

Measurements of Hydrogen Sulfide from Construction and Demolition (C&D) Debris Landfills

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[Presentation]

- Objective
- Flux Measurements
- Dispersion Modeling
- Conclusions

[H₂S Generation at C&D Landfills]

- The production of hydrogen sulfide occurs when calcium sulfate is reduced to the hydrogen sulfide gas. Sulfate reducing bacteria accept electrons to reduce sulfate and hydrogen sulfide is produced



[H_2S Generation at C&D Landfills]

- The rate at which hydrogen sulfide is generated depends on
 - moisture
 - organic matter
 - dissolved oxygen
 - pH
 - temperature



Project Objective

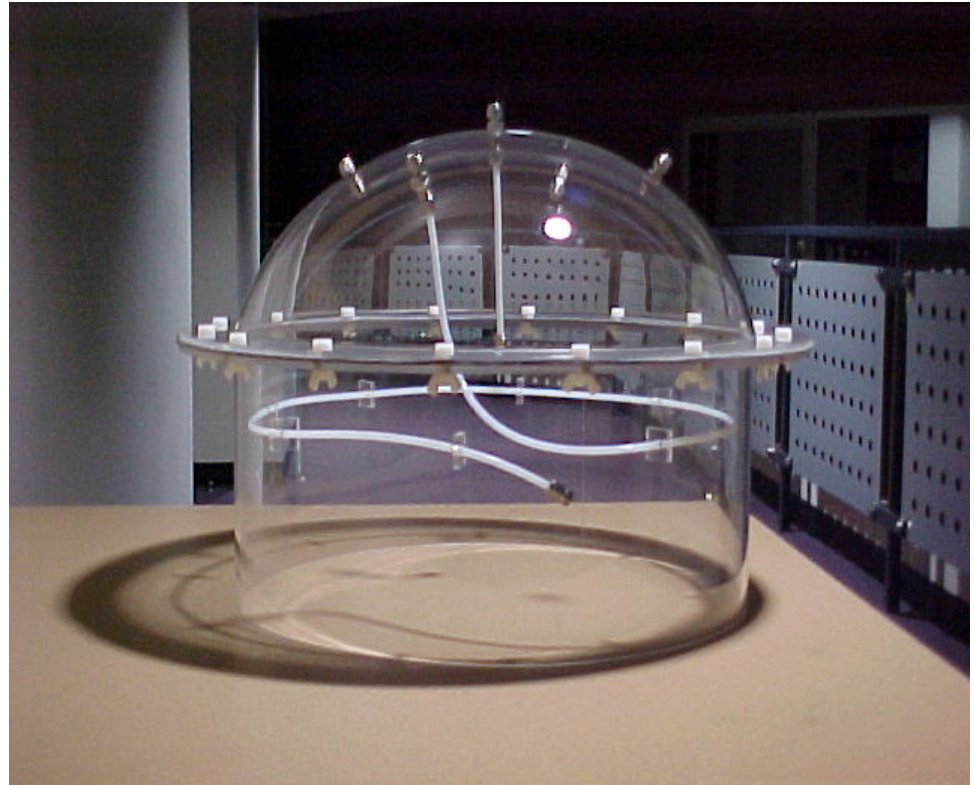
- To estimate the amount and variation of H_2S emission rates from C&D Landfills
- To evaluate the potential odor impacts of H_2S emissions from C&D Landfills

[Methodology]

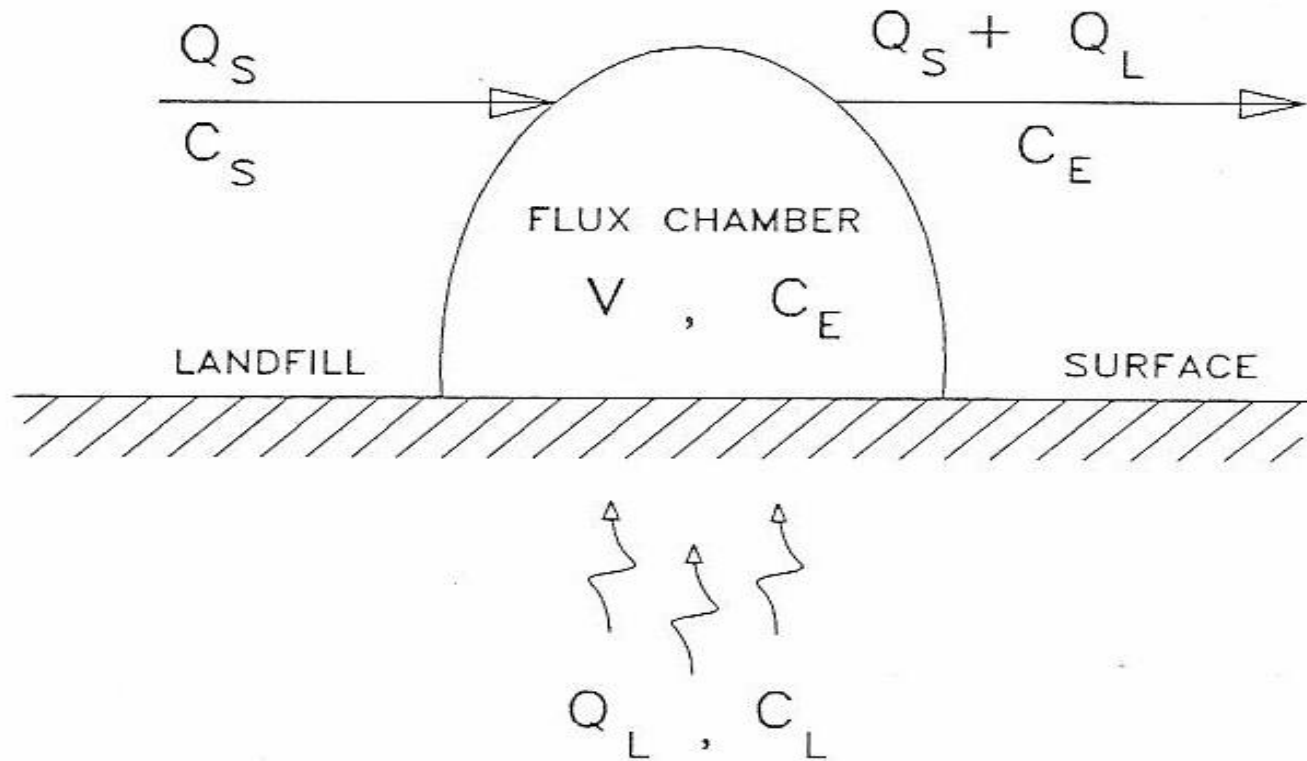
- Select 5 C&D landfill sites in Central Florida
- Perform 20 flux measurements at randomly selected locations per site
- Evaluate the potential odor impacts of H_2S emissions from these C & D Landfill using ISCST3

Flux Measurements using a Flux Chamber

- A flux chamber is a device that measures surface emissions.
- It is placed on a landfill surface and a controlled flow of sweep gas is applied
- Flux rate is estimated by measuring the concentration in the chamber effluent

