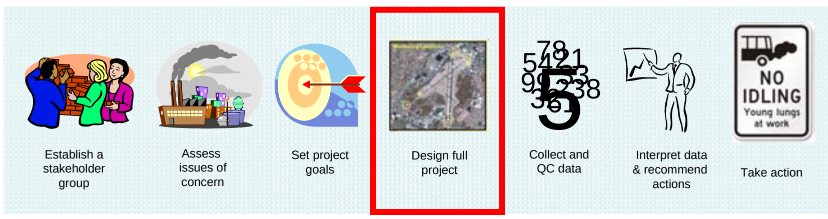
Monitoring Strategy and Design

- Developing a monitoring strategy
- Selecting pollutants of interest
- Standard air toxics sampling and analysis techniques
- Selecting frequency and duration of sampling
- Importance of meteorological measurements
- Leveraging with other studies
- Building quality into the plan



Developing a Monitoring Strategy

The monitoring strategy is a function of

- Project objectives
- Size of area to be assessed
- Number and distribution of sources
- Existing monitoring
- Number and types of pollutants
- Specificity, sensitivity of analytical technique
- Sampling frequency and duration
- Magnitude of concentration expected
- Available resources ($, manpower, schedule)

Nine Steps for Designing an Air Toxics Monitoring Project

1. Engage all stakeholders
2. Agree on project goals
3. Develop data quality objectives
4. Develop several measurement approaches; evaluate costs, resources, schedule; and select best alternative
5. Include plan to use all (collected and available) data during data interpretation

Nine Steps for Designing an Air Toxics Monitoring Project (cont.)

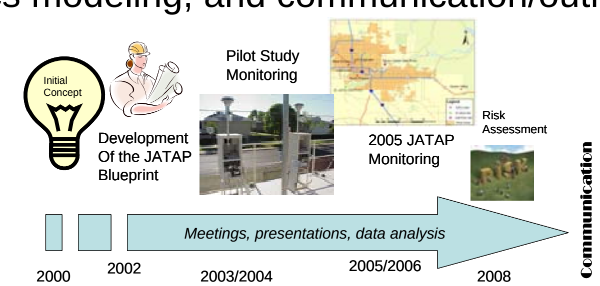
6. Ensure that you will get an answer, even if your prior understanding is wrong
7. Plan for time to share preliminary results with all stakeholders
8. Vet final plan with stakeholders
9. Develop actionable recommendations

Toxics Monitoring Measurement Design Issues to Address

- Understand detailed objectives, when results are needed, the audience for results, etc.
- When does the impact of interest occur? Annual, seasonal, daily, diurnal, short- or long-term, etc.
- Where is the impact of interest relative to the monitoring location?
- What are the available funds and resources?

Project Strategy: JATAP

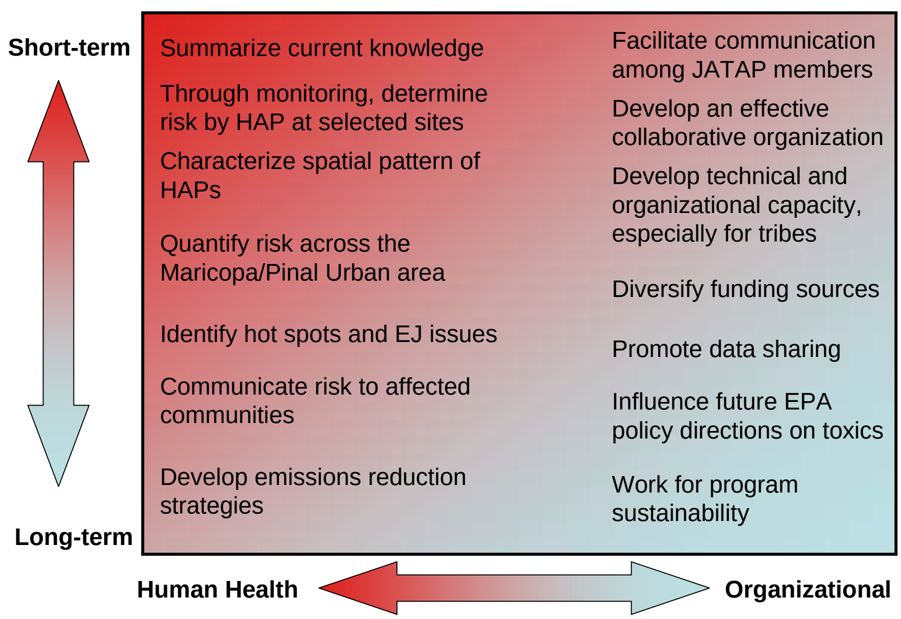
- The JATAP steering committee developed a four-year research road map, or blueprint.
- The blueprint originally called for nine monitoring sites, emissions inventory development, air toxics modeling, and communication/outreach.



