

# Management of munitions constituents in soil using alkaline hydrolysis: a practical guide.

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Development Center



# Report Documentation Page

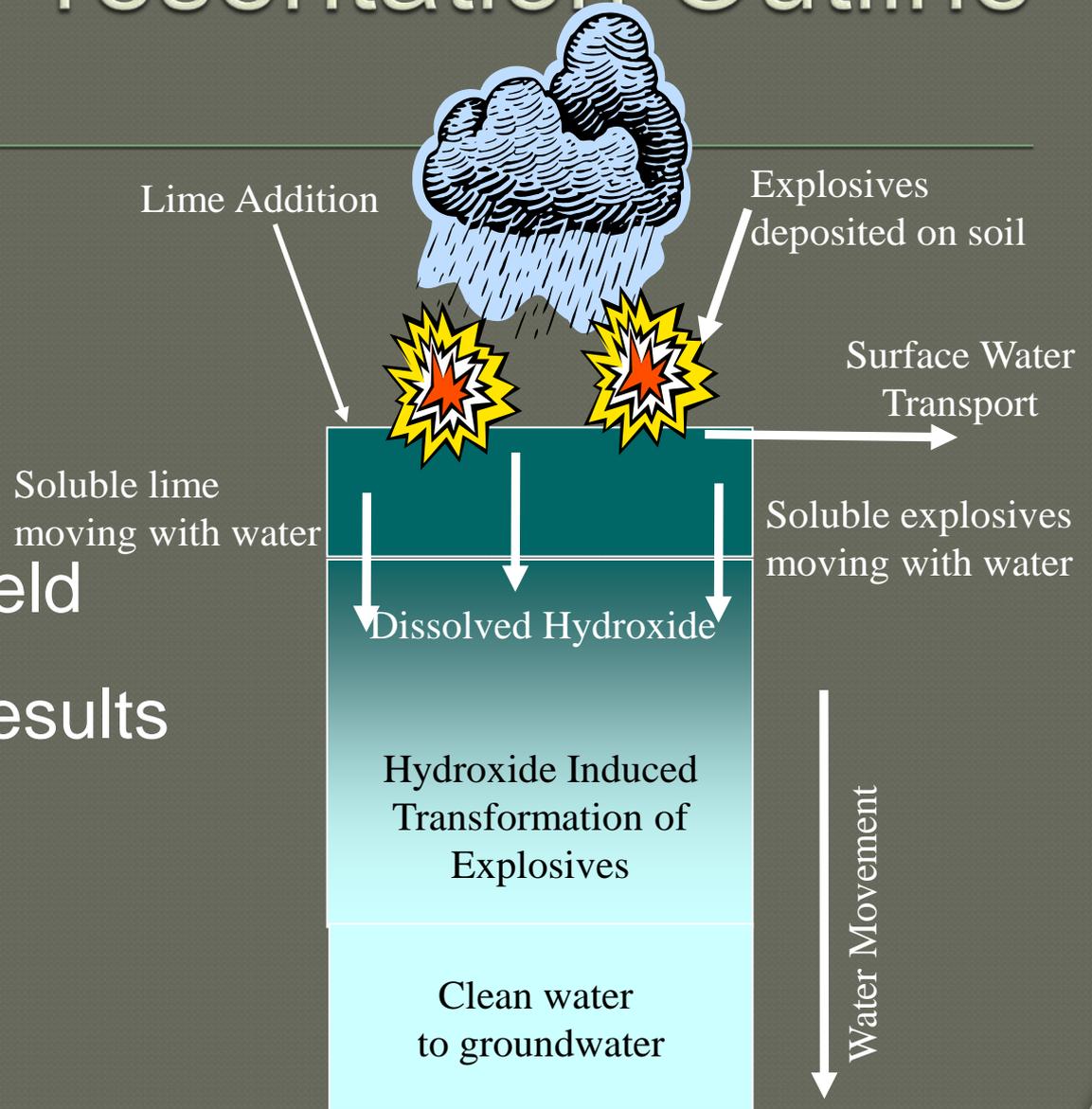
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# Presentation Outline

