

Spatial Range Munitions Constituents (MC) Modeling Capabilities

Zhonglong Zhang, PhD, PE

Billy Johnson, PhD, PE

ERDC/EL, Vicksburg, MS

Environment, Energy Security, and Sustainability
(E2S2) Symposium

May, 9-12, 2011



US Army Corps of Engineers
BUILDING STRONG®



Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE MAY 2011		2. REPORT TYPE		3. DATES COVERED 00-00-2011 to 00-00-2011	
4. TITLE AND SUBTITLE Spatial Range Munitions Constituents (MC) Modeling Capabilities				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Army Engineer Research and Development Center,Environmental Laboratory,3909 Halls Ferry Road,Vicksburg,MS,39180-6199				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 9-12 May 2011 in New Orleans, LA.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 19	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

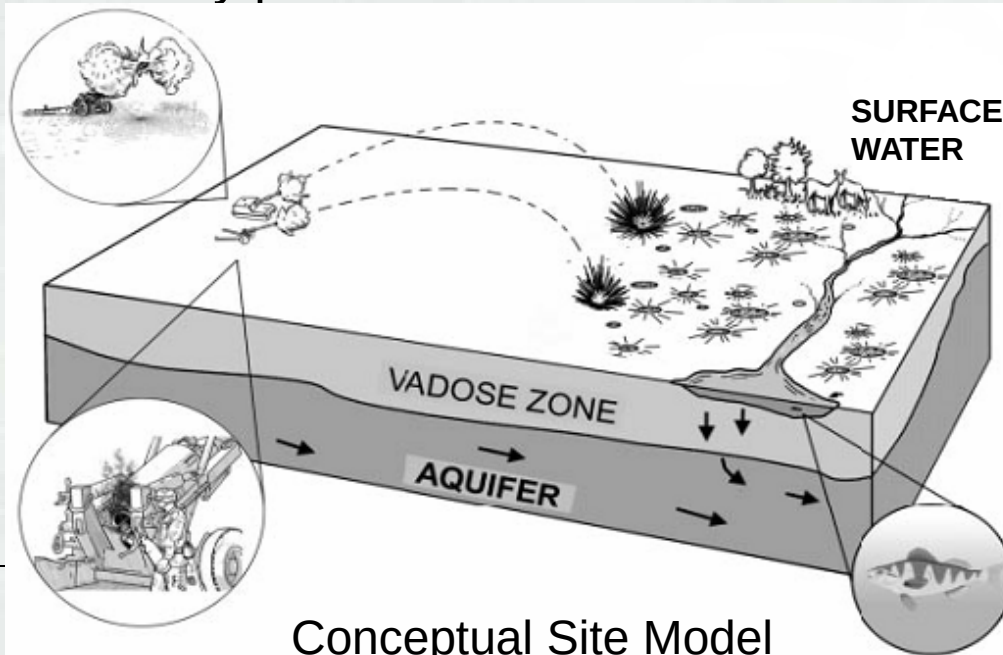
Objectives

- Provide the range manager with tools that can be implemented to meet regulatory compliance goals and long-term sustainable management of the installation
- Develop, test and validate an integrated, multi-scale, multi-media, multi-pathway model for evaluation of distributed sources of munitions constituents (MC) on military testing and training lands
- Build and demonstrate a watershed application that represents full hydrologic processes, erosion /sedimentation, contaminant loadings, and instream water quality responses from military testing and training lands within and outside the Installation



Background

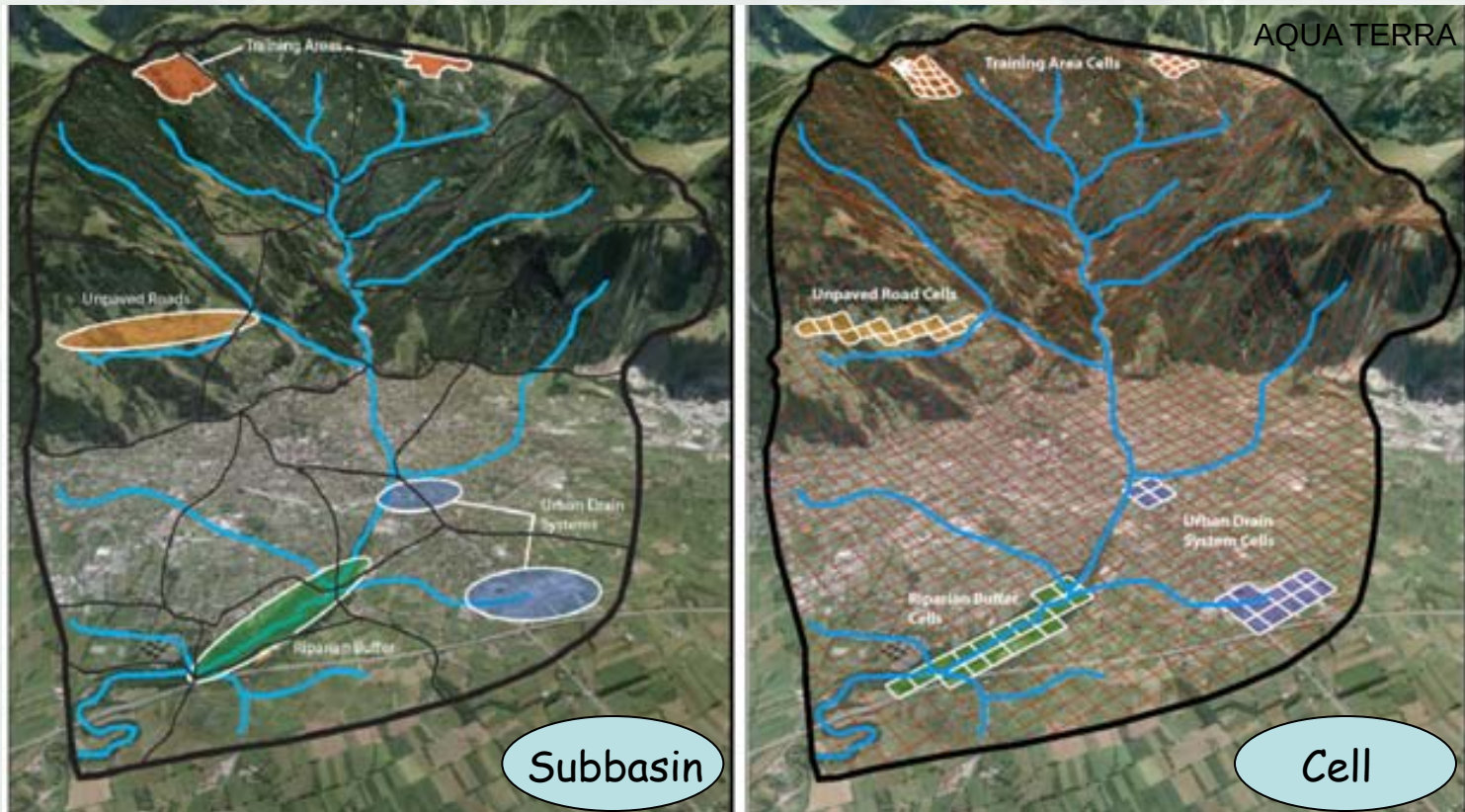
- Potentially Contaminates of Concern (CoCs)
 - ▶ Explosives (RDX, TNT, HMX, DNT...)
 - ▶ Heavy metals (lead, cadmium, chromium, nickel, copper...)
- Potentially environmental issues
 - ▶ CoCs may be moving off range areas in sufficient concentration and contaminate surface water or ground water
 - ▶ People, plants and animals may be exposed to the CoCs, eventually pose a toxic threat to human health and ecosystems



