2012

Watershed Modeling for Impact Assessment on U.S. Military Installations

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WATERSHED MODELING FOR IMPACT ASSESSMENT ON U.S. MILITARY INSTALLATIONS

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Vicksburg, MS

50 Years of Watershed Modeling:

Past, Present and Future

Boulder, CO

September 24-26, 2012

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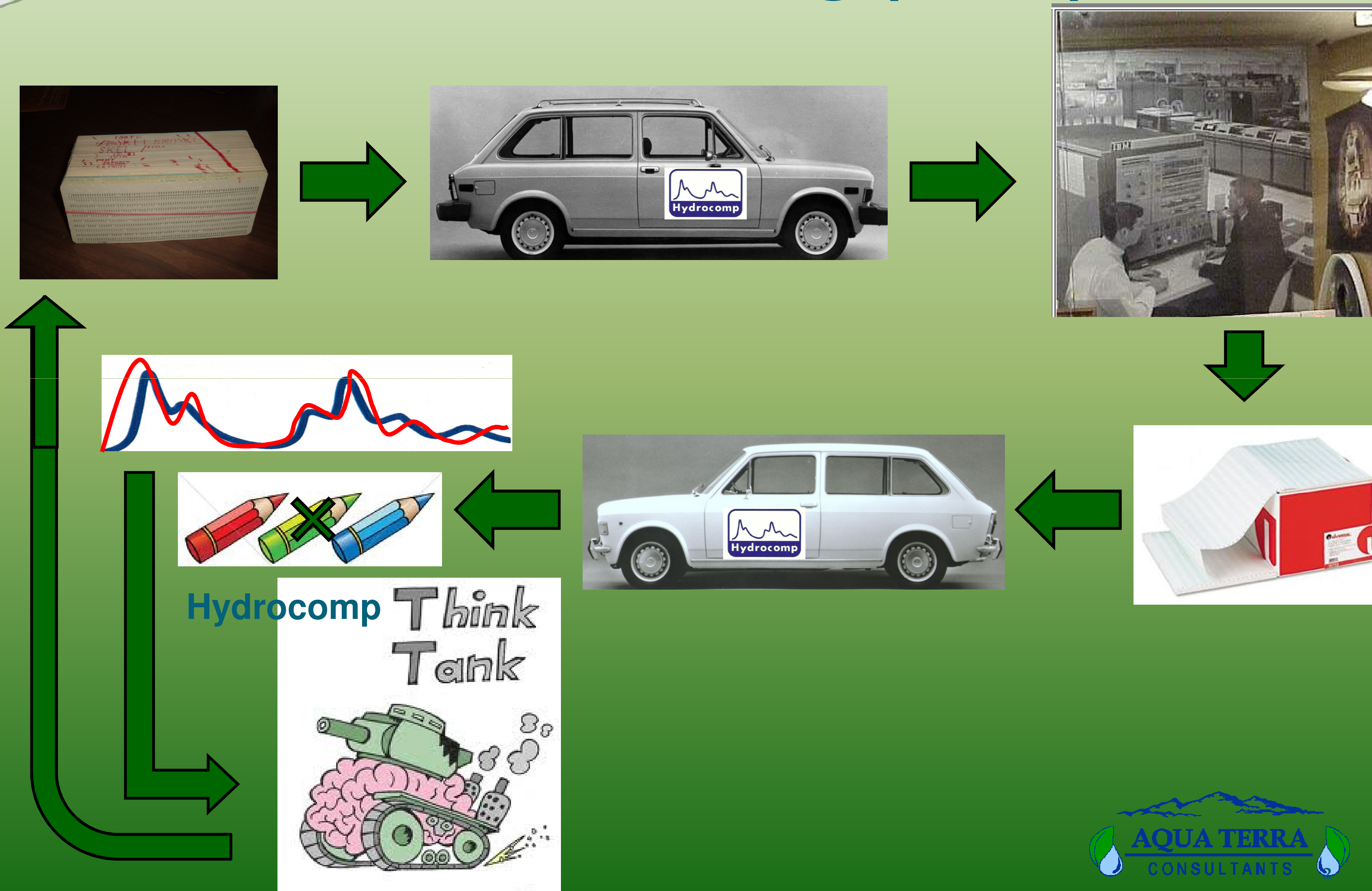
Watershed Modeling (1974)



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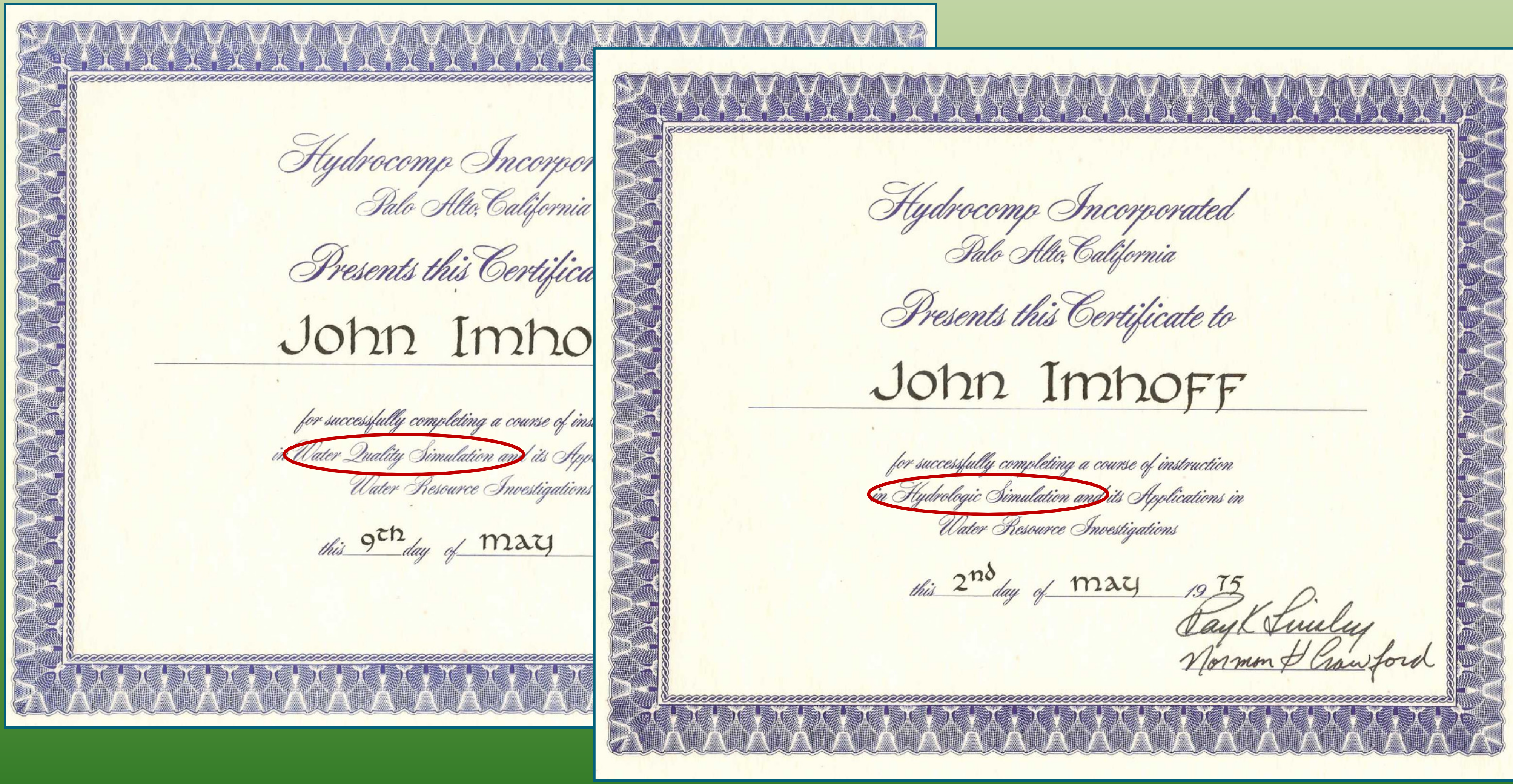
"Make Me a Respectable Man"... (1975)