- Concept
- Advantages and disadvantages
- Laboratory and field demonstrations results
- Lime dosage
- Summary
- References

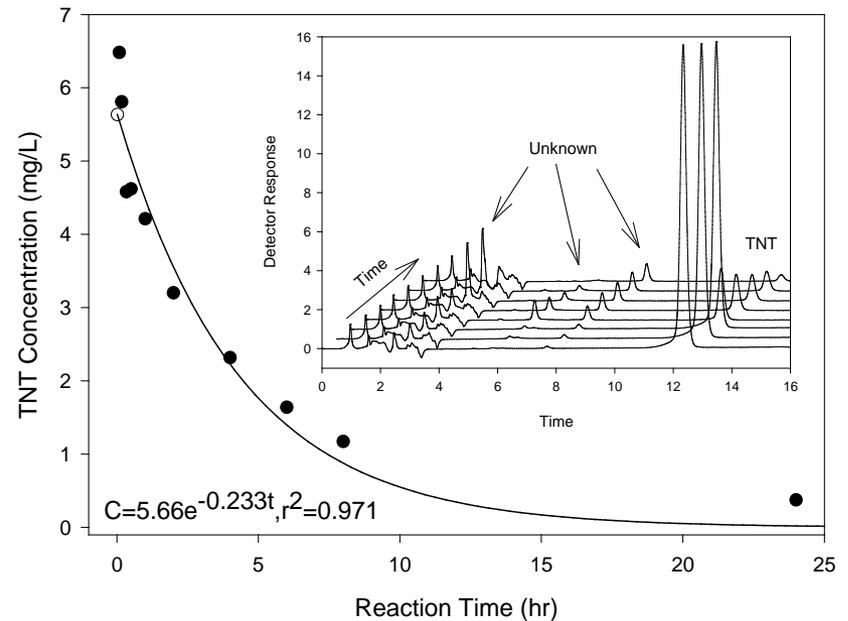
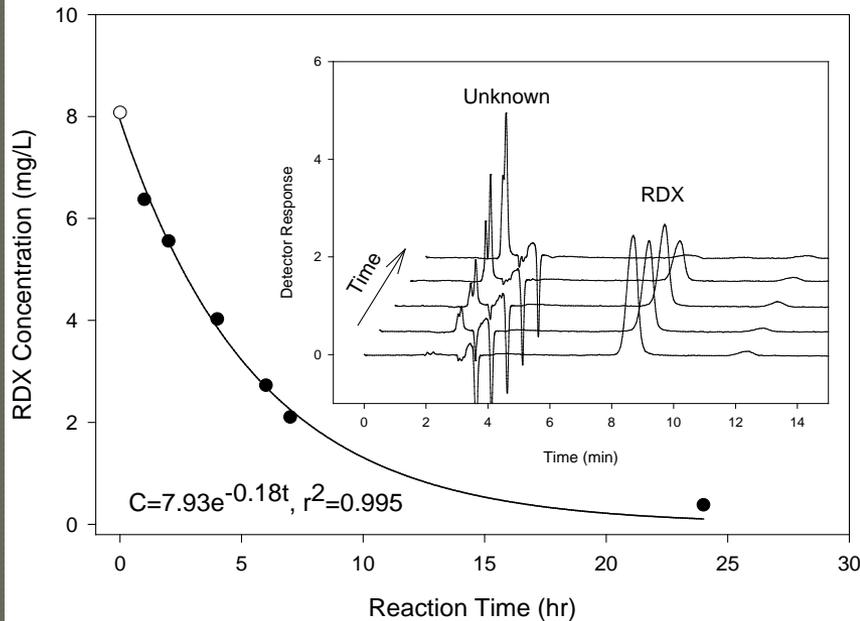


# Advantages/ Disadvantages

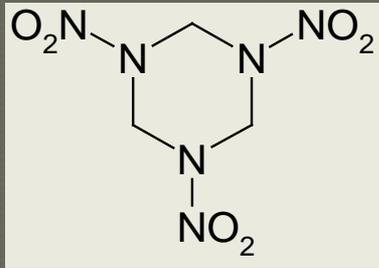
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- Advantages of using this approach:
  - *In-situ* treatment of munitions constituents
  - Incorporate lime into normal range activities
  - Reduce munitions constituents migration off range
  - Stabilize metals and transform explosives residues
  - Low cost approach (<\$2,000/acre/year)
  - Lime is readily available
  - Reduce potential future liability associated with migrating munitions constituents and source zone contamination
- Disadvantages
  - Amount of lime needed varies with soil type and weather conditions
  - Need to evaluate range soil characteristics
  - Application method will vary with site conditions, usage.

