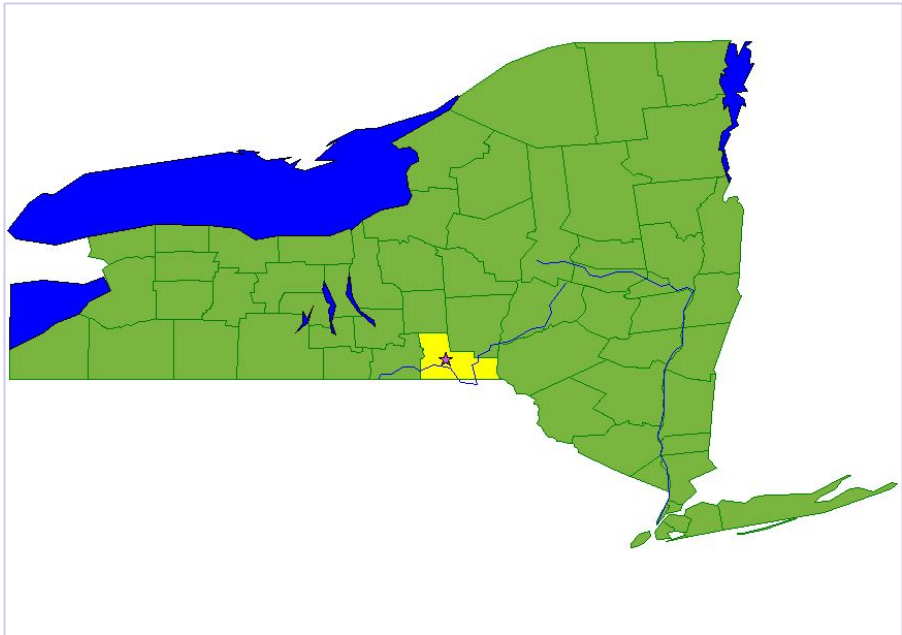
Real -Time Monitoring to Assess Mercury Emissions from Storage Activities



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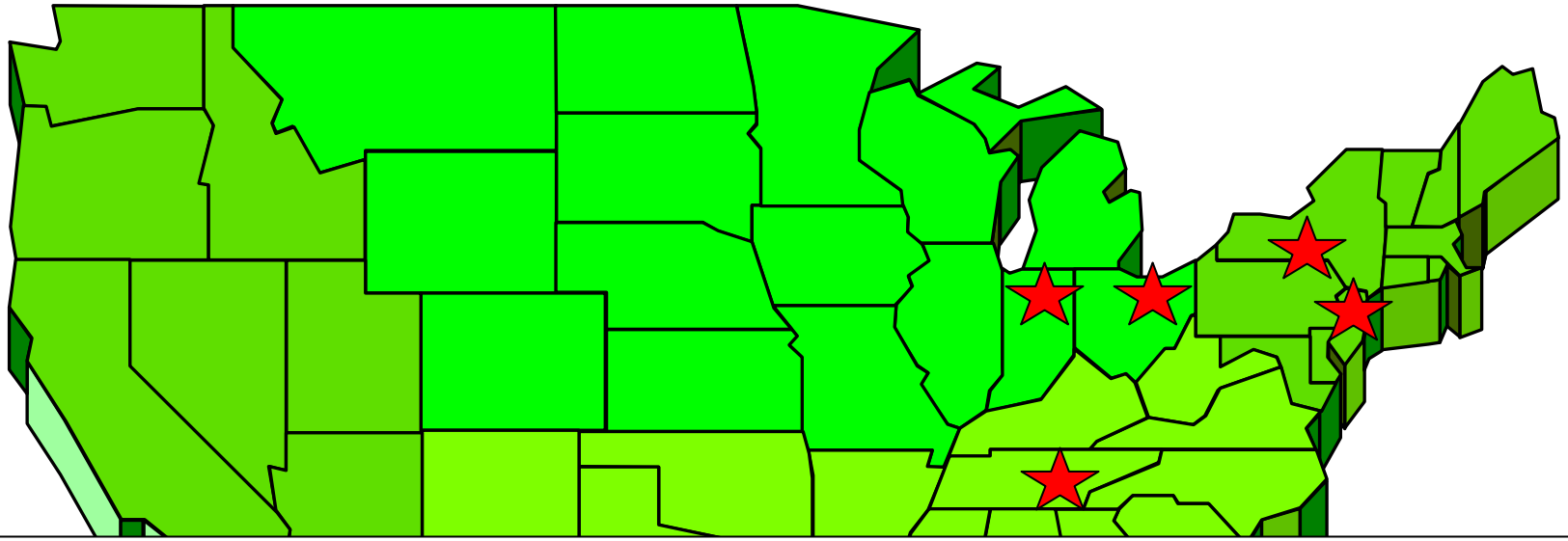
Assessment Goals:

1) Monitor Changes in Vapor Phase Mercury Concentrations Following Changes in Storage Practices :
   - Before, During and After Transport
   - Before, During and After Over-packing
   - Residual Concentrations Prior to Base Closures
2) Design monitoring methods that could be implemented by others



DoD Federal Mercury Stockpile Inventory Status

Location	Amount	Status
Binghamton, NY	(-211 mt)	Shipped to Somerville Fall 2000
Oak Ridge, TN	(-699 mt)	Shipped to Warren Fall 2004
Somerville, NJ	2617 mt	Over-packed Nov.2001 - Feb.2002
Warren, OH	1262 mt	Over-packed March 2002
New Haven, IN	557 mt	Over-packed April 2002

mt- metric tons

Warehouse Storage Complex
Binghamton Depot
Defense National Stockpile
Defense Logistics Agency

Pallets Containing Mercury Flasks

Storage Prior to Over-packing

Individual Flask of Mercury with Threaded Seal

Mock-Up of the Over-packing Procedure

size of an individual flask

completion of over-packing

New Haven Depot Storage (post over-packing procedure)

Warren Depot Storage (post over-packing procedure)

Fundamental Mercury Monitoring Concepts

-There are natural and anthropogenic sources of mercury vapor

-There is a global mercury vapor background regardless of where you reside (a low, but measureable baseline concentration)

-Everyone is exposed to mercury vapor on a daily basis

-Concentrations in urban areas tend to be higher than in rural locations

- You are likely exposed to higher concentrations of mercury vapor in indoor versus outdoor activities

-There are different types of mercury species with differing toxicities

-Elemental	Hg^0	(least toxic)
-Oxidized	Hg^{+2}	
-Methylated	CH_3Hg	(most toxic)

-Elemental Hg^0 vapor is the “easiest” to measure, and is likely to be the most common form (by far) in the air inside the DoD warehouses

Examples of Mercury Vapor Exposure Guidelines

- Inside Warehouses (worker exposure)
- 25,000 ng/m^3 (one hour exposure, ACGIH)

- Offsite (residential exposure)
- 300 ng/m^3 (average annual exposure, New York State recommendations)

Warehouse Construction, Access, and Ventilation Systems may all exert Control on Mercury Vapor Emissions

Overhead Doors and Wall Vents

Roof Vents

Monitoring Methods

- Tekran and Lumex Instruments

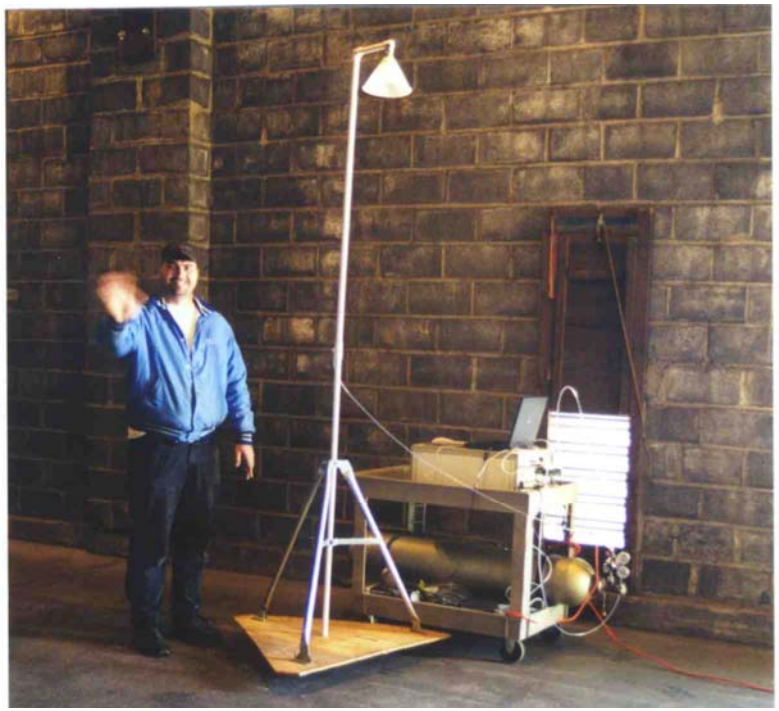
- Inside Warehouses
  - conduct x-y grid sampling
  - conduct x-y-z gradient sampling