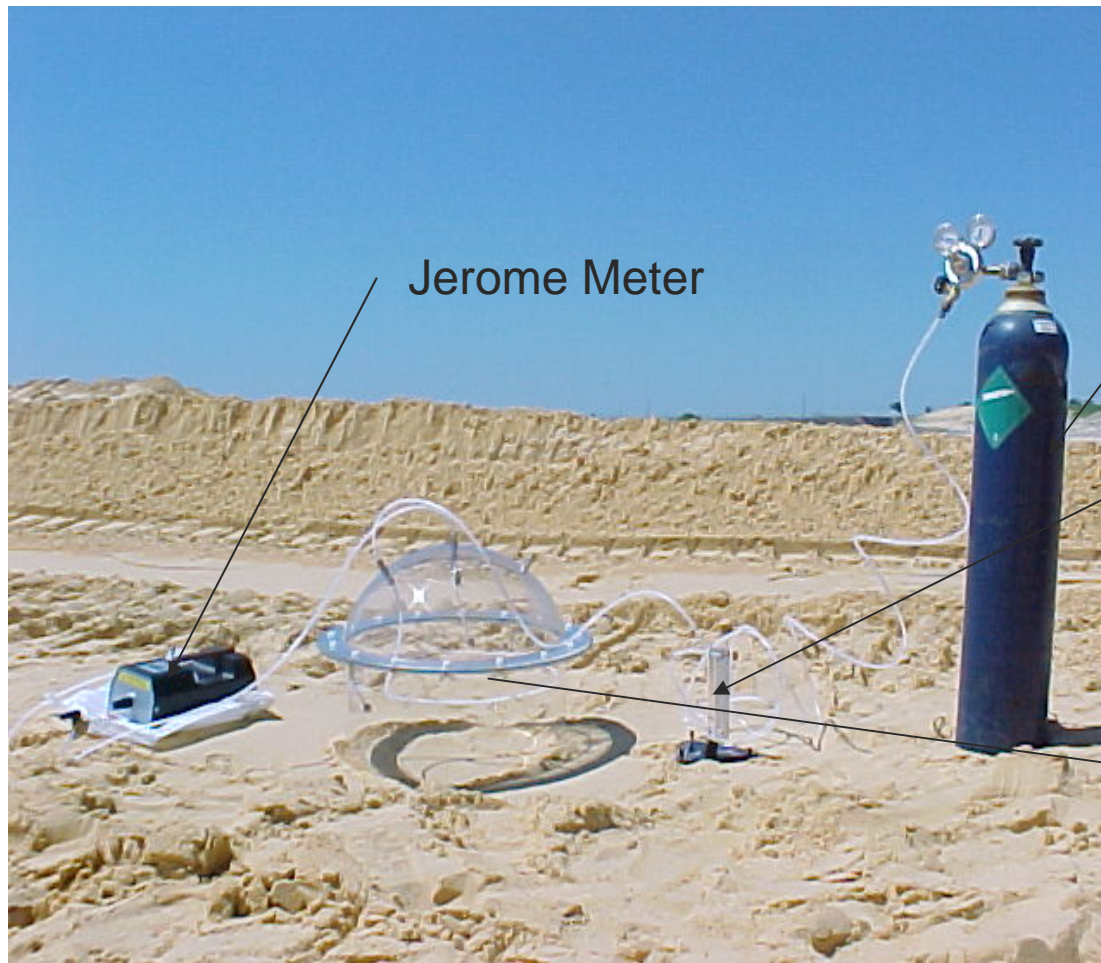


Flux Chamber Method



$$Flux = \frac{C_E Q_S}{A}$$

Flux Chamber and Peripheral Equipment



Jerome Meter

Sweep Air Source

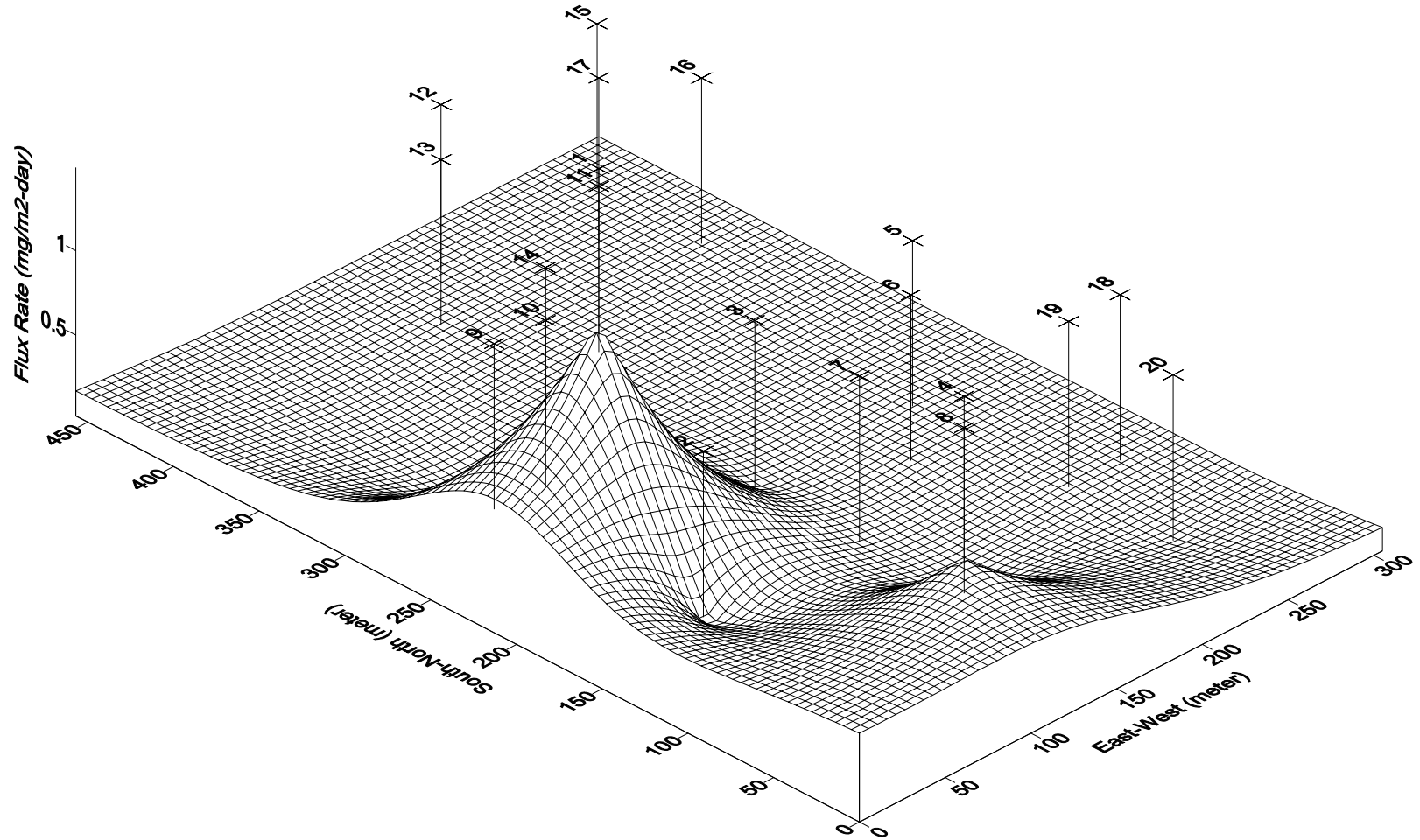
Flow Meter

Flux Chamber

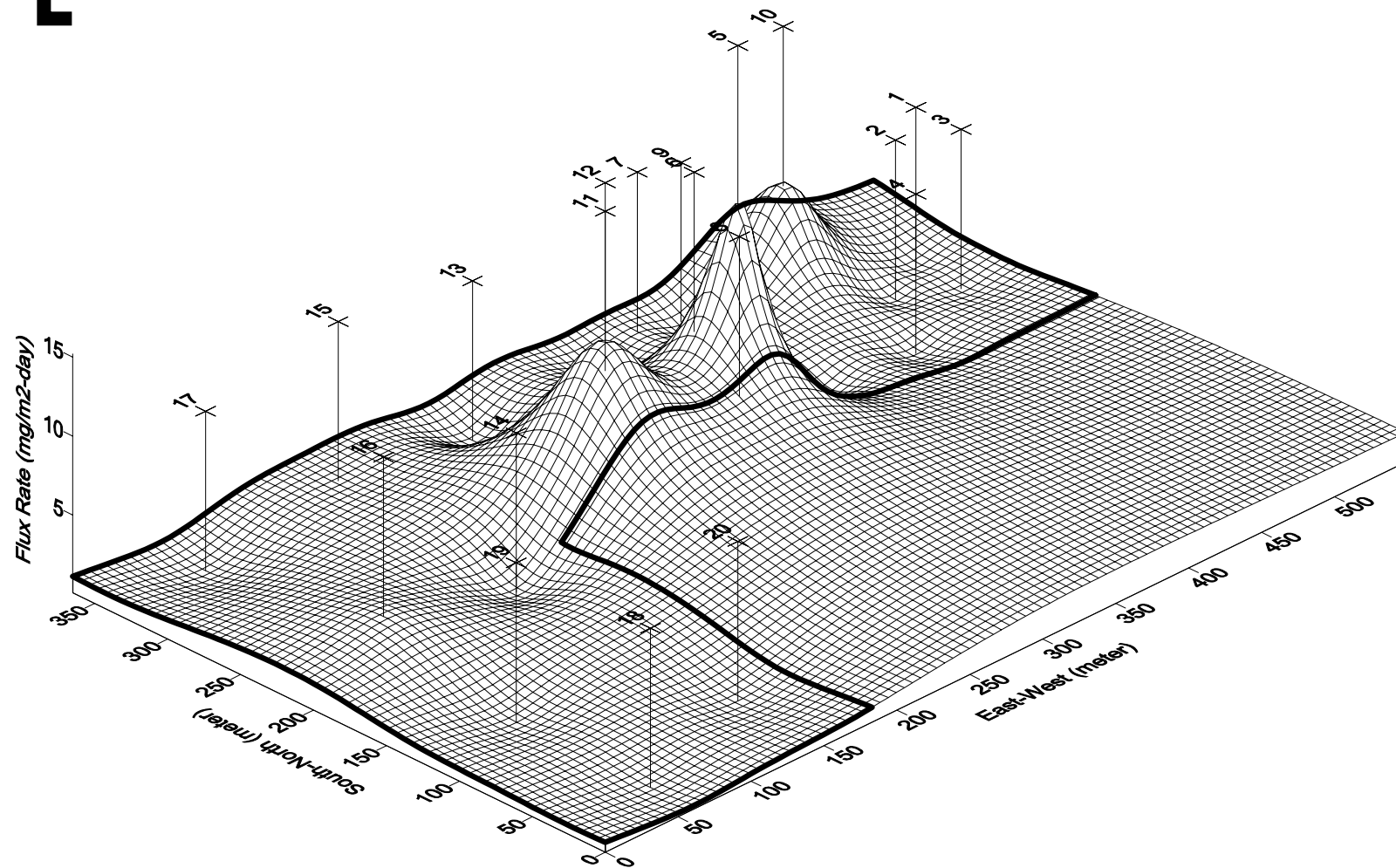
Site Characteristics

| Landfill | Area, acres | Comments |
|----------|----------------|----------------------------|
| A | 42 | In operation since 1991 |
| B | 37 | History of odor complaints |
| C | 95 | Weekly intermediate cover |
| D | 47 | In operation since 1980s |
| E | 20 | History of odor complaints |