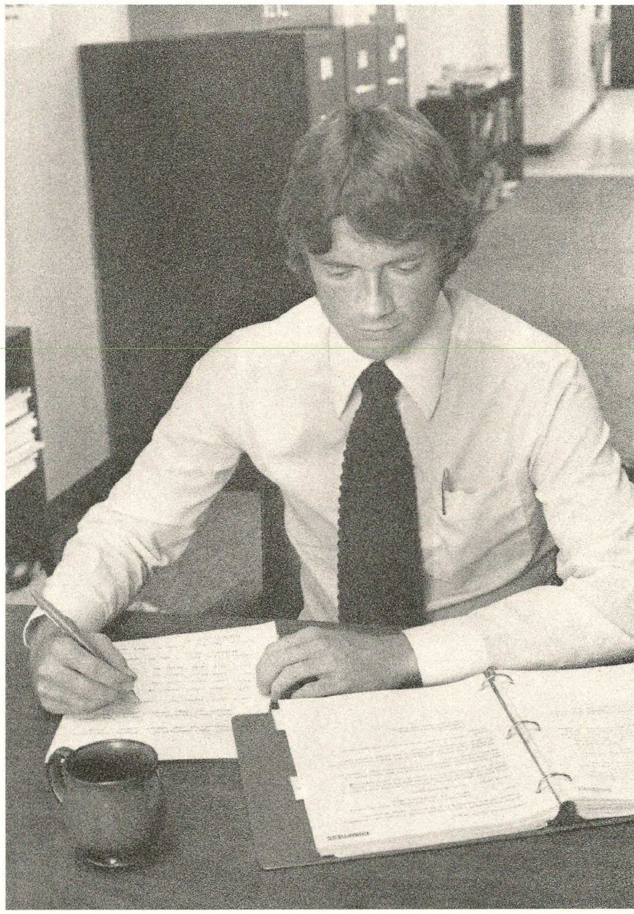
Hydrocomp Incorpor
Palo Alto, California
Presents this Certifica
John Imho
for successfully completing a course of ins
in Water Quality Simulation and its App
Water Resource Investigations
this 9th day of May

Hydrocomp Incorporated
Palo Alto, California
Presents this Certificate to
John Imhoff
for successfully completing a course of instruction
in Hydrologic Simulation and its Applications in
Water Resource Investigations
this 2nd day of May 1975
Ray K Linsley
Norman H Crawford

Another Year, Another Project

Hydrocomp Simulation Processor II (HSPII)
Data Management System (DMS)
Reference Manual

Hydrocomp



+ ~37 Years =

Watershed Modeling for Impact Assessment on U.S. Military Installations

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Project Description

- 5-year effort for DoD's Strategic Environmental Research and Development Program
- Collaborative effort between ACOE's Engineer Research and Development Center (ERDC), Eco Modeling, and AQUA TERRA
- Modeling efforts included use of
  - HSPF (133 subbasins, 131 reaches, 24 land uses)
  - EFDC/SEDZLJ (2700 channel cells)
  - WEPP& WEPP:Road (14 replacement OFEs for HSPF unpaved road PERLNDs)
  - AQUATOX (limited sites)
  - Ikeda bank erosion (all EFDC/SEDZLJ 'bank cells')
- Sediment is THE issue!

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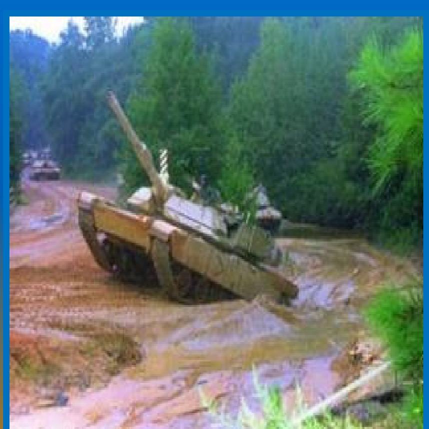
Technical Objectives

- Provide a management tool for addressing watershed impacts of activities on military installations
- Develop model initially for Fort Benning (GA), but with an eye towards transferability to other installations
- Advance the science of watershed modeling by developing and demonstrating new modeling approaches and code by applying them to military land use challenges

Military Training



Prescribed Burning

Unpaved Roads

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Major Products

- A fully calibrated/validated watershed model of Fort Benning's baseline conditions (i.e., **FB Baseline Model**)
- An Enhanced Baseline Model (EBM) of Fort Benning watersheds (i.e., **FB EBM**)
- **Proof-of-principle applications** using the FB EBM
- A military-enhanced watershed modeling system (i.e., **BASINS.MIL**)

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Selected Military Needs and Modeling Solutions

- Unpaved Road Simulation,
  Hybrid Modeling

- Military Training Intensity Methodology

- Multi-level Canopy and Prescribed Burning

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Approach to Modeling Erosion from Unpaved Roads (URs): Before and After

Before:

- URs are one of the 24 land use types modeled using HSPF
- Extensive literature search performed to compile unit area erosion values for URs
- Generalized catchment-scale formulations calibrated using literature-based UR erosion targets

After:

- URs modeled using hillslope-scale WEPP and WEPP:Road models
- Results replace all time series within the watershed-scale model for UR erosion that were previously simulated by HSPF

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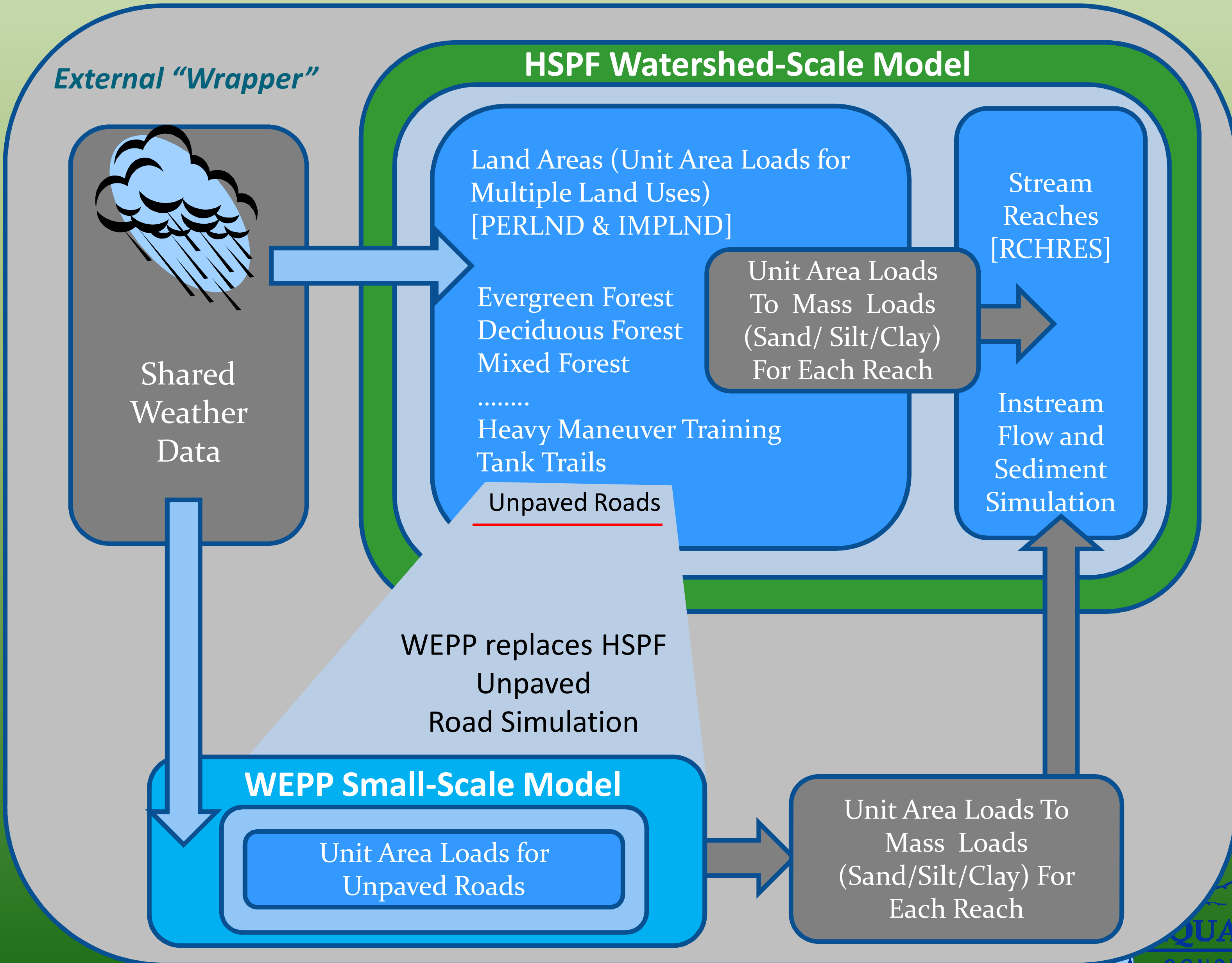
Hybrid Modeling: HSPF-WEPP Linkage



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Accomplishments

- Small-scale models with potential utility for military applications were identified and documented
- A proof of concept and demonstration of hybrid modeling was achieved and reported in detail
- Shared code (EXTMOD) needed to enable communication between HSPF and any small-scale model was developed and tested
- Impact of road characteristics/parameters was investigated at a smaller than catchment scale

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Challenges for Modelers (I)

- Fundamental challenge remains: use knowledge, available data, appropriate level of process representation and appropriate level of spatial and temporal detail to adequately represent the factors that determine watershed response

- Successful implementation of a hybrid modeling framework is VERY dependent on the compatibility of the two models that are targeted for use. Compatibility considerations include both those of model purpose and modeling paradigms

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Challenges for Modelers (II)

- Combining a deterministic model (HSPF) with a design model (WEPP:Road) introduces significant challenges (Importance of storages, importance of ‘special actions’)

- Fundamental differences in how two models estimate a process response can create additional challenges to using a hybrid approach

- Deciding whether it is worthwhile to develop a re-usable interface to support hybrid modeling support is not straightforward

Approach to Modeling Erosion from Offroad Mechanized Training: Before and After

Before:

- Heavy Maneuver Areas (HMAs) are one of the 24 land use types modeled using HSPF
- Absence of literature values for unit area erosion values for HMAs – rely on minimal values for vegetative cover & infiltration to represent impacts

After:

- Developed relationships between mechanized training intensity and model parameters that most strongly determine runoff and erosion
- Re-evaluation of parameter values used for baseline simulation

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Military Training Intensity Methodology