- Outside Warehouses
  - emissions from vents (on warehouse roofs)
  - ambient air in adjacent residential areas

-Document Temporal and Spatial Variations

-Inclusion of Meteorological Conditions Assessment

Real-Time Mercury Vapor Monitoring



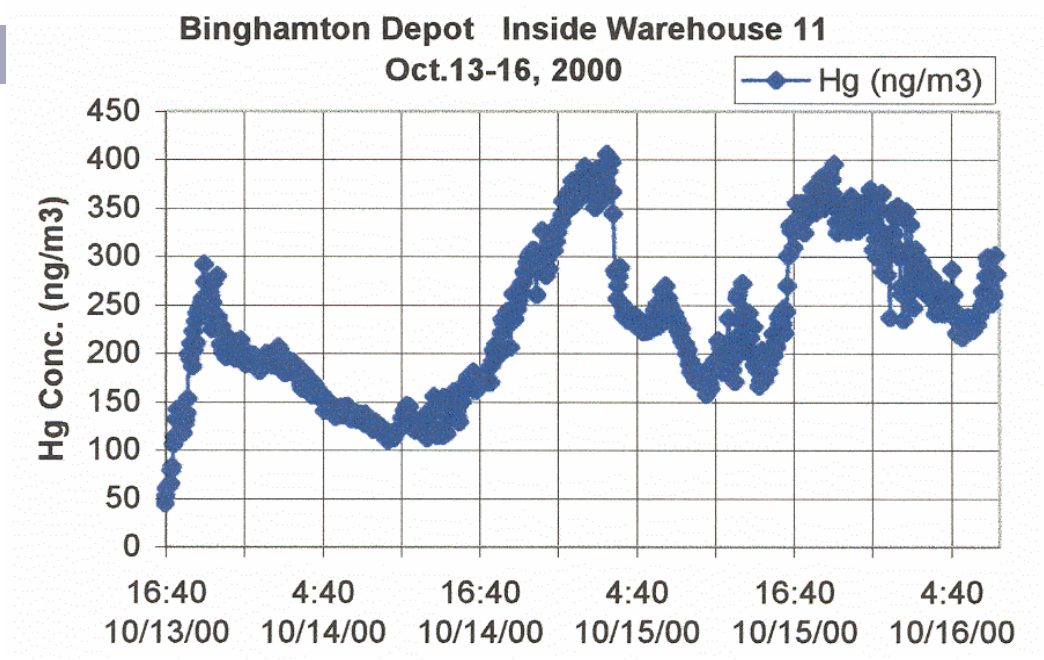
Tekran 2537A
5 minute sample collection
Hg conc. range 1.0 - 2000 ng/m^3
cart mounted - AC power

Ohio-Lumex
1 second sampling interval
Hg conc. range 20 - 50,000 ng/m^3
portable - battery powered

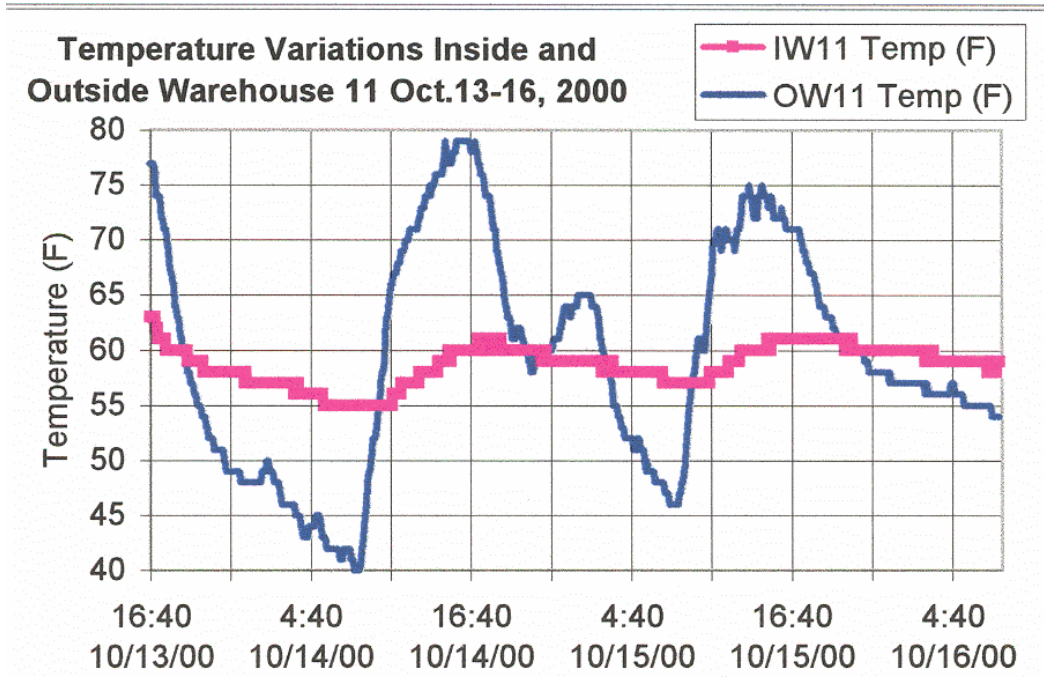
Results from Mercury Vapor Monitoring with Tekran Instrumentation Prior to Over-Packing

Oct. 26th, 2000. Monitoring vapor phase mercury concentrations over wooden box pallets containing flasks of mercury in Warehouse 11D.

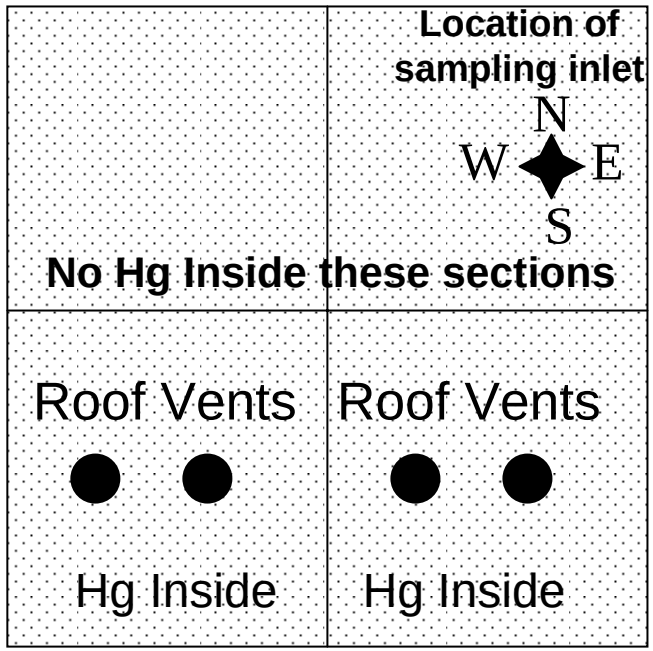
Binghamton Depot Fall 2000



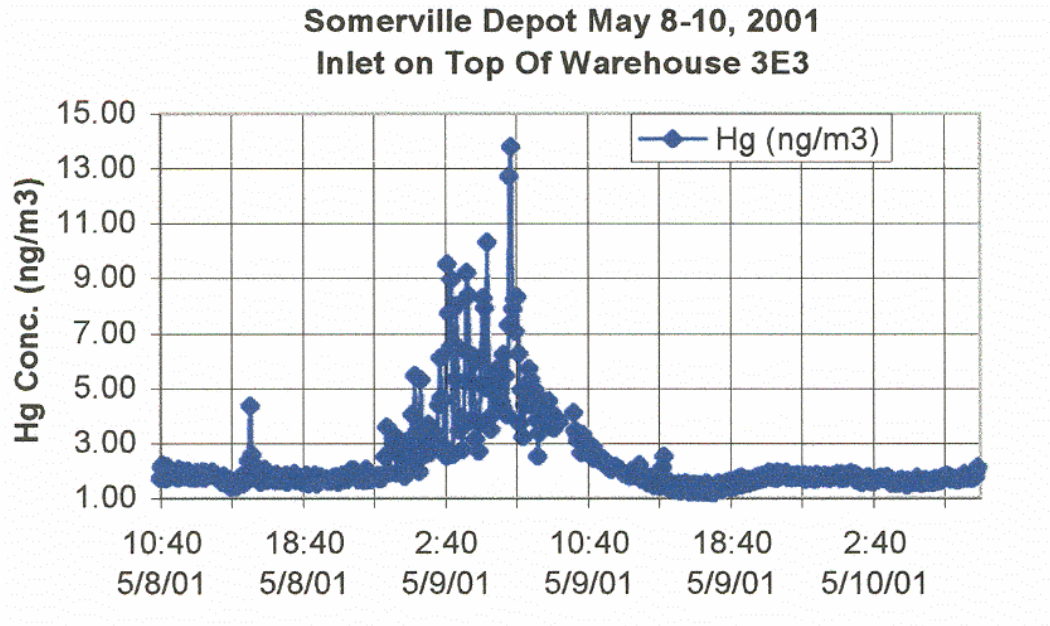
Hg Concentrations Inside the Warehouse are Related to Temperature Inside and Outside Warehouse (however natural ventilation rates also exert controls on the concentrations)