Conceptual Site Model



Watershed Modeling



- ▶ HEC-HMS
- ▶ HSPF
- ▶ SWAT
- ▶ SWMM

- ▶ GSSHA
- ▶ DSVHM
- ▶ MIKE-SHE



GSSHA

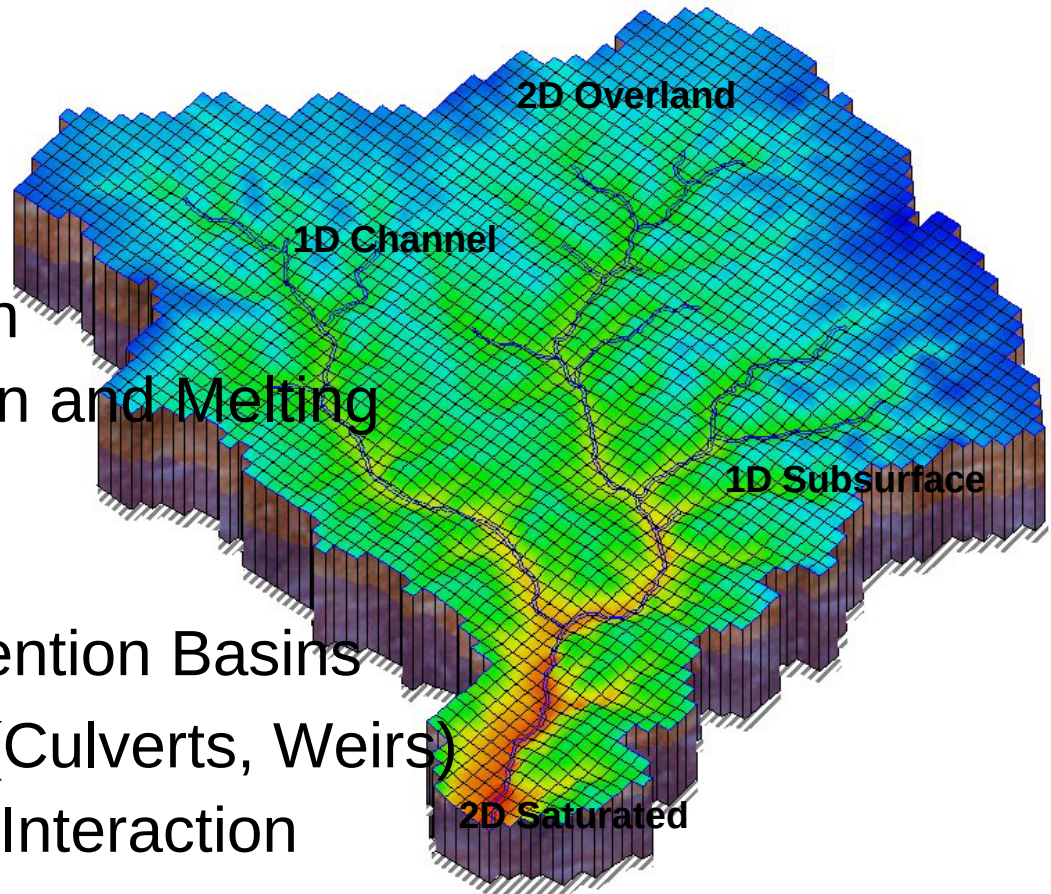
- **G**ridded **S**urface **S**ubsurface **H**ydrologic **A**nalysis
- Developed and maintained at the ERDC
- GSSHA is a physically based and fully distributed watershed model.
- GSSHA works on a uniform spatial grid.
- GSSHA closely links the hydrologic compartments at the watershed scale.
- GSSHA explicitly include spatially heterogeneous features, such as varying land use, source areas, BMPs, etc.
- GSSHA has been tested on a number of very different watersheds.

-
- <http://gsshawiki.com>

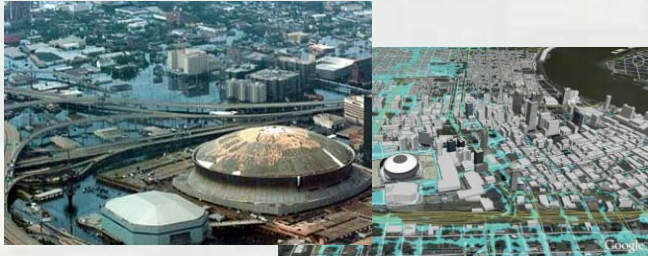


GSSHA

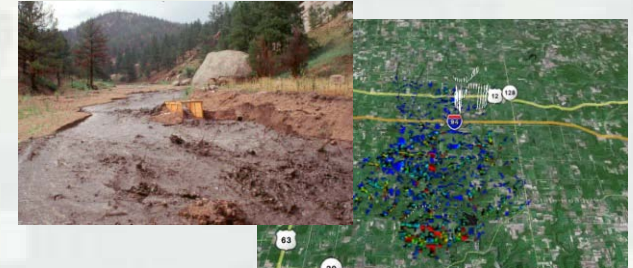
- 2D Overland Flow
- 1D Channel Network
- 2Dx1D Infiltration
- 2D Groundwater
- 2D Evapotranspiration
- Snowfall Accumulation and Melting
- Wetlands
- Storm/Tile Drains
- Small Lakes and Detention Basins
- Hydraulic Structures (Culverts, Weirs)
- Stream/Groundwater Interaction
- Sediment Erosion and Deposition