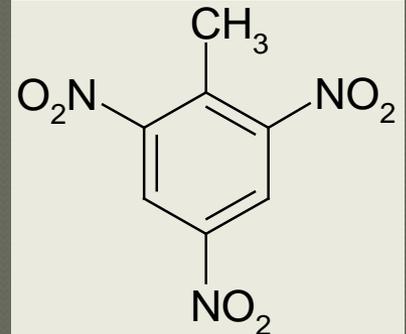
# Laboratory results



- RDX
- Aqueous
- pH=12
- Half Life  $\approx$  5 hrs

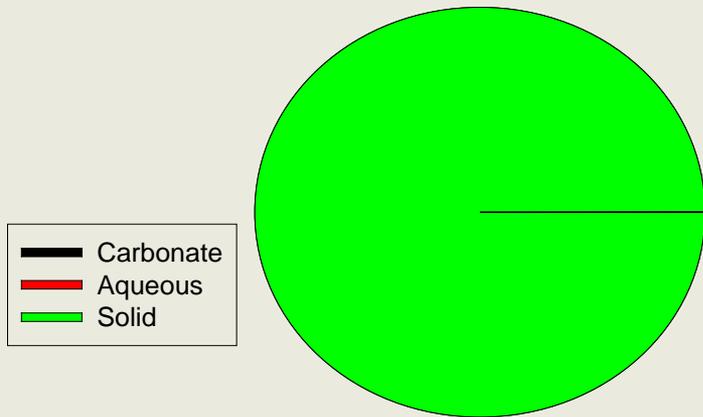


- TNT
- Aqueous
- pH=11.5
- Half Life < 2 hrs

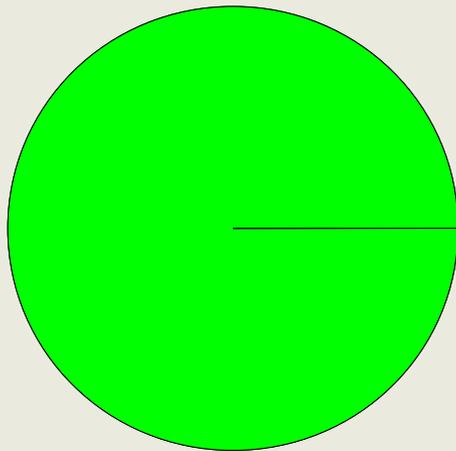


# Bio-mineralization of RDX base-hydrolysis products

RDX without alkaline hydrolysis



RDX following alkaline hydrolysis



The degradation of RDX base induced transformation products continues via both anaerobic and aerobic degradation

>75% aerobic mineralization obtained in  $^{14}\text{C}$  labeled study after a few weeks

# Bench-scale Mesocosms

- Types of lime tested
  - Hydrated lime ( $\text{Ca(OH)}_2$ )
  - Quicklime ( $\text{CaO}$ )
  - Class C fly ash
  - Caustic solutions
- Application methods
  - Till or no till
  - Acid rain



Benches holding soil-filled pots are on the upper level and the leachate collection and secondary containment system are on the lower level.

# Field demonstrations

- Blow in place facility- Redstone Arsenal, Huntsville, AL
- Hand grenade range- Fort Jackson, S.C.
- Open detonation facility- Aberdeen Proving Grounds, N.J.

Blow-in-place site after treatment with 227 kg of hydrated lime.



# Blow-in-place application



High calcium hydrated lime was applied with a 5 ft drop spreader pulled behind an ATV. 227 kg lime was applied across a 30 m by 30 m area centered on the crater. Lime was applied manually in the craters.

