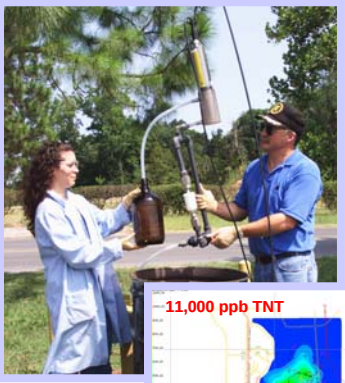
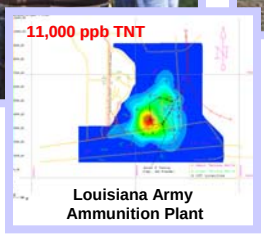
Research Perspectives

Judith C. Pennington
U.S. Army Engineer Research and Development Center
Environmental Laboratory





The Challenge

Tools needed to integrate the two are limited.

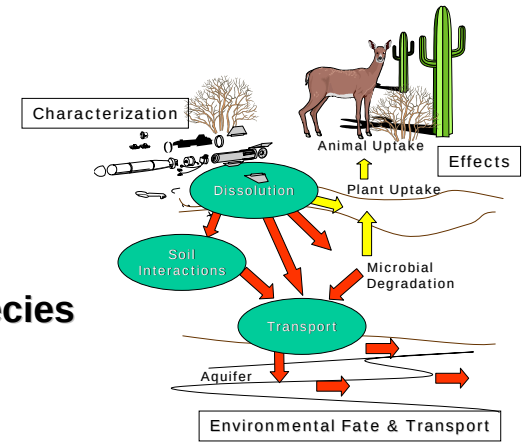
The database upon which to develop those tools is also limited.

Military Readiness

- Training Range Activities (HE)
  - Artillery/Mortar
  - Antitank
    - Battleruns (pop-up targets)
    - Antitank rockets
  - Hand grenades
  - Multi-Use ranges
  - Air to ground bombing/missiles
  - Ground to air missiles
  - Demolitions “blow-in-place”
  - Mines
- Weapon Systems Testing

Environmental Stewardship

- Ground water
- Soil
- Ecosystems
- Threatened and endangered species
- Public health



Origins of Explosives in the Environment

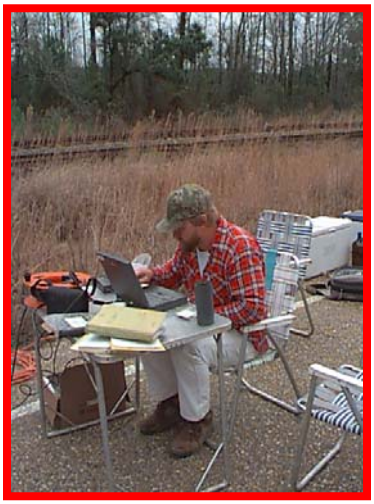
- Manufacturing of explosives
- "Load-and-Pack" operations/filling munitions with explosives
- Live-fire soldier training
- Weapon systems testing
- Commercial enterprises

Status of Explosives Contamination

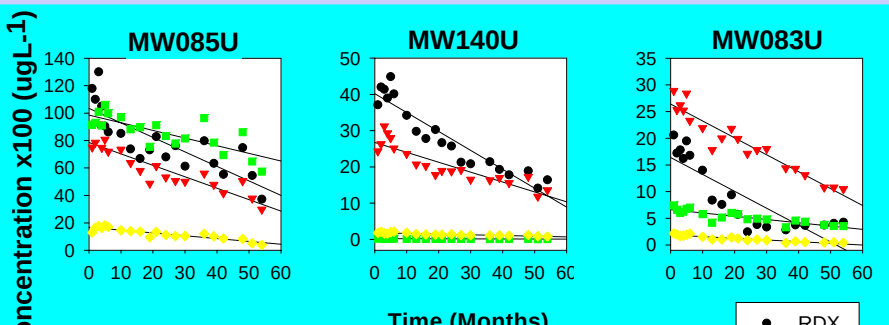
- Manufacture and load-and-pack sites
  - Focus of clean-up efforts since early 1980s
  - Most heavily contaminated soils and ground water have been treated, or are currently under treatment
    - Incineration • Composting • Pump-and-treat • In situ
  - Point sources; originally aqueous
- Live-fire training and weapon systems testing ranges
  - Characterization has only recently begun
  - Massachusetts Military Reservation
  - More distributed point sources; solid material