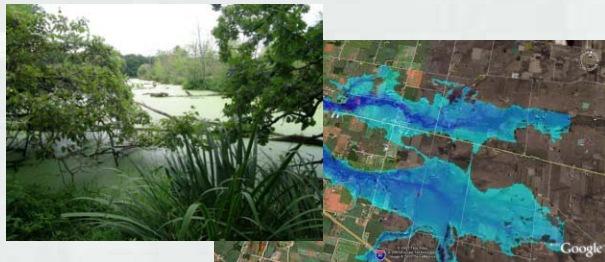
GSSHA Applications



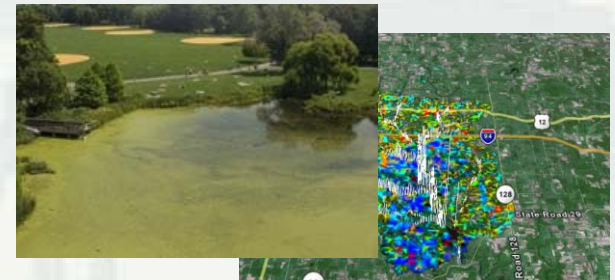
Surface water hydrology



Sediment and
Contaminant Transport



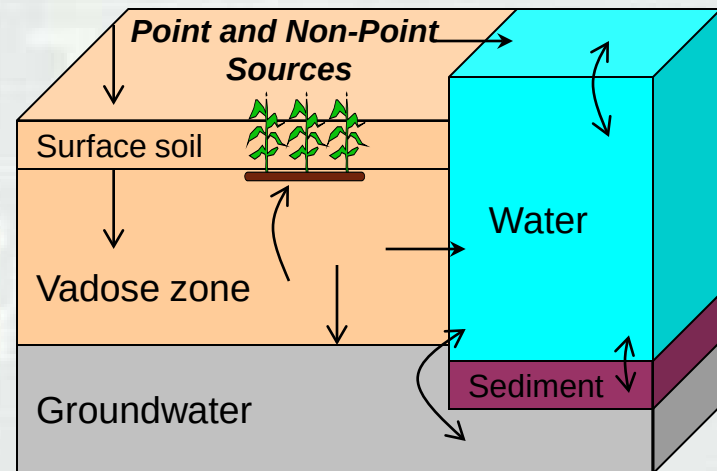
Surface Water/Groundwater
Interaction



Surface water quality and
TMDL's

Contaminant Transport, Transformation & Fate (CTT&F)

- GSSHA simulates surface runoff, interflow, baseflow and streamflow discharge, quantifies sediment rates of each grain size fraction for erosion from the soil surface and bed, and for deposition.
- **CTT&F** accounts for contaminant sources, movement, and chemical reactions for:
 - ▶ Surface runoff
 - ▶ Soil and interflow
 - ▶ Groundwater discharge
 - ▶ Streamflow