Project Strategy: JATAP (cont.)

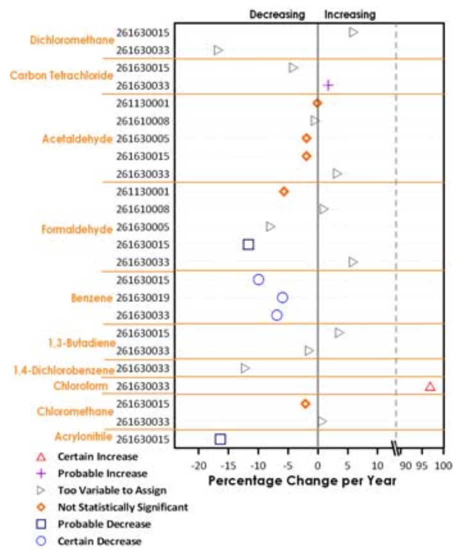
- A pilot study was run for a year at a small number of sites
- For the larger-scale study, monitoring was to be conducted for at least a full calendar year
  - focus on annual average concentrations for comparison to chronic risk levels
- Tribal sites, analysis of Tribal data, and their data reports were originally handled separately

JATAP Objectives and Strategies

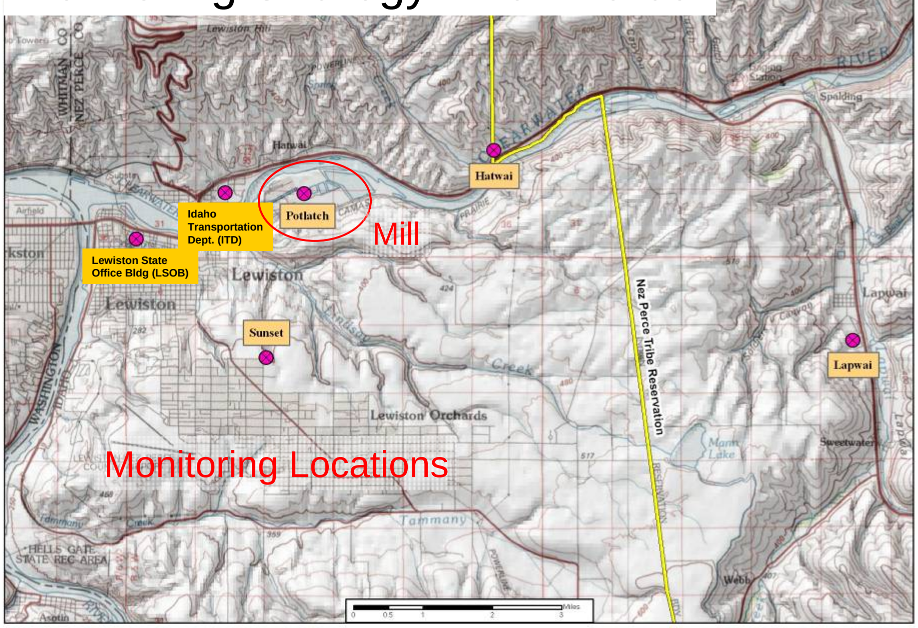


Monitoring Strategy: Michigan

- The Michigan DEQ project did not entail new monitoring because it focused on data analysis.
- The data analysis strategy built upon previous projects and was designed (partly) to address unanswered questions.