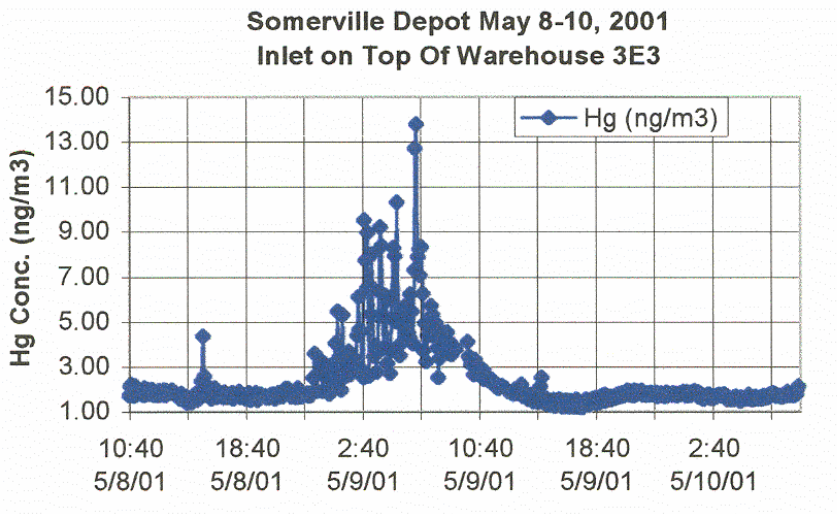
Somerville Depot May 2001
Monitoring emissions from roof vents Prior to Over-packing



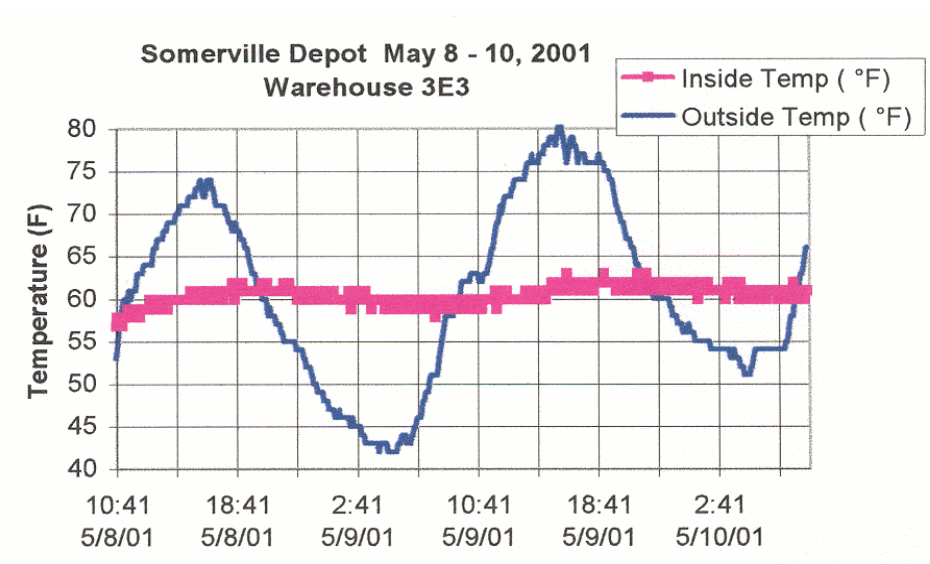
Warehouse Roof Schematic
(above 4 warehouse sections)

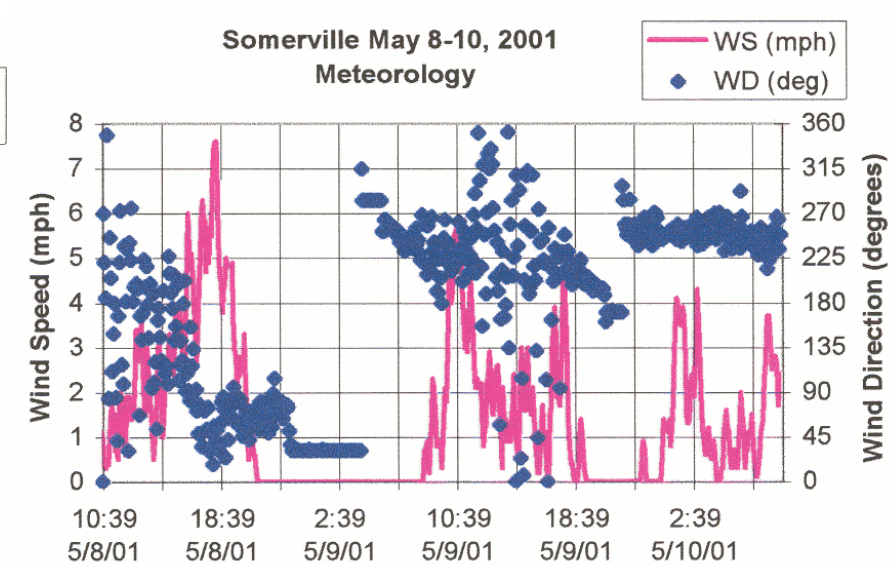


Small Elevations in Levels of Mercury Vapor were found outside of the Warehouses (superimposed over baseline concentrations)

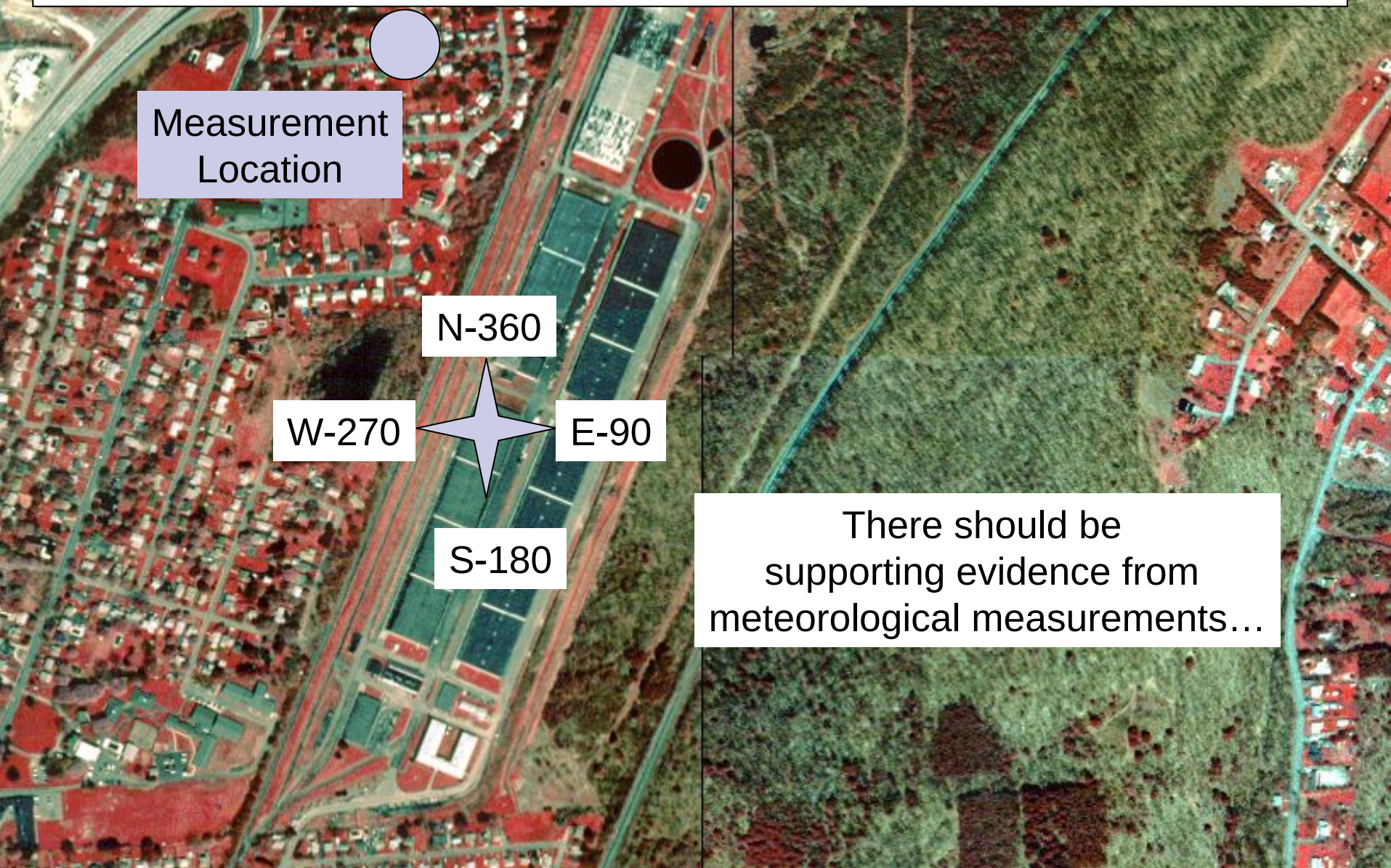


Findings: 1) Inside-Outside temperature difference provides conditions conducive to emission of Hg vapor through roof vents at Somerville, 2) Meteorological variability is also reflected in changes in the concentration levels at the Inlet location