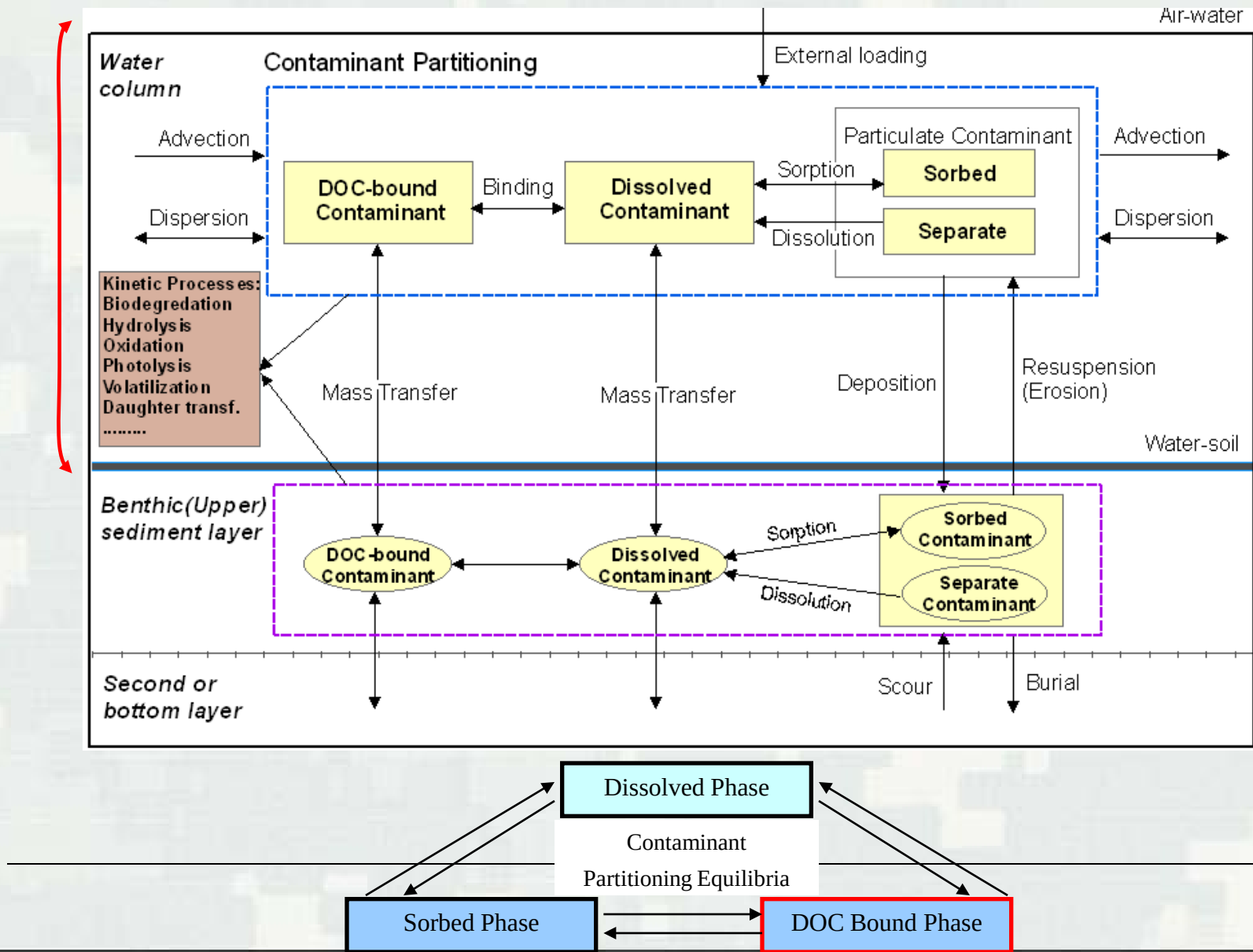


Current CTT&F Capabilities

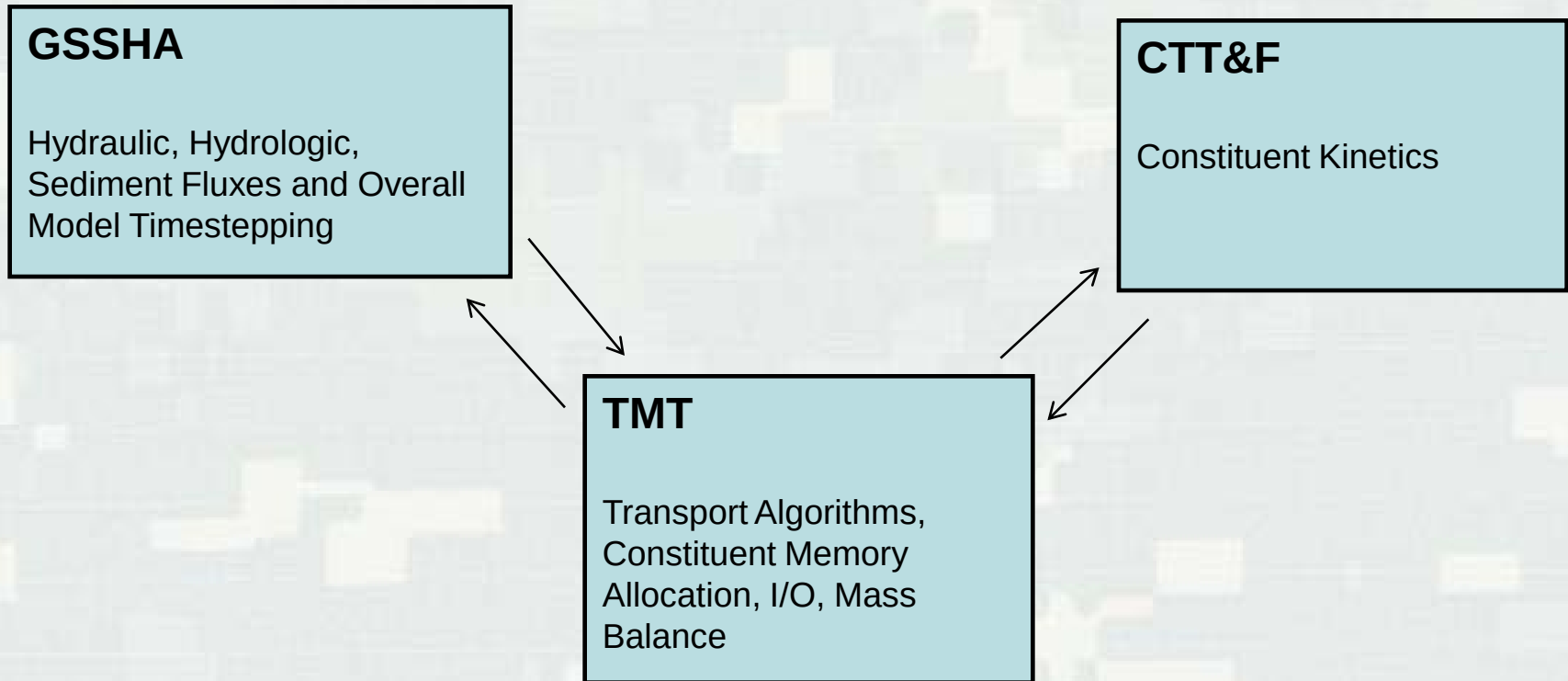
- Multiple (4) phase partitioning of MCs
 - ▶ Solids, Dissolved in water, Bound to DOC (Dissolved Organic Carbon), Sorbed to sediment particles
 - Multi-media physical transport processes
 - ▶ Overland flow
 - ▶ Stream network
 - Eight (8) biochemical transformation processes
 - ▶ Dissolution of solids
 - ▶ Biodegradation
 - ▶ Hydrolysis
 - ▶ Oxidation
 - ▶ Photolysis (Photodegradation)
 - ▶ Volatilization
 - ▶ User-defined extra reaction (second-order)
-
- ▶ Transformations and daughter products



CTT&F Framework



Integrated GSSHA-CTT&F



Facilitates the addition of new kinetic packages (e.g. NSM, Heavy Metals, Radionuclides, etc.) in the future.