Monitoring Strategy: Nez Perce



View from Lewiston Hill to the south over Lewiston, ID, and Clarkston, WA

Data Quality Objectives

- EPA has developed and refined a framework for planning data collection known as the Data Quality Objective (DQO) process.
- The DQO process addresses the project planning cycle for a project from problem statement through the data collection design with a goal of providing data of sufficient quality for decision-making.

DQO Process

1. State the problem.
   – *Concisely describe the problem to be studied.*
   – *Review prior studies and existing information to gain sufficient understanding to define the problem.*
   – *Why are new data needed?*
2. Identify the decision.
   – *What questions will the study attempt to resolve with this data?*
   – *What actions may result?*

DQO Process (cont.)

3. Identify inputs to the decision.
   – *What information is needed?*
   – *What measurements are required to resolve the decision statement?*
4. Define study boundaries.
   – *What are the study's time periods and spatial area?*
   – *Where and when should data be collected?*

DQO Process (cont.)

5. Develop a decision rule.
   – *"If x happens, then y will be done."*
6. Specify limits on decision errors.
   – *What are acceptable levels of uncertainty? (Consider consequences of making an incorrect decision.)*
7. Optimize the study design.
   – *Balance resources and study design.*
   – *Choose the most resource-effective design that meets all DQOs.*

DQO Example

- Southeastern States Regional Air Toxics Analysis
  – Meta-analysis of existing air quality measurements from southeastern states
  – Two categories of DQOs for different types of analyses; quantitative and qualitative

- Balance DQO requirements with data availability
  – For example, data with >50% below MDL included but colored or flagged
- Quantitative results had more stringent DQOs than qualitative

Quantitative	Qualitative
Statistical summaries	NATA comparison
Annual trends	Spatial variability
National perspective	Effectiveness of control strategies
Comparison to health benchmarks	
MDL comparison	

Monitoring Strategy

- **Physical location characteristics** – geophysical setting, meteorology, types and characteristics of sources, and existing monitoring programs.
- **Precision and accuracy** – how precisely or accurately do pollutants need to be measured to meet DQOs?
- **Sampling plan** – pollutants, sampling frequency and duration, length of campaign, and monitoring and analytical methods.
- **QA/QC** – quality assurance project plan (QAPP), standard operating procedures (SOPs), audits, intercomparisons, collocated data requirements, QA programs for analytical laboratories, and data validation guidelines for ambient data.
- **Options for data analysis and exploration** – including available tools, data analyses, data needs, and training needs.

Monitoring Platforms

fixed (long-term) sites

movable platforms

temporary sites

vehicles

carried by individuals

Sampling Options

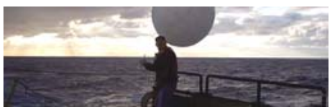

Passive


Active

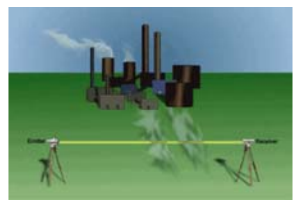

Grab sample


Integrated

Direct-read instruments


Manual


Automated


Open path

Example Considerations When Selecting Monitoring or Sampling Options

- Passive samplers – advantages
  - Inexpensive, compact, portable
  - Useful for assessing personal and environmental exposures over varying time frames (e.g., one day to two weeks)
  - Useful for assessing average spatial variations in pollutant concentrations
- Passive samplers – disadvantages
  - Do not provide information for trace levels of pollutants or for short time frames
  - Available pollutant list is relatively limited

Monitoring Tips

- Build adequate time into your plan
  - to acquire equipment
  - to perform bench and field tests to ensure the equipment operate as expected
  - to obtain adequate training for equipment new to you (e.g., timers, data acquisition system)
- Develop plan for sample storage, shipping, and handling
- Include quality assurance plans

"In trace level pollutant sampling, the little things matter."

