EVALUATION OF WATER MISTING SYSTEMS 
FOR USE AT LEMON LANE 
August 11, 2000

Introduction

Water spraying has been used extensively in the past at Lemon Lane for dust suppression. A sprinkler system was set up at the load out pile to keep the surface of the pile wet. The purpose was to prevent dust, which could contain PCB, from forming and blowing into the atmosphere. At the excavations a fire hose was used to wet the excavation face and the soil in the excavator buckets. The top of the soil in the onsite trucks was also wetted before the dirt was transported to the loadout pile. In addition, a water truck was used to spray water on the TSCA and non-TSCA transport roads on site to prevent dust formation.

A recent review of the literature by CBS has shown that excessive wetting of PCB contaminated soil may prevent dust but could also be causing higher volatilization of the PCB content of the soils. Based on the recent evaluation of the elevated PCB emission events at Lemon Lane, CBS now believes that volatilization of PCBs contributed significantly to these events. CBS review of recent research has shown that PCBs volatilize from wet soils much more that from dry soils.

Objective

Alternative uses of water sprays have been investigated that will prevent dust but minimize the soaking of PCB contaminated soils. Specifically, water misting or fogging systems using atomizing nozzles that form a very fine mist of small micron size water particles were investigated. The fine droplets will form a fog over the exposed PCB contaminated soils that will act to contain and prevent dust emissions but will not soak or saturate the soils.

The main benefit of using fine water particle fogging may be that a high degree of evaporative cooling will be realized that will reduce volatilization. The fine water particles evaporate in the air over the exposed PCB soils, soaking up heat and dropping temperatures locally. This principal is used extensively in evaporative water cooling towers to cool closed loop water systems.

Literature presented by CBS showed that PCB volatilization increases exponentially with increased temperature. The increase in volatilization was shown to be especially sensitive in the temperature ranges (>80 °F) being experienced at the site during the hot summer months.

Some researchers have also theorized that as the water content in PCB soils evaporates and desorbs out of the soil, the water vapor may also carry PCBs with it, similar to steam stripping. Therefore if the humidity of the air was increased around PCB soils, the evaporation of the water content of the soil will be reduced. Any PCBs being carried with the water vapor will also be reduced.
The fogging nozzles will increase the humidity of the air above the exposed PCB soils to near saturation so that evaporation of the water content from the soil should be greatly reduced.

Therefore the use of a misting fog system over exposed PCB soils should reduce PCB volatilization in three ways:

1) reducing the moisture content in the soils caused by soaking sprays
2) reducing the temperature of the PCB soils and
3) increasing the humidity of the air around the PCB soils.

Misting systems have been used successfully in the past to reduce PCB emissions at a Ford Motor Co. site in Atlanta, GA.

Application of Misting Systems to the Lemon Lane Site

As indicated previously, two areas of the site have exposed PCB soils that are a concern. These two areas are the excavation pit itself and the loadout pile where the excavated TSCA soils are stockpiled and loaded into trucks for disposal. Separate misting systems are being developed for each of these two areas.

Portable Misting Systems for Excavation Faces

The system for the excavation face must be portable so that it can be moved and positioned as the excavation progresses. This system will allow for readjustment and redirection several times during the day as the excavator digs along a sidewall or as the prevailing winds change direction.

To produce a portable system, a structural framework is being fabricated as shown in Figure 1. Multiple spray bars (2 or 3) will be mounted on the frame containing up to 50 fogging nozzles. A high pressure pump and gas powered generator will be mounted to the frame and hard-plumbed to the spray nozzles. The entire assembly (or fogging rack) will be lifted by an all terrain forklift, as shown in Figure 2 and moved into position. The pump will be supplied by a flexible hose from the city water supply piped from the fire hydrant at the northeast of the site on Lemon Lane.

Three of these fogging racks will be fabricated and positioned with three all-terrain forklifts around the excavation to get complete coverage of the exposed excavation area. The racks will be positioned upwind of the excavation to allow the wind to carry the fog over the exposed soil. The forklifts can maneuver to position the fog as desired.
Stationary Misting System for the Load Out Pile

A misting system will also be installed surrounding the perimeter of the loadout pile. The misting system will be installed in conjunction with a windbreak around the loadout pile, as shown in Figure 3 and 4. Spray bars will be installed around the top of the windbreak, and directed to spray a fog onto the loadout pile.