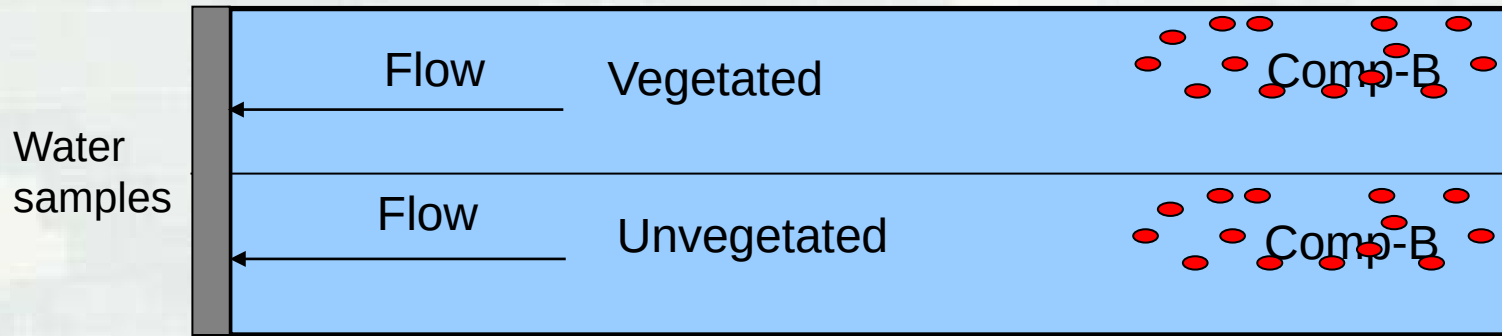


Model Testing & Validation

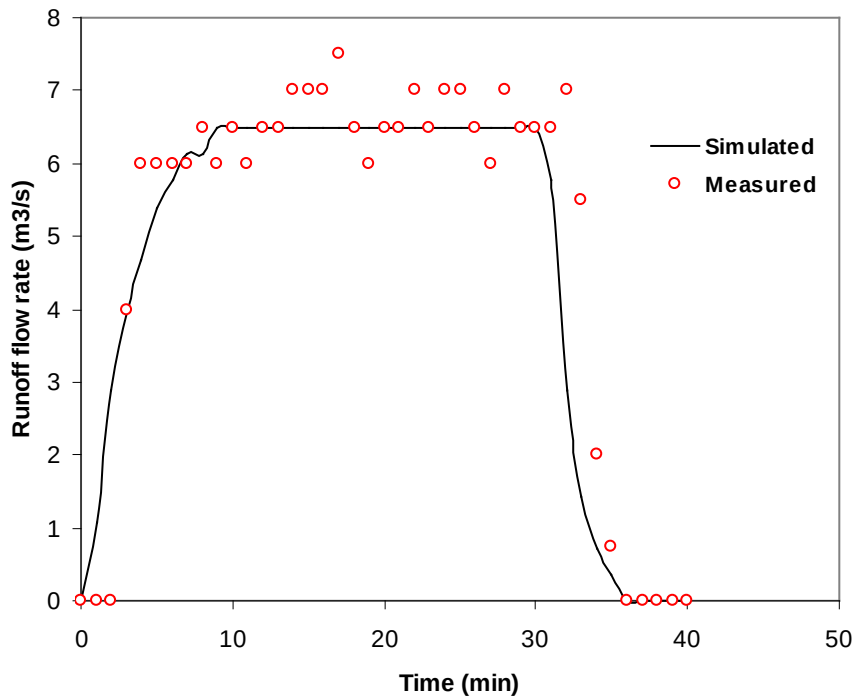
- Experiment plots was designed to simulate rainfall driven transport and transformations of explosives residues deposited on surface soils of firing ranges
- Explosive particles (Comp B) and RDX and TNT were modeled
- Two land covers were used to simulate two different surface roughness conditions: “disturbed” (unvegetated) and “undisturbed” (vegetated).
- Initial chemical loading: $500\text{g} / 67.5\text{ft}^2 = 79.73\text{g} / \text{m}^2$.
- The rainfall (2.8 in/hr) corresponds to a 50 year rainfall event.



