

2001

## Casco Bay Deposition Study

Casco Bay Estuary Partnership

Maine Department of Environmental Protection (DEP)

U.S. Environmental Protection Agency (EPA)

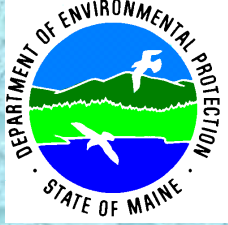
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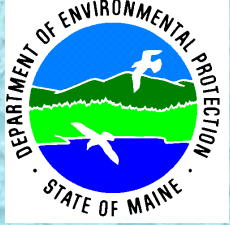
### Recommended Citation

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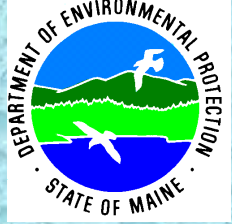


# Casco Bay Deposition Study



**In 1990, Casco Bay was designated an "estuary of national significance" and included in the U.S. Environmental Protection Agency's National Estuary Program, established in 1987 to protect nationally significant estuaries threatened by pollution, development or overuse. As a result of this designation, the Casco Bay Estuary Project (CBEP) was formed with the mission of preserving the ecological integrity of Casco Bay and ensuring compatible human uses of the Bay's resources through public stewardship and effective management.**

# Casco Bay Estuary Project:

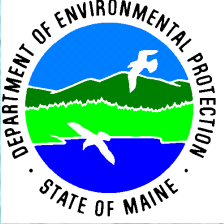


Collaborative interagency and citizen effort to develop a plan for managing the Casco Bay watershed

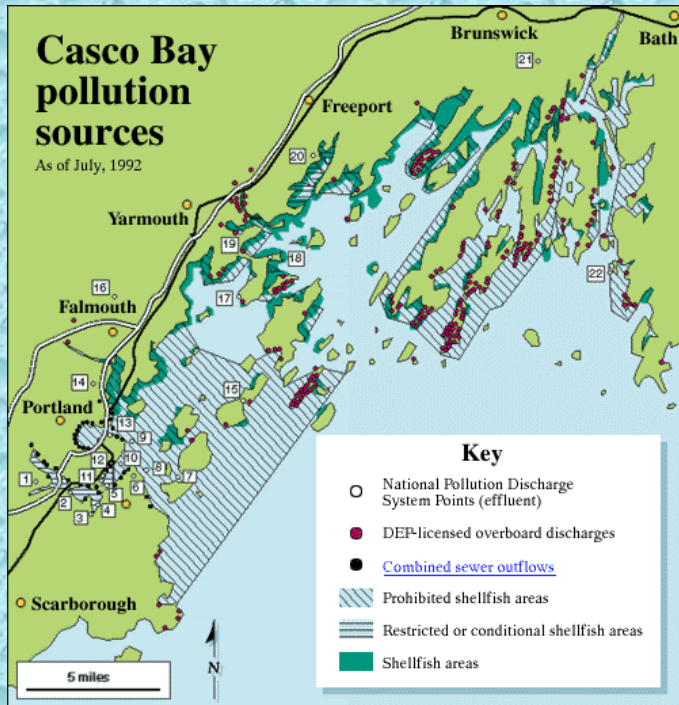
## Casco Bay Plan - adopted 1996



- ✓ **protect wildlife habitat**
- ✓ **improve water quality**
- ✓ **reduce pollution from stormwater runoff and combined sewer overflows**
- ✓ **reduce toxic pollution**
- ✓ **protect and restore clamflats and swimming areas**



# Issues Identified by Casco Bay Plan:



- ✓ nuisance algal blooms from excess nitrogen causing mortality in shell fish and other marine animals
- ✓ elevated levels of Hg, Cd, PAH
- ✓ fish advisories due to elevated levels of methyl mercury in watershed fish



## Air Deposition Study funded by Great Waters Program

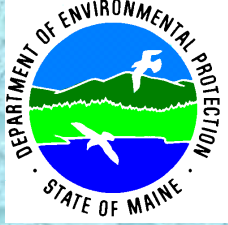


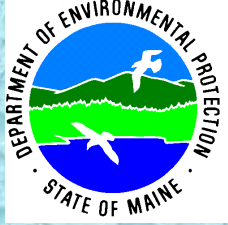
- ☞ Is air deposition a current source of pollution to the bay?
- ☞ What is the contribution of deposition to total pollution loading?
- ☞ What is the relationship of the estuary to regional patterns of air pollution?



# Casco Bay Deposition Study Objectives:

1. Establish a long-term deposition monitoring site near Casco Bay (PAH, Nitrogen, Mercury, Acid Deposition, Fine Particulates)
2. Develop a relatively simple method to estimate atmospheric mass loading of “target” pollutants.



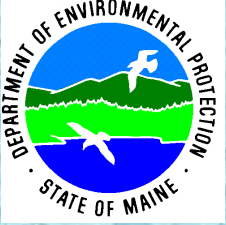


# Air Deposition Study Team Members

- **Maine DEP**
  - Cathy Richardson, Ellen Doering, Jeff Emery, Don Prince, Doug Saball, Andy Johnson - Advisory Committee
  - Don Prince - site operator
- **USEPA Region 1**
  - Diane Gould, Alan Van Arsdale, Jeri Weiss - Advisory Committee
- **Casco Bay Estuary Project**
  - Beverly Bayley-Smith - Grant Administrator, Advisory Committee
- Byard Mosher - Contractor for Data Analysis

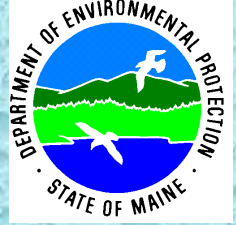




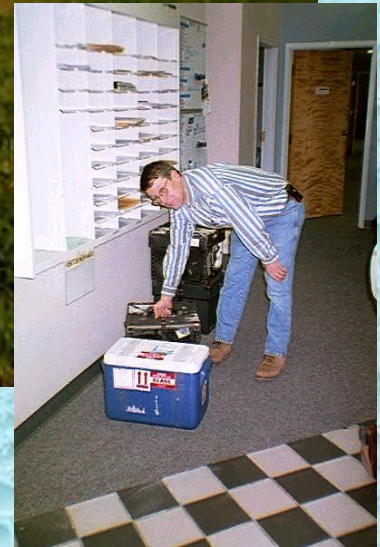


# Location of Air Deposition Site: Wolfe's Neck Farm - Freeport, Maine

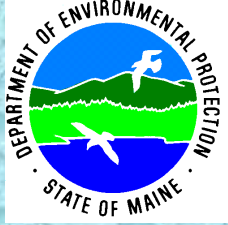




Collecting the MDN Sample



Sending it out for analysis



## Site Configuration

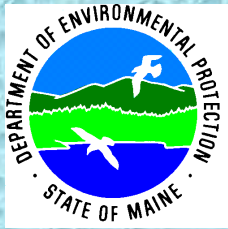
- Fine Aerosol Chemistry - **IMPROVE** Sampler
- Precipitation Ion Chemistry - **NADP** Sampler
- Mercury Deposition - **MDN** Sampler
- PAH Wet and Dry Deposition - UMass Lowell Sampler
- Meteorological Data - Recording rain gauge and wind speed / direction

# Sampling Frequency

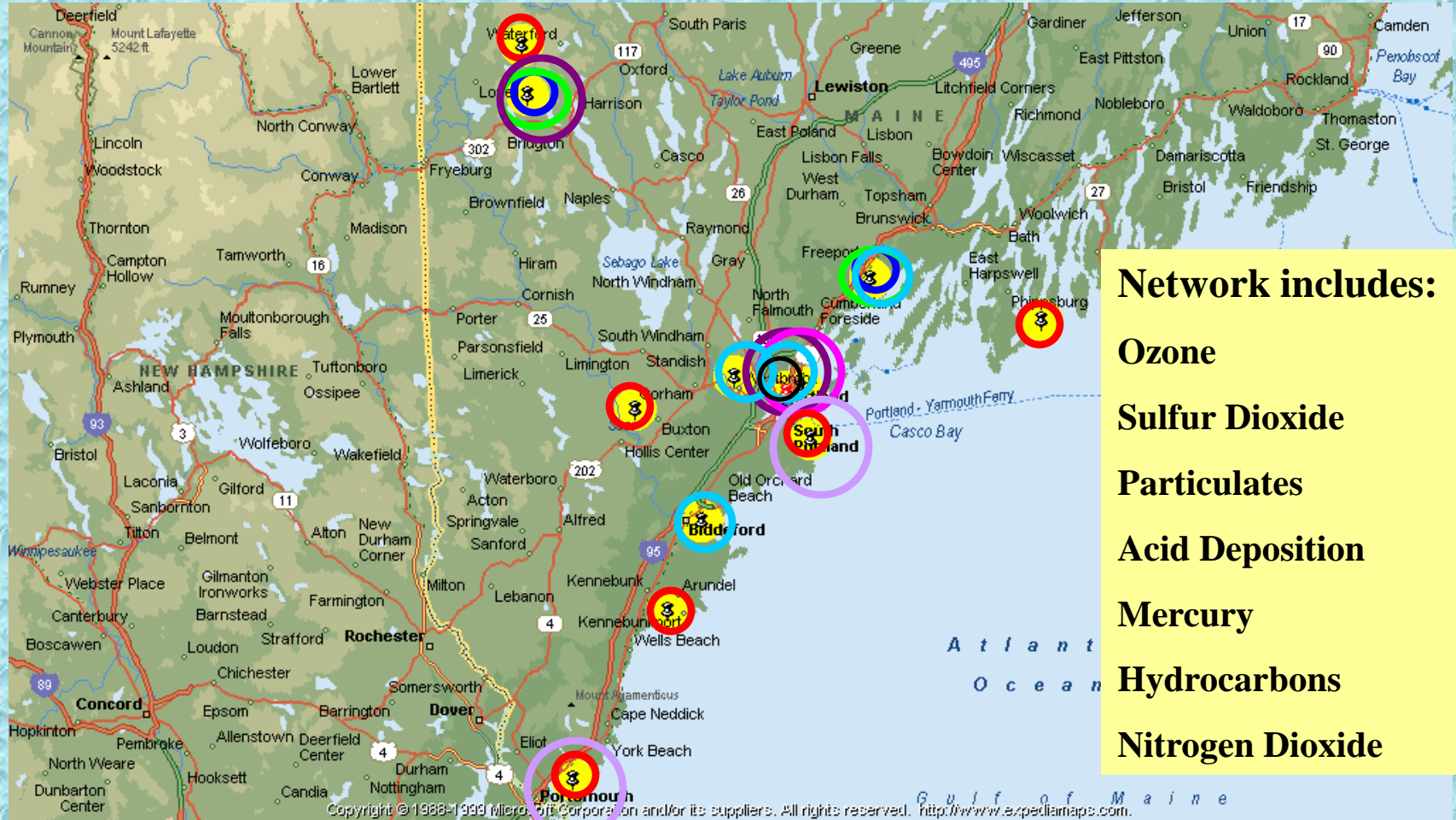


- Fine aerosol (IMPROVE)- SIP calendar, every 6th day
- Precipitation chemistry (NADP)- weekly integrated sampling (sampling bucket set up on Tuesday and removed the following Tuesday)
- Mercury deposition (MDN)- weekly integrated sampling (same as NADP)
- PAH deposition - weekly integrated sampling, one week/month for one year (same as NADP)
- Sampling began Jan-Feb 1998 and will continue for three years