The purpose of the windbreak is to prevent the wind from blowing dust into the atmosphere from the loadout pile. The windbreak should especially contain any dust formed from dumping loads of excavated PCR soils from the onsite trucks into the loadout pile. The windbreak will be constructed out of a berm of clean clay about 8 to 10 feet tall around all four sides of the loadout pile. An opening will be positioned in the east berm to allow the onsite trucks access to bring excavated soils to the loadout pile.

The west berm will be wide enough to allow the excavator to sit atop and load disposal trucks. A small dozer will be used inside the windbreak berms to push soil to the truck-loading excavator. This should minimize dust formed by the excavator handling the material.

Spray bars will be positioned on poles around the top of the berms. About 50 spray nozzles will be positioned around the berm and fed from a high pressure pump. The pump will be powered from the electric supply in the scale house.

Spray Nozzle Comparison

Two different types of misting spray nozzles have been procured, high pressure (~200 psi) and low pressure (~25 psi) nozzles. Table 1 lists three high pressure nozzles and two low pressure nozzles that were obtained. The low pressure nozzles are constructed of plastic and can be supplied directly from the city water line. The high pressure nozzles are constructed out of stainless steel or brass and require a booster pump.

The nozzle outlets are severely restricted to produce a fine mist of very small particles. They consume much less water (2 to 38 gallons per hour) than the sprinkler type spray systems we previously used, which used several gallons per minute.

The nozzles form spray patterns which vary from a hollow to solid cone. The spray pattern of the John Deere low pressure nozzle is a fan pattern. The nozzles are manufactured with different spray angles ranging from 30° to 180° to get different coverage. High spray angles give wide mist coverage close to the nozzle. Low spray angles produce a narrow spray pattern that penetrates further away from the nozzles.

Spray Nozzle Testing

These nozzles have been assembled onto spray bars and tested at the site. Table 1 shows the droplet size for the high pressure nozzles. Droplet size is not specified for the low pressure nozzles. However, in trying out these different nozzles it was found that the
high pressure nozzles produce much smaller droplet sizes and make a much finer mist or fog than the low pressure nozzles.

The smaller droplet size is preferred for evaporative cooling. The smaller the droplets, the more surface area is available for evaporation.

The low pressure nozzles did not produce a true fog but a heavier mist that will result in more of the water falling to the ground before it evaporated. Therefore, evaporative cooling will not be realized from the water that falls to the ground. This water will also cause wetter PCB soils in the exposed area, which will encourage PCB volatilization.

As the nozzles were tried out at the site, some temperature measurements were taken under the actual uncontrolled conditions that the misting systems will be operating. The nozzles were mounted outside under variable wind speeds and directions and sunlight. The number and spacing of nozzles varied and the flow rates achieved for different spray bars of nozzles also varied. The number of nozzles operated was much less than will eventually be used during excavation.

With the limited number of nozzles used it was found that air temperatures were reduced up to 9°F at a distance of 5 feet from the high pressure nozzles. Ambient air temperatures were at about 85 to 90°F. Wind speeds varied from 6 to 11 mph. Relative humidity was between 66 and 77%.

Additional temperature reduction testing was performed with an array of 14 Westgate 2.8 gph nozzles and an array of 17 Hago 5gph nozzles. Temperature probes were set up 5 feet in front of the nozzles. A probe was also set up away from the spray to record ambient temperatures. Figure 6 shows that a 3.5°C (6.3°F) temperature drop was achieved with the Westgate nozzles and up to a 9°C (16°F) temperature drop with the Hago nozzles.

It is assumed that if many more fogging nozzles are used and in combination with nozzles which spray out further, the temperature drop and coverage can be improved.

