Rapid Risk Assessment: The Application of Science for Use in Emergency Response

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** Outdoor WTC data published: *Environmental Health Perspectives, July 2002*
** Outdoor/indoor WTC PAH data published: *ES&T, February 2003*
America’s Focus During the Week Prior to 9-11
What is Rapid Risk Assessment?

- **Determines**
  - the potential magnitude and extent of acute exposures and associated health outcomes

- **Identifies**
  - the potential for longer term health outcomes

- **Involves**
  - exposure situations with unusually high concentrations of common pollutants, or presence of “unusual” toxicants (WMD)

- **Requires preparadness**
  - scenario development and use for practice
  - development of flexible/adaptive strategies for assessment
  - rapid deployment of resources
  - continual training and development of communication strategies
Do We Know How to Deal with Such Situations?

- We are learning but we are not quite ready

- What is involved?
  - Problem recognition
  - Acute toxicity and population impact
  - Exposure characterization
  - Scenario development
  - Training
  - Medical and emergency response
  - Measurement strategies and methodologies
  - Deployment
  - Communication
What Did We Learn from 9-11
On Environmental and Occupational Health?
Exposed Population on September 11, 2001

Associated Press, US News and World Report
Who Could Have Been Exposed?

- **Initial fire and collapse of the WTC**
  - Survivors
  - Local and downwind residents
  - Rescue workers
  - Commuters
  - Shop/business owners, operators and customers

- **Emission and resuspension of dust/smoke during the first week**
  - Professional and volunteer rescue workers (not wearing respiratory protection)
  - Outdoor and indoor cleanup workers
  - Residents and workers on Wall Street area downwind

- **Emission and resuspension of dust/smoke in following weeks/months**
  - Rescue workers not wearing respiratory protection at the 16-acre WTC site
  - Cleanup workers not wearing respiratory protection at businesses and residences
  - Residents and workers retiring to poorly cleaned buildings

*Note: although not measured, gases would be associated with many of these exposures*
Concepts on WTC Exposure: Georgopoulos and Lioy

WTC Decay Models Vs. Time

![Graph showing WTC Decay Models vs. Time with different decay models represented: Sigmoidal, Linear, and Second Order. The graph illustrates the decay of dust/smoke, rain, and smoldering fires over time.](image_url)
The General Appearance of the Bulk Dust from WTC

Outdoor Sample

Indoor Sample
## General Characteristics of World Trade Center Settled Dust and Smoke Samples from the First Days After the Fire and Collapse

### AERODYNAMICALLY SEPARATED SAMPLE (%)

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Cortlandt Street</th>
<th>Cherry Street</th>
<th>Market Street</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2.5 um diameter</td>
<td>1.12</td>
<td>0.88</td>
<td>1.30</td>
</tr>
<tr>
<td>2.5 – 10</td>
<td>0.35</td>
<td>0.30</td>
<td>0.40</td>
</tr>
<tr>
<td>10 um – 53 um</td>
<td>37.03</td>
<td>46.61</td>
<td>34.69</td>
</tr>
<tr>
<td>diameter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;53 um diameter</td>
<td>61.50</td>
<td>52.21</td>
<td>63.60</td>
</tr>
</tbody>
</table>

Key: ND = Not Detectable * = Values reported to NYU, L. Chen, by Ambient Group, TNC, NYC, NY.