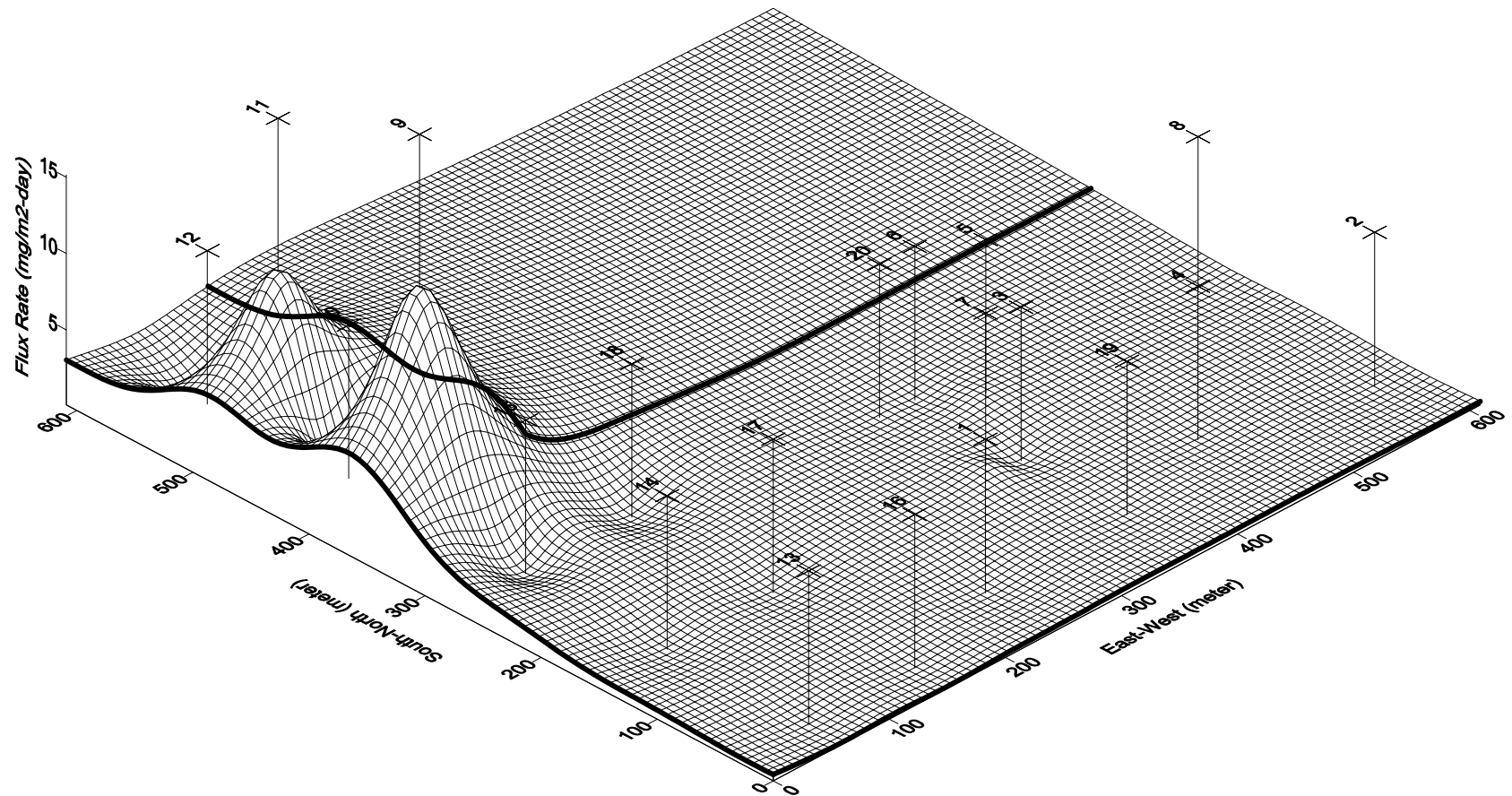
Site A



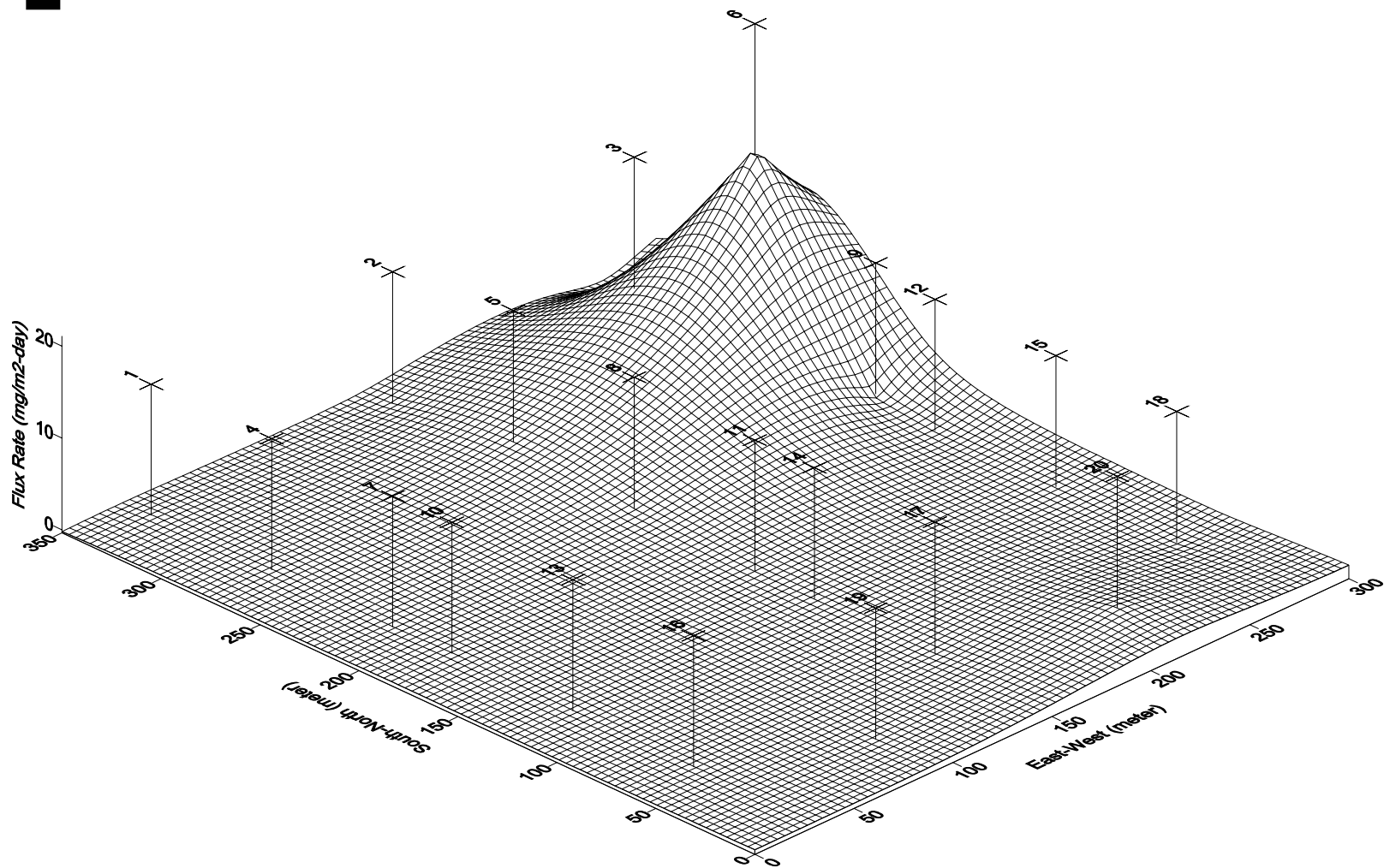
[Site B]



