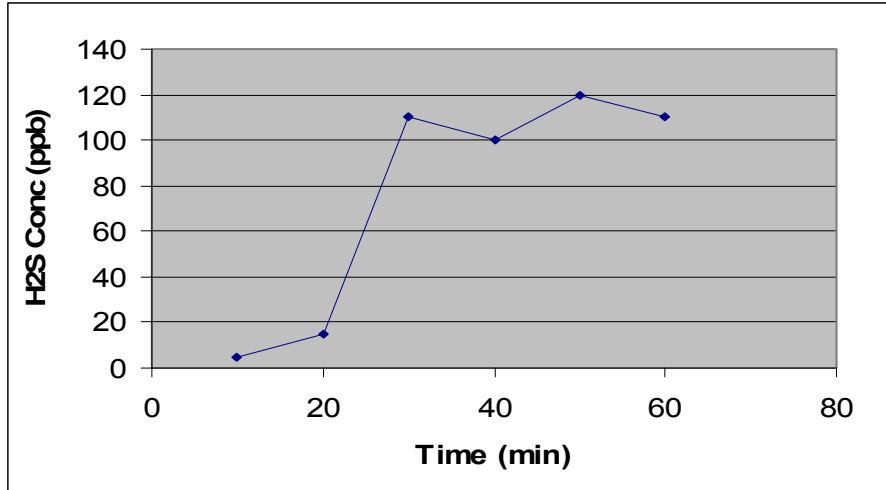
Table 9: Results of Dynamic Flux Method (C.R. 545 Landfill)

a) BDL :Below Detection Limit

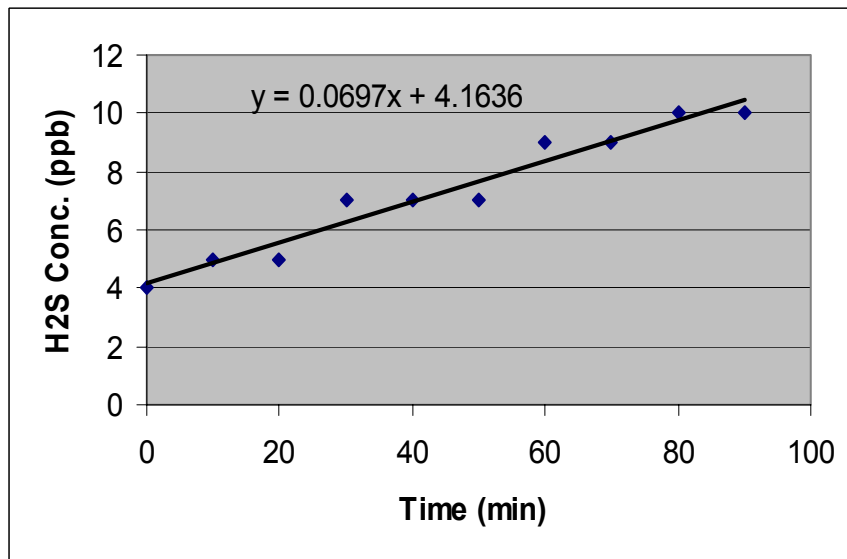
LOCATION #	VISIT DATE	AIR FLOW RATE (L/MIN)	RETENTION TIME (MIN)	H ₂ S CONC. (PPM)	H ₂ S FLUX (MG/M ² -DAY)
9	1-April-03	10	25	BDL ^a	N/A
10	1-April-03	10	25	BDL	N/A
3	1-April-03	10	25	BDL	N/A
5	1-April-03	10	25	BDL	N/A
11	1-April-03	10	25	BDL	N/A
		8	30	BDL	N/A
6	1-April-03	5	45	BDL	N/A
7	17-April-03	6	40	BDL	N/A
15	9-June-03	6	40	BDL	N/A
16	9-June-03	6	40	BDL	N/A
17	9-June-03	6	40	BDL	N/A
18	9-June-03	6	40	BDL	N/A
19	9-June-03	6	40	BDL	N/A
20	9-June-03	6	40	BDL	N/A

Table 10: Results of Static Flux Measurement (C.R. 545 Landfill)

LOCATION #	VISIT DATE	TIME (MIN)	H ₂ S CONC. (PPM)	H ₂ S FLUX. (MG/M ² -DAY)
2	17-April-03	10 – 60	BDL	N/A
8		10 – 60	BDL	N/A
1		10	0.005	Non linear response, therefore the data were not used.
		20	0.015	
		30	0.110	
		40	0.100	
		50	0.120	
		60	0.110	
12	25-April-03	10 – 60	BDL	N/A
13		10 – 60	BDL	N/A
14		10 – 60	BDL	N/A
4		0	4	0.046
		10	5	
		20	5	
		30	7	
		40	7	
		50	7	
		60	9	
	70	9		
	80	10		
	90	10		



a) Location 1



b) Location 4

Figure 13: H₂S Concentration vs. Time for Static Mode

REFERENCES

- Atwood, D.E. and Tessitore, J.L., (1995). Preliminary H₂S Monitoring Report: Orange Waste, Recycling and Materials, Inc. September 19, 1995. Harding Lawson Associates. 20 pp.
- Chakrabarti S. (2002) "Generation and Composition of Construction and Demolition Waste in Florida," Master's Thesis, University of Central Florida, Orlando, FL
- Gowing A., Farquhar G.J. (1997) "Laboratory Assessment of a Flux Chamber to Determine Landfill Gas Emissions." Proceedings of the Air & Waste Management Association's 90th Annual Meeting & Exhibition, June 8 –13, Toronto, Ontario, Canada.
- Lee, S. (2000). "Landfill Gas Compositon At Florida Construction and Demolition debris Facilities." Master of Engineering Thesis, University of Florida, Gainesville, FL.
- Liao, W., Chou F.S. (1998), "Measurement of Methane Emission from a Landfill with Flux Chamber." Proceedings of the Air & Waste Management Association's 91st Annual Meeting & Exhibition, June 14 - 18 San Diego, California
- Rash, F.D. (1992) "Landfill Gas Emission Rate Measurement Using an Emission Isolation Flux Chamber," Master's Thesis, University of Central Florida, Orlando, FL.
- Rolston, D. E. (1986) Gas Flux. 1103-1119 in Klute, A. (ed), Methods of Soil Analysis: Part 1, Physical and Mineralogical Methods, 2nd Edition. American Society of Agronomy/Soil Science of America, Madison, Wisconsin
- Walker, B. L. (1991), "Flux Chamber Design and Operation for the Measurement of MSW Landfill Gas Emission Rates," Masters Thesis, University of Central Florida, Orlando, Florida.