### Composition:
- Construction Debris (Vemiculite, plaster, paint, foam, glass fibers/fragments, etc.)
- Cement
- Chrysotile 0.8%-3.0%
- Cotton Fibers/Lint
- Tarry and Charred Wood
- Soot (PAH, Pthalates, Other Organics)
Glass Fiber Detected in the Market Street, NYC Sample
Cough and Bronchial Responsiveness in Firefighters at the World Trade Center (Prezant et al., 2002)

Number of firefighters employed by the Fire Department of New York City (FDNY) on September 11, 2001, and number who were subsequently evaluated for World Trade Center (WTC) cough and bronchial hyperactivity, according to the level of exposure to respiratory irritants at the site of the collapse.
Lessons Learned From the Attack on the WTC
Lioy and Gochfeld, Am J Occ Med, November 2002

• Environmental Exposure Monitoring
  • Need more portable and flexible emergency response monitors and monitoring strategies
  • Monitors should be capable of sampling and/or analyzing for an array of materials including those not routinely monitored by agencies
  • Deployment and communications strategies must be in effect
  • Path forward: outline and recommend the features of an emergency response framework and “tool box” and fund its development and validation
Concentrations of $\sum_{37}$PAHs on size-fractionated, re-suspended settled dust samples collected around lower Manhattan on 12, 13, 16 and 17 September 2001. Note: * indicates that insufficient mass was collected to successfully analyze the 2.5 to 10 $\mu$m size fraction. 

*(from Offenberg et al. 2002)*
Lessons Learned From the Attack on the WTC
Lioy and Gochfeld, Am J Occ Med, November 2002

- Air Exposure Standards
  - Emergency response standards for “all clear” must first address acute toxicants and then long term toxicants
  - Emergency response standards need to be tailored to the community environment and to the occupational environment
  - Guidelines must be developed for community re-entry
  - Path Forward: develop community standards for evacuation and re-entry, and establish zones of concern for single or multimedia events – start with EPA-AEGL committee activities but expand to biological and radioactive materials

- Acute Exposure Guidelines (AEGL’s)
  - Thresholds for General Public –Including susceptible individuals
  - Duration – 10 and 30 minutes, 1 and 4 or 8 hours
  - AEGL 1 - Transient Effects - Irritation etc.
  - AEGL 2 - Irreversible Effects - Impair Escape
  - AEGL 3 – Life Threatening Effects – Death
  - Needed for Biological Agents !!!
Indoor Deposition of Dust and Smoke that was Released by the Collapse of the World Trade Center on September 11, 2001

Lioy et al, 2002
• **Indoor Environmental Cleanup**
  - Design a formal cleanup and re-entry plan for all indoor environments after a dust/smoke disaster
  - Identify a Federal Agency to implement specific programs for all types of emergencies – both *Natural and Security*
  - Develop “clearance standards” for re-entry into a building
  - Develop a systematic plan for cleanup that starts outside a building and works its way to clean-up of individual rooms.
  - *Path Forward: Government needs to improve response to indoor air and settled dust issues during specific types of security environmental health emergencies*
Lessons Learned From the Attack on the WTC
Lioy and Gochfeld, Am J Occ Med, November 2002

- Air Exposures Occupational Health
  - Design and develop more “user friendly” respirators (and PPE) for first response emergency personnel
  - Develop first responder protocols for respirator use; implement training programs
  - Path forward: Initiate/support development programs for improved respirators (and PPE) and first responder procedures
Center for Exposure and Risk Modeling at EOHSI
Directed By Drs. Paul J. Lioy and Panos G. Georgopoulos
A University Partnership Funded by and in Collaboration with US EPA National Exposure Research Laboratory (NERL)

- Developing a Modeling ENvironment for TOtal Risk - MENTOR
  - Has evolved as an open “modeling support system”
    - Can also be described as an expandable “computational toolbox”
  - Uses existing and new approaches to
    - Implement mechanistically consistent multiscale source-to-dose modeling
    - Evaluate and refine existing models
    - Enhance understanding of environmental and biological processes
  - Examples of accomplishments
    - Source-to-dose assessment of simultaneous exposures to $O_3$, PM, air toxics
    - Multimedia/multipathway/multiroute assessment of population exposures/doses to Arsenic
  - Current and evolving research
    - Computational Toxicology
    - Informatics and modeling for Homeland Security issues
Current MENTOR Research on Emergency Events