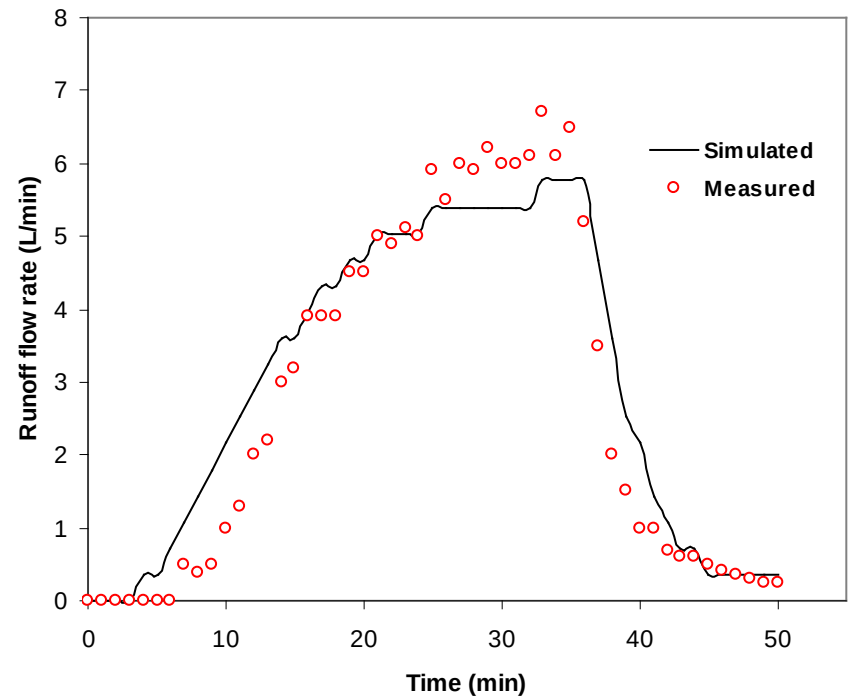
Model Testing & Validation



Unvegetated

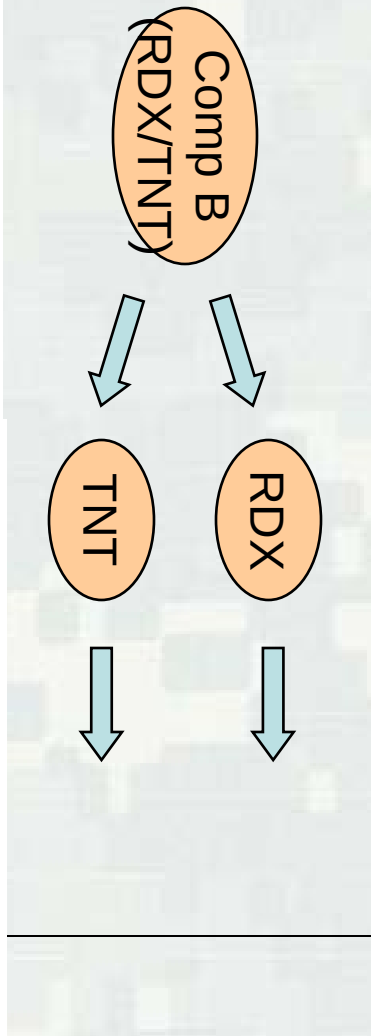
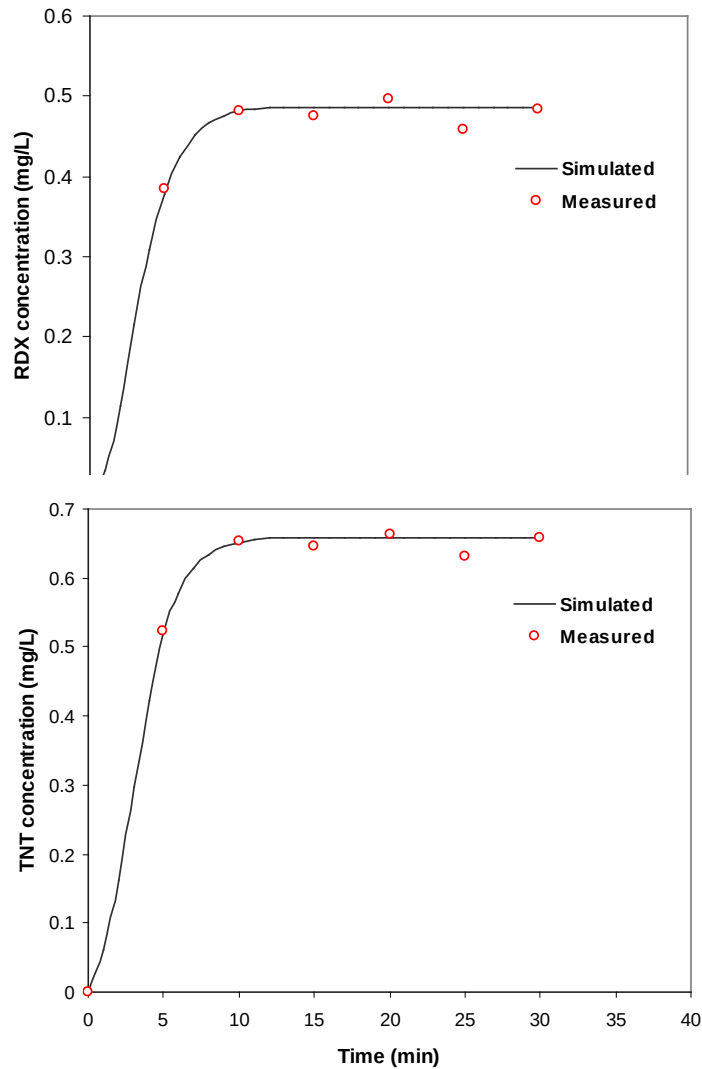