Sampler/Monitor Placement

- At receptors of concern
- Near the source
- At existing sites, if parameters of interest are not measured there
- To augment existing measurements

How Many Sites Do I Need?

A function of the following:

- Resources, funds, people
- Distance between source and receptor
- Need for background measurement
- Location of receptors of concern (e.g., receptors only in direction of predominant wind or in multiple directions?)
- Expected spatial gradients (due to wind direction, wind speed, geography, etc.)
- Statistical power needed for results

Monitoring Scales

Monitoring scale is the area represented by the data collected at the site (varies by pollutant). *More important for projects that are trying to characterize neighborhood/urban level.*

Collocated	1 to 10 m
Micro-scale (i.e., near-source)	10 to 100 m
Middle-scale (i.e., gradients from sources such as roadways)	100 to 500 m
Neighborhood-scale	500 m to 4 km
Urban-scale	4 to 100 km
Regional-scale	100 to 1,000 km

Frequency and Duration of Sampling Considerations

The following example alternatives are based on about $80,000-120,000 plus in-kind resources (labor, existing sites, etc.), or the equivalent of about 264 24-hr canisters in one year, including 10% QA.

Method	Frequency	Duration	Operating Period	No. Samples per site	# of Sites
TO-15	1-in-12 day	24-hr	One Year	30	8
TO-15	1-in-6 day	24-hr	One Year	60	4
TO-15	1-in-3 day	24-hr	One Year	120	2
TO-15	Daily	24-hr	One Month	30	8
TO-15	1-in-2 day	24-hr	One Month	15	16
Auto-GC (FID)	1-hr	1-hr	Three Months	2400	1
Passive	Weekly	164-hr (1 week)	One Year	52	20

Note the trade-off between # of samples and # of sites for a given budget.

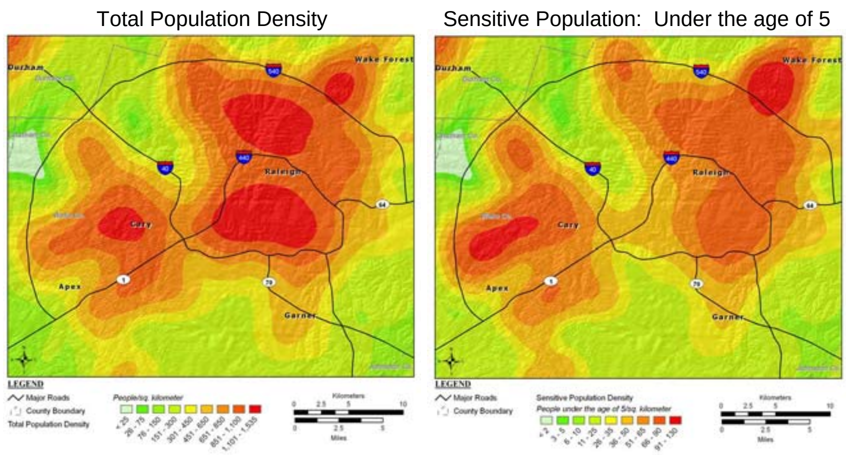
Frequency and Duration of Sampling Considerations (cont.)

The following example alternatives are based on about $80,000-120,000 plus in-kind resources (labor, existing sites, etc.), or the equivalent of about 264 24-hr canisters in one year, including 10% QA.

Project Objective	Method	TO-15 24-hr					Auto-GC	Passive
	Data Needed	1-in-12	1-in-6	1-in-3	1-in-2	Daily	Hourly	Weekly
Health effect assessment	Annual averages, multiple sites	X	X	\				X
Community baseline	Annual averages, multiple sites	X	X	\				X
Characterizing emissions sources	Temporally or spatially resolved, meteorology			\	X	X	X	
Support exposure modeling and evaluation efforts	Multiple sites, temporal resolution		\	X	X	X		

No one alternative meets all objectives.

