Transport of RDX and TNT from Composition-B Explosive During Simulated Rainfall

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INTRODUCTION

- Migration of contaminants from artillery training areas is a concern
- Low-order detonations can result in distributed Composition-B explosive (Comp-B) particles on the training area surface
- Comp-B can contribute to contaminant migration through the surface water runoff pathway
- Effects of landscape characteristics (soil properties and vegetative type and cover) on Comp-B migration is unknown


JUSTIFICATION

- Surface water is a primary pathway for migration of explosive compounds from impact areas (Simmers, 1997)
- Soil physicochemical and cover characteristics can affect fate of explosives in surface water (Price, 1997, 1999)
- Mitigating effects of landscape buffer on source zone discharge of Comp-B has not been well characterized
- Determining the effects landscape characteristics have on migration of Comp-B can support chemical fate and transport watershed models

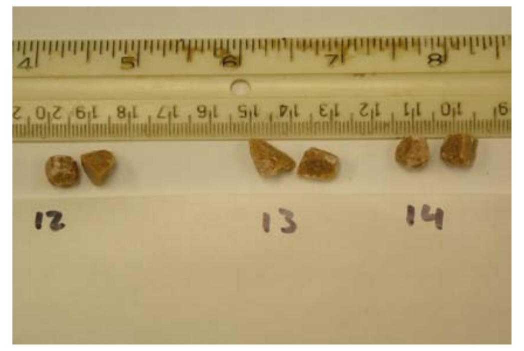
APPROACH

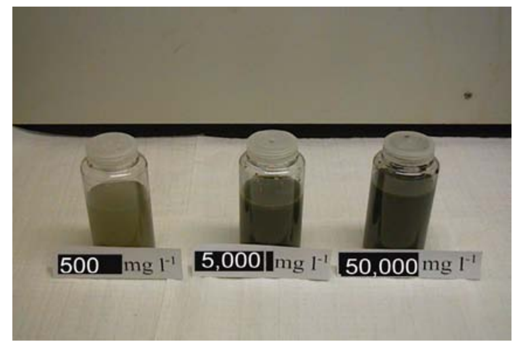
- Determine the fate of Comp-B in surface flow from source zones
- Approach should consider the effects of dilution and removal across a 2-D plane
  - Partitioning in surface water runoff - soluble, bound, and particulate (total)
  - Surface soil distribution - source zone expansion
  - Removal by plants - plant uptake into tissues
  - Adsorption by detritus - binding by dead plant matter

METHODS AND MATERIALS

Saturation and Dissolution Tests

- Saturation Procedure:
  - 400 mL DI H2O spiked with 50, 500, 1000, 5000, and 50000 mg of Comp-B
  - Agitated on horizontal shaker for 30 minutes at 72rpm
  - Recovered particles for mass balance
  - Filter and chemical analysis for HMX, RDX, and TNT
- Dissolution Procedure:
  - 400mL DI H2O spiked with 0.5g of Comp-B
  - Three distinct soils were added to evaluate soil physical/chemical effects of suspended soil in surface runoff, TSS= 50, 500, 5000, and 50000mg/L
  - Agitated on horizontal shaker for 30 minutes at 72rpm
  - Recovered particles for mass balance
  - Filter and chemical analysis for HMX, RDX, and TNT