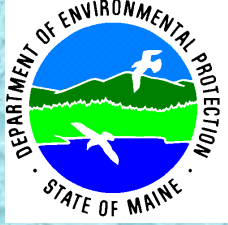


# The Casco Bay deposition site is part of the MEDEP's Southern Maine Air Monitoring Network



- Network includes:**
- Ozone**
  - Sulfur Dioxide**
  - Particulates**
  - Acid Deposition**
  - Mercury**
  - Hydrocarbons**
  - Nitrogen Dioxide**

# The deposition site is also part of the National Atmospheric Deposition Program - NADP

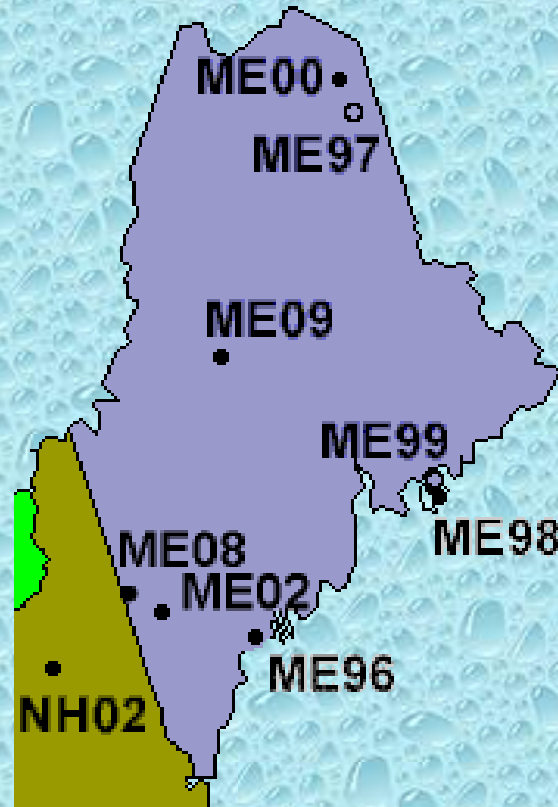


National Atmospheric Deposition Program

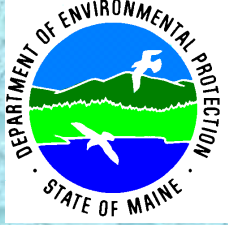
Not Shown:  
Alaska  
American Samoa  
Hawaii  
Puerto Rico  
Virgin Islands



- |              |                               |
|--------------|-------------------------------|
| <b>ME00:</b> | <b>Caribou</b>                |
| <b>ME02:</b> | <b>Bridgton</b>               |
| <b>ME08:</b> | <b>Gilead</b>                 |
| <b>ME09:</b> | <b>Greenville</b>             |
| <b>ME96:</b> | <b>Freeport</b>               |
| <b>ME98:</b> | <b>Acadia, McFarland Hill</b> |



Inactive: 97 Presque Isle; 99 Acadia Paradise Hill

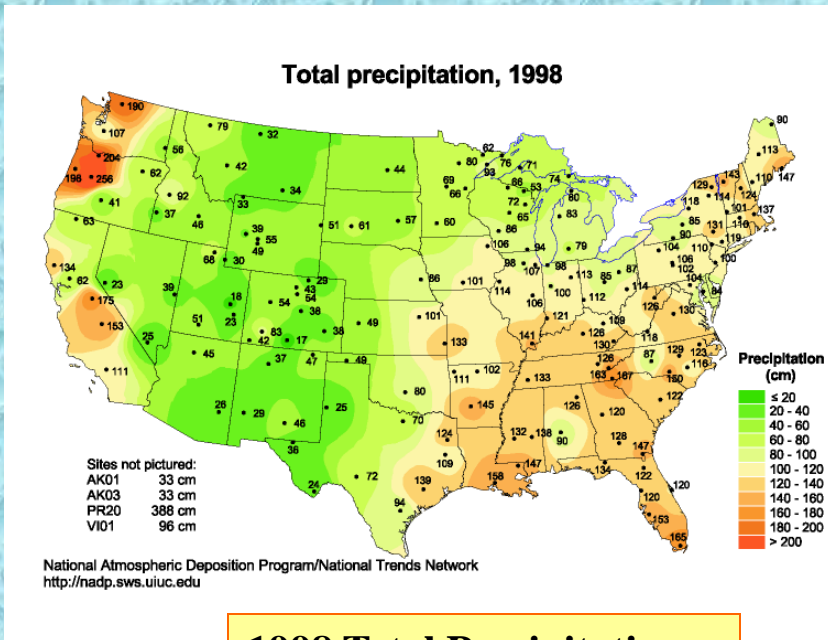


# NADP precipitation isopleth maps.

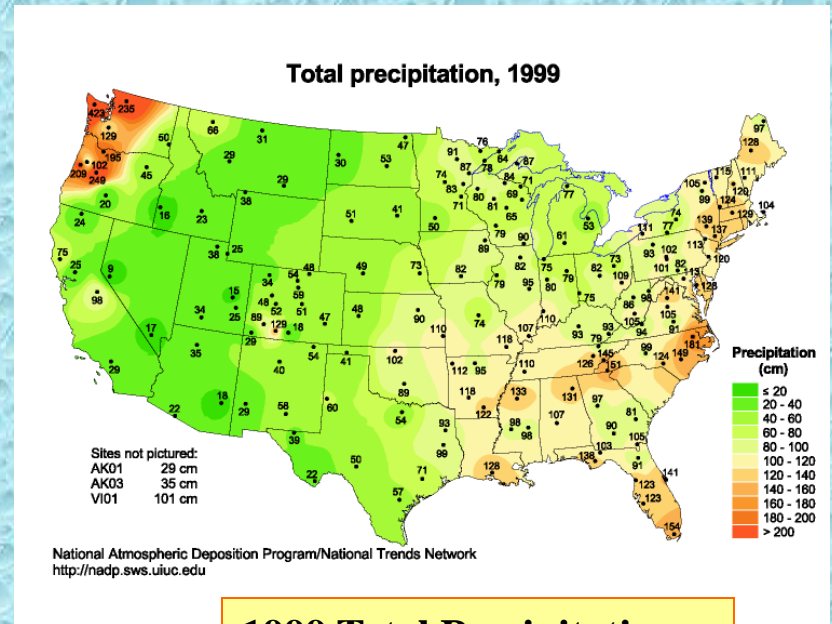
The CBDP data is in the box adjacent to the corresponding map