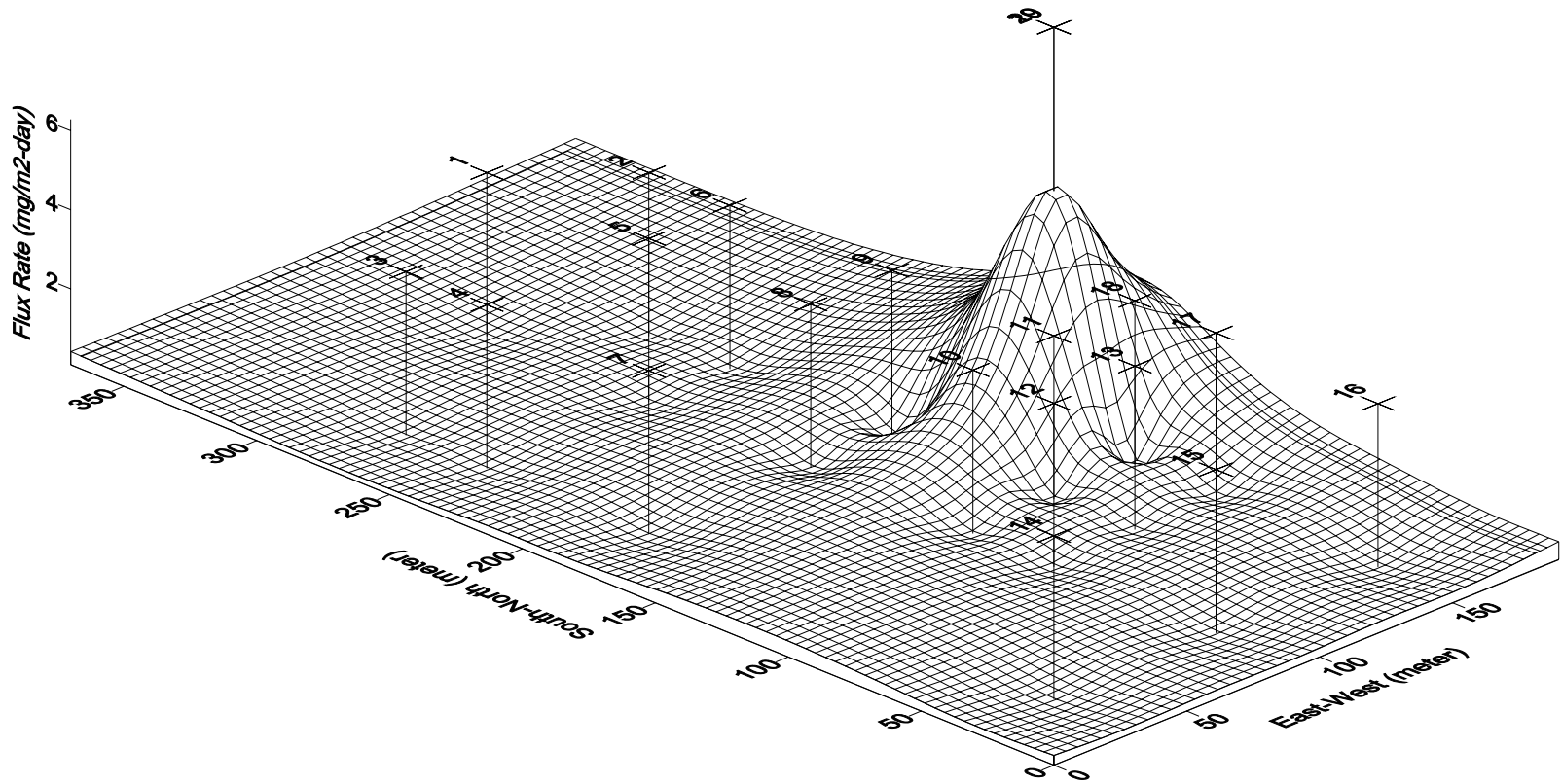
[Site C]



[Site D]



[Site E]



Summary of H₂S Flux Results

| Site | Site A | Site B | Site C | Site D | Site E |
|--|--------|--------|--------|--------|--------|
| # of Flux Measure ments | 20 | 20 | 20 | 20 | 19* |
| # of Below Detection Limit | 18 | 9 | 9 | 12 | 16 |
| Arithmetic Mean (mg/m ² -day) | 0.179 | 1.94 | 1.54 | 1.47 | 0.716 |
| IDW Mean (mg/m ² -day) | 0.192 | 1.76 | 1.53 | 1.47 | 0.543 |

* Exclude High Flux Rate

Emissions Observations

- Range of 0.192 to 1.76 mg/m²-day (3-6 oom below landfill methane flux rates)
- High spatial variability among measured locations
 - More than half of the flux measurements were near or below the detection limit
 - A few locations were responsible for a majority of the emissions
- Emissions appear to be proportional to landfilled drywall percentage

[H₂S Regulations (Guidelines)]

■ Health and Safety Level Analysis

- NIOSH - 10 ppm over 10-min exposure
- OSHA - 20 ppm over 15-min exposure

■ Odor Impact Level Analysis - Odor Detection Threshold

- Amoores (1985) – **8 ppb**
- Prokop (1992), Metcalf and Eddy (2003) – **0.5 ppb**
- Ambient Air Standard (California) – 30 ppb

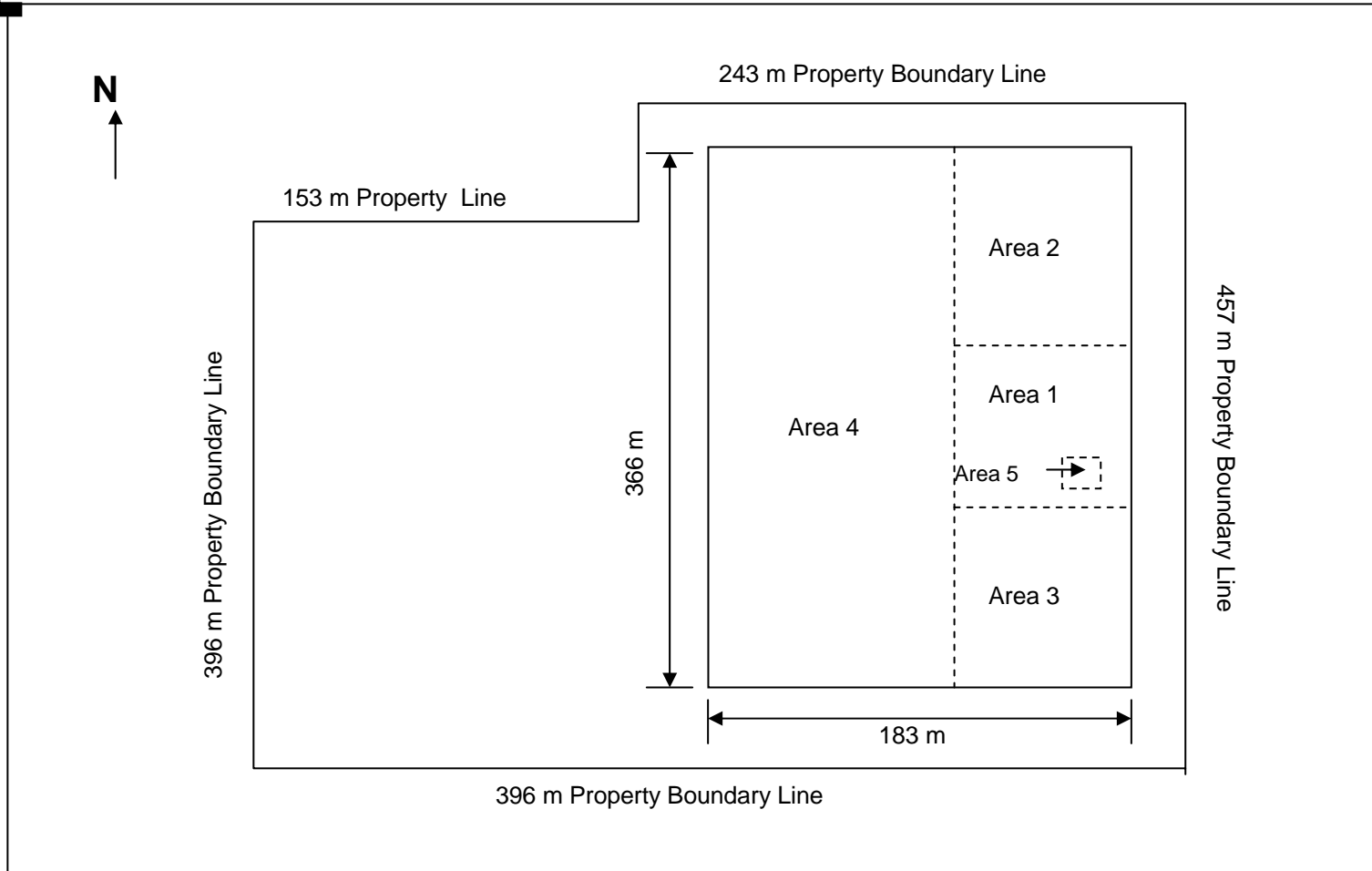
[ISCST3 Dispersion Model]

- Industrial Source Complex Short Term EPA Dispersion Model
- Refined Gaussian Plume Model used for regulatory purposes.
- ISCST3 can handle dozens of point sources and area sources at the same modeling run; hundreds of receptors and tens of thousands of hours of meteorological data.