- Evaluation of existing models in emergency situations
  - Accuracy/precision vs speed/robustness/simplicity
  - Physical/chemical assumptions, data needs
  - Reconstruction of WTC/future planning exercises

- Development and application of comprehensive models and integrated systems for transport/fate and exposure/dose
  - To fully characterize an event
  - To benchmark and systematically improve simpler models
  - To “diagnose” causes of “historic” phenomena

- Development and application of real time “model/data fusion” techniques
  - Inverse problem solution (source characterization)
  - Bayesian real-time model “calibration”
  - Uncertainty characterization and reduction
  - Optimization of monitoring network design
Assessing Exposures and Doses for Emergency Events: Realizations and Special Challenges

• Multiple levels of ignorance/uncertainty
  - Uncertainty in source and contaminant characterization
  - Uncertainty in receptor location and activities

• Multiple (potentially) temporal and spatial scales of impact

• Multiple levels of analysis are needed
  - Operational – field (screening)
  - Operational – response center (management)
  - Diagnostic/comprehensive (planning and reconstruction analyses)

• Not issue of modeling vs monitoring: need for “model/data fusion”
  - Need to use and integrate information with diverse origins and formats
  - Need to characterize uncertainties - reduce them via iterative (Bayesian) "fusion" of modeling with observations

• Evaluation of exposure/dose modeling more challenging (than transport/fate modeling)
An Important Note: Inhalation Exposure has Largest Impact but is not the Only Route of Concern

- A crisis requiring rapid risk assessment could also be caused by
  - Ingestion of chemical, physical or biological agents with water or food
  - Dermal exposures to chemical or biological agents in various media
- Considering multiple routes of contact and exposure requires
  - complex scenario development for simple/multiple releases and/or release points
- General information needs for planning and response include:
  - Terrain topography, land use, buildings attributes
  - Transportation routes
  - Locations of schools, hospitals, police stations, fire stations, etc.
  - Population distribution, demographic attributes, and activities
  - Real-time meteorological data
  - Water distribution and sources
  - Location of major industries and commercial activities
  - Scenario development and testing – “Thinking Out of the Box”
  - Properties of chemical, physical and biological agents of concern

It is important to note that comprehensive (geo)databases are evolving...
Interlude: Example EPANET Application for Distribution of a Toxicant in Municipal Water Network Involving Two Suppliers
Back to the Airborne Contaminant Problem Assessment:
First Essential Steps - Emissions Characterization and Multiscale
Atmospheric Contaminant Dispersion and Deposition Modeling

3-D numerical grids are used to compute transport/fate in Eulerian or Lagrangian frameworks.

Simple Start: Trajectory Analysis for Screening Regional Scale Characterization Using the NOAA HYSPLIT Model
(Started on 9/11/2001: Analysis of Long Range Transport Potential of the WTC Plume)
Caveat: Neighborhood Scale Effects Can Modify Significantly Estimates from Atmospheric Transport Models or from Monitor Interpolations (Barriers, Channeling, Local Flows, Trapping): Need for Both CFD & Simplified Models
Atmospheric Transport Modeling for Emergency Response: A Hierarchical Framework
Contaminant Dispersion Models Linked With GIS-Based Information on Monitors and Receptors

MET & GIS (TOPO, RECEPTOR) DATA

- Real Time/On Line
- Other Lab & Field Data

Research Lab Modeling
Prognostic/Diagnostic

Response Center Modeling

“Field Model” (on Wireless Laptop or PDA)

- Real Time
- Real Time/On Line
- Off-Line Scenario Based

- Trained EM Personnel
- Center Scientists
- Research Scientists

Guidance & Decision Support

Real Time Assimilation

Correction & Decision Support (Real Time)

Systematic Simplification

Evaluation of Assumptions

Query Real Time

Contaminant Dispersion Models Linked With GIS-Based Information on Monitors and Receptors
Contaminant Dispersion Models Linked With GIS-Based Information on Monitors and Receptors