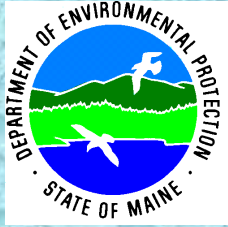
## NADP



**1998 Total Precipitation:  
128.7 cm**

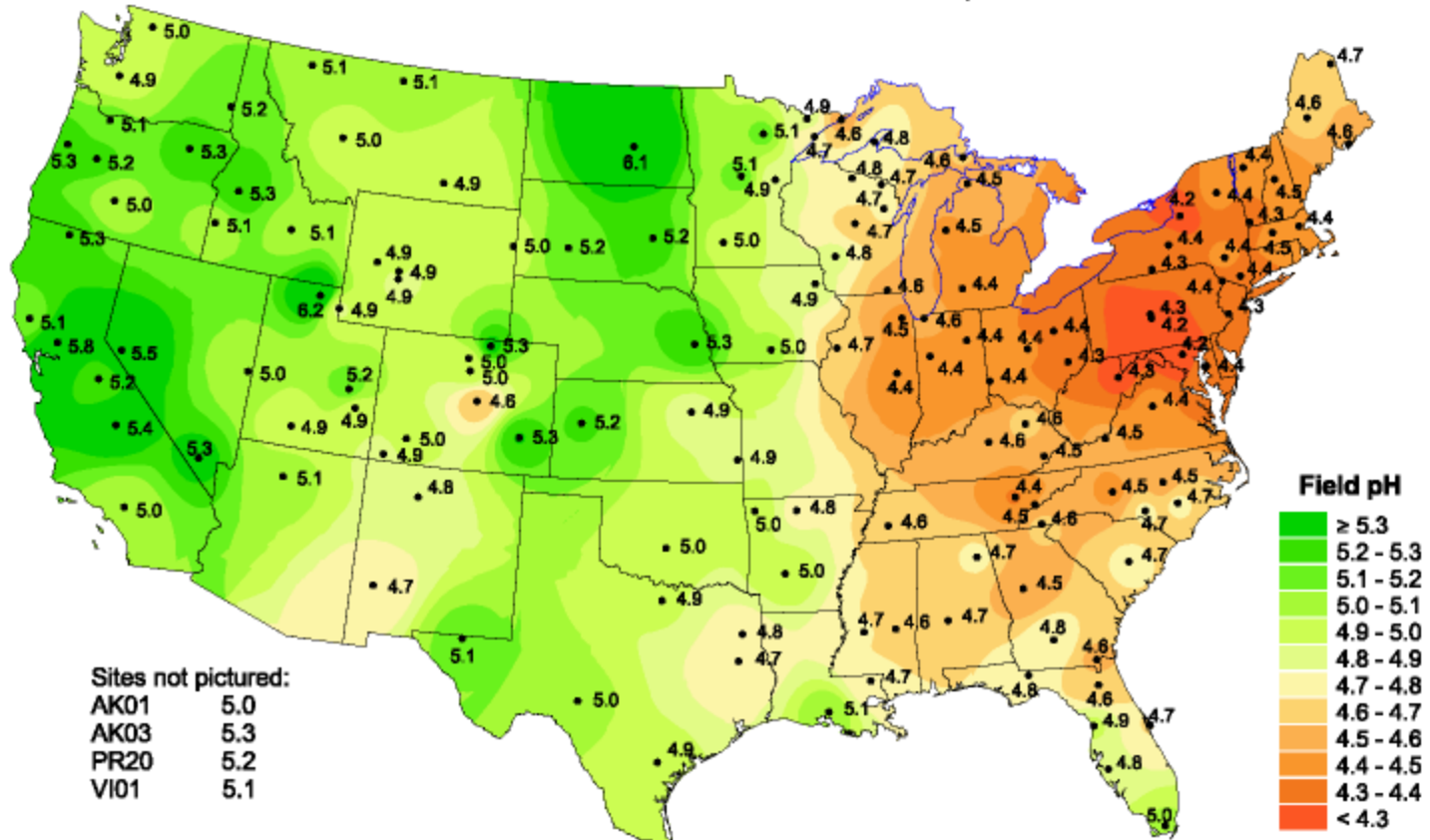


**1999 Total Precipitation:  
118.5 cm**



NADP

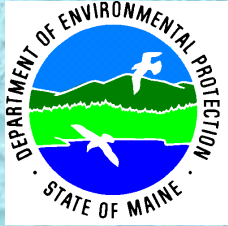
## Hydrogen ion concentration as pH from measurements made at the field laboratories, 1998



National Atmospheric Deposition Program/National Trends Network  
<http://nadp.sws.uiuc.edu>

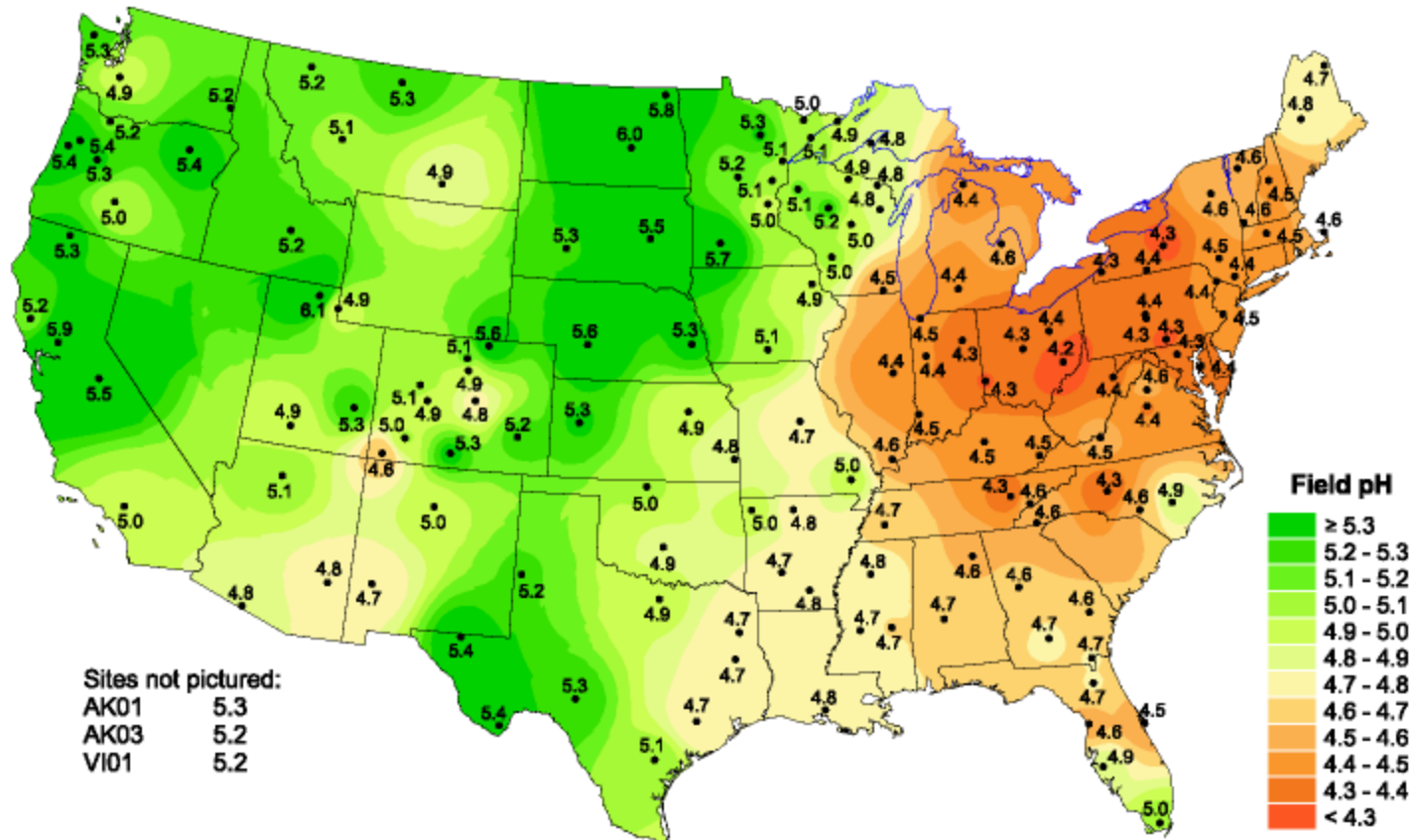
1998 Annual Average pH:  
**4.62**





NADP

## Hydrogen ion concentration as pH from measurements made at the field laboratories, 1999



National Atmospheric Deposition Program/National Trends Network  
<http://nadp.sws.uiuc.edu>

1999 Annual Average pH:  
**4.58**



## Deposition Trends



**Precipitation chemistry dominated by sulfates and nitrates**

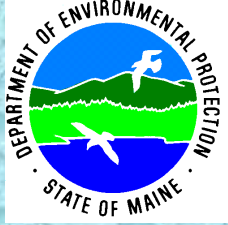
**NADP**



**Coastal marine environment has significant influence on precipitation chemistry (sodium and chloride 42% of measured species)**

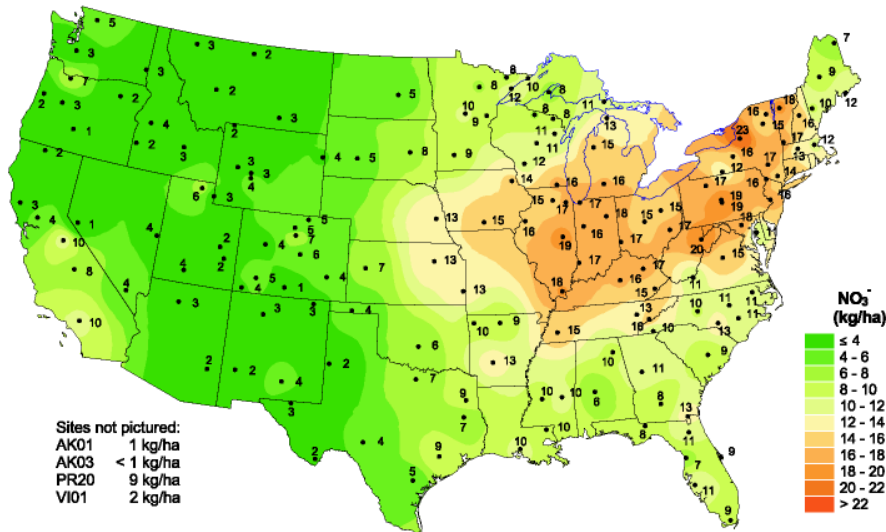


**East / West and North / South variations in precipitation chemistry across the state ( other pollutants like ozone show this kind of variation)**



NADP

### Estimated nitrate ion deposition, 1998



Sites not pictured:  
AK01 1 kg/ha  
AK03 < 1 kg/ha  
PR20 9 kg/ha  
VI01 2 kg/ha

National Atmospheric Deposition Program/National Trends Network  
<http://nadp.sws.uiuc.edu>

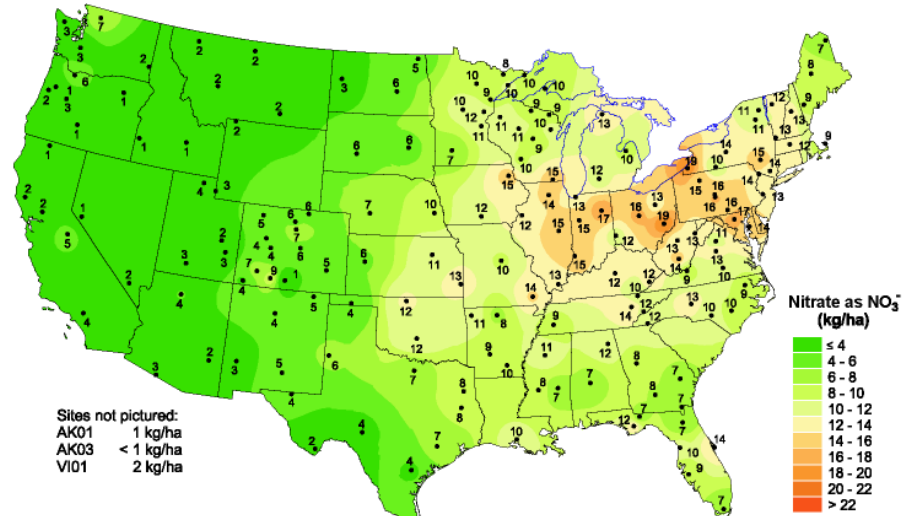
**1998 Nitrate Annual Average:**

**10.91 kg/ha**

**Highest seasonal average in 1998:**

**Summer: 3.71 kg/ha**

### Estimated nitrate ion deposition, 1999



Sites not pictured:  
AK01 1 kg/ha  
AK03 < 1 kg/ha  
VI01 2 kg/ha

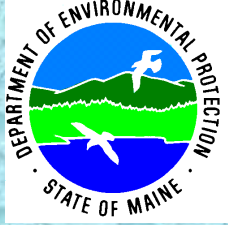
National Atmospheric Deposition Program/National Trends Network  
<http://nadp.sws.uiuc.edu>