Training Data

Infiltration Change Data

Vegetative Change Data

Training Level
- How Much
- Planning Data
- ARRM
- Quantitative

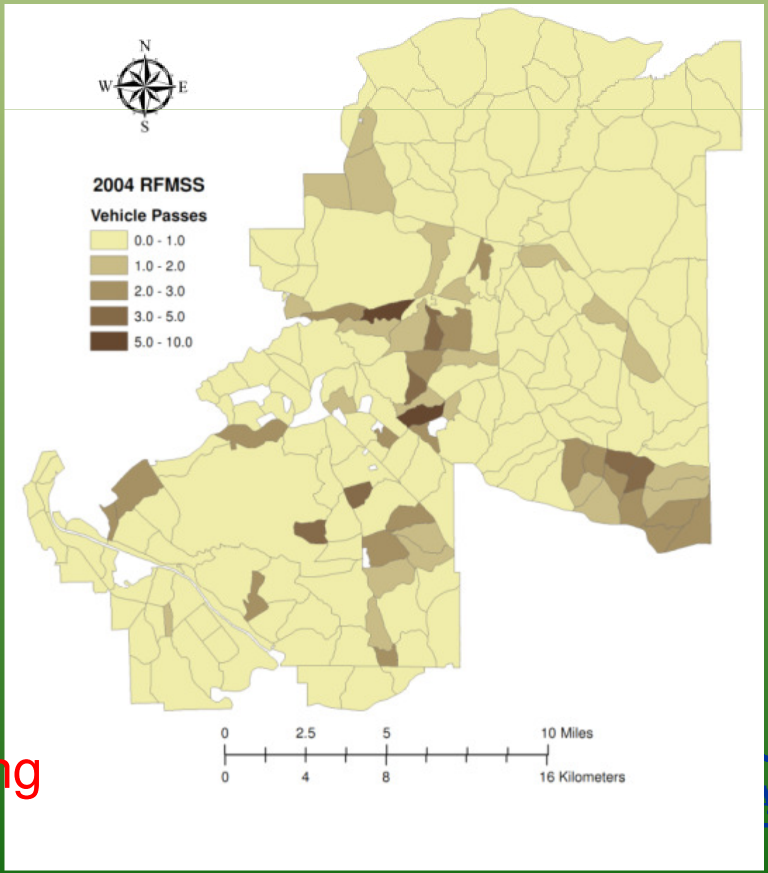
Training Distribution
- Where
- Reporting Data
- RFMSS
- Spatial

Training Load
- How much & where
- Area
- Spatially distributed

Training Load Conversion
- Vehicular Intensity
- # of vehicle passes

Infiltration Data
- Uniform or based on soil-type
- 1 pass = 20% reduction

Vegetative Data
- RTLA-based
- 1 pass = 52.6% reduction in ground cover



2004: 219,224 Total MIMs for Fort Benning

Accomplishments

- Developed "bottom line" understanding of implications of typical mechanized training practices to land condition and hydrologic and erosion responses:
  - Methodology developed by CERL is most powerful and useful when data are available for non-uniform training load distribution across an installation, and when training areas are large compared to training load.
  - For Installation areas that experience significant training loads it is defensible to use model parameter values that correspond to minimum infiltration rates and maximum vegetative loss to represent HMA land condition in lieu of utilizing the CERL methodology.

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Challenges for Modelers

DATA!

- Access limitations to training intensity data
- Currently no basis for considering non-uniformity (spatial, temporal, or intensity) of training distribution
- Need for infiltration/cover impact data for different soils types
- Infiltration relationship to # of vehicle passes is poorly studied and needs further investigation

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Approach to Modeling Runoff & Erosion from Disturbed Forests: Before and After

Before:

- Single layer canopy representation
- Representation of three different forest canopy area/conditions corresponding to each year of a 3-year understory burn and recovery cycle

After:

- Multi-layer canopy representation
- Implementation of an approach to accommodate fire impacts (through the use of time series input) that reflects fire occurrence, intensity, and areal distribution within the watershed

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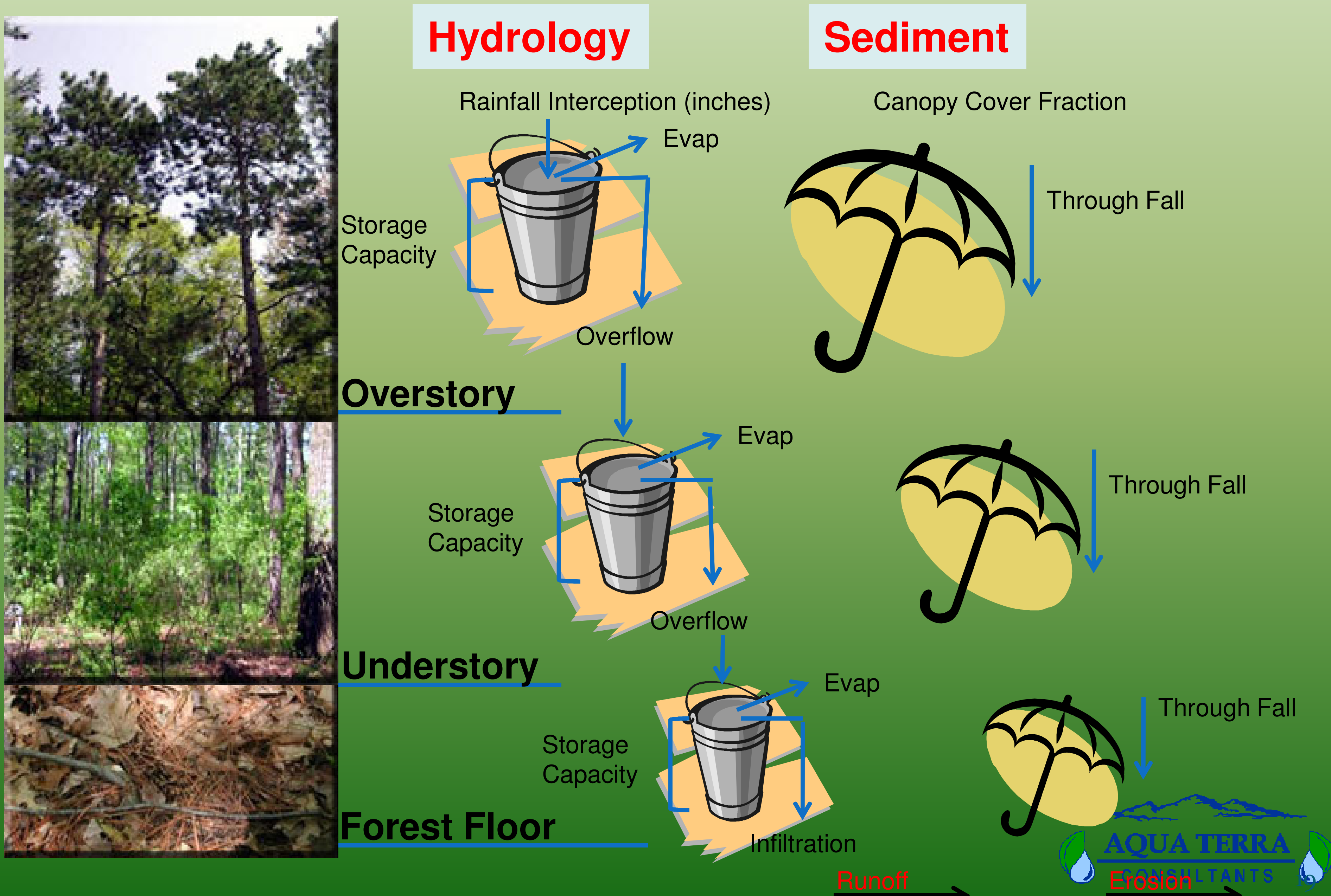
Canopy Representation