[Modeling Methodology]

- Input data developed
 - Source
 - Receptor
 - Meteorological
- Model output analyzed for predicted ambient concentrations
- Frequency distributions were developed for levels exceeding hourly and 3-minute odor thresholds

Site E Layout

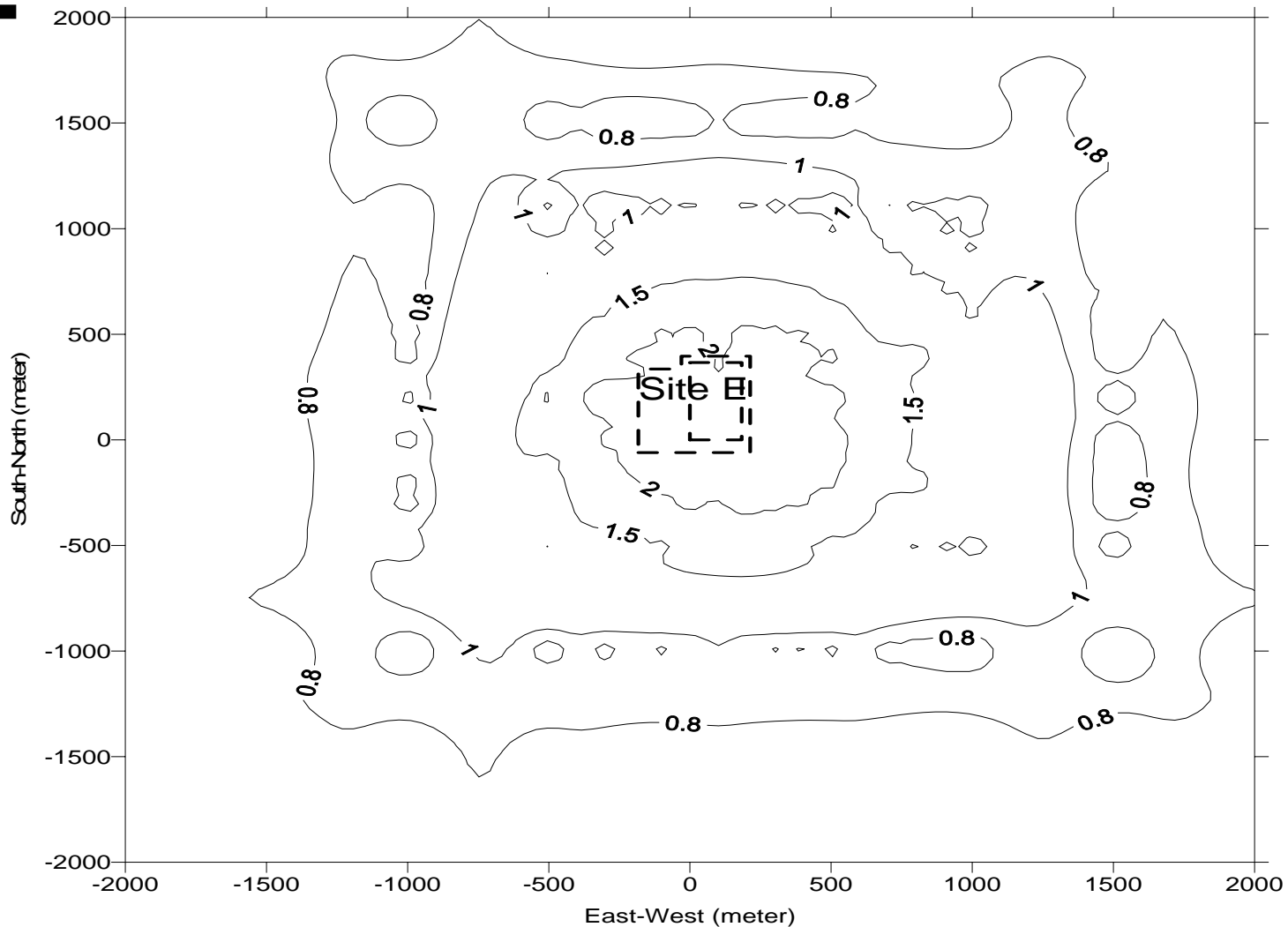


Site E Maximum 1-hr and 3-min Concentrations

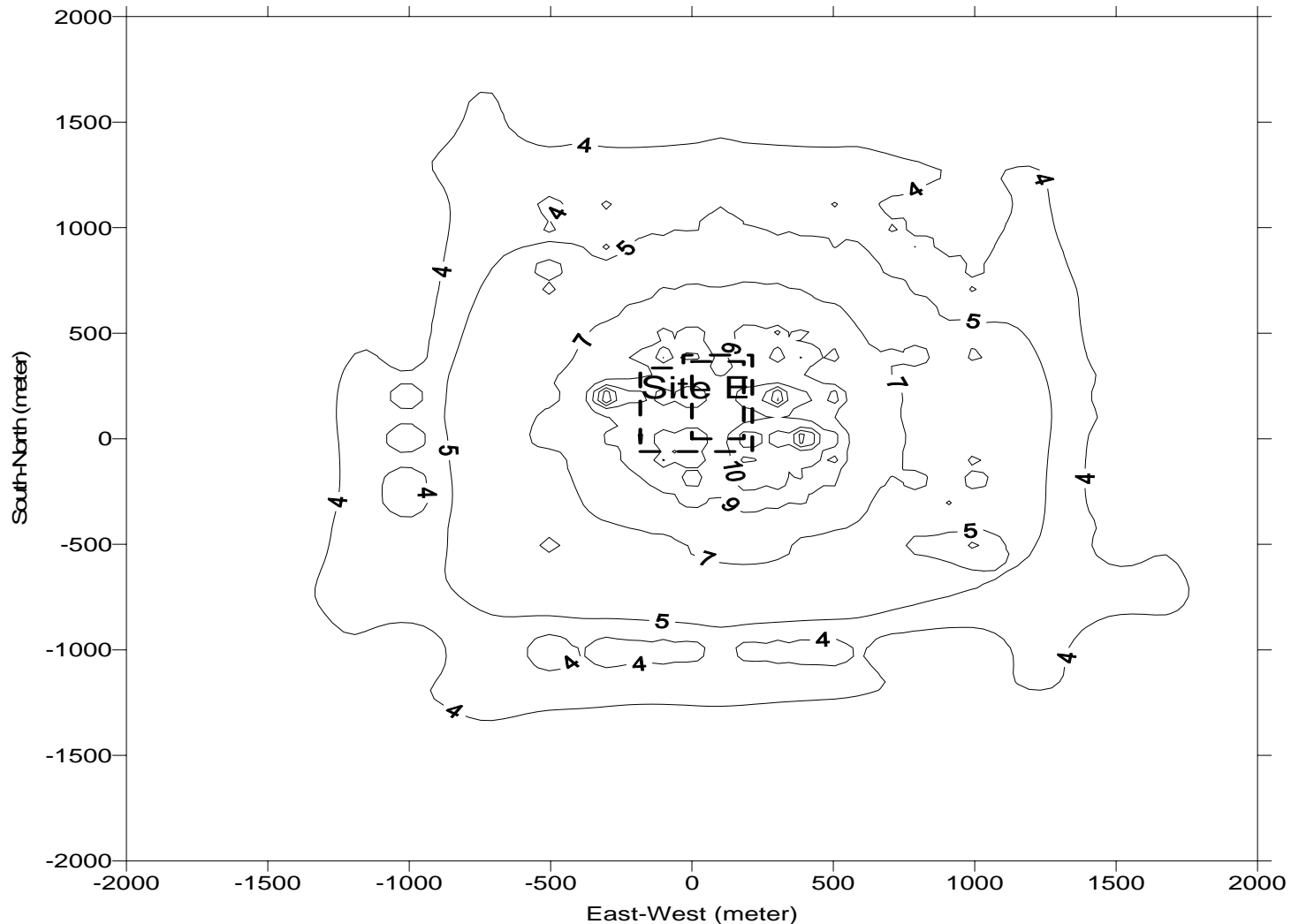
| Location | Max.1-hr conc. (ppb) | Ratio of max. conc. to ODT (0.5 ppb) | Ratio of max. conc. to ODT (8 ppb) |
|----------|-------------------------|--|--|
| On-site | 0.12 | 0.24 | 0.02 |
| Off-site | 0.13 | 0.26 | 0.02 |

| Location | Max. 3-min conc. (ppb) | Ratio of max. conc. to ODT (0.5 ppb) | Ratio of max. conc. to ODT (8 ppb) |
|----------|---------------------------|--|--|
| On-site | 0.20 to 0.55 | 0.40 to 1.09 | 0.03 to 0.07 |
| Off-site | 0.21 to 0.58 | 0.43 to 1.16 | 0.03 to 0.07 |