**Spray Nozzle Selection**

It was decided to use an assortment of many of the different high pressure nozzles to produce a broader coverage with the fog. Wide and narrow spray angles will both be used to achieve coverage both close to the spray bars and further away. Some of the higher flow M 15 Hago nozzles will also be used to get additional distance away from the spray bars. These different high pressure nozzles will be “mixed and matched” as we use the misting systems. Different nozzles will be tested throughout the excavation process to attempt to optimize the coverage and cooling effects.
Misting System Testing

It is planned to have the three portable spray racks assembled by Tuesday, August 15, to demonstrate. The three racks will be set up to simulate misting of a 25ft by 25ft excavation area.

An array of 9 temperature-measuring probes will be positioned between the three racks as shown in Figure 5. One temperature probe will be set up upwind of the fogging area to chart the ambient temperature. The probes will be connected to a temperature recorder to continuously record air temperature. The air temperatures will first be recorded with no water flow for about an hour to obtain a baseline. The water spray will be turned on to form a fog and the temperature will continue to be recorded for a period of time to determine the temperature reduction. After the fogging nozzles are shut off, the temperatures will continue to be monitored for about one more hour to see how the temperatures again approach ambient conditions. Data from the data recorders will be downloaded onto Excel spreadsheets and plotted.

Wind speed and direction and relative humidity will be monitored along with the temperatures.

The stationary misting system for the loadout pile along with the clay berm windbreak is also planned to be completed by Tuesday, August 15, weather permitting. If it is completed, it will also be demonstrated on that day.
PORTABLE MISTING SYSTEM

FIGURE 1 FORKLIFT-MOUNTED (FRONT VIEW)

14 SPRAY NOZZLES
SPACED ON 2 FOOT CENTERS

HIGH PRESSURE BOOSTER PUMP

FEED LINE FROM HYDRANT

24 FEET
Gradall Material Handlers

You can be sure it's the right machine for the job. As long as it's from Gradall.

Whatever the job, Gradall makes a machine with the strength, power and versatility to handle it. Handlers with load capacities from 6,000 to 12,000 pounds. Lift capacities up to five full stories. And longer reach capability, up to 36 feet.

Each is powered by a Cummins four-cylinder diesel engine, delivering the maximum horsepower-to-weight ratio and the power to perform in the most demanding applications.

This high-performance engine is mid-mounted in a single-piece, fully welded frame with a single-piece tiered. Add Gradall's rugged steer and planetary drive axles, and you can bank on greater reliability, reduced maintenance and longer machine life.

544B/544B-2S
The big reach 544B forklift can lift 4,000 pounds five full stories when the fully hydraulic, automatic fourth boom section is extended. The 544B-2S capacity is 12,000 pounds and it can lift loads a full 26 feet. Both are equipped with easily extended outriggers for extra support.

544B
<table>
<thead>
<tr>
<th>Reach</th>
<th>Lift</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>35 ft</td>
<td>48 ft</td>
<td>10,000 lbs</td>
</tr>
<tr>
<td>10.7 m</td>
<td>14.5 m</td>
<td>4,536 kg</td>
</tr>
</tbody>
</table>

544B-2S
<table>
<thead>
<tr>
<th>Reach</th>
<th>Lift</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 ft 6 in</td>
<td>26 ft</td>
<td>12,000 lbs</td>
</tr>
<tr>
<td>5 m</td>
<td>7.9 m</td>
<td>5,443 kg</td>
</tr>
</tbody>
</table>

524/524-3S
Setting now industry standards for value and productivity, the four-wheel-drive 524 has a hydrostatic drive train with 3-ton weight capacity with two boost options. Also available is the 522 with two-wheel drive.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Lift</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 ft</td>
<td>24 ft 6 in</td>
<td>6,000 lbs</td>
</tr>
<tr>
<td>4 m</td>
<td>7.4 m</td>
<td>2,722 kg</td>
</tr>
</tbody>
</table>

524-3S
<table>
<thead>
<tr>
<th>Reach</th>
<th>Lift</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 ft 6 in</td>
<td>32 ft</td>
<td>5,000 lbs</td>
</tr>
<tr>
<td>6.4 m</td>
<td>9.8 m</td>
<td>2,722 kg</td>
</tr>
</tbody>
</table>