# Blow in place- sampling



Mortar round prepared for blow-in-place operations

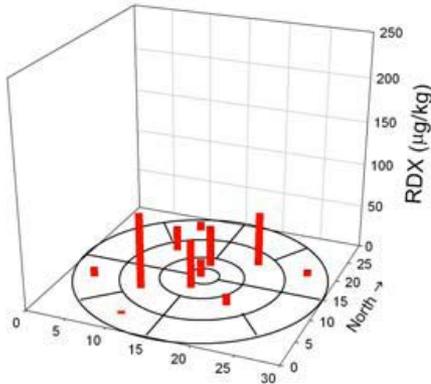


Soil sampling with tool

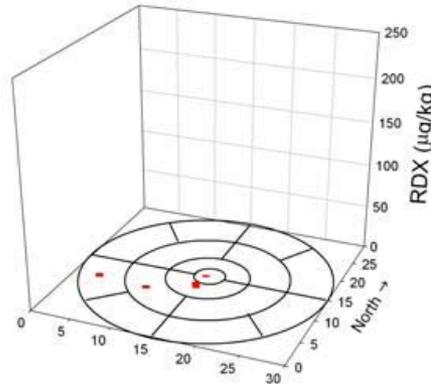


Pushing soil core out of the tool.

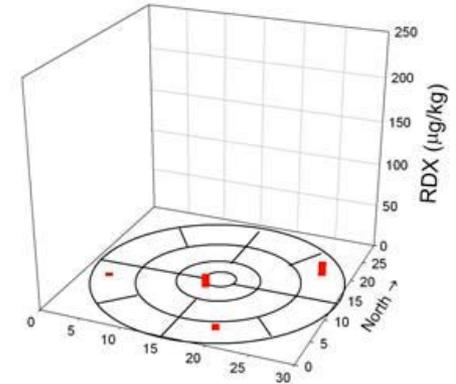
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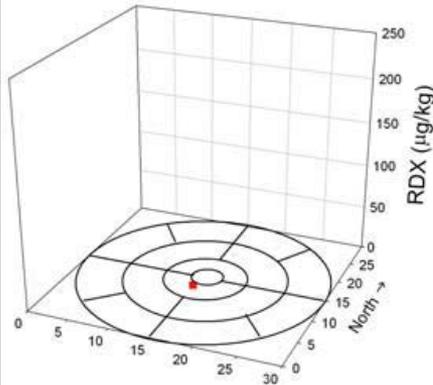
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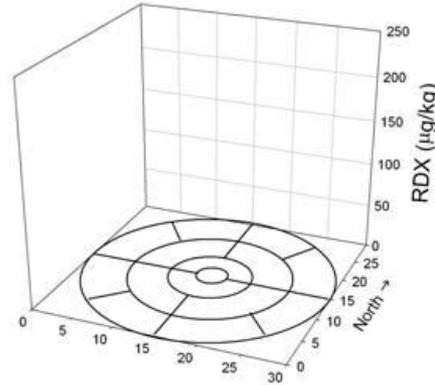
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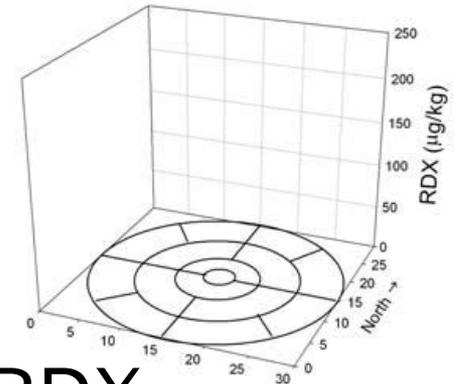
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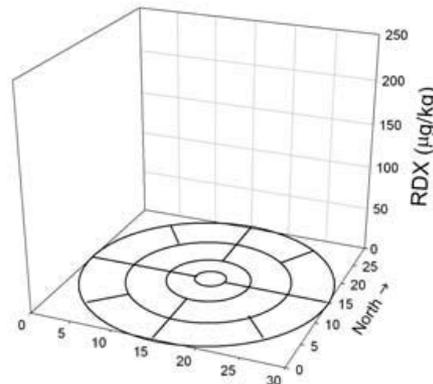
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Site #4 29Mar 2005