- Comprehensive Diagnostic
- All Available
- Fast
- On-Line Real Time
- Simple/Fast
- Minimal

Source & Contaminant Data
- Real-Time Sensor & Monitor Data
- Controlled Experiments & Research Monitoring Network

Model Application & Operators
- Real Time
- Real Time/On Line
- Off-Line Scenario Based
- Trained EM Personnel
- Center Scientists
- Research Scientists

MET & GIS (TOPO, RECEPTOR) DATA

- Real Time/On Line
- Other Lab & Field Data

e.g. MENTOR/ RAMS (CCL-EOHSI)
- Systematic Simplification
- Evaluation of Assumptions
- Real Time Assimilation
- Real Time Response Center
- Correction & Decision Support (Real Time)

e.g. LLNL-NARAC Model (DOE)
- Query Real Time

e.g. VLSTRAVK (NSWC), HPAC/SciPUFF (DSWA)
- Correction & Decision Support

e.g. CAMEO/ ALOHA (EPA)
- Guidance & Decision Support

Model Complexities & Data Requirements

Scenario Based Research

Evaluation of Assumptions
A Framework for Model/Data Fusion with Application to Both Forward and Inverse Problems

- **SOURCE**
  - Inverse Problem
  - 1\textsuperscript{ST} Level Transport Problem

- **MONITORS**
  - Inverse Problem
  - 2\textsuperscript{ND} Level Transport Problem

- **SENSITIVE RECEPTORS**
  - Bayesian Model/Data Fusion

EXPOSURE & RISK ANALYSIS
The Bayesian Approach for Analyzing Complex Uncertain Problems when Mechanistic (and not only) Models are Available

“in this new century ... a significant part of the everyday practice of Statistics ... will consist of applying Bayes' formula via MCMC ...”

Atmospheric Transport/Fate Examples: Complexities of Applications and Limitations of Models
Real Time Meteorological Monitors in New Jersey and Delaware
Example I: Calculations with ALOHA Model for Hypothetical Release in New Jersey
Simulation of the Same Case Study With a Comprehensive System that Accounts for the 3-D Structure of Sea Breezes (RAMS-HYPACT): A Very Different Picture of the Dispersing Plume and its Impact
Example II: CRESP-EXIS for the Savannah River Site (NLCD Data)
(CRESP: Consortium for Risk Evaluation with Stakeholder Participation)
(EXIS: Environmental/Exposure Information System)

Savannah River Site
Land Cover Classification
(30m resolution)

Legend
- Open Water
- Perennial Ice/Snow
- Low Intensity Residential
- High Intensity Residential
- Commercial/Industrial
- Barn, Pond, Sand, Clay
- Quarries/Strip Mines, Gravel Pits
- Transitional
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Orchards/Grain
- Grassland/Herbaceous
- Pasture/Hay
- Row Crops
- Small Grains
- Fallow
- Urban/Recreational Grasses
- Woody Wetlands
- Emergent Herbaceous Wetlands

Projection: Albers Equal-Area

50 km radius
Examples of Other Data in CRESP-EXIS for SRS: Vital Receptor Information
3-D Views of Smoke Plume Simulation from a (Controlled) Fire in the Vicinity of SRS (Superimposed to the ABL Wind Field): The Observed/Simulated Dispersion Patterns are in Contrast to those Predicted by “Simple Models”

the smoke plume at 2200 GMT (5:00 PM local time)  the smoke plume at 0800 GMT (3:00 AM local time, next day)
Next Step:
Coupling Atmospheric Transport and Fate Models with Microenvironmental and Activity/Physiology Based Exposure/Dose Models
Fact: In addition to time and geographic location, factors such as: dynamic microenvironmental attributes, demographic and physiological characteristics, activity patterns, etc. differentiate significantly the exposures and doses of individuals (and of selected subpopulations) that result from an environmental (emergency) event.