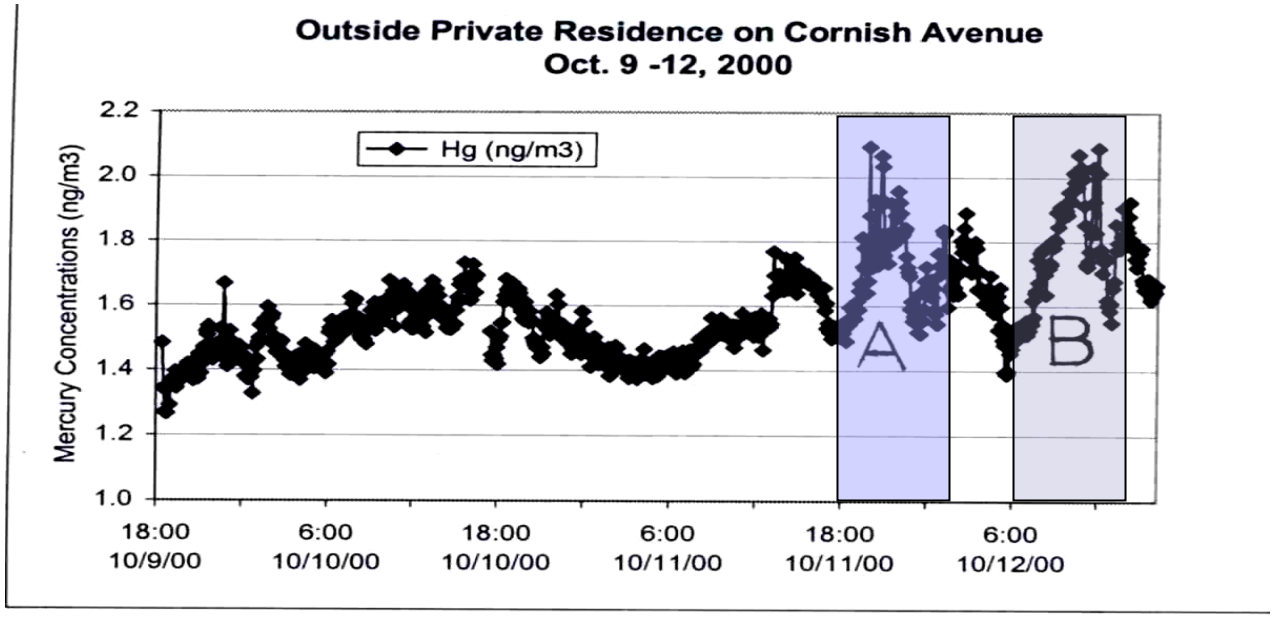


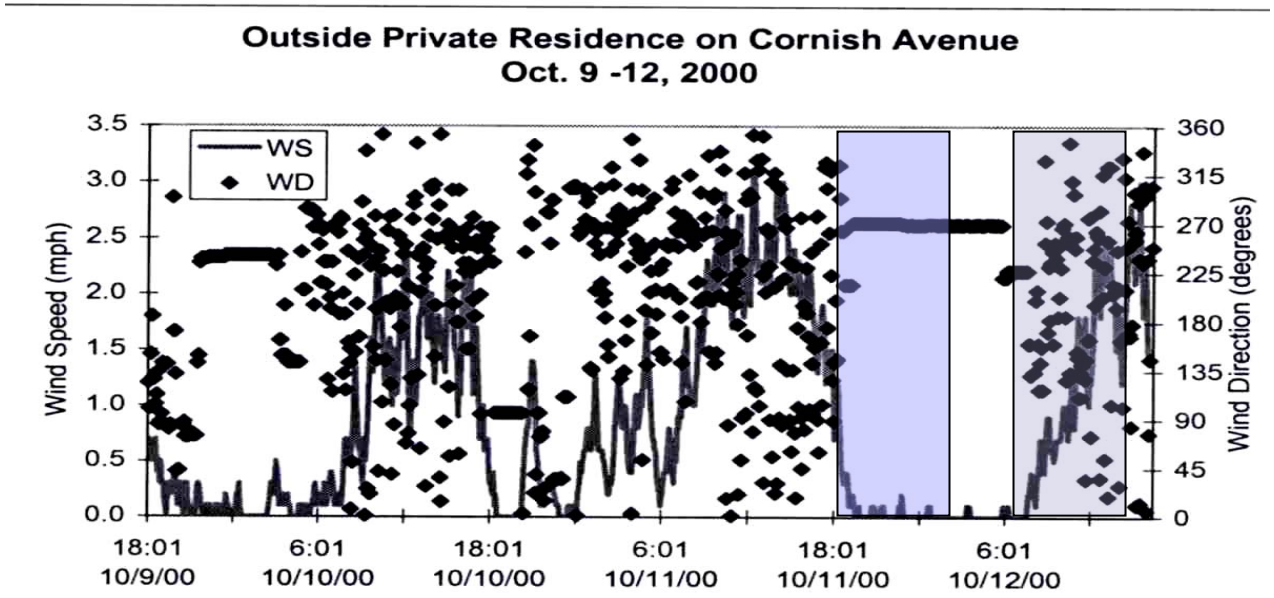


Prior to the removal of the Mercury Stockpile, what was the source of the vapor phase mercury in the residential neighborhood adjacent to the Binghamton Depot?



There should be supporting evidence from meteorological measurements…





Note: The Hg concentrations are very low!

Times of "Elevated" Mercury….

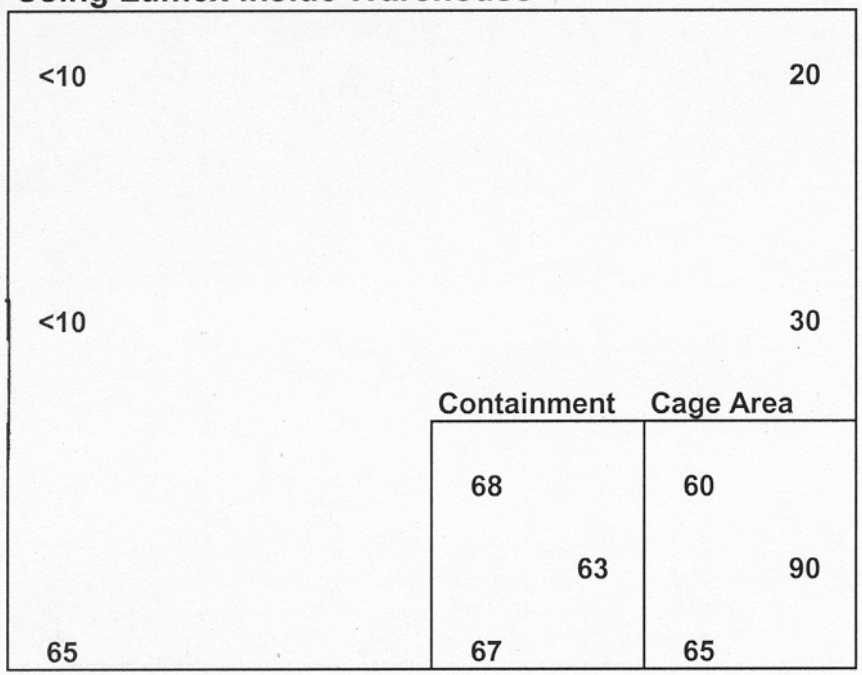
<u>Time A:</u> Evening, Low wind speeds, pollution buildup enhanced by river valley topography (Hg source possibly from the Depot, but not conclusive)

<u>Time B:</u> Daytime, Winds from the southwest (distal Hg source, not from the Depot…)