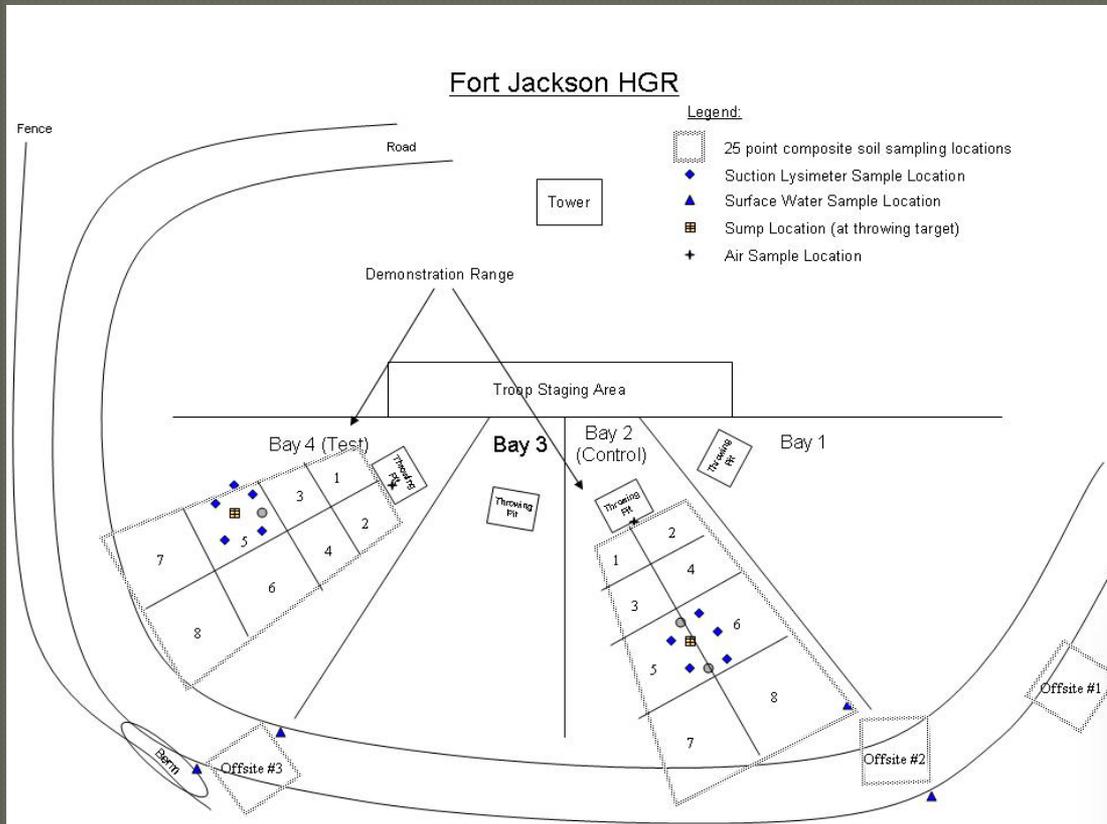
Site #4 26Apr 2005



Redstone  
Arsenal  
results

RDX  
Concentrations  
on site #4  
(treated) during  
the duration of  
the study

# Hand grenade range- Ft Jackson



**Schematic (not to scale) of Fort Jackson Hand Grenade Range; Bay 2 was the control and Bay 4 was the test bay (or limed).**



**Surface water sampler**

# Ft Jackson hand grenade range application method



Lime was spread with an ATV pulling a spreader. The lime was then disked into the soil. Level D PPE is recommended for personnel during application.