Challenge: All relevant information must be integrated in a consistent/unifying framework (Spatiotemporal Exposure Information System).

Example: Dependence of inhaled fine PM dose on gender, age, and activity (MET= Metabolic Equivalent of Tasks).
<table>
<thead>
<tr>
<th>Attributes of Available Comprehensive Inhalation Exposure Models</th>
<th>pNEM</th>
<th>HAPEM</th>
<th>APEX</th>
<th>SHEDS</th>
<th>MENTOR/SHEDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure Estimate</td>
<td>Hourly averaged</td>
<td>Annual averaged</td>
<td>Hourly averaged</td>
<td>Hourly averaged</td>
<td>Activity event based</td>
</tr>
<tr>
<td>Characterization of the High-End Exposures</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Typical Spatial Scale/Resolution</td>
<td>Urban areas/Census tract level</td>
<td>Ranging from urban to national/ Census tract level</td>
<td>Urban area/census tract level</td>
<td>Urban areas/Census tract level</td>
<td>Multiscale/ Census tract level</td>
</tr>
<tr>
<td>Temporal Scale/Resolution</td>
<td>A year/one hour</td>
<td>A year/one hour</td>
<td>A year/one hour</td>
<td>A year/one hour</td>
<td>A year/activity event based time step</td>
</tr>
<tr>
<td>Population Activity Patterns Assembling</td>
<td>Top-down approach</td>
<td>Top-down approach</td>
<td>Bottom-up approach</td>
<td>Bottom-up approach</td>
<td>Bottom-up approach</td>
</tr>
<tr>
<td>Microenvironment Concentration Estimation</td>
<td>Non-steady-state and steady-state mass balance equations (hard-coded)</td>
<td>Linear relationship method (hard-coded)</td>
<td>Non-steady-state mass balance and linear regression (flexibility of selecting algorithms)</td>
<td>Steady-state mass balance equation (residential) and linear regression (non-residential) (hard-coded)</td>
<td>Non-steady-state mass balance equation with indoor air chemistry module or regression methods (flexibility of selecting algorithms)</td>
</tr>
<tr>
<td>Microenvironmental (ME) Factors</td>
<td>Random samples from probability distributions</td>
<td>Point estimates</td>
<td>Random samples from probability distributions</td>
<td>Random samples from probability distributions</td>
<td>Random samples from probability distributions</td>
</tr>
<tr>
<td>Specification of Indoor Source Emissions</td>
<td>Yes (gas-stove, tobacco smoking)</td>
<td>No</td>
<td>Yes (multiple sources defined by the user)</td>
<td>Yes (gas-stove, tobacco smoking, other sources)</td>
<td>Yes (multiple sources defined by the user)</td>
</tr>
<tr>
<td>Commuting Patterns</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Exposure Routes</td>
<td>Inhalation</td>
<td>Inhalation</td>
<td>Inhalation</td>
<td>Inhalation</td>
<td>Multiple</td>
</tr>
<tr>
<td>Potential Dose Calculation</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Physiologically Based Dose</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Viability/Uncertainty</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes (Various “Tools”)</td>
</tr>
</tbody>
</table>
Source-to-Dose Framework for Reconstructing Exposures to the WTC Plume

1. "Baseline Definition": Estimate background levels of air pollutants at various scales through:
   a. multivariate spatiotemporal analysis of monitor data (STRF, BME)
   b. emissions-based multiscale air quality modeling

2. Estimate spatiotemporal levels of outdoor contamination at neighborhood scale (e.g. for census tracts, or local grid) via:
   a. "constrained" analysis of monitor data
   b. application of multiscale model at high resolution
   c. physical "corrections" of the estimates of multiscale fate and transport model

3. Estimate pollutant "profiles" in microenvironments (streets, residences, offices, vehicles, etc.) through:
   a. regression of observational data
   b. simple mass balances
   c. gas/aerosol dynamics modeling
   d. CFD & transformation modeling