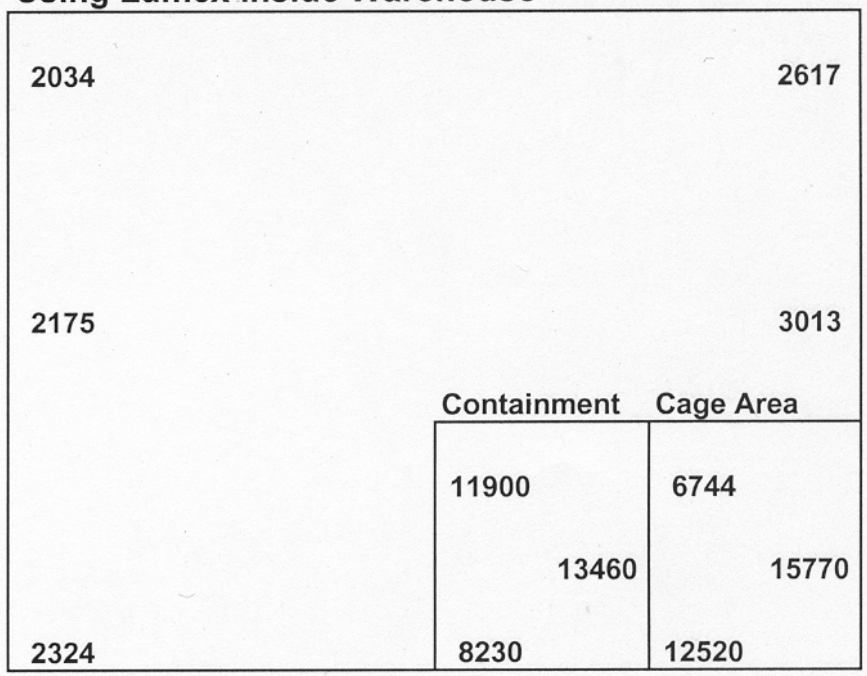
Use of the Lumex Instrumentation Before, During, and After Over-packing Operations

Hg Concentrations Before and During Over-packing Inside a Warehouse at the Warren Depot (x-y grid sampling)

Warren Depot February 2002
Hg Conc. (ng/m3) Prior to Over-packing
Using Lumex inside Warehouse

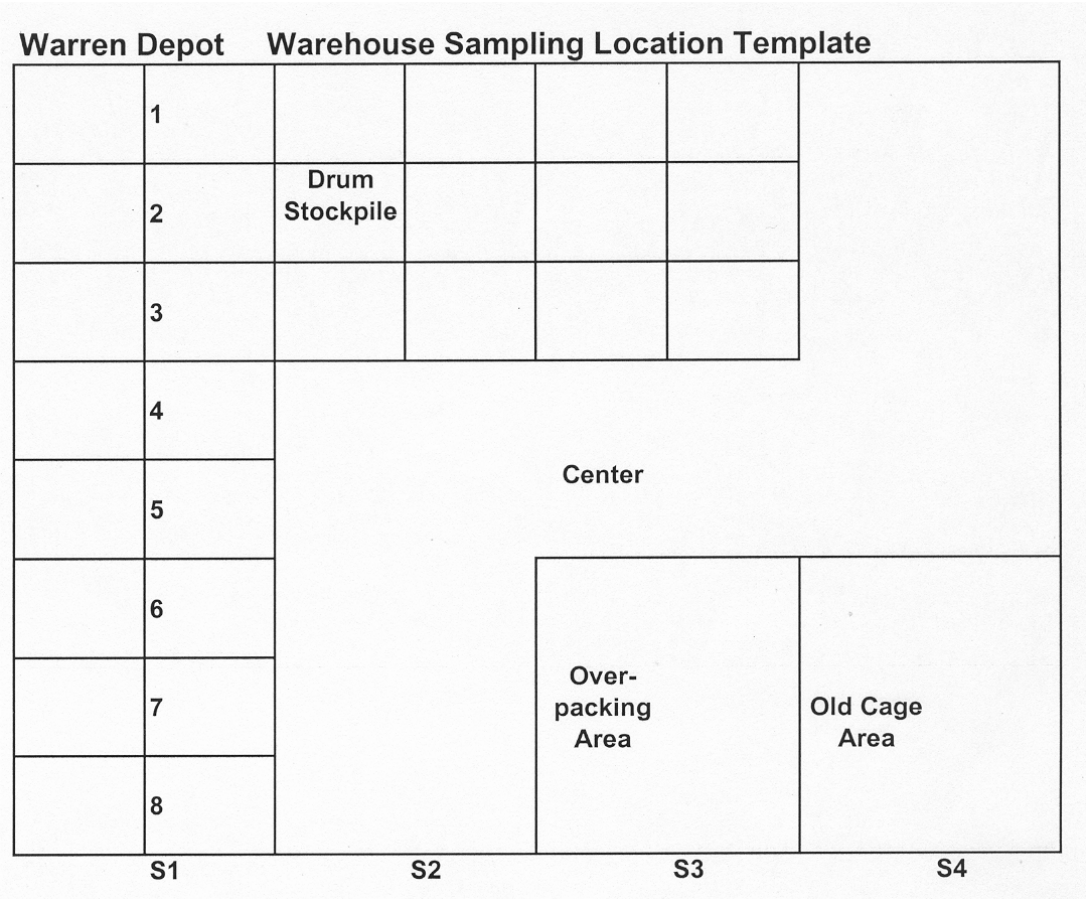


Warren Depot March 2002
Hg Conc. (ng/m3) During Over-packing
Using Lumex inside Warehouse

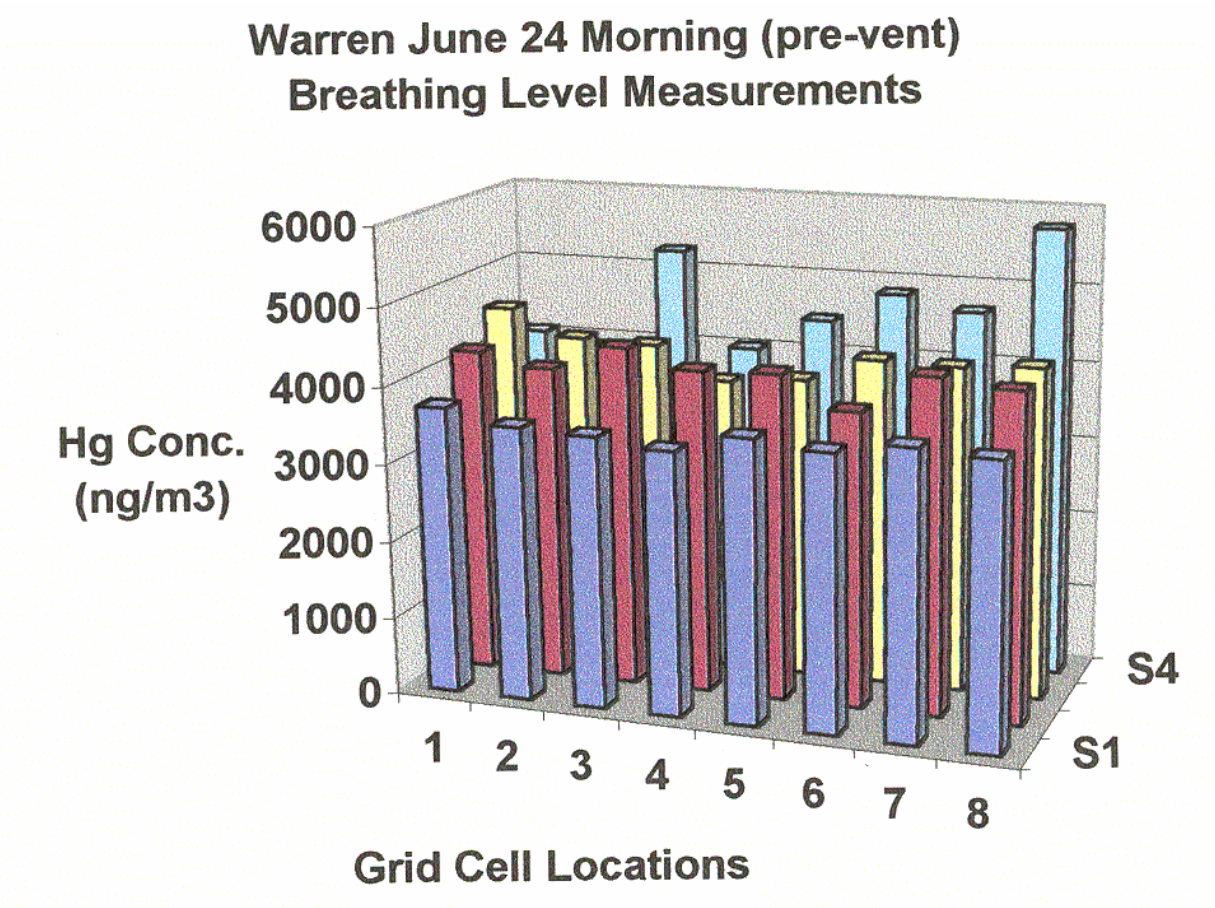


- Mercury originally stored inside the “cage” area
- Overpacking took place within containment area
- Workers required to wear respirators if Hg Concentrations are > 25,000 ng/m^3