**1999 Nitrate Annual Average:**

**11.09 kg/ha**

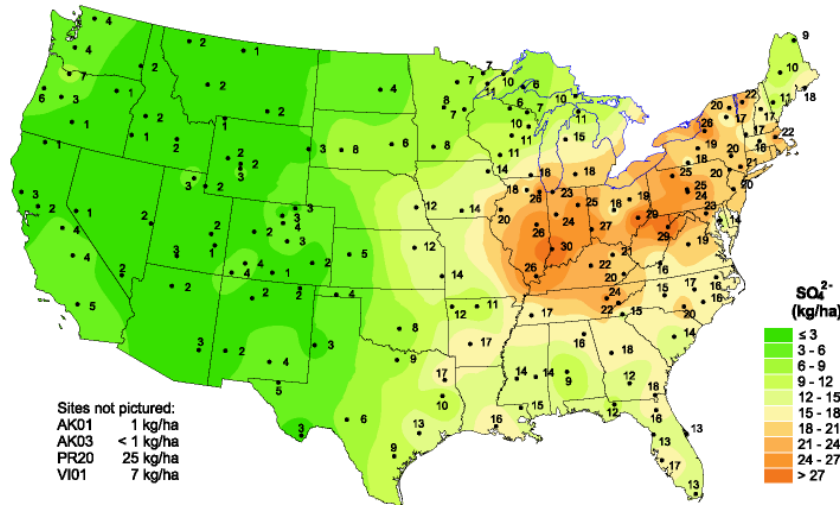
**Highest seasonal average in 1999:**

**Winter: 3.32 kg/ha**



NADP

### Estimated sulfate ion deposition, 1998



Sites not pictured:  
AK01 1 kg/ha  
AK03 < 1 kg/ha  
PR20 25 kg/ha  
VI01 7 kg/ha

National Atmospheric Deposition Program/National Trends Network  
<http://nadp.sws.uiuc.edu>

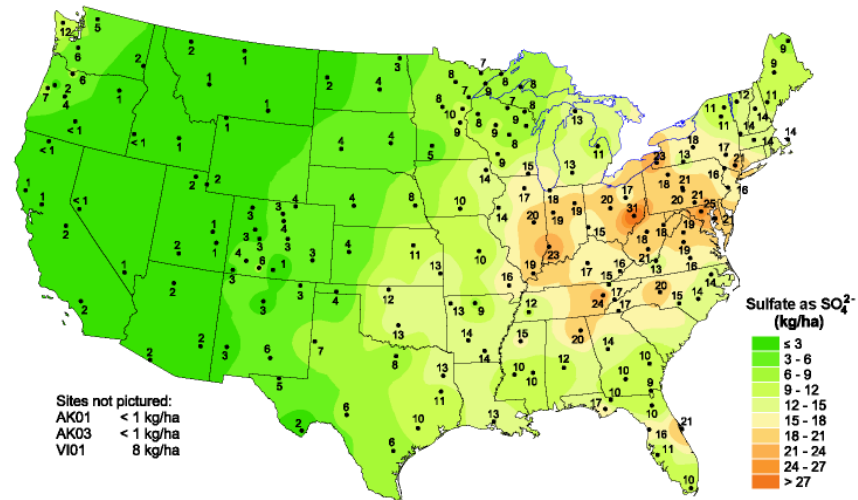
**1998 Sulfate Annual Average:**

**14.22 kg/ha**

**Highest Seasonal Average:**

**Summer - 6.24 kg/ha**

### Estimated sulfate ion deposition, 1999



Sites not pictured:  
AK01 < 1 kg/ha  
AK03 < 1 kg/ha  
VI01 8 kg/ha

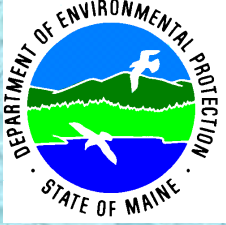
National Atmospheric Deposition Program/National Trends Network  
<http://nadp.sws.uiuc.edu>

**1999 Sulfate Annual Average:**

**14.44 kg/ha**

**Highest Seasonal average:**

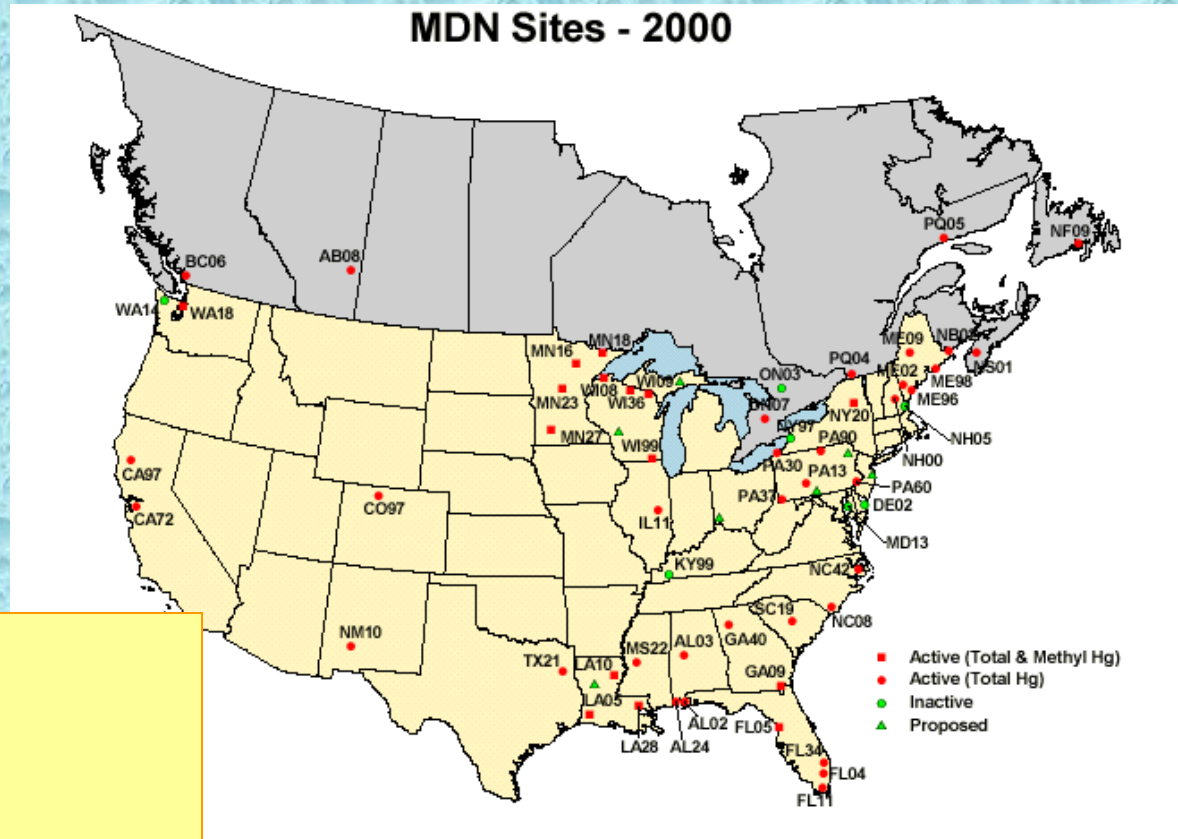
**Winter - 4.08 kg/ha**



# The CBDP is also part of the national Mercury Deposition Network.



MDN



- ME00:** Caribou
- ME02:** Bridgton
- ME09:** Greenville
- ME96:** Freeport
- ME98:** Acadia, McFarland Hill



**MDN**

✓ Fairly uniform annual concentration averages  
(nannograms per liter or ng/l) across the state in 1998:

Greenville 5.87 ng/l

Bridgton 6.56 ng/l

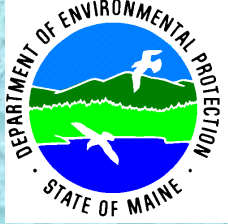
Freeport 7.78 ng/l

Acadia 6.06 ng/l

✓ Highest concentrations in summer months of  
June, July and August

✓ In 1998 Freeport had the highest annual  
deposition rate of 12.1 ug/m<sup>2</sup> (micrograms per meter  
squared)