534C-6
Designed to handle many different types of construction jobs, the 534C-6 has four-wheel drive, hydrostatic drive train, 5-ton weight capacity with an added lift range of 36 feet. Also, the 532C-6 is available with two-wheel drive.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Lift</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 ft</td>
<td>36 ft</td>
<td>6,000 lbs</td>
</tr>
<tr>
<td>7 m</td>
<td>11 m</td>
<td>2,722 kg</td>
</tr>
</tbody>
</table>

534C-9
The newest addition to the Gradall handler line, this model now boasts a 40-foot lift height. It also features an easy-to-operate hydrostatic drive train and four-wheel drive.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Lift</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 ft 2 in</td>
<td>40 ft</td>
<td>8,000 lbs</td>
</tr>
<tr>
<td>7.3 m</td>
<td>12.2 m</td>
<td>4,080 kg</td>
</tr>
</tbody>
</table>

534C-10
The innovative 534C-10 offers the unique advantages of 46 feet of lift and a 10,000-pound capacity along with a convenient hydrostatic drive train and standard outriggers.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Lift</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 ft 2 in</td>
<td>40 ft</td>
<td>10,000 lbs</td>
</tr>
<tr>
<td>7.3 m</td>
<td>12.2 m</td>
<td>4,536 kg</td>
</tr>
</tbody>
</table>
FIGURE 3
MISTING SYSTEM – TSCA LOAD-OUT PILE
(TOP VIEW)

CLAY BERM

8 NOZZLES PLACED
ON 3 FOOT CENTERS

TSCA LOAD-OUT PILE

16 NOZZLES PLACED
ON 3 FOOT CENTERS

CLAY BERM

SCALE:
1 INCH = 5 FEET

SCALE HOUSE
FIGURE 4
WEST CLAY BERM – BARRIER WALL
(SIDE VIEW - LOOKING NORTH)

WEST CLAY BERM – BARRIER WALL
FRONT VIEW
(LOOKING EAST)

8 FOOT HIGH (MINIMUM)
PLYWOOD BARRIER WALL
(BETWEEN WEST BERM AND SCALES)
FIGURE 5
MISTING SYSTEM
TEMPERATURE PROFILE TEST SET UP

SPRAY RACKS, 3

TEMPERATURE PROBES, 9

25'

10'

5'

WIND

AMBIENT TEMPERATURE PROBE

REF
4/10/94
Lemon Lane Misting Test

- 1 - Unsprayed Probe
- 2 - Sprayed 4" NC
- 5 - Ambient

Temperature in deg C

2:00:00 - 2:30:00 - 3:00:00 - 3:30:00 - 4:00:00 - 4:30:00 - 5:00:00
# Table 1

## Misting Nozzels

<table>
<thead>
<tr>
<th>Type</th>
<th>Model</th>
<th>Nozzle Type</th>
<th>Pressure (psi)</th>
<th>Operating Pressure (psi)</th>
<th>Temperature (°C)</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hago Type 'Mini Nozzle'</td>
<td>M 15</td>
<td>15</td>
<td>21.21</td>
<td>36.6</td>
<td>80°</td>
<td>brass</td>
</tr>
<tr>
<td>Hago Type 'Oil Burner'</td>
<td>1.0C</td>
<td>4</td>
<td>5.09</td>
<td>-27.0</td>
<td>80°</td>
<td>stainless steel</td>
</tr>
<tr>
<td>Hago Type 'Oil Burner'</td>
<td>9.0C</td>
<td>9</td>
<td>11.43</td>
<td>N/A</td>
<td>320°</td>
<td>30° brass</td>
</tr>
<tr>
<td>W.A. Westgate</td>
<td>W-2.0</td>
<td>2</td>
<td>2.3</td>
<td>60.0</td>
<td>78.4</td>
<td>70° stainless steel</td>
</tr>
</tbody>
</table>

- **Raindrip** R167C
  - 11.9
  - hollow
  - 19°C plastic

- **John Deere Spray Master** RF8 Drift
  - 37.8
  - fan
  - 18°C plastic

*Tested operating pressure at Lemon Lane Landfill*