Results after Over-packing Activities Had Been Completed at Warren

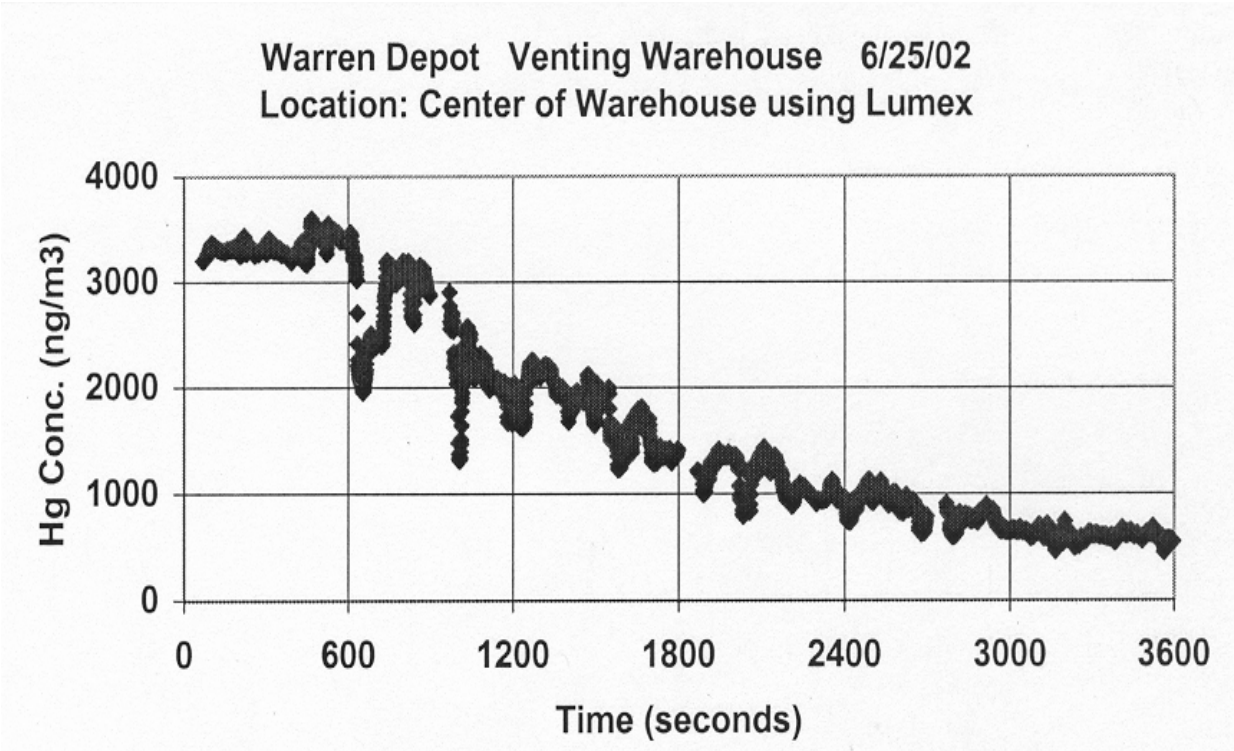


Grid Sampling Results at Warren…



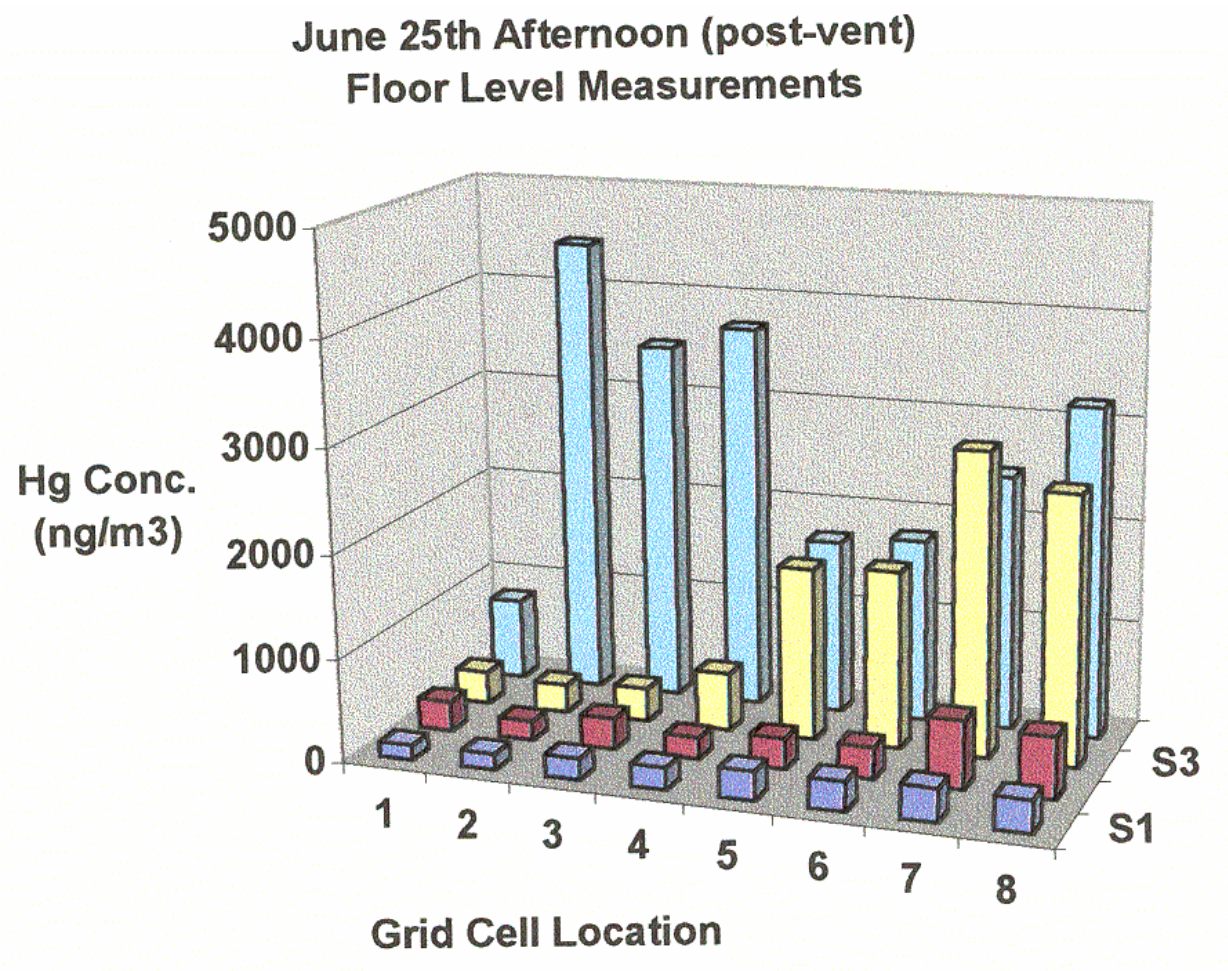
Concentrations are similar throughout the warehouse (well mixed)

Monitoring Rate of Hg Concentration Decrease after Opening Overhead Doors at Warren Depot