# Fort Jackson Hand Grenade Range (HGR) Results

Sampling Date	Bay 4 (Limed) Average RDX Conc. (ppm)			Rain Between Sample Events (inches)	Post Lime % Soil Moisture
	Pre Lime	Post Lime	% Change		
Apr 06	4.21	<1.75 <sup>1</sup>	>58%	0.12	2.21
Oct 06	0.42	<0.08	>59%	3.2	6.36
Jan 07	<0.09	<0.10	No Change	0	6.83

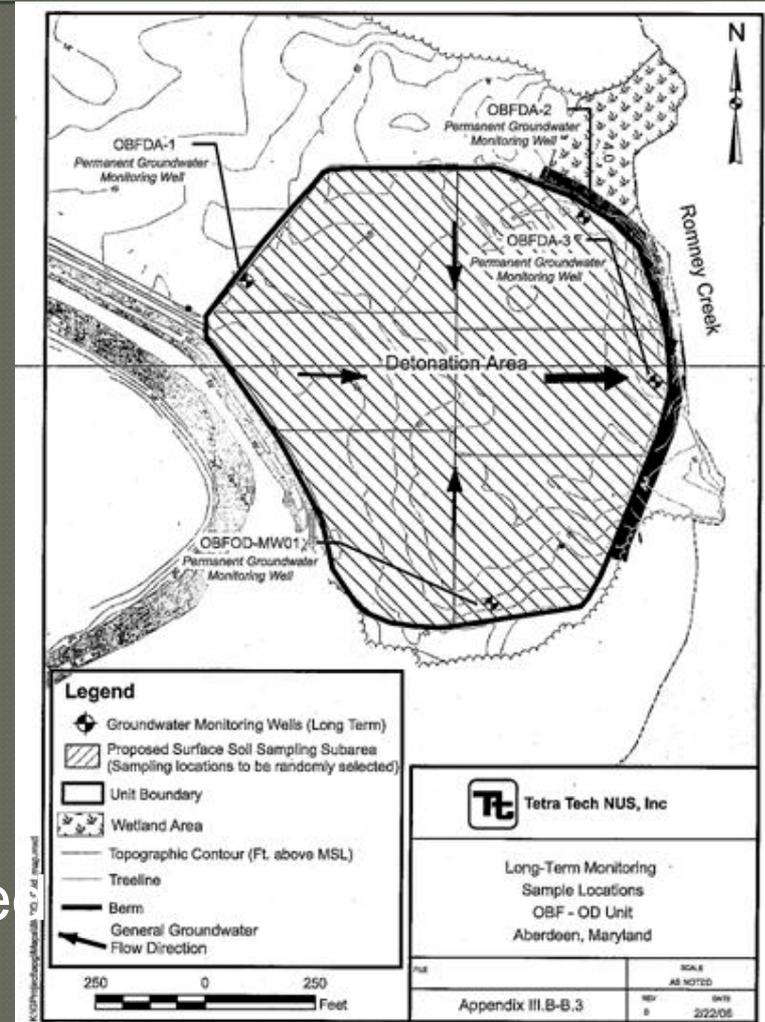
<sup>1</sup> Report limit (0.02 ppm) used in calculations where '<' present.

Application was accomplished in about 4 hours.  
Approximate cost of \$400 per bay/application.

# Open detonation facility Aberdeen Proving Grounds, NJ

Site characteristics:

- ✓ Active range
- ✓ Accessible year round
- ✓ Shallow depth to groundwater.
- ✓ Sufficient soil explosives concentrations
- ✓ APG provides on-site UXO support
- ✓ There were no known environmental drivers that limit the technology use.



# OD facility- application method



The most effective application method was to place bags of lime around the soil mound. The detonation mixed the lime. RAC 3 was recommended for this operation.