✓ More pollutant and acidity laden precipitation  
tends to contain more mercury

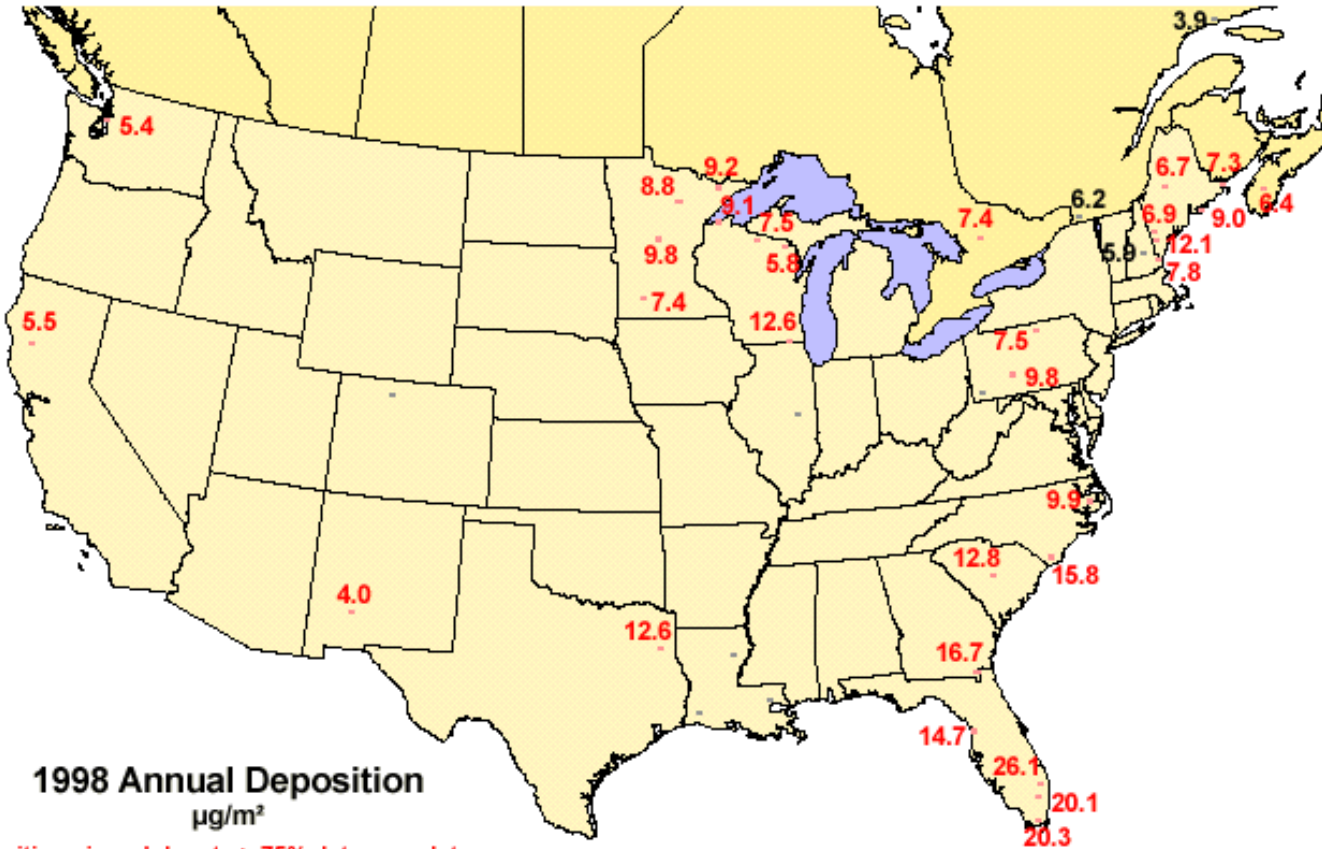


# 1998 Annual Deposition Values

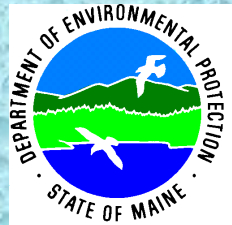


MDN

## National Atmospheric Deposition Program Mercury Deposition Network



Depositions in red denote > 75% data completeness

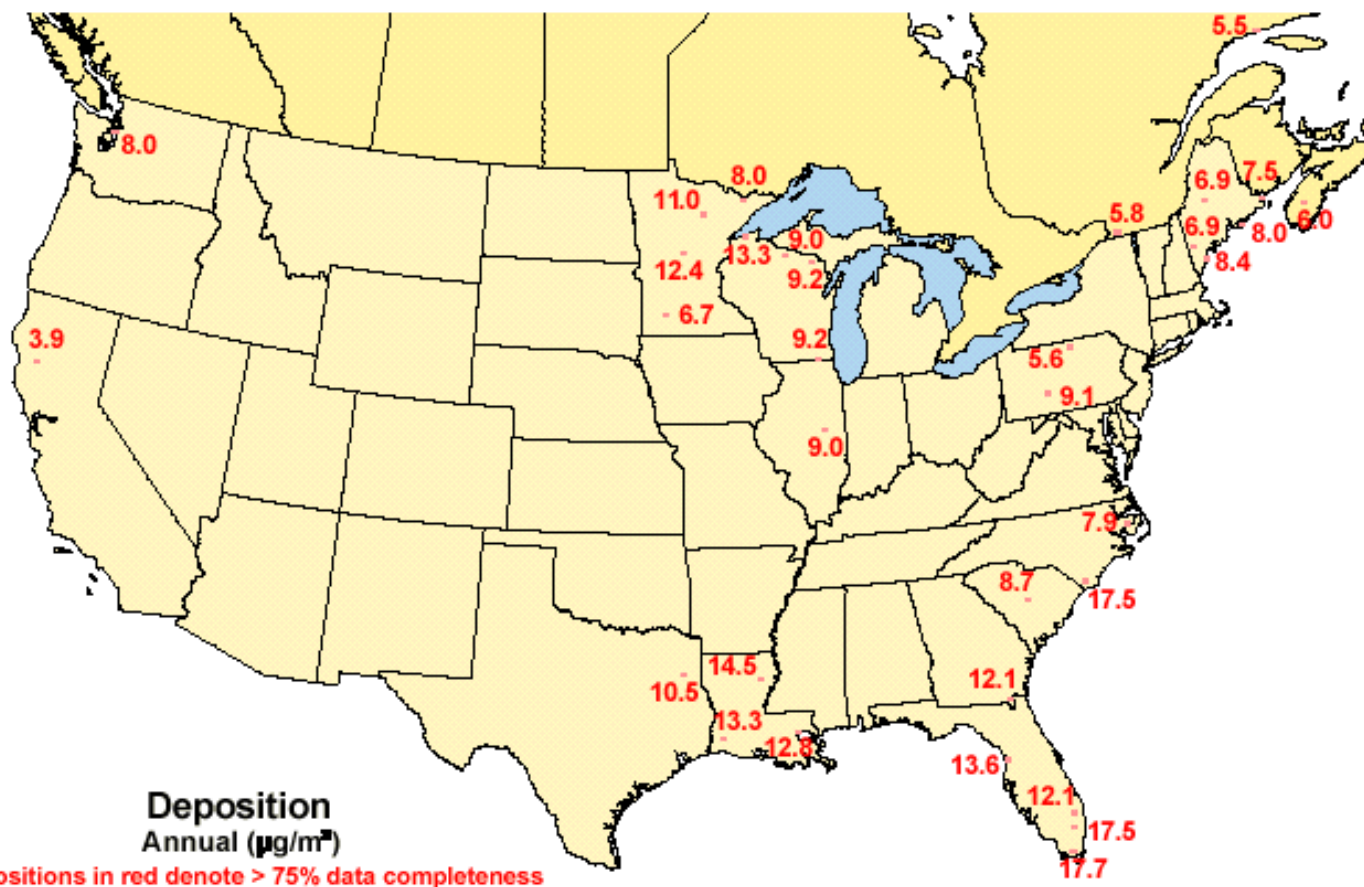


# 1999 Annual Deposition Values

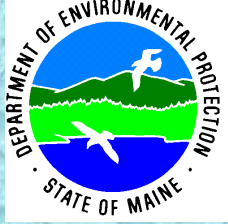


MDN

MDN - 1999





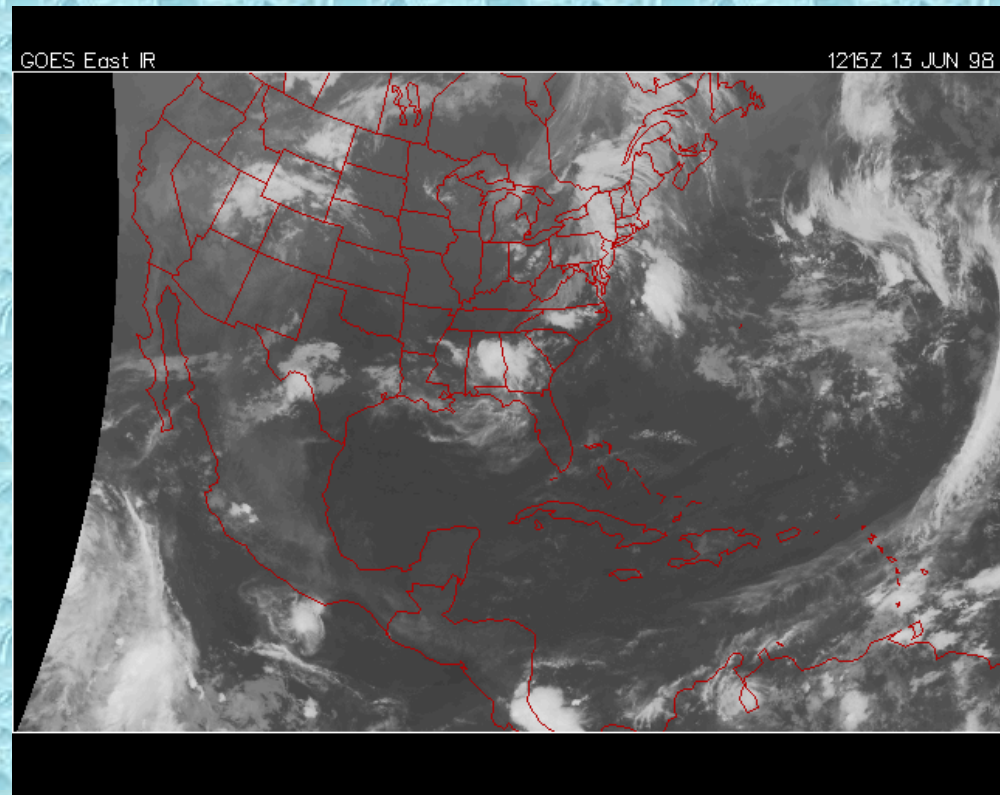


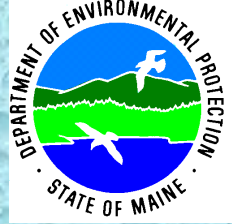
**2.208 ug/m<sup>3</sup> or 18% of the annual Mercury deposition occurred during the sampling period of 6/9/98 - 6/16/98.**



**MDN**

- ✓ June was 3rd wettest on record - 9.01 inches; 7 inches fell from 6/12 through 6/17
- ✓ On June 13th Freeport received 3.58 inches of rain