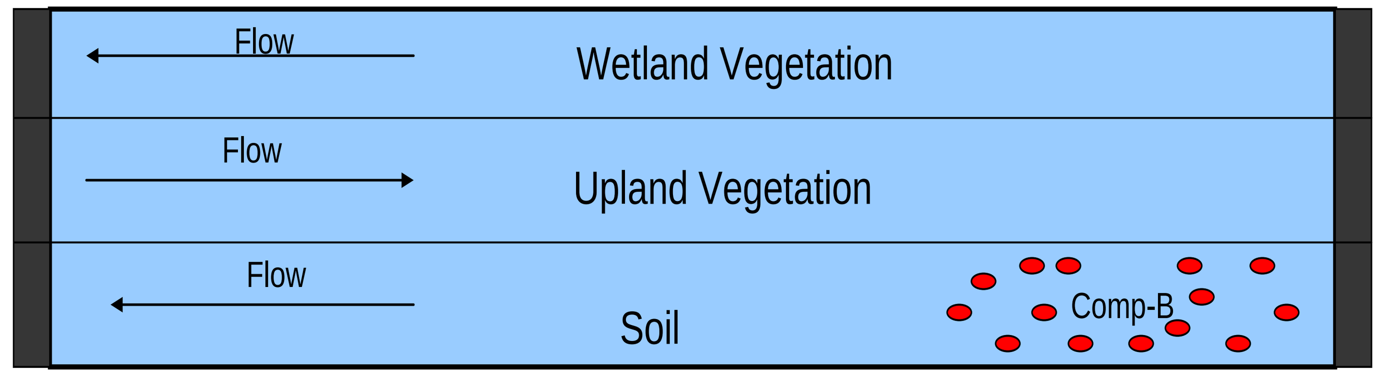
Rainfall Runoff Study

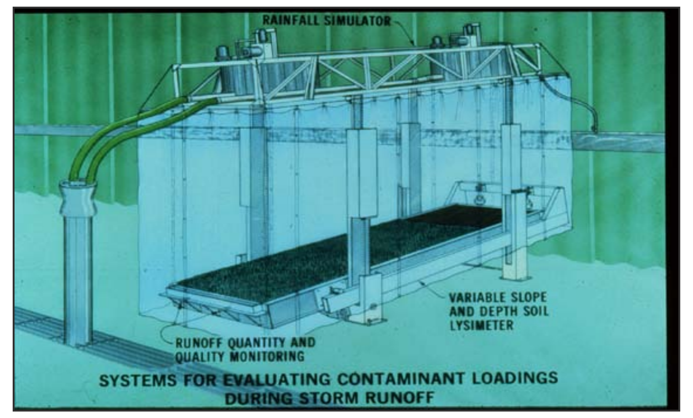
- Rainfall simulator/terrestrial mesocosms setup (Figure 1)
  - Bare upland soil with Comp-B source zone
  - Vegetated upland soil- overland flow buffer zone
  - Vegetated wetland soil- settling and treatment basin
- 100g of Comp-B particles placed in Quad 1 of the bare upland
- 30 min rainfall event at 5.08 cm hr^{-1}
- Runoff samples were collected at the end of each mesocosm at 1-15, 20, 25, and 30 min for physical and chemical analyses
- Soil and plant samples were collected before and after the three replicate test series
- Test was identically repeated once plants were dormant
- Measurements determined:
  - Runoff rate, TSS, pH, TOC, salinity, bulk density, soil moisture
  - Chemical analysis by HPLC for HMX, RDX, TNT in water, soil, and plant tissues (EPA Method 8330)
  - Runoff water- total and soluble at each landscape transition
  - Plant- Comp-B uptake and adsorption
  - Soil- Comp-B concentration gradient down slope over time

Live test plot

Dormant test plot

Figure 1. Three cell mesocosm for rainfall runoff s study





RESULTS AND DISCUSSION

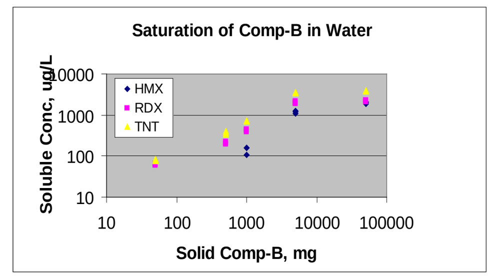
Saturation and Dissolution Test

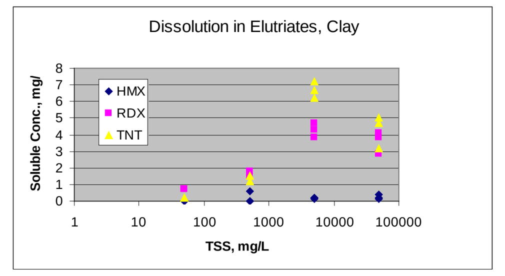
Figure right shows:

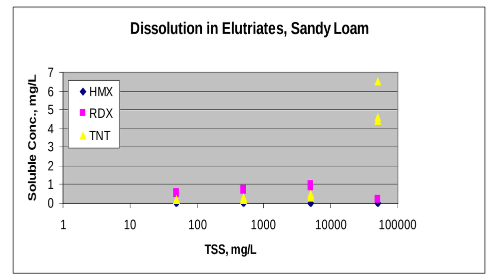
- Saturation of Comp-B constituents in water was limited to 4ppm

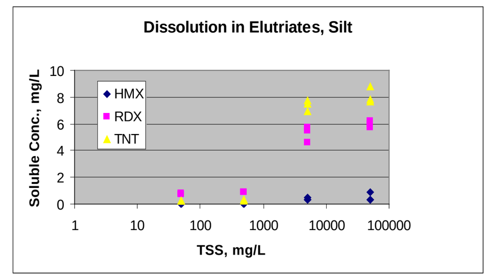
Figures below show:

- HMX and RDX were limited in sandy loam soil elutriates
  - Soil chemical properties (such as Ca and Fe) may control fate of Comp-B in runoff









	Mehlich 1 Soil Properties mg/kg (ppm)													
Soil	Ag	Ba	Be	Ca	Cd	Cl	Cr	Cu	F	Fe	K	Li	Mg	Mn
Sandy Loam	<0.0004	17.10	0.09	53	<0.008	6.99	0.03	0.65	0.25	19.73	15.32	1.92	10.40	7.58
Clay	<0.0004	168.10	1.89	5420	<0.008	9.74	0.05	0.05	0.26	0.64	28.61	9.39	82.50	4.57
Silt	<0.0004	118.10	0.44	4940	<0.008	13.59	0.05	0.04	0.34	0.25	13.65	4.11	461.90	11.01