Accomplishments

- Multi-level canopy provides a much improved conceptual representation of the plant compartment by incorporating individual processes associated with the forest overstory, understory, and potentially the forest floor and litter layer

- In conjunction with HSPF SPECIAL ACTIONS capability, the time series input option can be used to assess the impacts of fire events (or other vegetative perturbations) as well as subsequent regrowth/return to baseline conditions

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Challenges for Modelers

- Allowing user-defined time series approach to parameterizing the plant canopy layers provides improved operational procedures for representing dynamic changing canopy processes. However, it imposes greater demands on the user to accurately assess canopy parameters through a very flexible mechanism

- Incorporation of a dynamic plant growth model would greatly expand the process capabilities and potential applications for watershed impact assessment

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Conclusions and Implications for Future Research/Implementation

- Sediment is the key issue related to impacts of military activities on streams
- Modeling enhancements and strategies for military-specific activities advance the state-of-the science of watershed modeling
- Watershed modeling system provides a scientifically credible tool to support management and funding decisions
- Components of the watershed modeling system are directly transferrable to other installations

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BACK UP SLIDES

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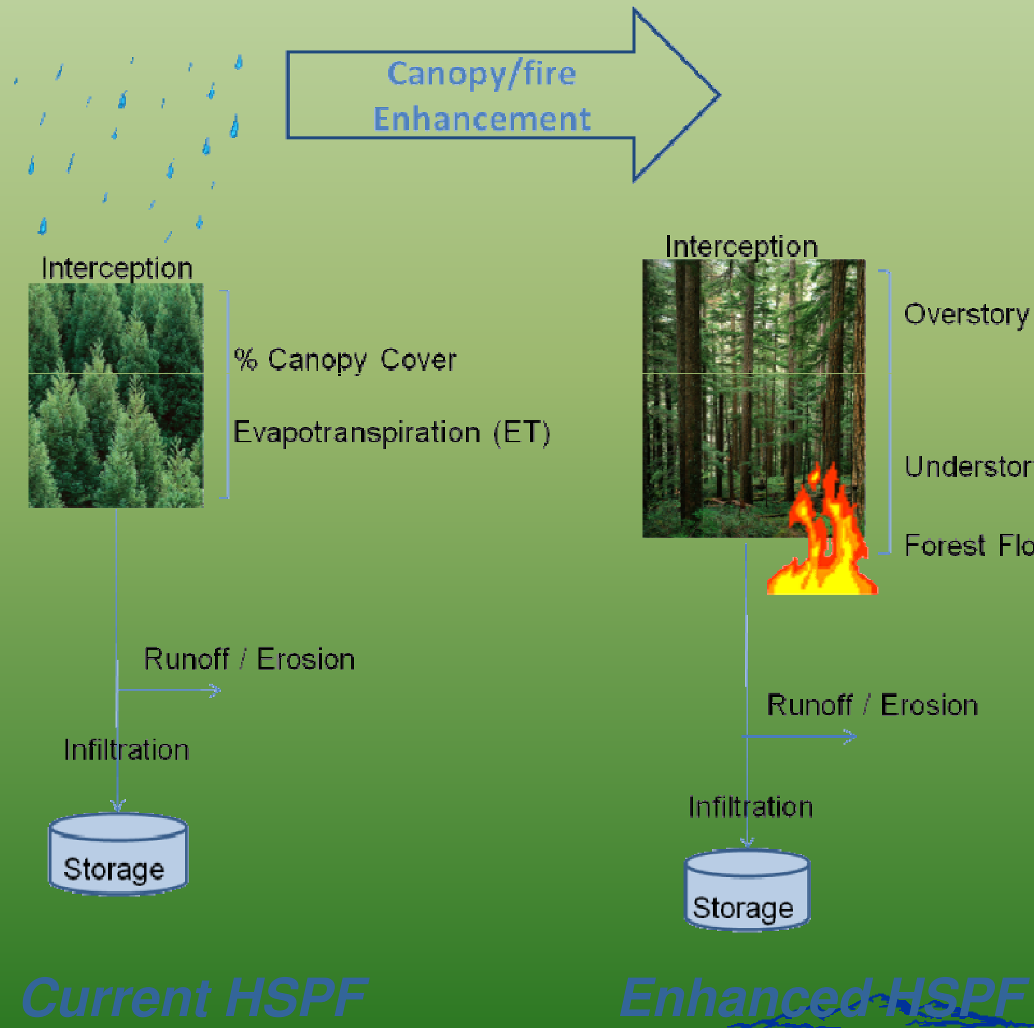
Results: Canopy/Fire Enhancement

- To better characterize the impacts of changes in vegetation cover (seasonally and from management actions such as prescribed burning) on hydrology and sediment loss.
- Bucket/umbrella approach implemented.