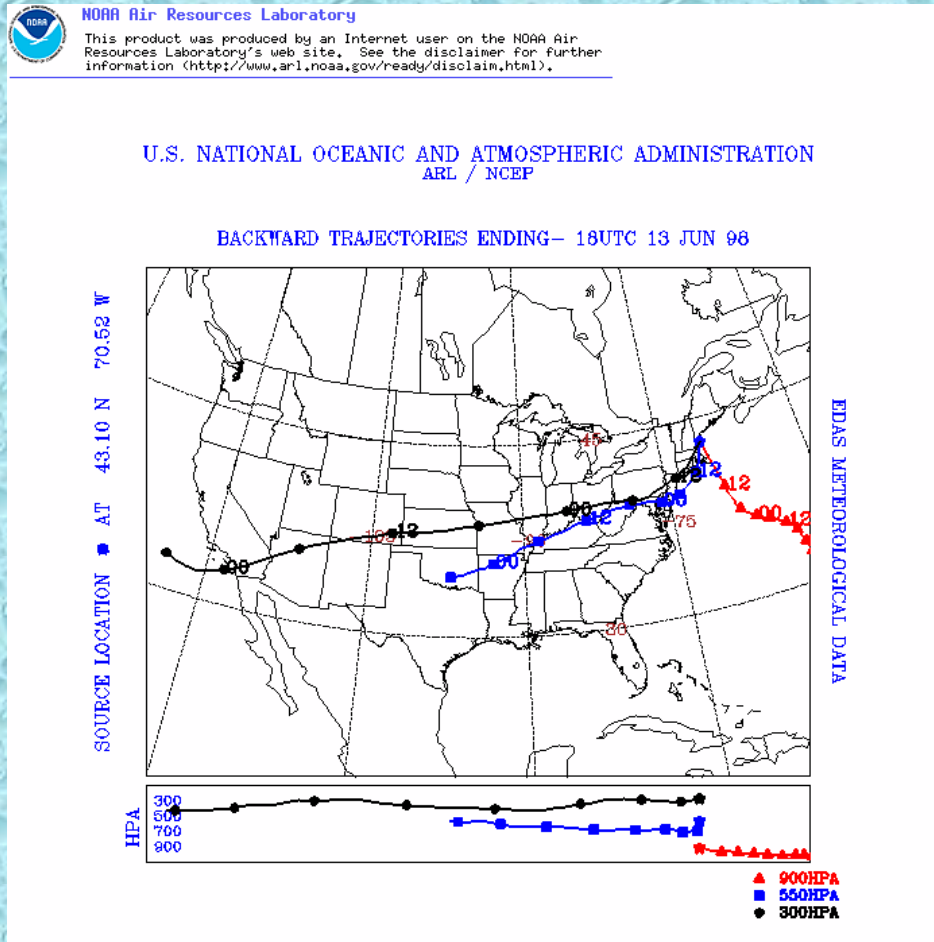


Trajectory map created by the READY HYSPLIT model. This is a back trajectory showing the origins of the system that produced so much rain.

[www.arl.noaa.gov/ready/hysplit4.html](http://www.arl.noaa.gov/ready/hysplit4.html)



MDN

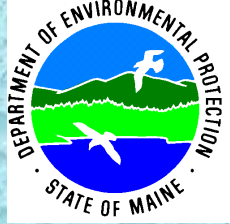


Red = 1000 m  
Blue = 5000 m  
Black = 10000 m



**NADP data corresponding to the sampling period of June 9, 1998 to June 16, 1998 and compared to annual averages for 1998:**

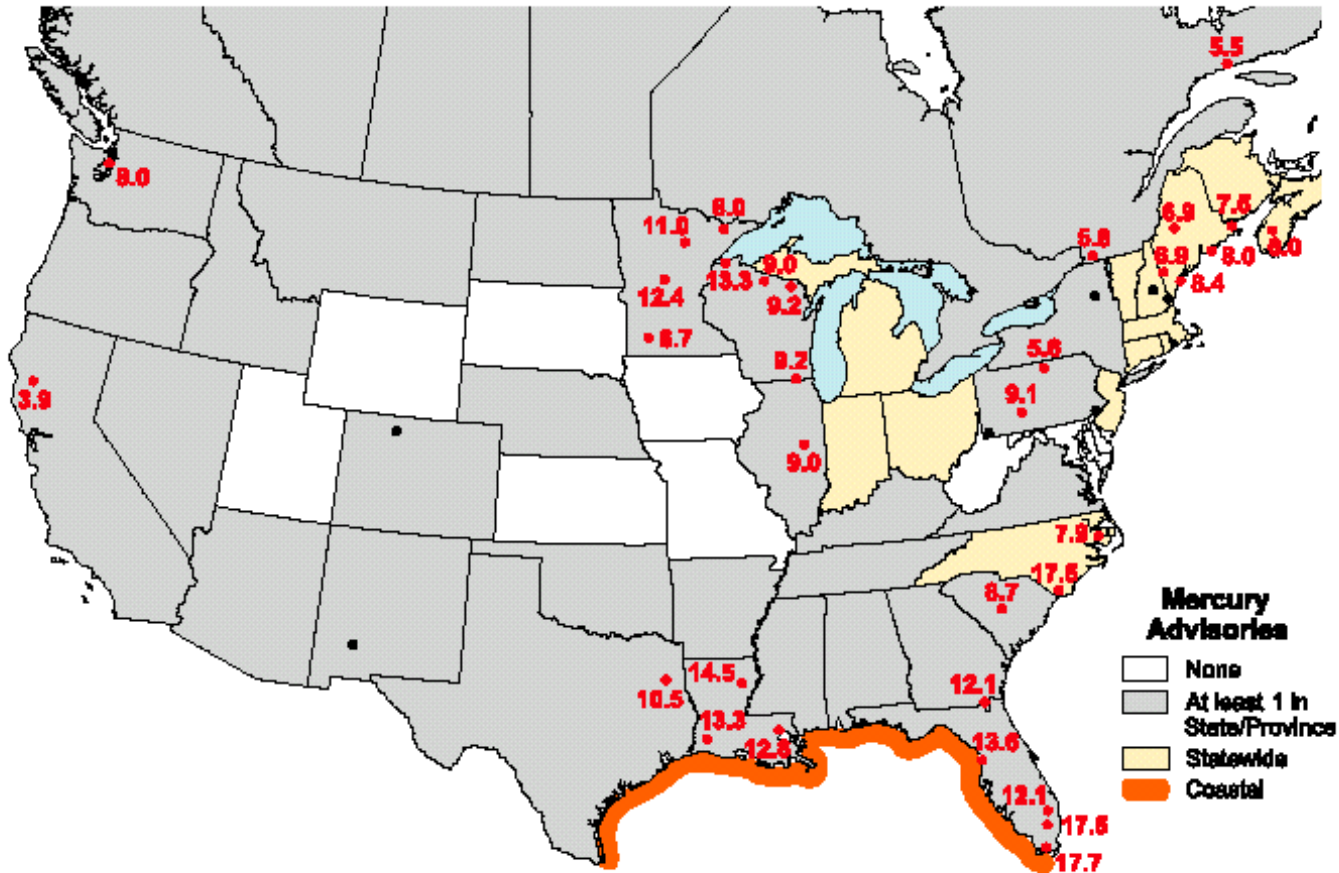
	<b>June</b>	<b>1998</b>
<b>pH:</b>	<b>4.65</b>	<b>4.62</b>
<b>Na</b>	<b>149.98 mg/m<sup>2</sup></b>	<b>775 mg/m<sup>2</sup></b>
<b>Cl:</b>	<b>258.68 mg/m<sup>2</sup></b>	<b>1305 mg/m<sup>2</sup></b>
<b>NO<sub>3</sub>:</b>	<b>86.69 mg/m<sup>2</sup></b>	<b>1090 mg/m<sup>2</sup></b>
<b>SO<sub>4</sub>:</b>	<b>154.11 mg/m<sup>2</sup></b>	<b>1422 mg/m<sup>2</sup></b>



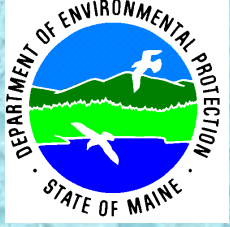
# Map showing Mercury Advisories and corresponding 1999 data:



MDN



National Atmospheric Deposition Program/Mercury Deposition Network

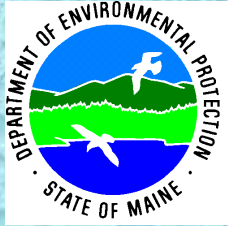


## **The CBDP is also a part of the Interagency Monitoring of Protected Visual Environments or IMPROVE network:**

### **IMPROVE**

- ✓ USEPA and National Park Service
- ✓ Measures the composition of visibility impairing aerosols
- ✓ Help identify sources of impairment on individual site, regional, and national scales
- ✓ Document trends

# Explanation of IMPROVE Sampling Modules:



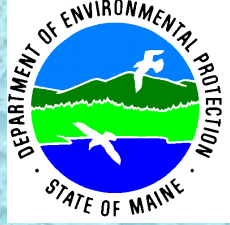
IMPROVE



IMPROVE Modular Aerosol Sampler

- **Module A**: PM<sub>2.5</sub> particles (0-2.5 5m) on Teflon. These are analyzed by five methods:
  - gravimetric mass for PM<sub>2.5</sub>
  - hybrid integrating plate/sphere method for optical absorption
  - Proton Elastic Scattering Analysis (PESA) for hydrogen
  - Proton Induced X-ray Emission (PIXE) for Na-Mn
  - X-Ray Fluorescence (XRF) for Fe-Pb
- **Module B**: PM<sub>2.5</sub> particles (0-2.5 5m) on nylon. A denuder before the nylon filter removes nitric acid vapors. These are analyzed by ion chromatography (IC) at Research Triangle Institute for nitrate (NO<sub>3</sub>-), chloride (CL-), sulfate (BSO<sub>4</sub>), and nitrite (NO<sub>2</sub>-).
- **Module C**: PM<sub>2.5</sub> particles (0-2.5 5m) on quartz. These are analyzed by at Desert Research Institute for carbon using the Thermal Optical Reflectance (TOR) combustion method. A secondary filter at selected sites is used to determine artifact. These are reported in 8 temperature categories.