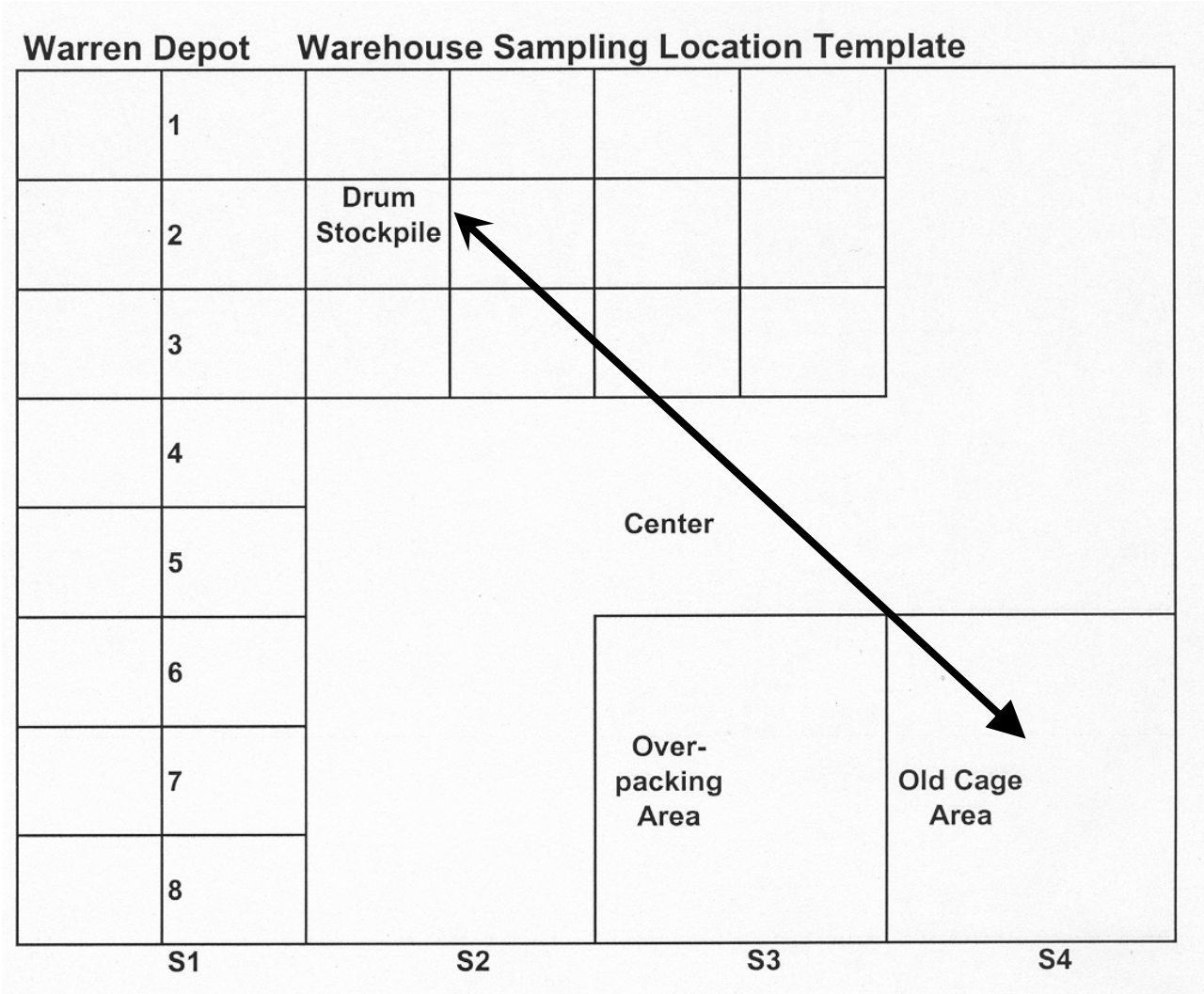


Mercury concentrations decrease due to mixing with lower concentrations within the air outside the warehouse (increasing the air exchange rate)

Locating Sources of Residual Hg Vapor Following Warehouse Venting (x-y grid sampling)



Vertical Gradient Sampling Cross-Section (x-y-z) to further define the residual Hg sources



Results from Vertical Gradient Sampling at Warren...

Vertical Gradient Sampling in Warehouse 2A, Warren Depot, June 24, 2002
All mercury concentrations in ng/m3

Doors Closed
Sampling at 11:20 A.M.
Inside T = 77 F, Outside T = 91 F

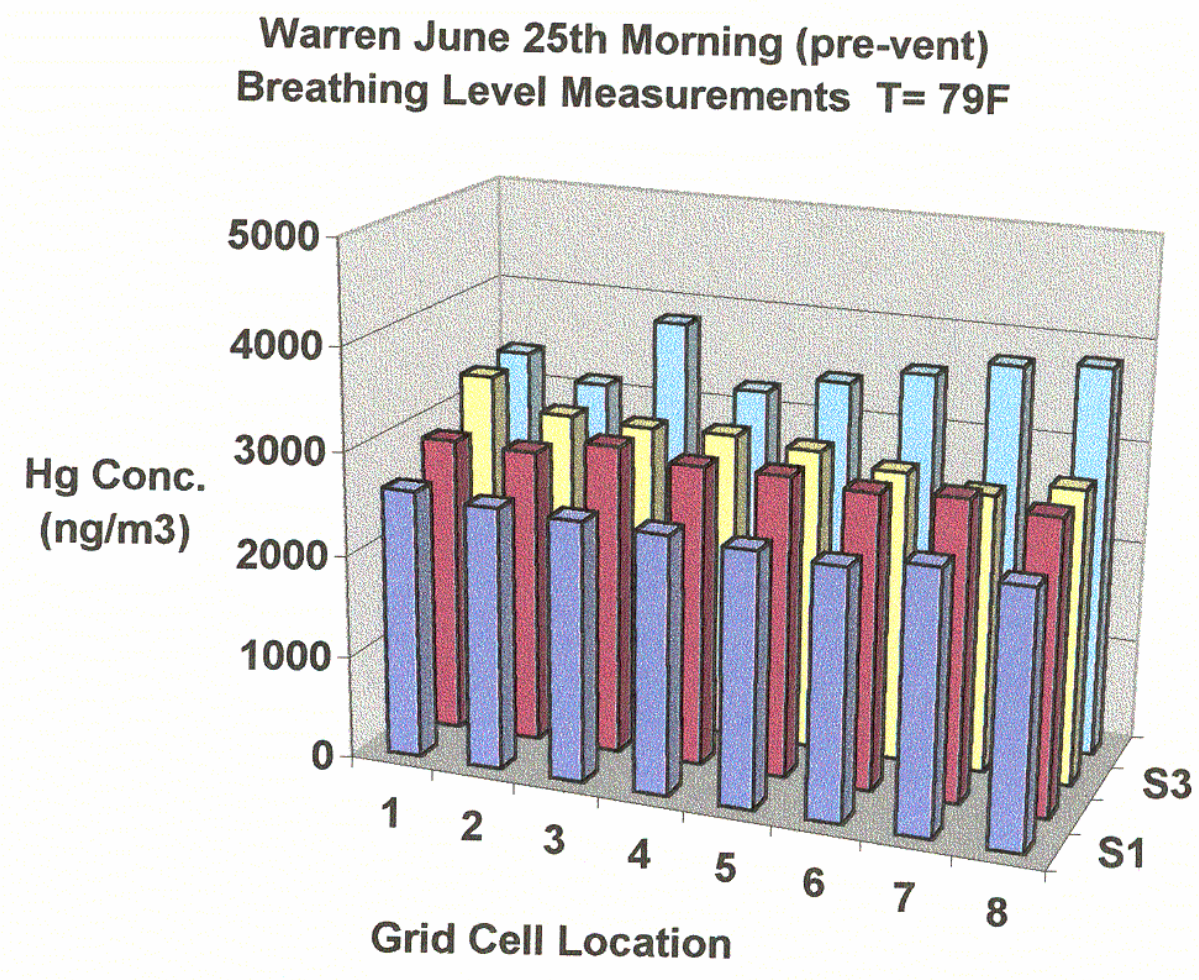
Location	In Stockpile	Center	Near Cage
16 feet	2732	4250	4520
12 feet	3443	4126	4140
8 feet	3686	4035	4138
4 feet	3287	3810	4370
Floor	3330	4450	9763

Doors Opened at 12:12P.M.
Sampling at 1:50 P.M.
Inside T = 84 F, Outside T = 94 F

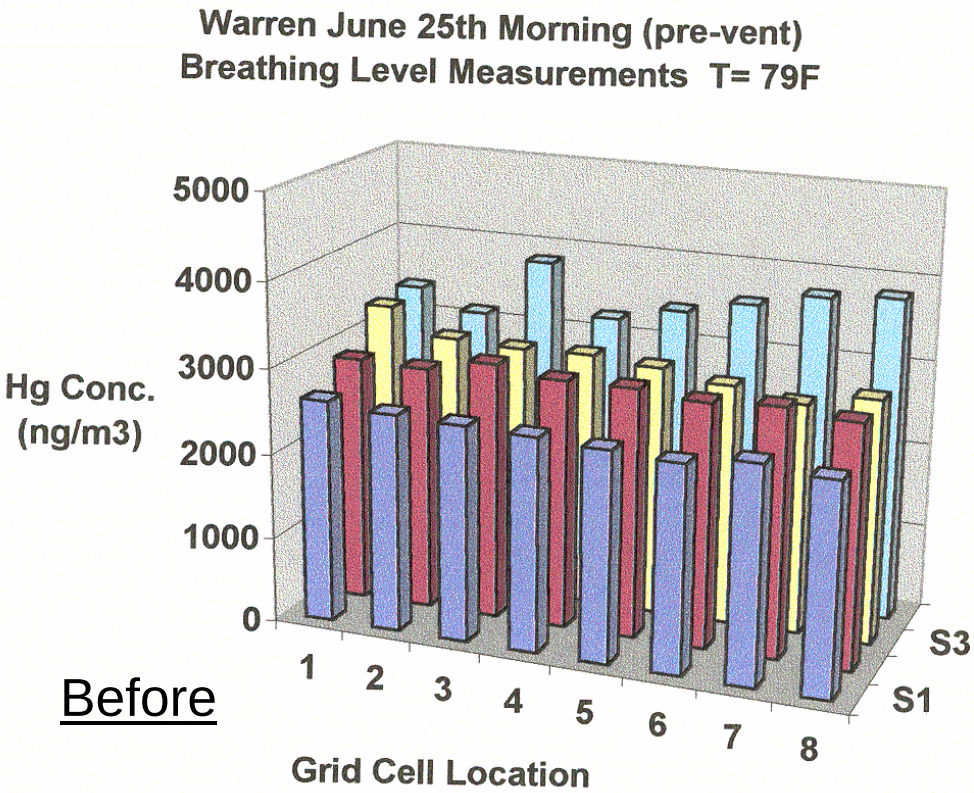
Location	In Stockpile	Center	Near Cage
16 feet	81	167	180
12 feet	89	153	225
8 feet	103	96	175
4 feet	111	169	173
Floor	177	536	4285

Highest mercury vapor concentrations were at floor level in area where flasks were stored prior to over-packing procedure

Hg Concentrations increased to previous morning's levels following the venting experiments, how do we decrease these residual concentrations?