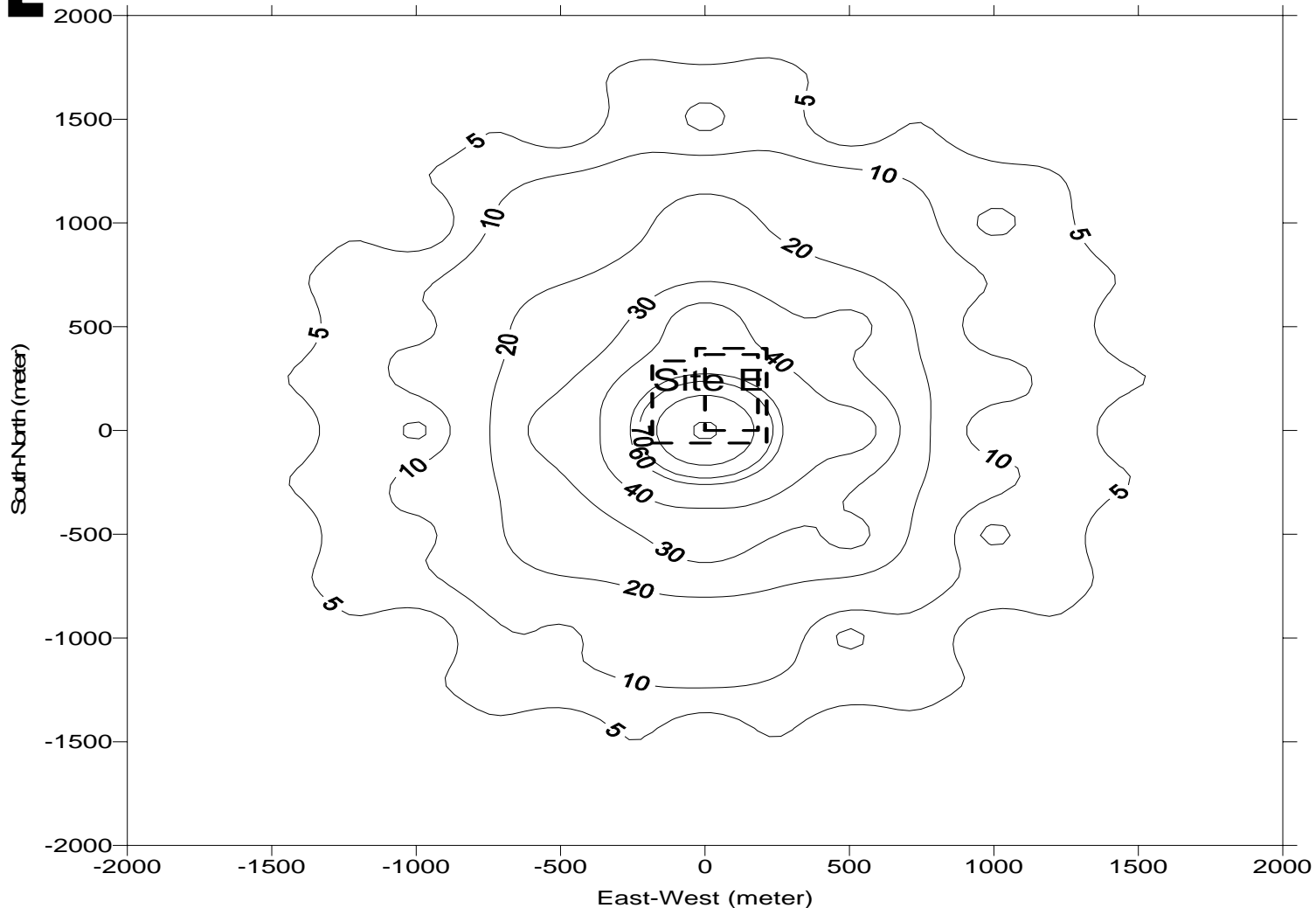
Site E Contour Map of Maximum 1-hr Concentration



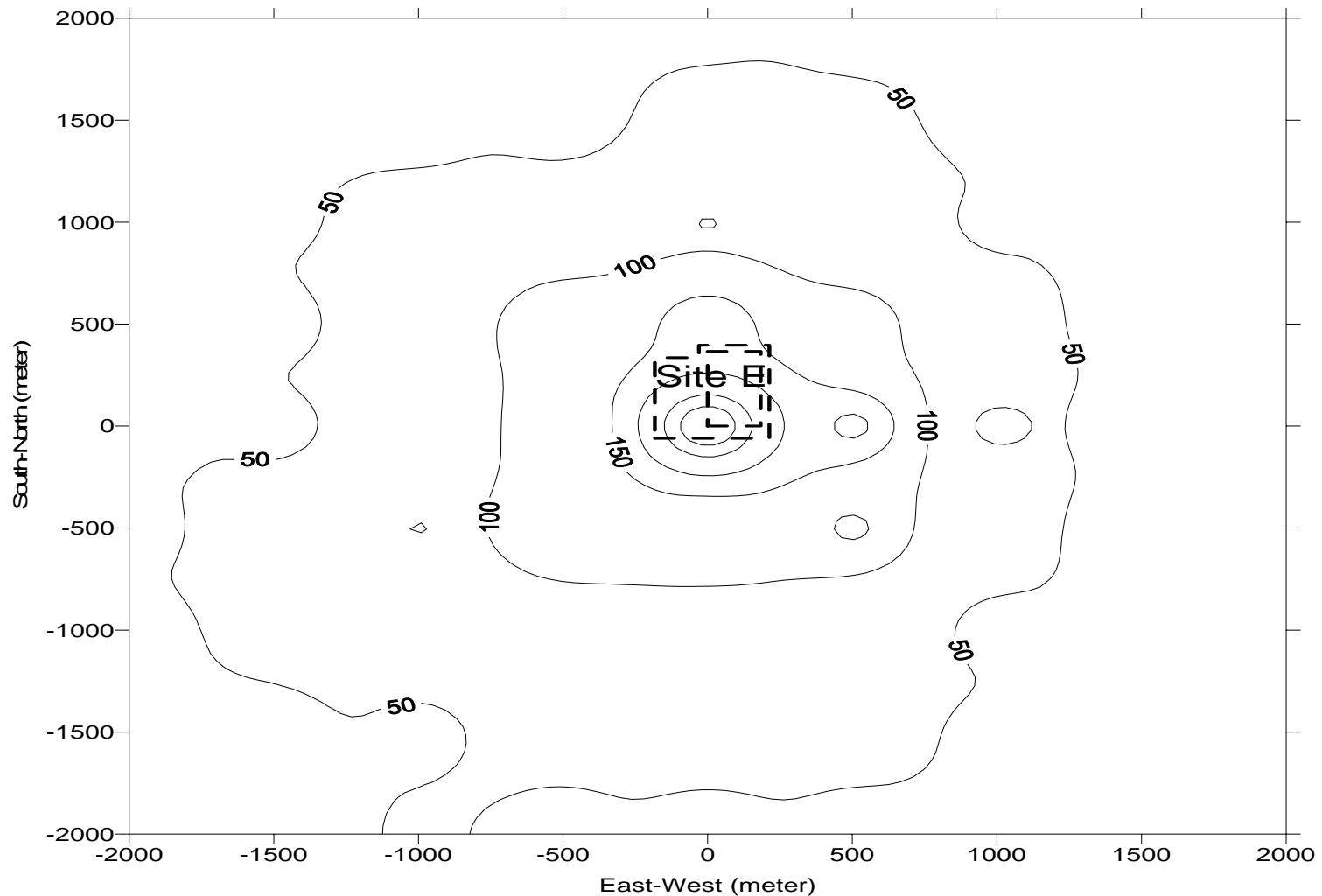
Site E Contour Map of Maximum 3-min Concentration



Site E Frequency per Year above 0.5 ppb for 1-hr



Site E Frequency per Year above 0.5 ppb for 3-min



Summary of Dispersion Modeling Results

| Site | Site A | Site B | Site C | Site D | Site E |
|---|--------|--------|--------|--------|--------|
| Predicted Max.1-hr Conc (ppb) | 0.37 | 3.8 | 2.7 | 5.1 | 3.6 |
| Predicted Max. 3-min Conc (ppb) | 1.7 | 17.0 | 12.0 | 22.8 | 15.9 |
| Frequency of 1-hr Maximum (occurrences/yr) | 0 | 119 | 1118 | 230 | 220 |
| Frequency of 3-min Maximum (occurrences/yr) | 100 | 5185 | 4062 | 1474 | 542 |