# IMPROVE composition at Freeport



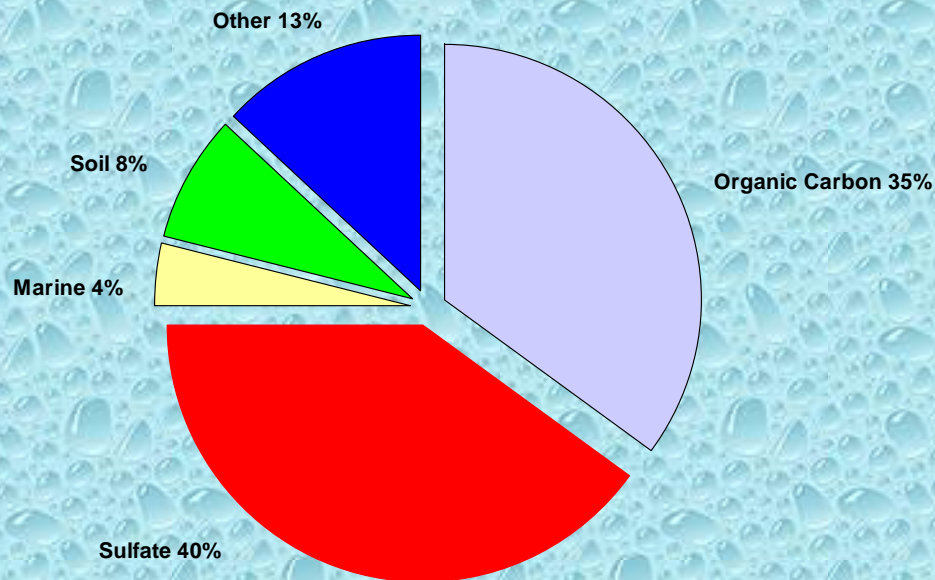
**Fine aerosol composition is dominated by pollutants from human activities**

**Levels of airborne pollutants at Freeport are generally lower than those found in urban areas such as Boston**

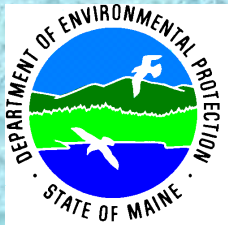
**Air mass trajectory analysis indicates that both regional and long range source regions influence pollutant levels in and around Casco Bay**



**IMPROVE**



**Aerosol Composition in Freeport, Maine**



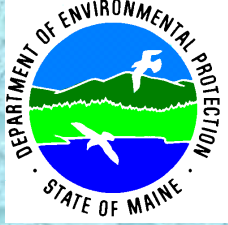
## **IMPROVE Caveats (Byard Mosher Data Report 9/27/00) :**



- 1. Fine Mass values may be suspect. Sum of Species values are much greater than the FM totals.**
- 2. Mercury values are suspect and much higher than values reported from other studies in the Northeast.**







# Comparison of CBDP Fine Mass data to National data trends:



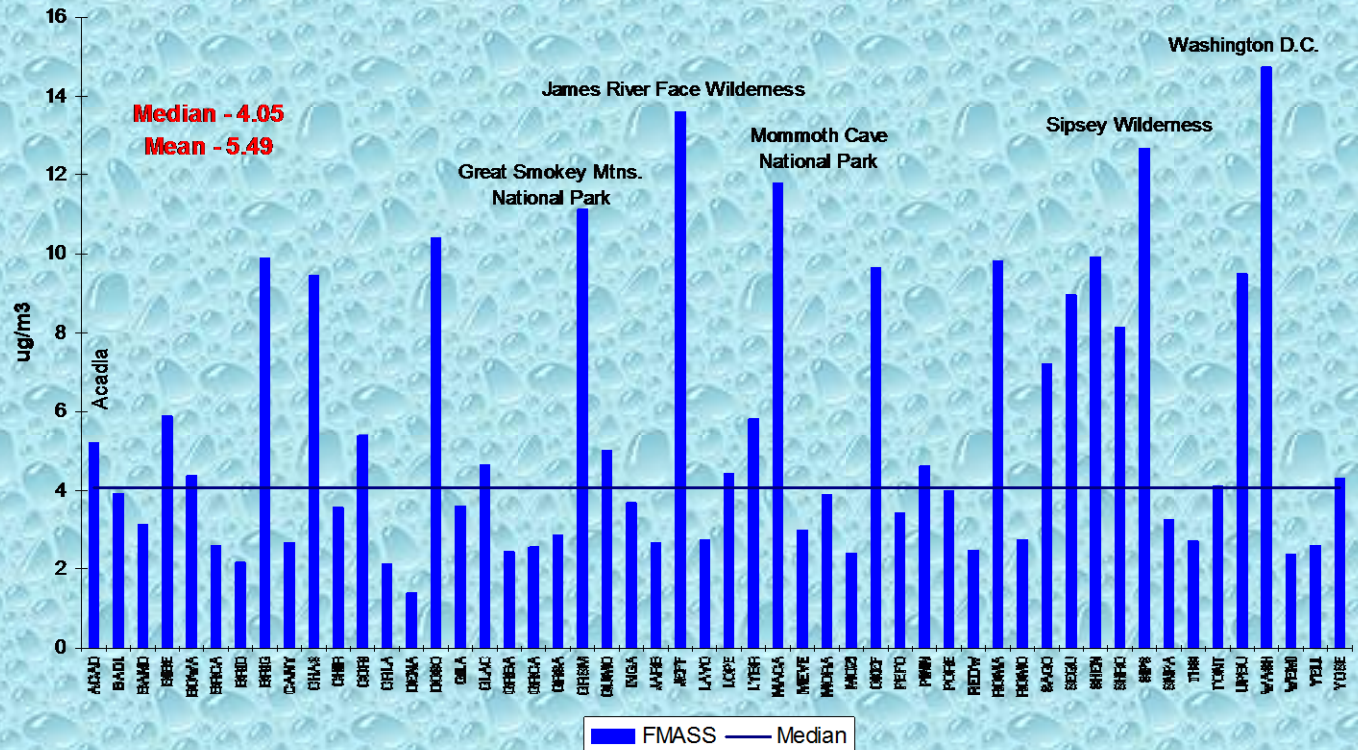
IMPROVE

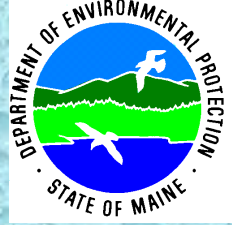
**1/98 -6/99 CBDP  
Fine Mass:**

**Median 3.5**

**Mean 5.05**

**5-Year Annual Average 1995 - 1999  
NPS Sites  
Fine Mass**



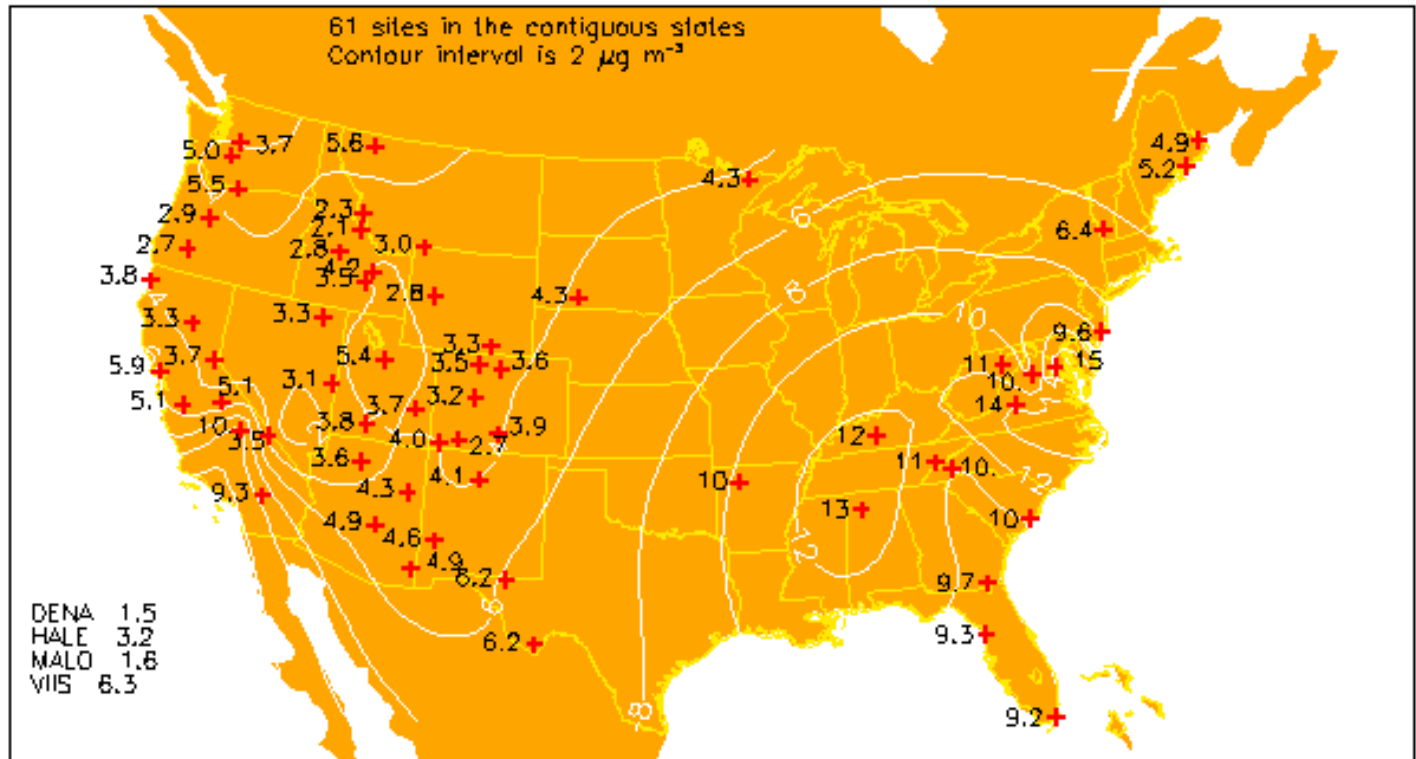


# IMPROVE Fine Mass isopleth map:



IMPROVE

IMPROVE 1994 to 1998 Annual FM Median



NPS ARD Fort Collins CO, Mon Aug 30 17:47:04 1999



## PAH Monitoring Configuration

**Dan S. Golomb and Eugene F. Barry**  
- Principal Investigators

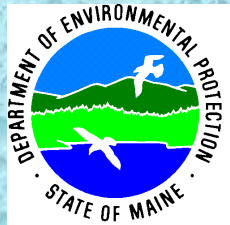
**University of Massachusetts - Lowell**