Simulated Rainfall

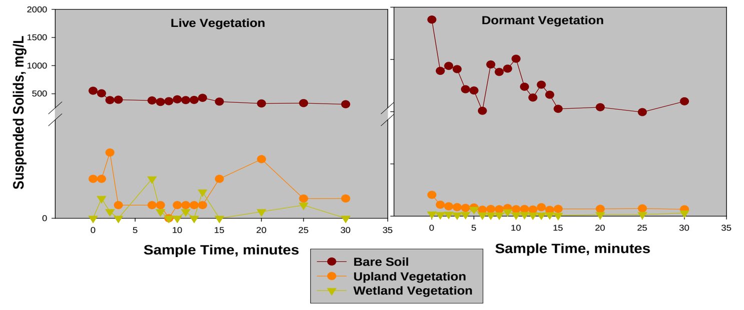
Figure and tables right show:

- Vegetation reduced total suspended solids (TSS) in runoff
- Soil RDX distribution variable, most remaining near source zone - wetland concentration may be associated with submerged plant material
- RDX was distributed into plant tissue throughout the system
- RDX may leach readily from dormant upland plant tissue, subsequent tests have confirmed this Other plant related uptake, adsorption, release processes need further study

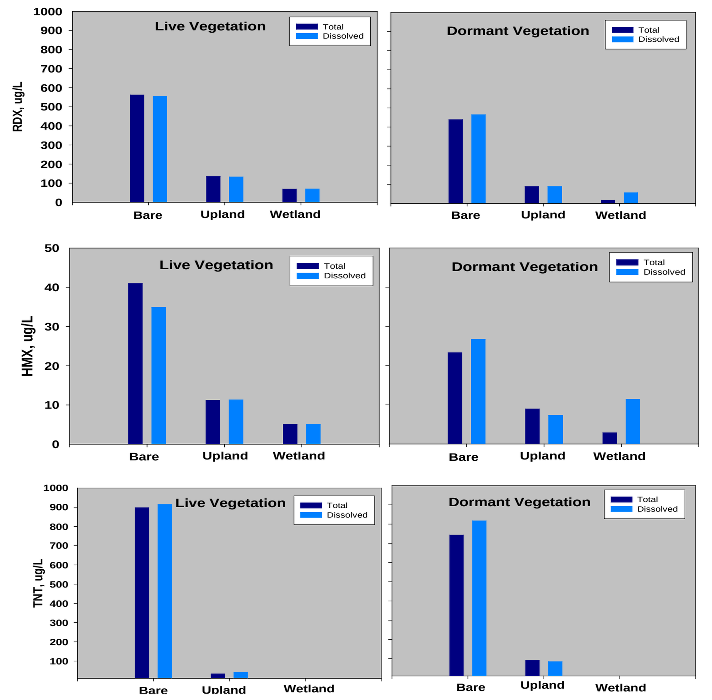
Figures below show:

- Vegetation significantly reduced RDX, HMX and TNT in runoff with TNT near or non-detectable, not associated with TSS

TSS in runoff



RDX, HMX, and TNT in runoff water



Soil concentration of RDX before and after rainfall events, ug kg^{-1}

Location	PRE-LIVE	POST-LIVE	PRE-DORMANT	POST-DORMANT
Bare 1	75	1340	730	3500
Bare 2	<100	770	1100	1950
Bare 3	<100	160	500	1020
Bare 4	<100	<100	180	185
Upland 1	<100	<100	<100	26
Upland 2	<100	55	<100	<100
Upland 3	55	230	<100	<100
Upland 4	<100	<100	<100	<100
Wetland 1	<100	115	<100	<100
Wetland 2	<100	2715	<100	<100
Wetland 3	<100	165	<100	<100
Wetland 4	<100	<100	<100	NA

Plant tissue concentration of RDX before and after rainfall, ug kg^{-1}

Location	PRE-LIVE	POST-LIVE	PRE-DORMANT	POST-DORMANT
Upland 1	<400	2270	3120	<400
Upland 2	<400	1570	1500	<400
Upland 3	<400	1070	1480	<400
Upland 4	<400	<400	<400	<400
Wetland 1	<400	<400	<400	<400
Wetland 2	<400	<400	<400	<400
Wetland 3	<400	755	<400	<400

SUMMARY

- Rainfall results in limited overland flow of RDX, HMX, and TNT from particulate Comp-B source zones, increasing soil concentration in the immediate source zone and in adjacent plant tissues
- Plant uptake/adsorption from contaminated surface runoff water acts as a vegetative filter strip to minimize overland flow to receiving waters
  - A vegetative buffer of at least 27 m in linear distance between the point of runoff exposure to surface distributed Comp-B and receiving water is needed to reduce surface water concentrations to below detectable concentrations
- Accumulated RDX in plant tissue may release readily once the tissue dies
  - Further study is needed to quantify mass balance and degradation potential in the plant uptake/adsorption processes