Vegetated

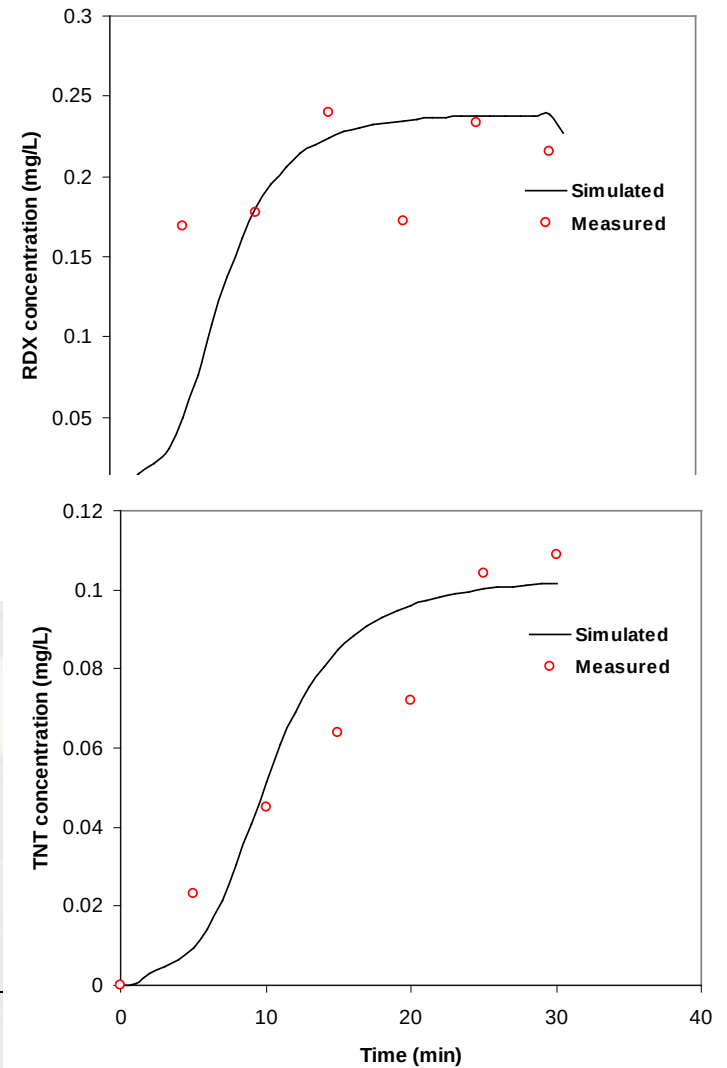


Model Testing & Validation

Unvegetated

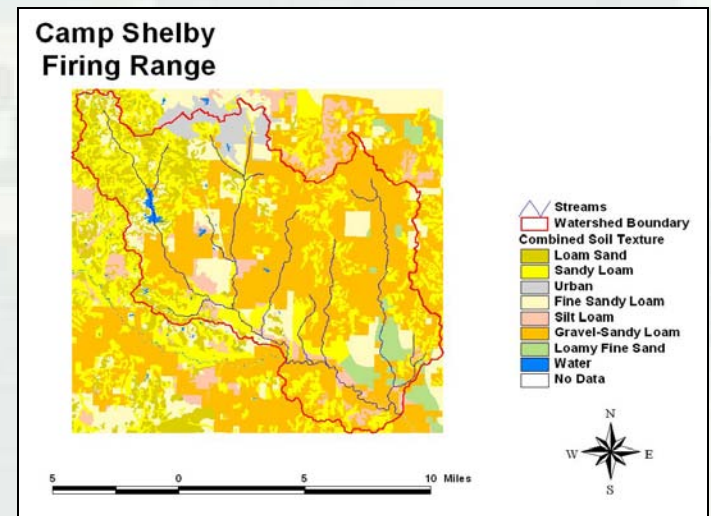
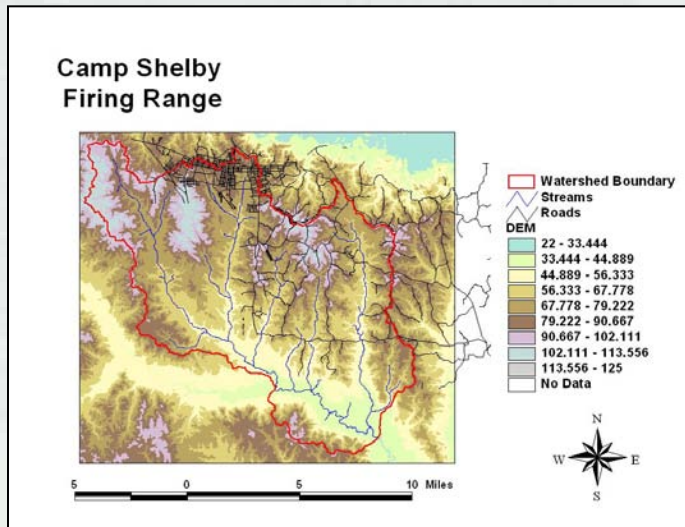
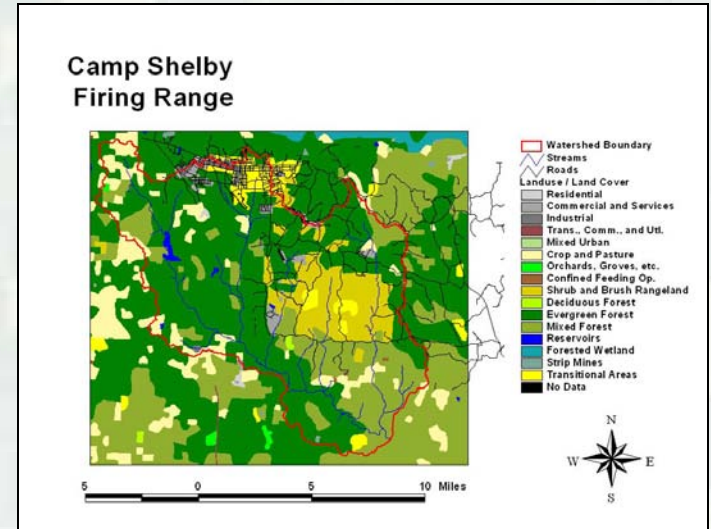


Vegetated



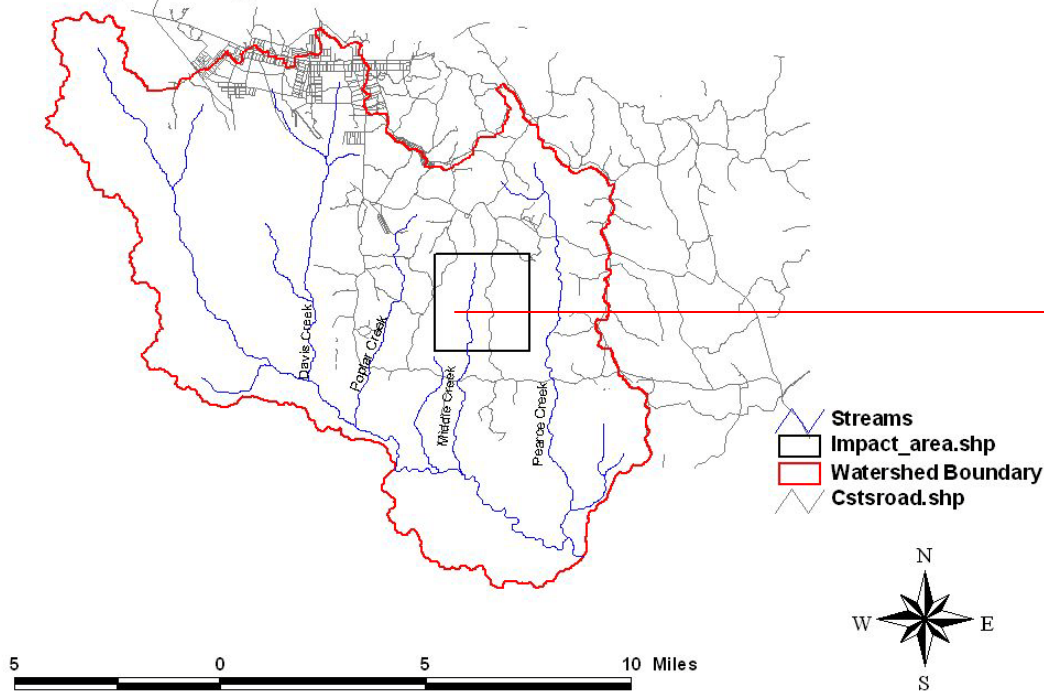
Watershed Application Demonstration

- Training Site is the largest reserve component training site, covering 136,000 acres, and a wide range of support facilities to support a variety of missions
- Watershed Area is approximately 112 square miles.