Example: Potentially Different Locations for Different Segments of the Population



Selecting Pollutants of Interest

- Defined by your project goals
- Are additional pollutants needed to meet project goals?
  - Validating emissions profiles
  - Characterizing confounding factors/source types
  - Providing adequate data for source apportionment

Selecting Pollutants of Interest (cont.)

Measurement technique partially defines the time-resolution, cost, and specificity of analysis

- Are detection limits sufficient to quantify at levels of concern?
- Is technology available to meet required detection limits?
- Are data reporting practices consistent with needs?

Other Pollutants to Consider (and Why)

- Chemical markers for sources
  - Ni, V for oil combustion
  - SO_2 for high-sulfur content fuel combustion
  - Al, Si, Ca for soil
  - Black or elemental carbon for gasoline, diesel fuel combustion
  - CO, NO_x for combustion
- Additional species
  - If performing analysis of air samples for air toxics, consider expanding the analysis to include non-toxic VOCs to aid in source identification

Sampling and Analysis Techniques

- Because air toxics are present in the atmosphere in gaseous, particulate, and semi-volatile form, no single measurement technique is adequate.
- EPA offers 17 approved sampling and analysis methods for toxic gases; among the most commonly used methods are the following:
  - **Compendium method TO-11A.** Used to measure formaldehyde and other carbonyl compounds.
  - **Compendium method TO-13A.** Used to measure Polycyclic Aromatic Hydrocarbon (PAH) compounds.
  - **Compendium method TO-15.** Created to target 97 compounds on the list of 187 hazardous air pollutants.

Sampling and Analysis Techniques (cont.)

- EPA-approved methods for collection and analysis of suspended particulate matter are documented in the "Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air."
  - Chapter IO-3, Chemical Species Analysis of Filter-Collected Suspended Particulate Matter (SPM), is of considerable importance to the air toxics ambient monitoring program.
  - Several different methods for speciated particulate analyses are available.
  - Each have advantages and disadvantages depending on the target analytes and desired minimum detection limits.
  - For Hazardous Air Pollutant (HAP) metals, IO-3.5 (Inductively Coupled Plasma / Mass Spectrometry [ICP/MS]) offers the lowest detection limits.

Example Priority HAPS	1 in a million Cancer Risk Threshold (ug/m3)	Noncancer Threshold HI=1 (ug/m3)	Analysis Method	MDL (ug/m3)	Modeled Cancer Risk (in a milion)	Modeled Noncancer Risk (HI)
Acrolein		0.02	TO-15[1]	0.07		5.78
Coke oven	0.0016		NA	NA	1.86	
Diesel PM [a]	0.0033	5	NIOSH 5040[2]	0.4	NA	NA
POM[b]/PAH	0.000010		TO-13A[3]	0.0000024	1.34	
Chromium 6	0.000083	0.1	Modified CARB Method 039	0.000011	1.65	0.00081
Hydrazine	0.00020	0.2	OSHA 108	0.076	5	
Chlorine		0.2	NIOSH 6011	0.02		0.0998
Nickel compounds	0.006	0.065	IO-3.5	0.00023	0.15	0.01477
Arsenic Compounds	0.00023	0.03	IO-3.5	0.000079	0.38	
Benzidine	0.000015	10	TO-13A (XAD)	0.25	0.02	
Ethylene oxide	0.011	30	NIOSH 1614	0.04	0.45	
2,4-Toluene Diisocyanate	0.091	0.07	NIOSH 5522	0.000020	0.03	0.04
Cadmium compounds	0.00056	0.02	IO-3.5	0.000058	0.16	
Hexamethylene 1-6-diisocyanate		0.01	NIOSH 5522	0.000040		0.0065
Triethylamine		7	OSHA PV2060	0.20		0.00059
1,3-Butadiene	0.033	2	TO-15[1]	0.080	3.99	
Hydrochloric acid		20	NIOSH 7903	0.000012		0.0009
Maleic anhydride		0.7	NIOSH 3512	0.000043		0.0062
Manganese compounds		0.05	IO-3.5	0.000095		0.038
Perchloroethylene	0.200	270	TO-15[1]	0.43	1.54	
Antimony		0.2	IO-3.5	0.000083		0.00032
Benzene	0.143	30	TO-15[1]	0.29	10.46	
Formaldehyde[c]	0.077	9.8	TO-11A	0.010	0.00006	0.152
Naphthalene	0.029	3	TO-13A	0.00000019	2.19	0.021
Carbon Tetrachloride	0.067	40	TO-15[1]	0.33	3.29	