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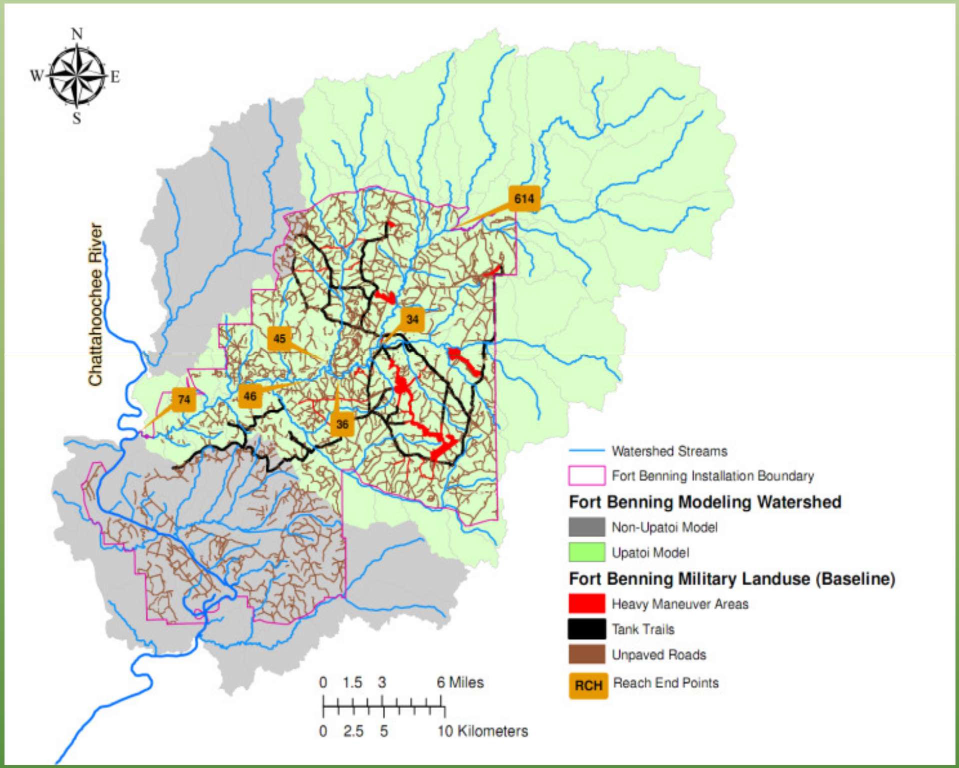
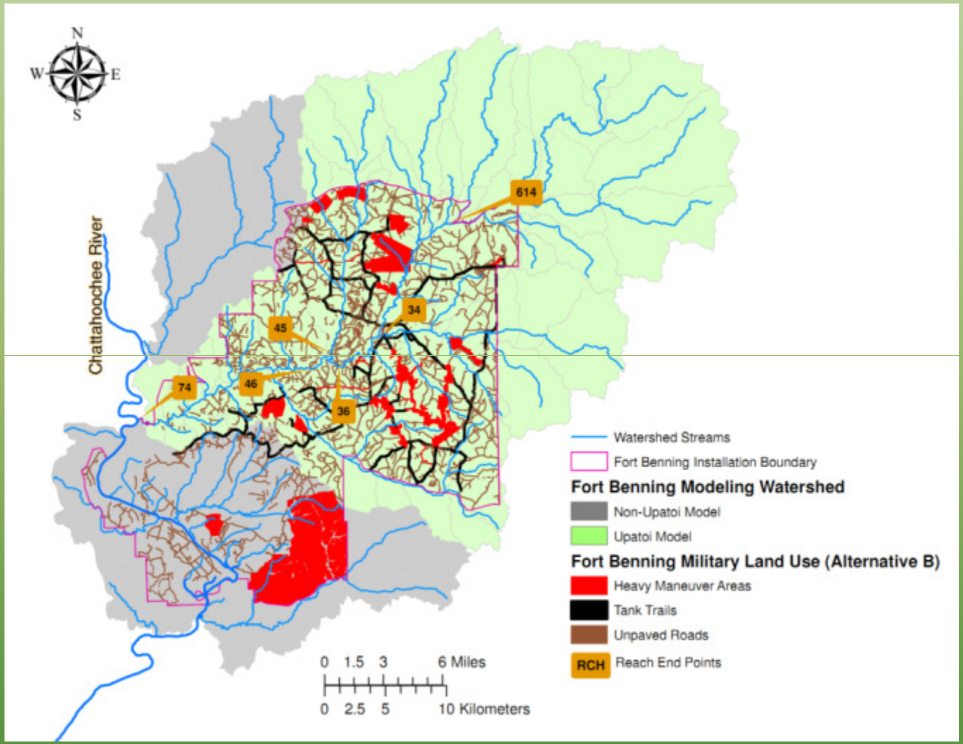
Results – BRAC Alternate B vs Enhanced Baseline

Enhanced Baseline



BRAC Alt B



HMA: 2,290 to 17,267 ac
Tank Trails: 241 to 318 ac
Unpaved Roads: 11,649 to 10,740 ac

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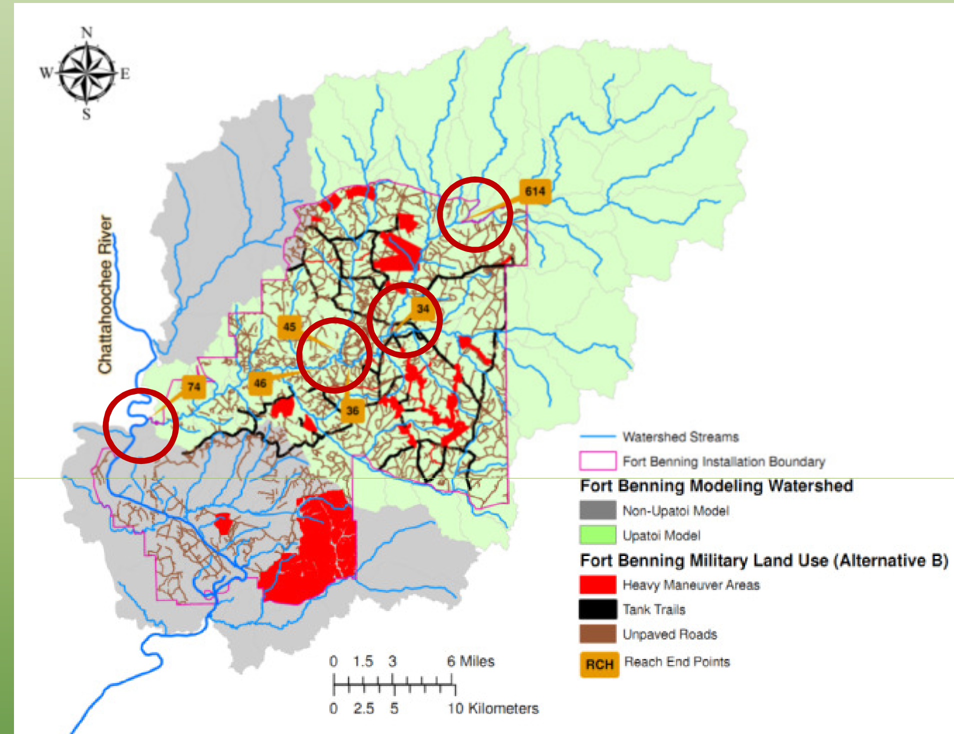
BRAC Run Results

- BRAC Alt B land use used
- Sediment loadings compared along Upatoi Creek
- Military contributions increase to 40% to 70% of total sediment load
- BMPs can be assessed to reduce these numbers



	R:614 North Upatoi Creek			R:34 Pine Knot Creek			R:46 Upatoi Creek at McBride Bridge			R:74 Upatoi Creek at Outlet		
	Washoff (t/ac/yr)	Sediment Loading (t/yr)	Military Contribution (%)	Washoff (t/ac/yr)	Sediment Loading (t/yr)	Military Contribution (%)	Washoff (t/ac/yr)	Sediment Loading (t/yr)	Military Contribution (%)	Washoff (t/ac/yr)	Sediment Loading (t/yr)	Military Contribution (%)
Baseline	2.7	9306	7.5	2.5	5672	42.3	2.1	22352	29.1	2.0	28903	34.5
Enhanced Baseline	2.7	10169	7.5	2.5	5878	41.8	2.1	23433	29.1	2.0	30912	34.4
Alternative B	2.7	10173	7.5	2.6	6661	48.7	2.3	27852	40.2	2.1	36401	44.6