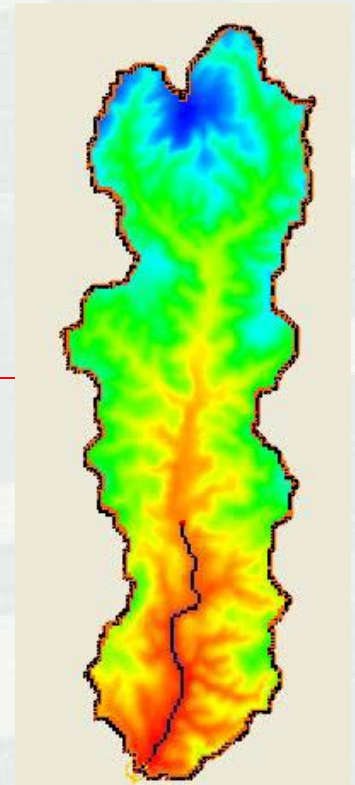


Watershed Application Demonstration

Camp Shelby Firing Range



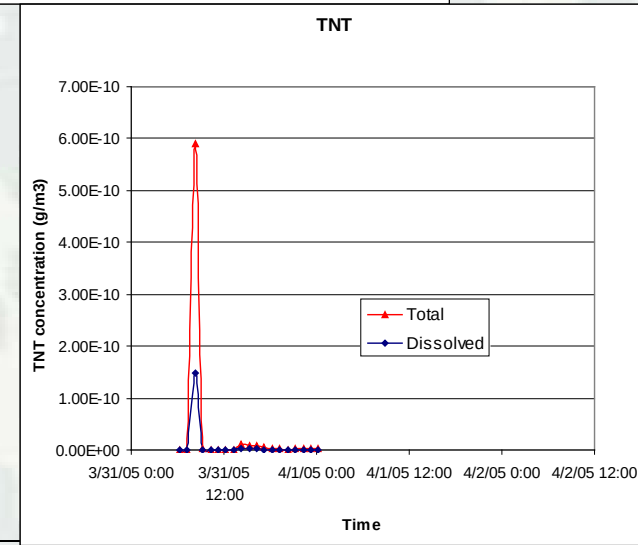
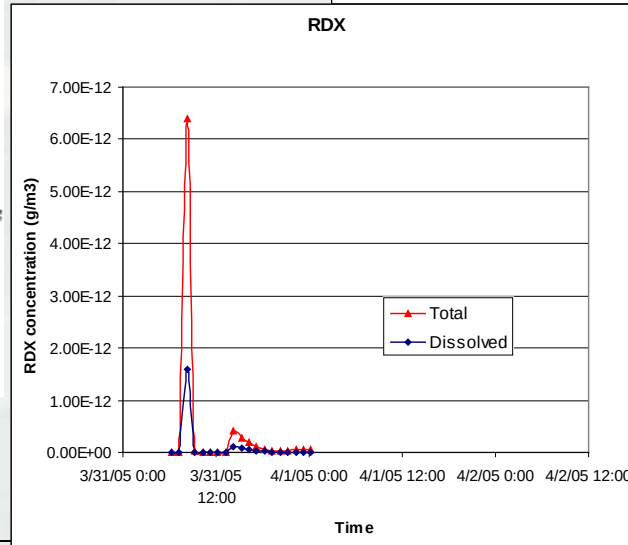
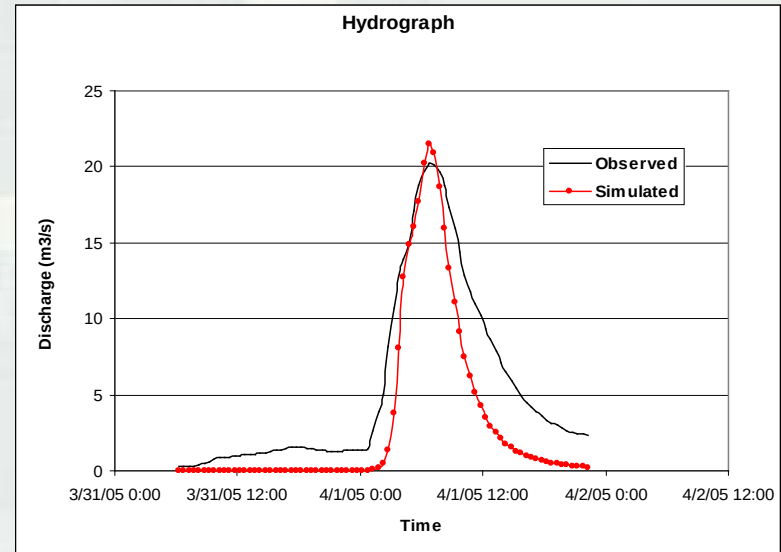
Middle Creek



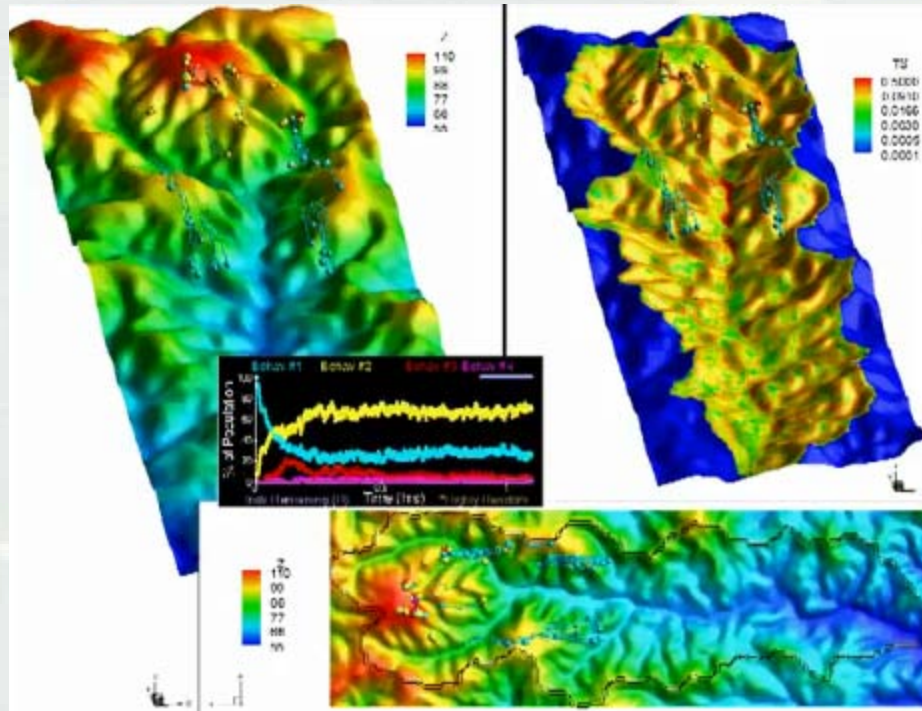
Drainage Area = 4.0 mi²



Watershed Application Demonstration



Watershed Application Demonstration



<http://www.youtube.com/user/CognitiveEcologyTeam#p/u/3/kzbQMnbd20I>



Summary

- GSSHA-CTT&F has been developed as a physically based, distributed, integrated watershed scale modeling system
- Application of the model to the training range indicates the GSSHA-CTT&F is a useful tool for predicting the site-specific behavior of explosives residue and multiple compounds
- The CTT&F algorithms and integration with GSSHA will be further validated directly against monitored range scale data
- Further development and enhancement of the CTT&F sub-model are underway.