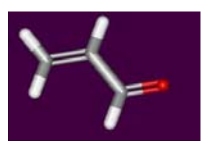
[a] Based on CALEPA URE
[b] POM cancer threshold utilized most potent compound
[c] Uses IRIS value that is undergoing review

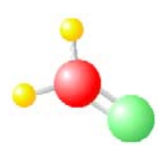
[1] SIM mode
[2] Particulate Diesel as elemental carbon
[3] Total of all PAHs using PUF

Jones (2006)

Sampling and Analysis Issues

- Acrolein is an analytical challenge. See EPA's website for current discussions and guidance: http://www.epa.gov/ttn/amtic/airtox.html
- Effective methods for hexavalent chromium have been developed, and discussion is also available on the above website.
- Continuous formaldehyde measurements remain a challenge.





Selecting Frequency and Duration of Sampling

The duration of a monitoring program is a function of

- Monitoring objectives
- Number of samples needed for analysis and certainty
- Frequency at which samples are collected
- Resources available

Selecting Frequency and Duration of Sampling (cont.)

- Continuous data (e.g., 1-hr) are useful for
  - wind sector and trajectory analyses
  - investigating diurnal variation
  - tying pollutant concentrations to meteorological conditions (e.g., mixing height)
  - allowing detailed exploration of high concentration episodes
- Not all species can be monitored using continuous methods
- Integrated samples are useful for many analyses, but a sufficient number of samples are needed to separate out day-of-week, seasonal, and annual variations

Selecting Frequency and Duration of Sampling (cont.)

- Advantages of integrated (e.g., 24-hr) samples over continuous methods
  - More species are measurable
  - Easier to operate
  - Suitable for a wider range of monitoring locations
  - Typically well understood methods
- Disadvantages
  - Temporal coverage is poor
  - Trajectory and wind sector analysis is difficult
  - Diurnal analysis is impossible

Frequency and Duration Considerations

For any data analysis, more samples improve your certainty in results

- Therefore, higher frequency and shorter duration sampling is better for data analysis, but this approach is more expensive.
- Which project objectives get the most out of the additional samples?

Objective	Sample Number, Frequency, and Duration Requirements
Emissions characterization	Large improvements available from high sampling frequency and short duration. Source apportionment benefits from larger sample sizes.
Health assessment	24-hr average and 1-in-6 day sampling are sufficient for characterizing annual average concentrations
Trends	24-hr average and 1-in-6 day sampling are sufficient for characterizing annual average concentrations
Community baseline	24-hr average and 1-in-6 day sampling are sufficient for characterizing annual average concentrations

Emissions Characterization – Speciation, Frequency, Duration, and Sample Numbers

Emissions can be characterized using

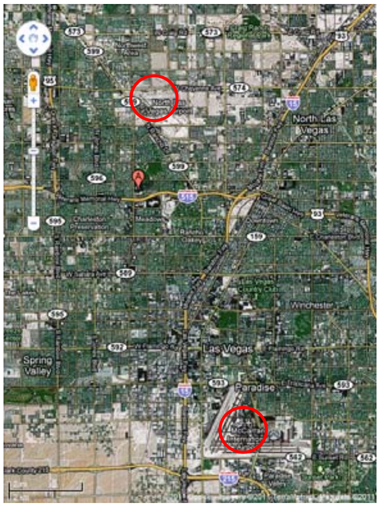
- Chemically unique tracer species
- Emissions activity (diurnal, day-of-week, seasonal)
- Meteorological analysis (pollution roses, trajectory analysis)
- Spatial gradients (site comparisons by wind direction)
- Source apportionment (temporal variability and chemical speciation)

Blue categories are improved by having short-duration, high-frequency sampling.