4. Characterize attributes of populations (geographic density, age, gender, race, income, etc.):
   a. select fixed-size sample populations that statistically reproduce essential demographics, or
   b. divide population of interest into exhaustive set of cohorts

5. Develop activity event (or exposure event) sequences for each member of the sample population, or for each cohort, from:
   a. existing databases from composites of past studies (for baseline assessment)
   b. study-specific information (special registries)

6. Calculate appropriate inhalation (and other relevant uptake*) rates for the members of the sample population combining:
   a. physiological attributes of the study subjects and
   b. activities pursued during the individual exposure events
   *e.g. non-dietary ingestion

7. Combine intake rates and microenvironmental concentrations for each activity event to assess exposures
Efforts to Reconstruct the WTC Plume and Associated Exposures: Main Focus Area for Exposure Reconstruction Study

The census tracts located within a 2.5km radius from the WTC site: distributions of microenvironmental parameters and corresponding concentrations/depositions will be developed for each census block (~4 per census tract) through the study.
Rapid Risk Assessment Computational Chemodynamics Laboratory – EMAD/EOHSI

Multiscale Atmospheric Analysis Involves a Triple-Nested RAMS 4.3 (Regional Atmospheric Modeling System, Implemented with HYPACT) Modeling Domain with 4 km (D1), 1 km (D2), and 250 m (D3) Horizontal Grid Structure

- RAMS4.3 simulations utilized the following data for the initial fields:
  - Eta data available every 3 hours over a horizontal grid resolution of 40 km
  - ASOS data from 4 nearby airports (Newark, Teterboro, J.F.K., LaGuardia) and Central Park available every hour
  - Surface data from NCAR available every 6 hours

- Initial RAMS4.3 simulations utilized the following for the surface fields:
  - DEM 30 seconds topography data from RAMS database
  - 30 seconds vegetation data from RAMS database
WTC Plume Dispersion Modeling Employing the Mesoscale 3-D Prognostic RAMS/HYPACT Platform
WTC Plume Dispersion Modeling Employing the Mesoscale 3-D Prognostic RAMS/HYPACT Platform
(Georgopoulos et al., 2003)

Instantaneous views at 13:00 EDT of the simulated WTC plume on 9/11, 12, 13/2001
(3-d, top; surface layer, wind fields and normalized concentrations, bottom)
Demographic Information
MENTOR-SHEDS Test “Base” Case Run, 11/19/2001

Average outdoor PM2.5 concentration for 11/19/01

95th Percentile of Outdoor PM2.5 Dose per Census Tract for 11/19/01

95th Percentile of Outdoor+ Indoor PM2.5 Dose per Census Tract for 11/19/01
From Microenvironmental to Personal: The Convective Personal Flow Field Affects Inhalation Intake and the Release from the Body (Video from G. Settles)
Example Study: Protection of Hospital Workers Working with Victims of Chemical Exposure – A Process to Select Appropriate PPE Levels

P. Georgopoulos*, M. Hodgson**, P. Fedele***, P. Shade*, P. Lioy* et al.****

*EOHSI
** Veterans Administration
*** US Army
**** OSHA

Locations:
1, 2: HOT ZONE; 3, 4: WARM ZONE; 5: COLD ZONE
Monte Carlo forecast of total integrated exposure concentration ($CT$) of sarin when the mass deposition ($mo$) is represented by a triangular distribution with a maximum value of 100 g and a likeliest value of 10 g. The time-integrated exposure concentration is then the sum of exposure concentration as contaminated patients file past the medical personnel. The integration begins after a 10-minute lag time which represents transport time to the facility; the integration is stopped when the decontamination process ends. In this scenario the contaminated body surface area is assumed to be 20%, which represents the potential exposure to healthcare workers when victims immediately disrobe.
Integrated Biological and Chemical Warfare Defense
N00014-02-C-0320
Intelligent Software for Crisis Management and Terrorism Defense