Transport of TNT to Ground Water

- Occurs when volume of soluble contamination exceed capacity of soil to attenuate, e.g., manufacturing sites, load-and-pack sites
- TNT transformation products are common when TNT is present
- Ground water associated with live-fire training typically does not contain TNT (data are limited)
  - Sources are small points
  - Sources are widely distributed
  - Sources are initially in solid form
  - Attenuation in surface soils is significant

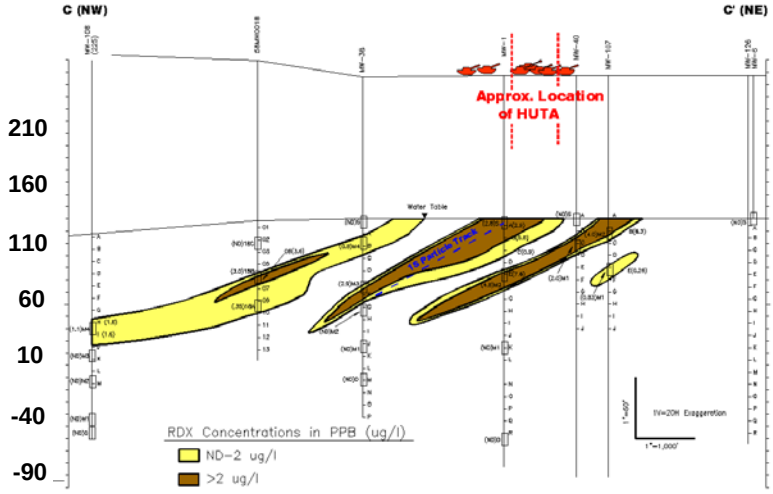


Concentrations in LAAP Ground Water Over Time



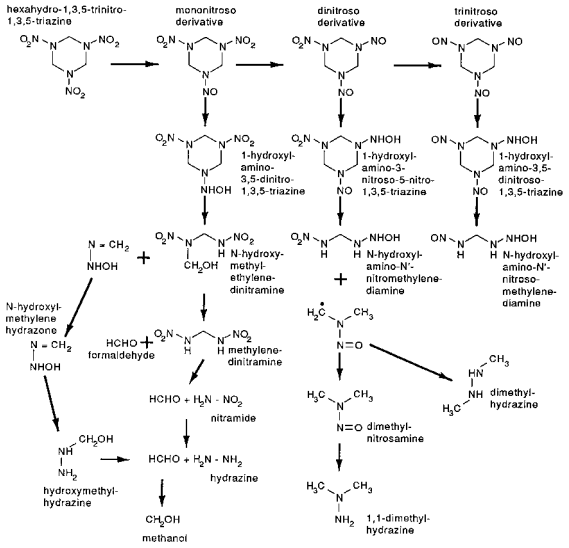
WELL #	RDX		TNT		TNB		HMX	
	R^2	SLOPE	R^2	SLOPE	R^2	SLOPE	R^2	SLOPE
0.85U	0.669	-105.864	0.822	-83.337	0.606	-55.781	0.824	-20.597
140U	0.890	-52.185	0.805	-27.363	0.559	-0.236	0.783	-1.952
083U	0.725	-31.665	0.914	-31.710	0.767	-6.201	0.861	-3.166

Longitudinal Cross-Section through the Impact Area



RDX Transport/Degradation

- **Mineralization requires anaerobic conditions**
- **Readily transported from soil to ground water**
- **Transport behavior is similar to that of a conservative tracer**
- **RDX is readily taken up by some plants**