Importance of Meteorological Measurements

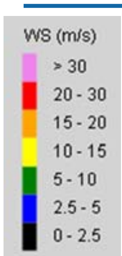
- Surface met measurements at “nearby” sites may be inadequate to meet your goals
- Collocated, good quality surface meteorological data are necessary for supporting data analysis objectives:
  - Understanding diurnal changes in concentration associated with meteorology (temperature, wind speed, mixing height), especially during data validation and interpretation
  - Correlating/understanding observed concentrations with known emissions sources
  - Assessing trajectories in transport analyses
  - Assessing trajectory- and quadrant-specific speciation in emissions inventory analysis using wind direction and wind speed
  - Assisting with model evaluation using wind direction and wind speed data

Pre-Study Analysis of Available Winds



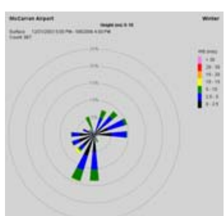
Wind speed and direction data were available at North Las Vegas Air Terminal and at McCarran International Airport, north and southeast of schools (A, along US95, now US95/I-515).

Wind Directions Are Different at Existing Sites North and Southeast of Schools

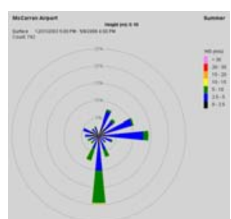


Average 7 a.m. – 2 p.m. wind speed and direction

North Las Vegas Air Terminal



McCarran International Airport

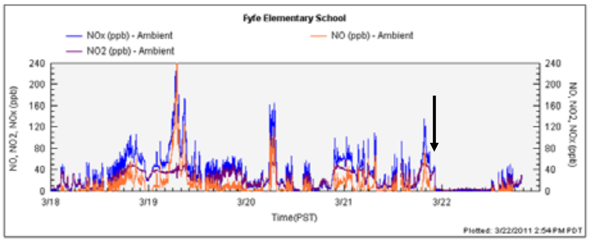


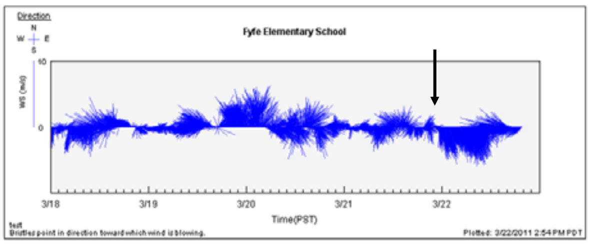
Winter

Summer

So we'd better measure winds at the study sites!

Pollutant Concentrations Depend on Wind Direction and Source Locations



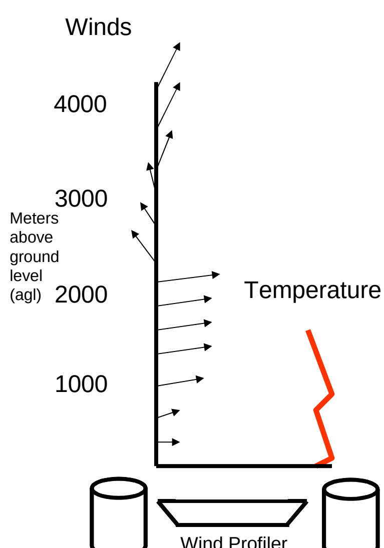


When winds turned to blow toward the freeway (10 p.m. on 3/21/08), NO concentrations dropped significantly.