California State University
Conclusions A:
Key Homeland Security Needs for Rapid Risk Assessment

- Compatible/consistent “families” of models are needed that:
  - Can quickly (real-time) use routine and on-site monitoring data (and modeling predictions, e.g. meteorology) to assess the environmental and microenvironmental situation and support emergency responses
  - Can supplement initial results with more detailed analyses
  - Help frame conditions at “near real time” for new agents and situations
  - Track population attributes and activities to support assessments of exposure, dose, and effects
  - Predict exposure, dose, and effect for various scenarios to help formulate and assess strategies for a range of incidents and to improve training exercises
  - Employ visual means – such as Geographic Information System tools - for displaying (in real time, if possible) qualitative and quantitative modeling outcomes for rapid interpretation and communication of results
    - It is however essential that consistent protocols and conventions are developed and used in the visual communication of results
Conclusions B:
Key Homeland Security Needs for Rapid Risk Assessment

- Monitoring devices are needed that:
  - Can provide rapid indication of classes of chemical, physical and biological agents
  - Are portable and flexible
  - Can provide some quantitative information rapidly (i.e. within minutes of arrival)
  - Can also collect samples that can be preserved for more extensive analysis later at laboratories
  - Can be used safely in emergency response situations
  - Can be used as personal monitors to ensure safe rehabilitation

- Detailed plans must be in place for emergency monitor deployment to address a variety of issues:
  - Transportation; coordination with law enforcement agencies; etc.
  - Communicating and sharing the information in standardized formats
BASIC PRINCIPLES OF CRISIS RESPONSE:
Applicable to Many Situations

- General Assessment of the Situation
  - Characterization of both acute and chronic toxicants
  - Identification of exposed and/or affected individuals
  - Characterization of exposures and internal doses

- Implementation of Comprehensive Immediate Action Plan
  - Establishment of effective communication among agencies
  - Identification of applicable standards for situation at hand
  - Examination of affected individuals
  - Assessment of criteria for eliminating exposure
  - Implementation of strategy for removal of waste

- Implementation of Longer-Term Action Plan
  - Criteria for returning individuals to “safe” locations
  - Evaluation and implementation of approaches for remediation and...
  - Assessment of the success of remediation for re-entry
Some General Recommendations to Address Needs of Exposure Modeling Associated with Emergency Events

- **Needed:**
  - appropriately adapted models (operational and diagnostic, multiscale)
  - appropriate databases (extant/national; event-specific: early monitoring)
  - computational tools for fast integration of data management and analysis
  - robust/efficient computational tools for reducing uncertainty in modeling

- **Recommendations:**
  - adapt and exercise existing exposure models for emergency scenarios (develop appropriate parameterizations, modify modules)
  - support development of integrated “exposure information systems” tools for emergency analysis that can utilize “rapidly” state-of-the-art static/dynamic data
    - the CAMEO/ALOHA/MARPLOT/LANDVIEW example, though overly simplistic, provides a valuable integration concept
    - utilize experience and infrastructure from real-time atmospheric modeling systems
    - utilize new databases (e.g. NED, NLCD) and computing tools (TGIS, O/RDBMS, DC)
  - upgrade capability for EARLY monitoring (mobile, self-contained, monitoring systems) including improvements in handling remotely sensed data
    - include capabilities for personal monitoring (IRB issues) & activity dataset development
  - develop and test approaches for improved coordination of federal, state, and local agencies in collecting and managing observational information
Who Should be Involved in Rapid Risk Assessment?

- Exposure Scientists
- Toxicologists
- Physicians
- Engineers
- Modelers
- Environmental and Occupational Health Scientists – Government
- Emergency Response Specialists
- Military Emergency Response Specialists
- FBI and other Law Enforcement Agencies
- Training Specialists – Educators
A Partial List of Collaborators on These Projects

Collaborators on Outdoor WTC Samples:
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