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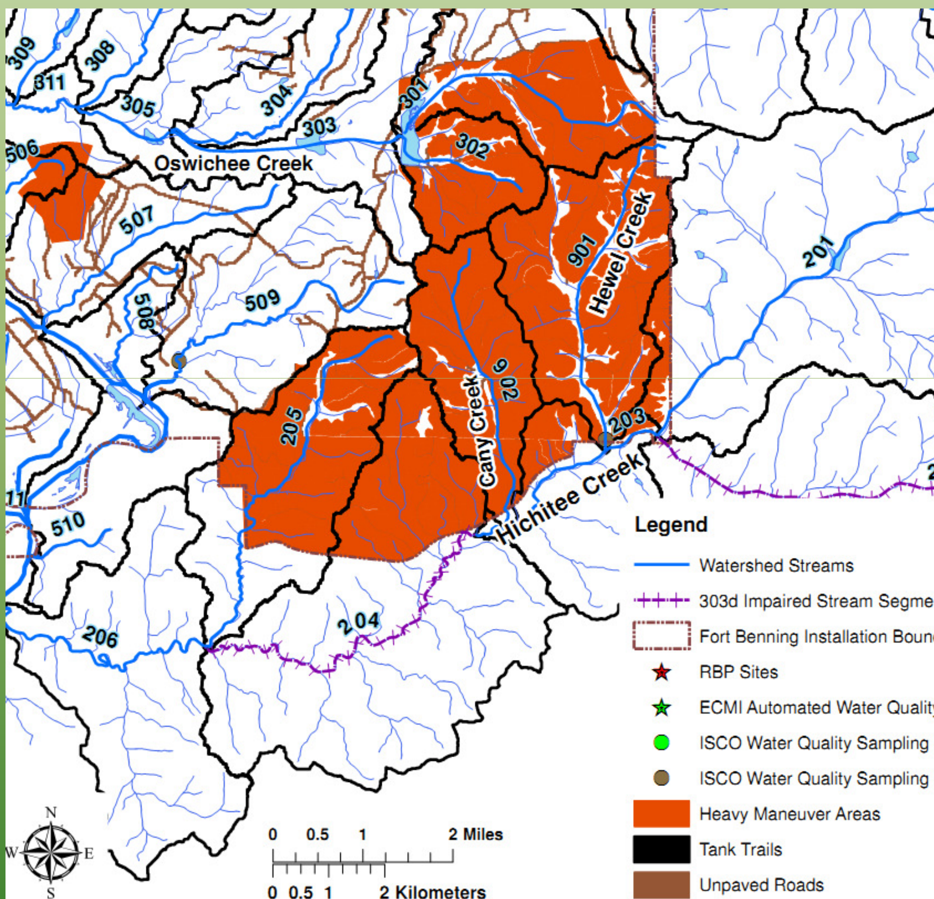
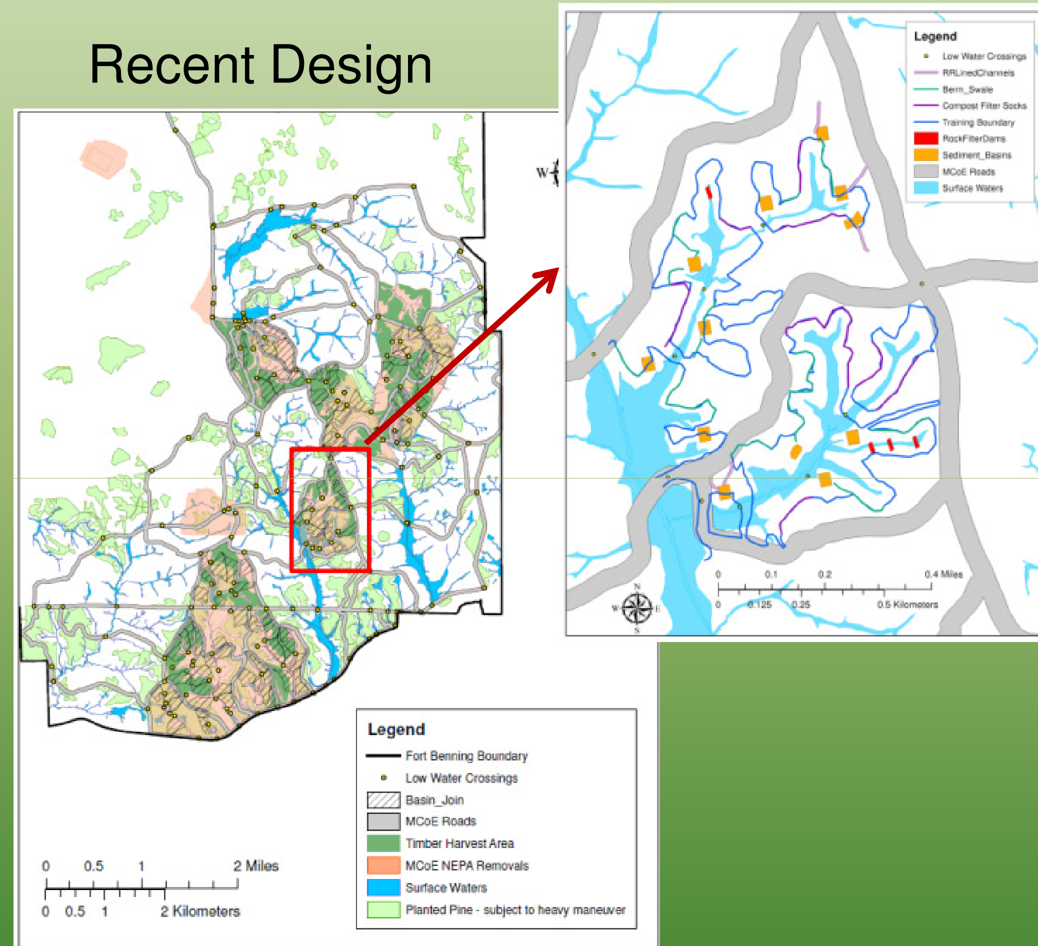
GHMTA: Alternative B vs Recent Design