Odor Complaints History from Residents

| | Site A | Site B | Site C | Site D | Site E |
|------|--------|--------|--------|---------|--------|
| 1988 | 0 | 9 | 0 | 0 | 28 |
| 1999 | 0 | 1 | 0 | 0 | 39 |
| 2000 | 0 | 0 | 0 | 0 | 20 |
| 2001 | 0 | 0 | 5 | 0 | 11 |
| 2002 | 0 | 0 | 0 | 0 | 9 |
| 2003 | 0 | 0 | 1 | “a few” | 2 |

Conclusions

- Based on the modeling results, the H₂S emissions from C&D Landfills presented no health and safety risk
- Odor complaints could be expected from 3/5 landfills based on the modeling results with the 0.5-ppb ODT
- Landfills should reconsider setback distance between the landfill cell limits and residential areas
- Further research studies are recommended to validate the modeling results (field measurements of ambient ground level concentration)

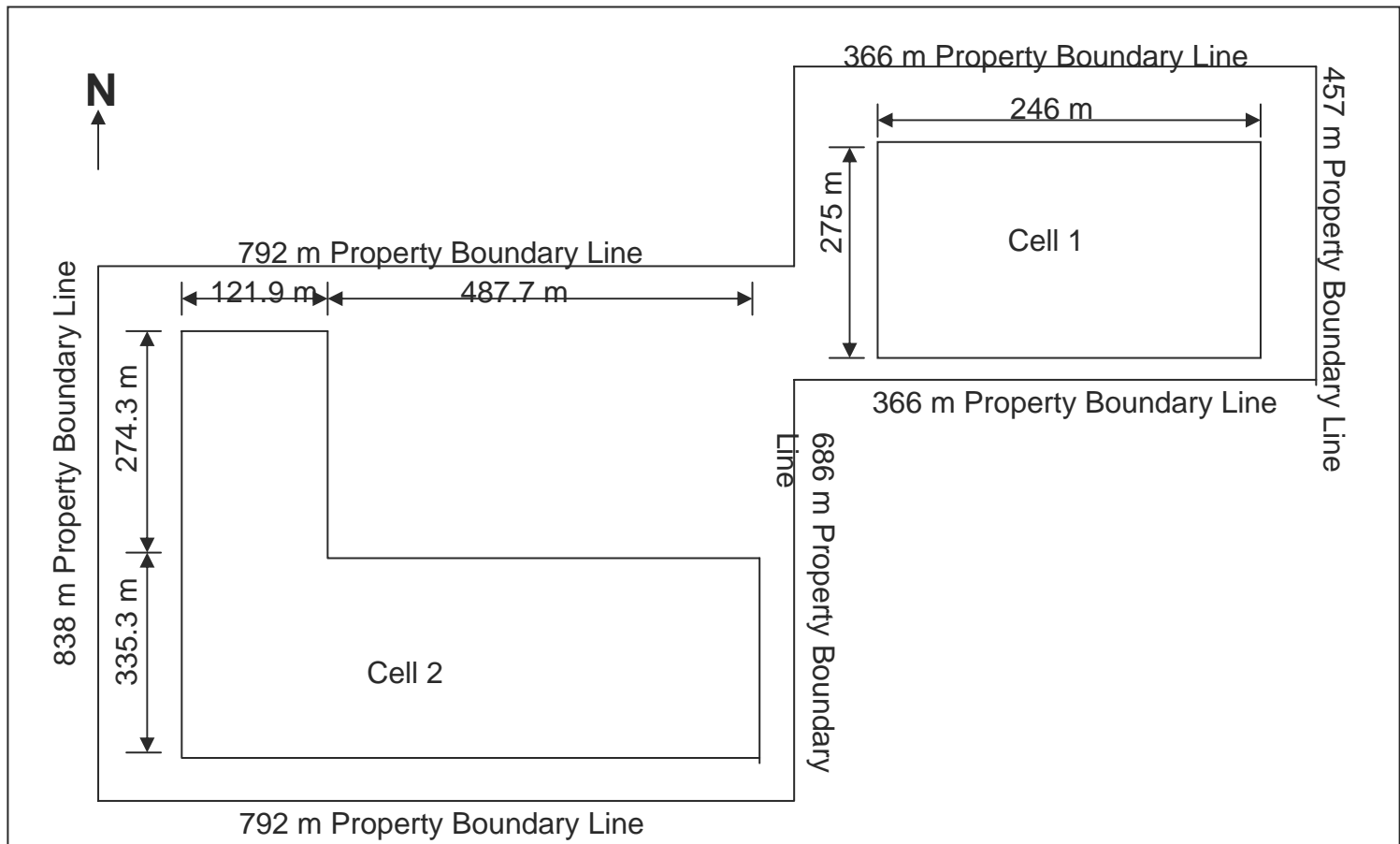
[Acknowledgements]

- This project was funded by the Florida Center for solid and Hazardous Waste
- The authors acknowledge research partners Dr. Tim Townsend and Qiyong Xu from the University of Florida



- More information at
<http://www.ees.ufl.edu/homepp/townsend/Research/CDOdor/default.asp>