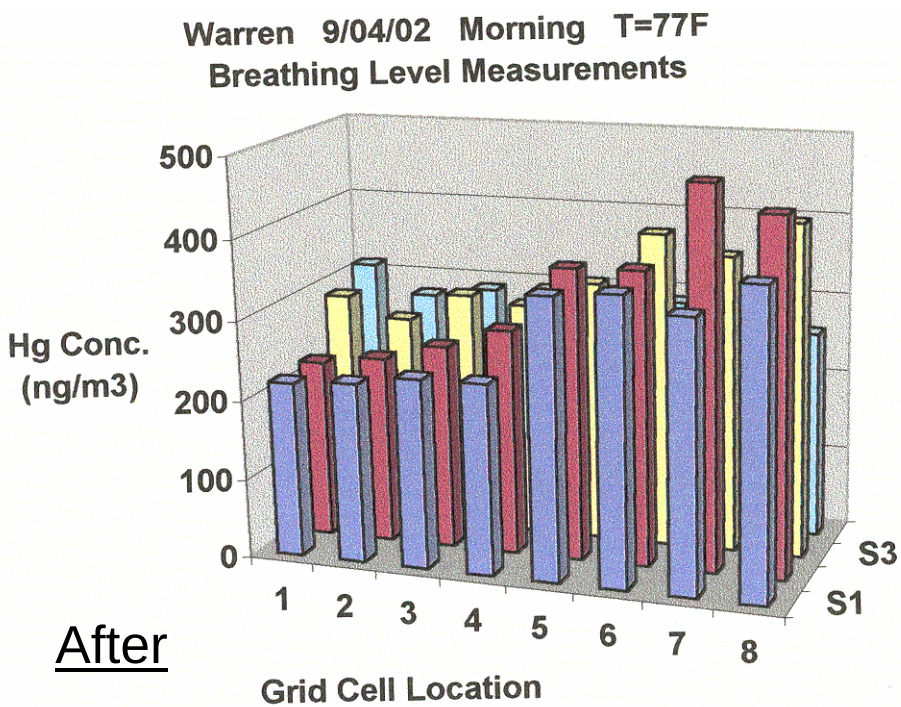


Floor Cleaning Methods were used to Reduce Residual Hg Concentrations at Warren….



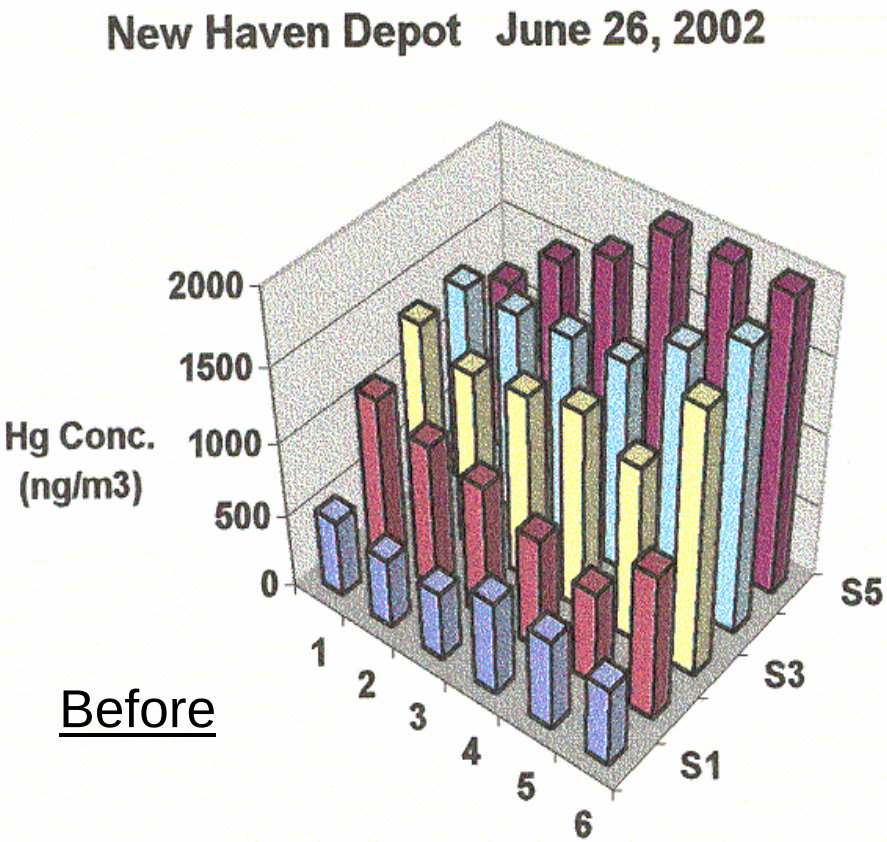
Before

Floors had been cleaned three times prior to return site visit in September….

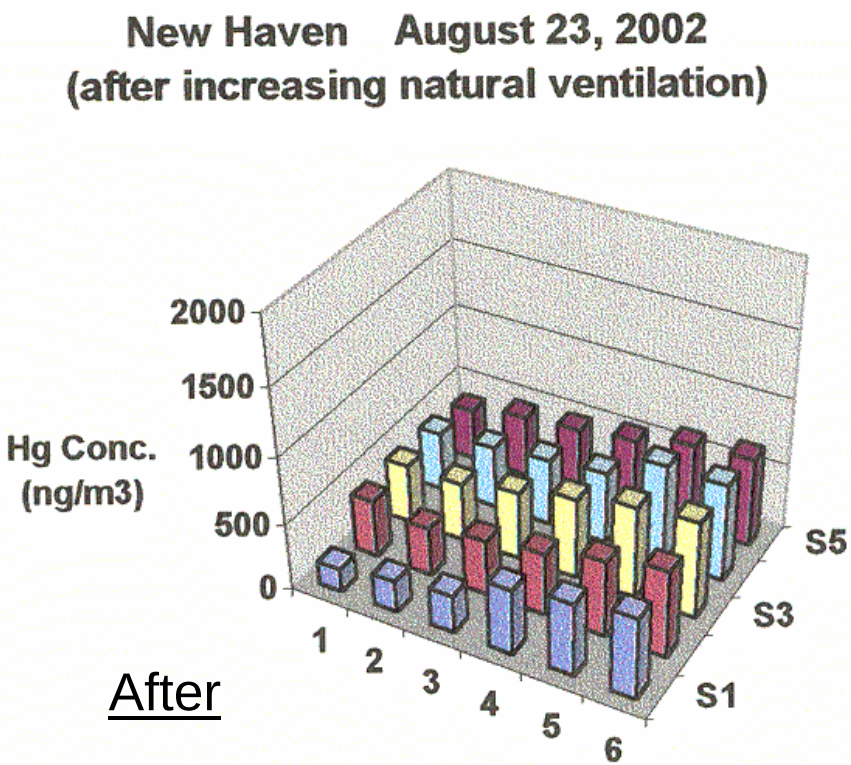


After

Residual Hg Concentrations at New Haven were reduced through use of natural processes….



Before



After

Wall vents had been left in open position for two months prior to return visit

Conclusions

- Highest Hg concentrations were associated with over-packing operations
- Over-packing during cool weather conditions helped to limit worker exposure to Hg vapor
- Highest residual Hg concentrations were located at floor level associated with containment areas and forklift traffic
- Hg movement and concentrations within warehouses reflected changes in meteorological conditions

Conclusions continued...

- Residual Hg concentrations were lowered through increasing natural ventilation rates as well as floor cleaning activities
- Over-packing operations were successful in confining the sources of mercury emissions and lowering Hg concentrations
- Over-packed Hg inventory is stored in a secure environment from health and safety perspectives
- Tekran instrumentation is ideal for monitoring low level mercury concentrations outside of warehouses, Lumex instrumentation is ideal for real - time measurements inside warehouses

Acknowledgements

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  - Tim Eriksen (mercury vapor sampling)
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- New Jersey Institute of Technology

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