Upper-Air Meteorological Measurements

Upper air met data are useful in supporting

- Assessment of daily mixing height and mixing height evolution
- Understanding pollutant transport
- Evaluation models



Monitoring Strategy: JATAP

- Originally, nine monitoring sites were planned
  - Final decision about monitor placement determined by jurisdictional issues, available resources, and the availability of the monitoring equipment
  - Some compromises on monitoring locations had to be made
- Existing sites used: three sites for the pilot, seven sites for the study

Pilot study indicated MDLs from first lab used were too high, so a new lab was selected.

Leveraging

- Leveraging is a vital component of any study because it helps you extend your resources
- Be familiar with
  - lessons learned from previous studies
  - other studies in the area
- Design your study around routine monitoring

Leveraging: Michigan

Michigan study built on numerous previous and ongoing monitoring projects and data analysis studies

- MDEQ and LADCO supplemented air toxics data with continuous EC/OC, carbon black measurements, and speciated organic carbon at some sites
- Community monitoring project conducted by MDEQ in Delray, Newberry School (speciated organics, criteria pollutants, BC)
- Detroit Exposure Aerosol Research Project (DEARS)
- Detroit Children's Health Study
- Detroit Cardiovascular Health Study
- Extensive data analysis of a range of data sets prior to the study

Leveraging: Nez Perce

The Nez Perce study built on previous air toxics studies in the area:

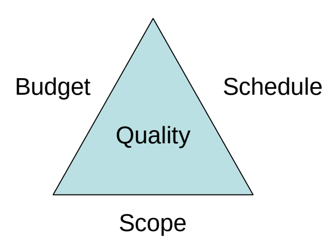
- 1990 study of chloroform concentrations near the mill
- Mid-1990s study with 13 sites, focused on five VOCs
- 2003 study on mill emissions

Building Quality Into Your Plan

- QAPPs will be required for all projects
- http://www.epa.gov/quality/qapps.html
  - QA/R-5: Requirements for QAPPs
  - G-5: Guidance for QAPPs
  - G-5S: Guidance on choosing sampling design for environmental data collection
- Budget for QA activities should be ~10% to 15% of project dollars

Implementing Your Plan

- Allocate adequate time (schedule) and resources (budget, staff) to your project.
- Balancing project goals (scope) and your budget and schedule is challenging.
  - The budget, scope, and schedule are linked.
- Build in contingency planning.



Be SMART

- In your project, be SMART about how you run the project, set goals, designate tasks:
  - S - specific, significant, stretching
  - M - measurable, meaningful, motivational
  - A - attainable, agreed upon, achievable, acceptable, action-oriented
  - R - results-oriented, realistic, relevant, reasonable, rewarding
  - T - time-bound, timely, tangible, trackable

Provide Project Leadership

- Manage expectations
  - Have a well thought out project plan
  - Lead the execution of the plan
- Own your project (accountability)
  - Encourage creativity and innovation
- Communicate
  - Early and often!
  - Use multiple approaches (find out what works best for your team)

Lessons Learned in Monitoring Strategy

- Complete an emissions inventory, site visits, and screening modeling/monitoring before finalizing monitoring locations and targeting which air toxics to monitor
- Ensure lab/method can give you the detection limits you need
- Understand the area to be monitored
- Get the right people together to develop the strategy

Lessons Learned in Project Planning

- Schedule
  - Set a realistic schedule
  - Allow more time for the project to account for monitor siting and setup issues
  - Consider data processing and analysis requirements (i.e., leave enough time and budget to do a good job)

Lessons Learned in Project Planning (cont.)

- Monitoring
  - Assess laboratory detection limits, data reporting methods, and comparability
  - If using more than one lab, perform a comparability study up front
  - Perform a micro-scale emissions inventory before selecting pollutants to measure and monitoring locations
  - Consider security measures for monitoring
  - If the project is NOT testing new sampling or analysis methods, use methods with a proven “track record”
  - Consider meteorology and geography in monitor location placement