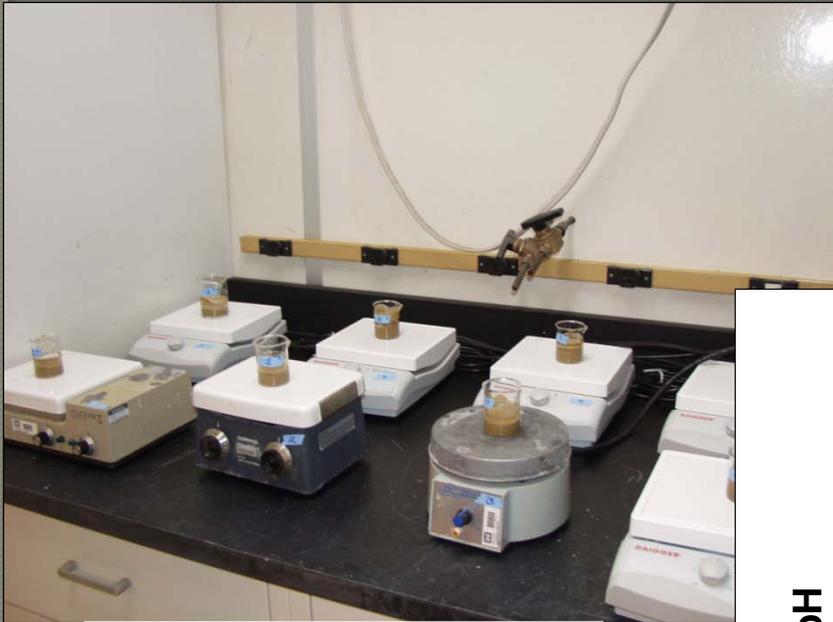


# OD facility- APG Results



- Explosives concentrations were reduced to non-detect values in pore, surface, and ground water and soil.
- Most metals were stabilized.
- Invertebrate population was not affected.
- Surface water pH was neutral at perimeter.
- Cost assessment depends on site specific conditions.

# Lime dosage determination



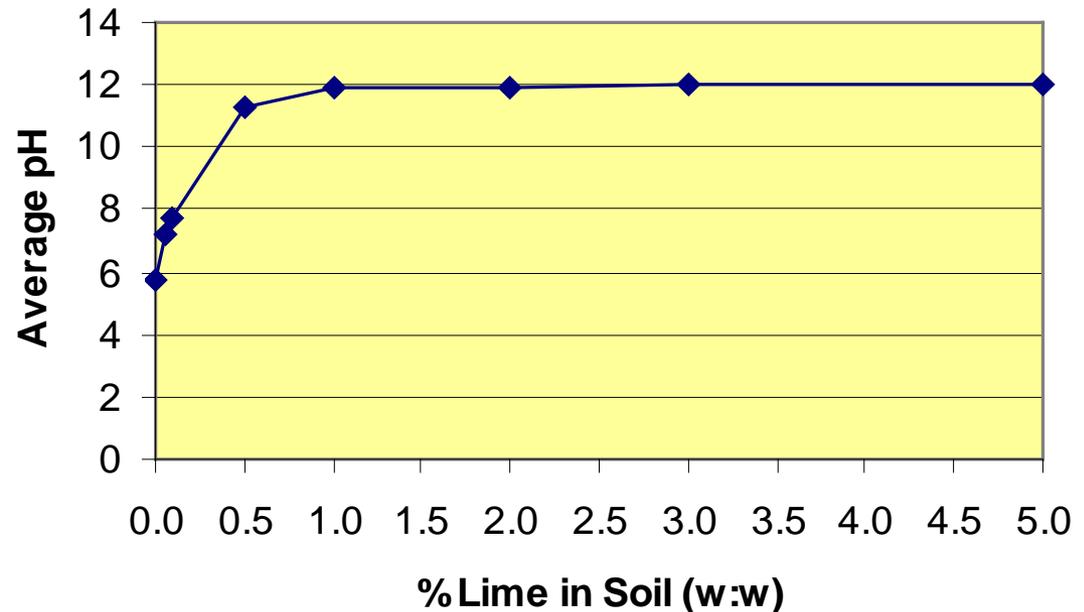
## Soil pH Slurry

0.5% (w:w) lime needed to elevate pH above 11.5

## Soil Slurries

- 1:1 (w:w) ratio soil to water
- Add varied amounts hydrated lime to establish curve.

## ATC - OD Range Soil pH Slurry



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# In summary

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✓ Alkaline hydrolysis can be used for different types of facilities:

- ✓ Small arms firing ranges
- ✓ Hand grenade ranges
- ✓ Demilitarization of munitions- BiP, OD
- ✓ Effective
- ✓ Reasonable costs using readily available equipment
- ✓ Application does not interfere with training activities
- ✓ Immobilize metals associated with common munitions.

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# Questions ?

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