Site C Layout

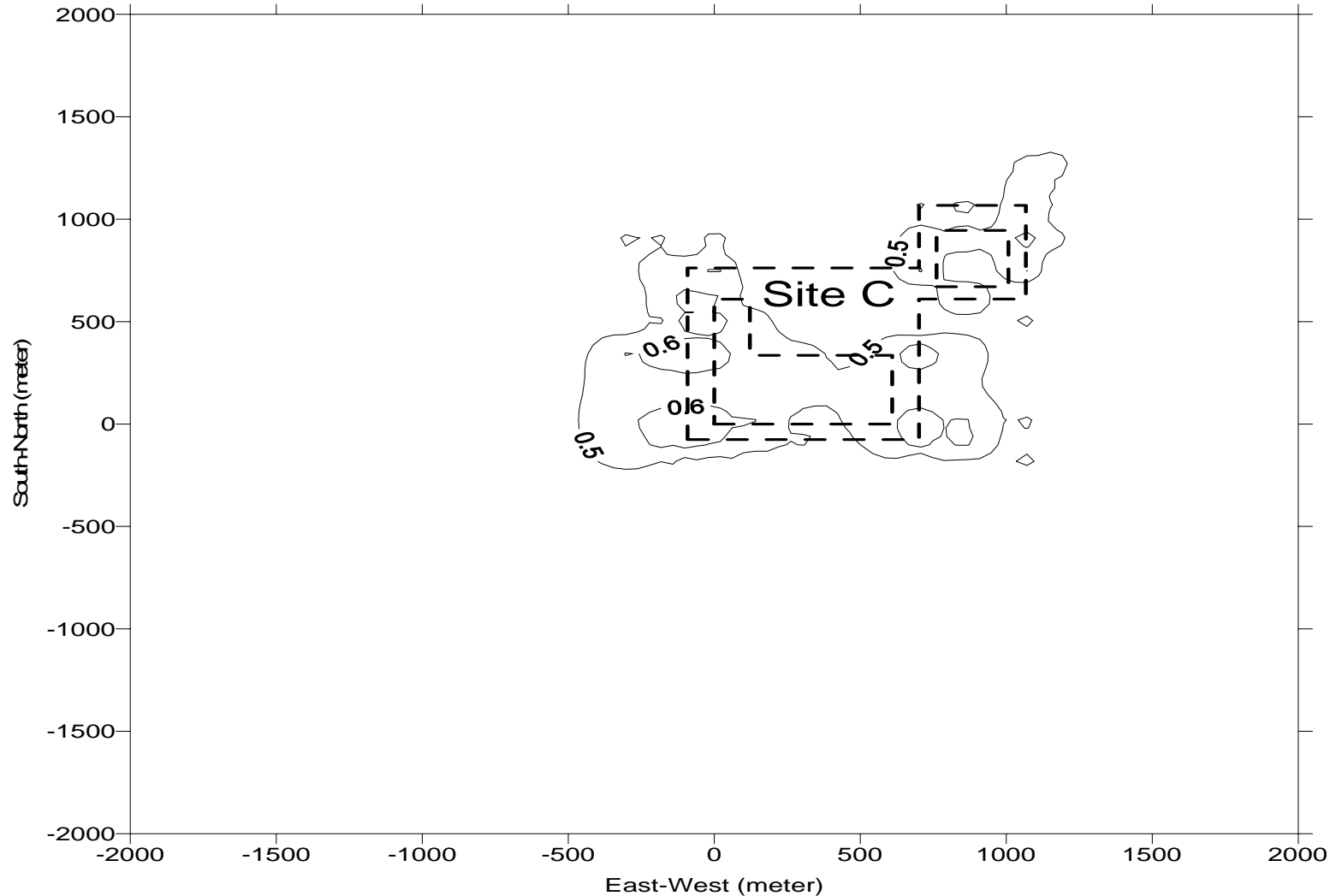


Site C Maximum 1-hr and 3-min Concentration

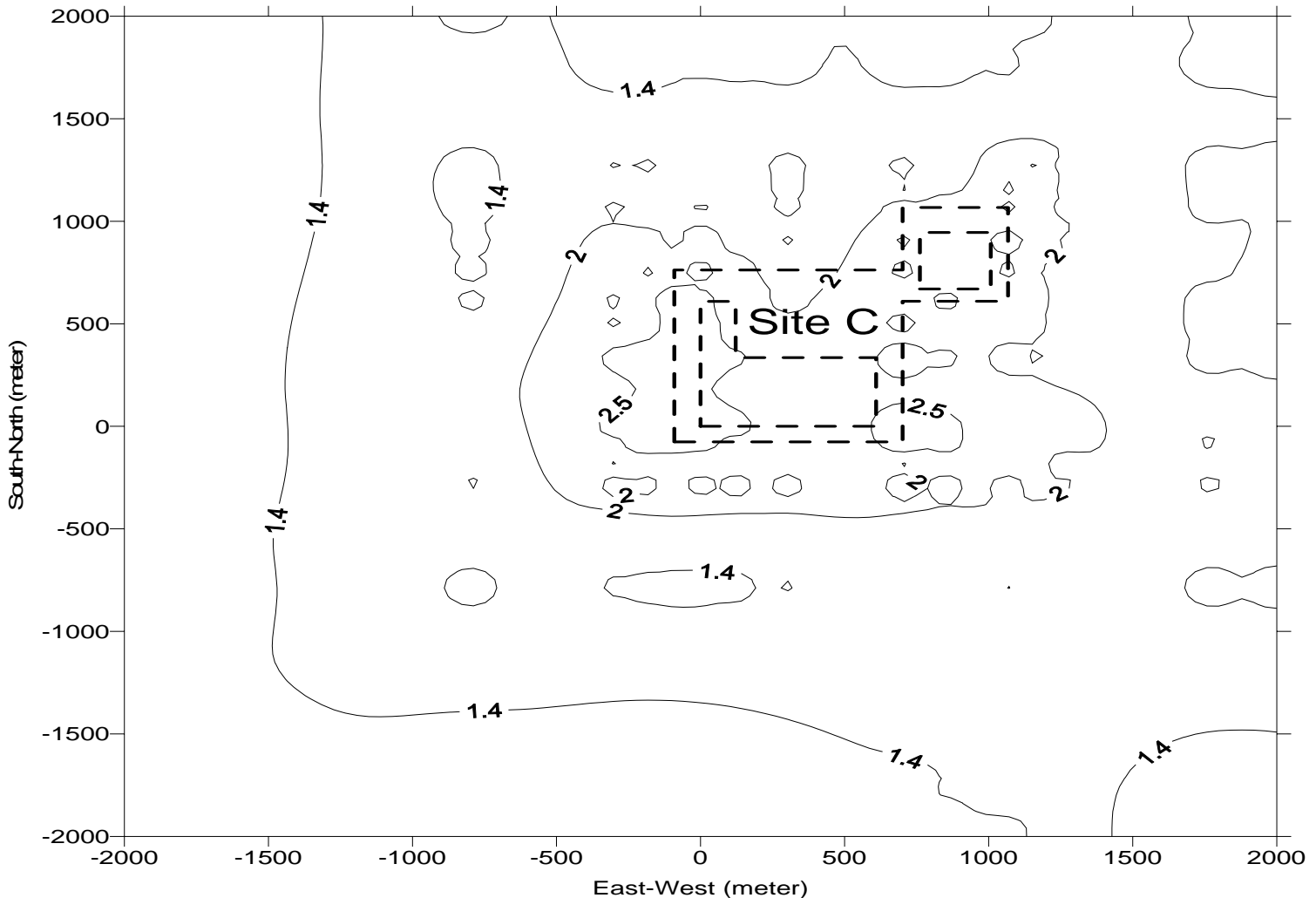
| Location | Max.1-hr conc. (ppb) | Ratio of max. conc. to ODT (0.5 ppb) | Ratio of max. conc. to ODT (8 ppb) |
|----------|-------------------------|--|--|
| On-site | 0.81 | 1.6 | 0.10 |
| Off-site | 0.69 | 1.4 | 0.09 |

| Location | Max. 3-min conc. (ppb) | Ratio of max. conc. to ODT (0.5 ppb) | Ratio of max. conc. to ODT (8 ppb) |
|----------|---------------------------|--|--|
| On-site | 1.3 to 3.6 | 2.7 to 7.2 | 0.17 to 0.45 |
| Off-site | 1.1 to 3.1 | 2.3 to 6.2 | 0.14 to 0.39 |

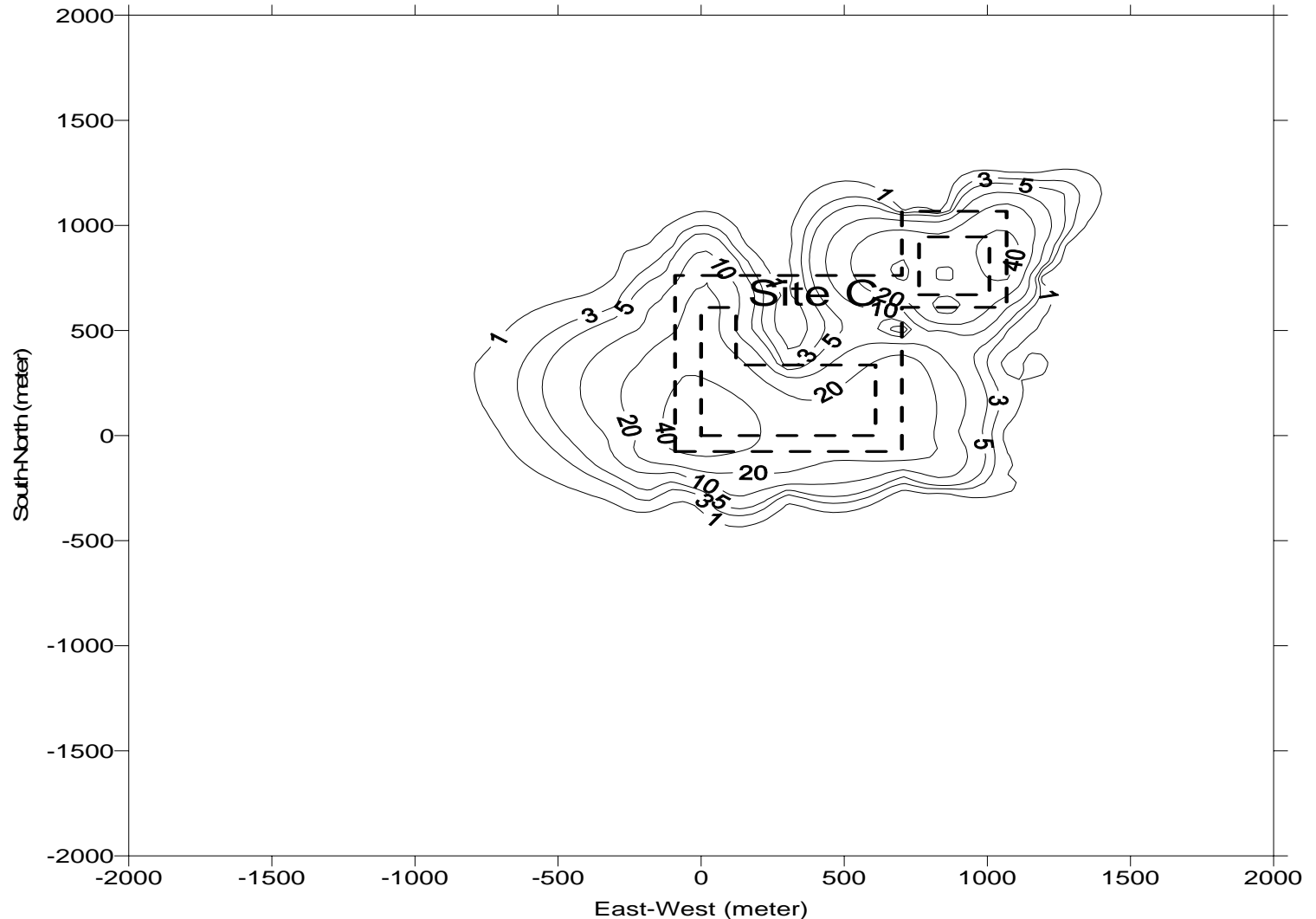
Site C Contour Map of Maximum 1-hr Concentration



Site C Contour Map of Maximum 3-min Concentrations



Site C Frequency above 0.5 ppb for 1-hr Period



Site C Frequency above 0.5 ppb for 3-min Period