**Figure 1.** The UML wet/dry collector



**Figure 2.** The interior of the dry collector



PAH

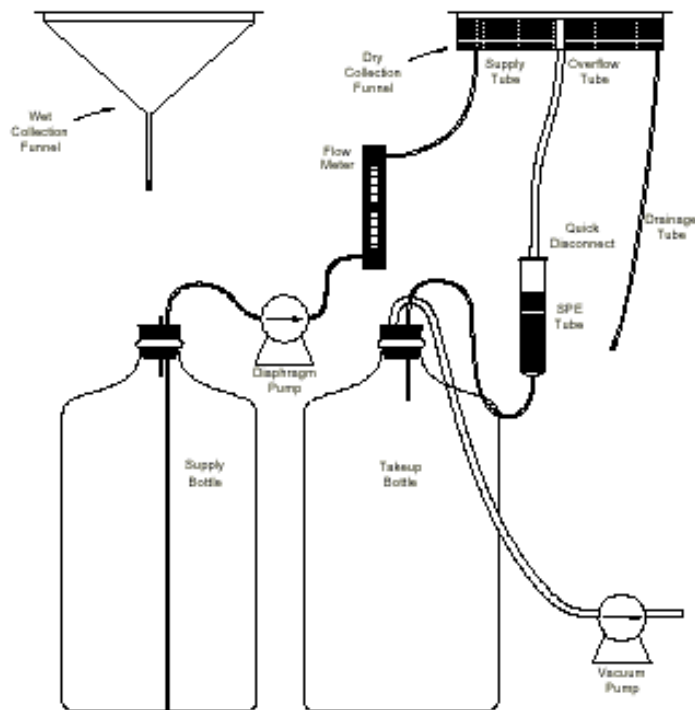


Figure 1. Schematic of UML wet/dry collector

Wet deposition runs into a funnel that drains into a temperature controlled, shielded collection flask. Dry deposition onto the surface of a funnel continually filled with purified water. The overflow (collection surface) is caught by the receiving flask. (Simulating the ocean surface)

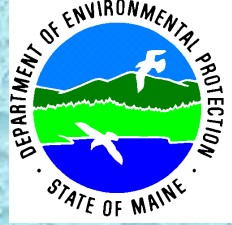


PAH

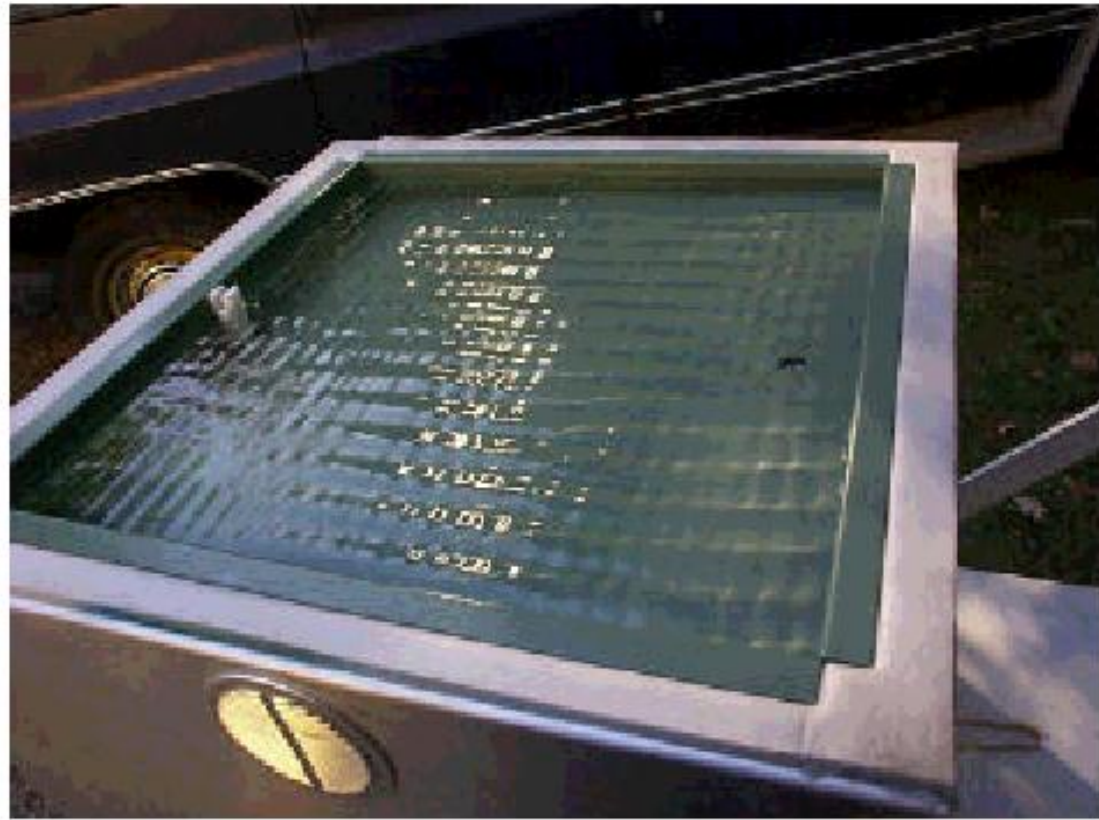


Figure 2. Photo of UML wet/dry collector

Photo of wet /dry PAH collector

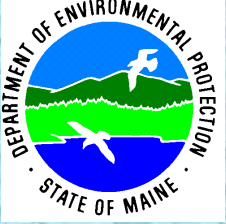


PAH



**Figure 3.** Top view of the dry collector

## PAH Monitoring Summary:



- ✓ A modified precipitation collector designed by Dr. Dan Golomb (UMass-Lowell) was deployed at the Freeport site for one year
- ✓ 16 dry deposition and 12 wet deposition samples were collected between March 1998 and February 1999
- ✓ Dry PAH deposition at Freeport was lowest during the summer and highest during the winter months
- ✓ Dry deposition rates at more urban locations (Boston area) are much higher than those found at Freeport, suggesting that local emissions are a major source for PAHs in dry deposition
- ✓ There was no clear seasonal variation in wet deposition of PAHs at Freeport
- ✓ Precipitation amount does not appear to influence PAH concentrations in precipitation
- ✓ No definitive source(s) for the PAHs found in wet and dry deposition at Freeport could be identified



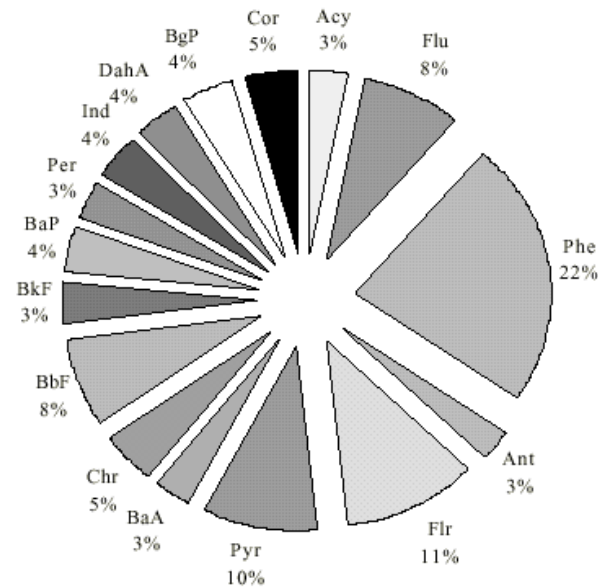
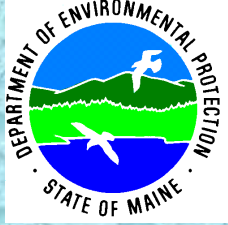


Figure 4. Average annual composition of PAH species in wet deposition

There was very little difference between the average annual composition of PAH species in the wet and dry deposition.

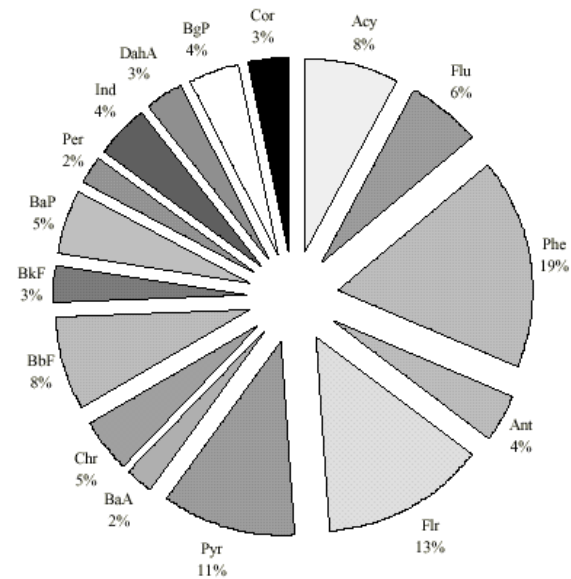
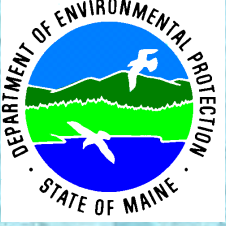


Figure 5. Average annual composition of PAH species in dry deposition



## **Summary of Preliminary Results from the Casco Bay Air Deposition Study**

- **Coastal regions of Maine experience higher concentrations and deposition of pollutants compared with in-land sites.**
- **Both fine particle and precipitation chemistry at Freeport are dominated by man-made pollutants.**
- **The deposition of Nitrogen and Mercury to Casco Bay is significant and comparable in magnitude to point source inputs.**
- **Regional sources of airborne pollutants appear to be varied and complex. Both nearby sources such as metropolitan areas along the eastern seaboard and more distant sources, such as the industrialized Ohio River Valley, are important.**