Ranges: Challenges of Source and Scale

Expansive size

Extreme spatial heterogeneity

Diverse uses over time

Variable munitions performance low-order

Blow-in-place practices

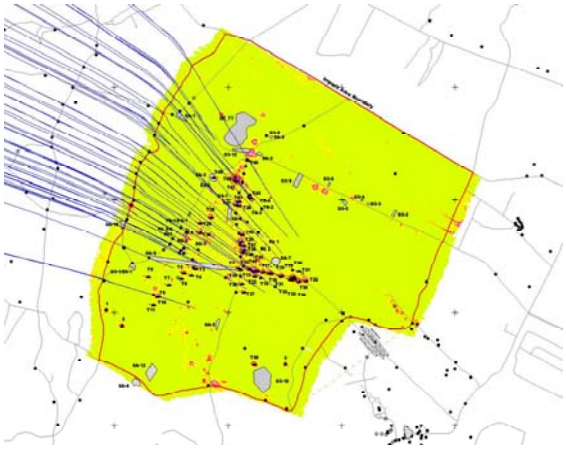
Various climates

Estimation of Residue Deposition by Ordnance Item

Munition Type	Residue (µg) Deposition		
	RDX	TNT	HMX
M67 Hand Grenade	26	<1	<1
81-mm Mortar (C4)	35,000	240	6,000
C4 alone	61,000	<1	26,000
M19 Anti-Tank Mine (C4)	280	<1	860
M15 Anti-Tank Mine (C4)	4,000	8	410
60-mm Mortar (Point Det)	630	18	8
60-mm Mortar (Proximity)	72	14	19
120-mm Mortar (Point Det)	4,000	320	140

Jenkins/CRREL 2002

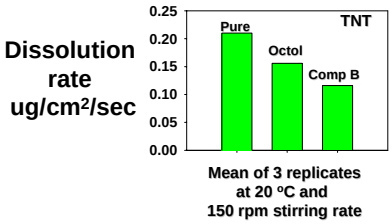
Potential Source Area



- High-order detonations
- Low-order detonations
- UXO
- EOD activities at the J Range
- Disposal/Burial sites
- Washout

Challenges of Component Behavior

- Corrosion rate
  - Munitions casings
  - Safety
  - Explosives residues

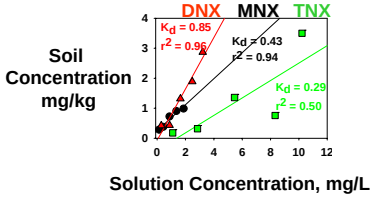


- Dissolution rate
  - Compositions

Octol
70% HMX, 30% TNT
Comp B
59.5 % RDX, 39.5% TNT, 1% wax

Challenges of Environmental Fate/Transport

- **Transport**
  - Various soil/climatic settings
  - Degradation products



- **Interactions with soils**
  - Adsorption and desorption
  - Transformation
  - Degradation

Challenge of Ecological Effects

- Extreme ecological diversity
- Defining exposure potential for a highly distributed source
- Current database limited to a few species
- Current database includes little information on transformation products and formulations

Challenges Unique to Live-Fire Training Ranges

What to monitor:

- Number of rounds fired and locations *(How much contamination is/will be out there?)*
- Number of low-order detonations *(How do you monitor these "hot spots"?)*
- Contamination in soils resulting from low-order detonations *(Where?)*
- Contamination in soils resulting from firing point residues *(Where?)*
- Contamination in ground water resulting from range activities *(Where do you put the wells?)*
- Contamination of air
- Contamination of surface water
- Ecological impacts *(What species are sentinel? In which regions of the country?)*

How to monitor:

- Access to
  - Ranges
  - Contaminated soils (finding it)
  - Contaminated ground water
  - Receptors
- Sustaining monitoring systems
  - Stability against blasts
  - Stability against range fires
  - Safety
- Scale and heterogeneity
- Release of data
  - Sensitivity levels
  - Whose data is it?

Principal Issues

- Distributed point sources of contamination
- Multiple contaminants, forms, and formulations
- Limited site access
- Orders of magnitude concentration ranges
- Various range use scenarios
- Broad geographical distribution