Alternative B

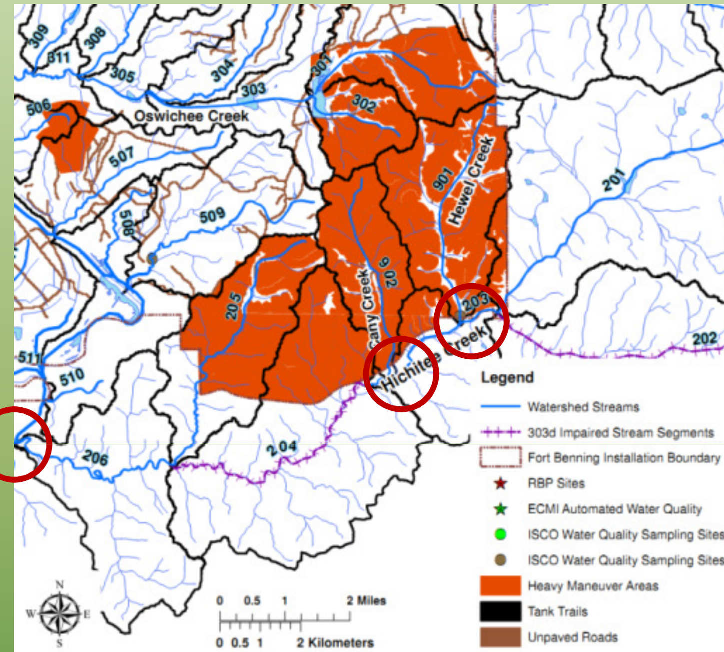


Recent Design



GHMTA BMP Results

- GHMTA run with Alt B and with BMPs applied
- BMPs assumed 75% removal of sediment
- Total loads and military contributions assessed
- BMPs reduced Total Load by 60+% at Hichitee outlet



	R:901 Hewel Creek			R:902 Caney Creek			R:206 Hichitee Creek		
	Washoff (t/ac/yr)	Sediment Loading (t/yr)	Military Contribution (%)	Washoff (t/ac/yr)	Sediment Loading (t/yr)	Military Contribution (%)	Washoff (t/ac/yr)	Sediment Loading (t/yr)	Military Contribution (%)
Enhanced Baseline	2.5	367	53.6	2.5	242	48.7	2.3	2460	39.0
Alternative B	3.2	3521	98.9	3.2	2553	99.8	3.1	10557	87.2
Alternative B_BMP	3.2	917	95.5	3.2	653	99.1	3.1	3948	63.0

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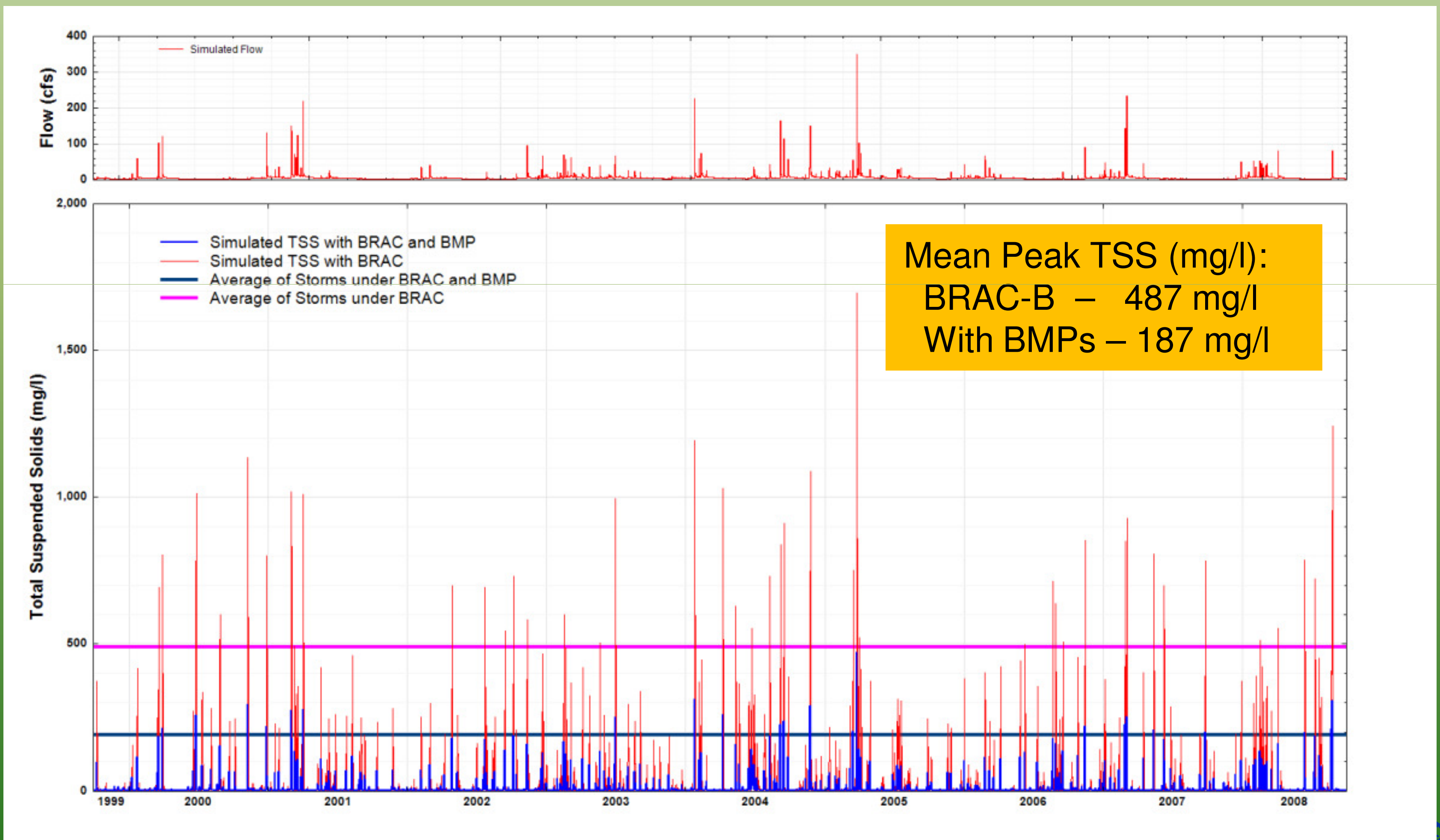
GHMTA BMP Impacts on TSS Concentrations (Reach 901)



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Conclusions/Implications for Future Research/Implementation

Research Gaps	How	Resolved Issues	Unresolved Issues
Natural Resource Management	Multi-level Canopy Enhancement	Improved interception/cover processes	Plant growth not included
Military Training	Intensity Methodology	Approximates training impacts	Data gap (e.g., actual training activities)
Sediment Transport	EFDC/SEDZLJ	Improved flow /sediment estimates	Impractical simulation times
Multi-scale Impacts	Hybrid modeling using WEPP-Roads and EFDC	Success depends on compatibility of linked models	Incompatibility – better tools available?
Aquatic Species Impacts	AQUATOX	Success depends on sediment concentration	Data requirements, high sediment concentration

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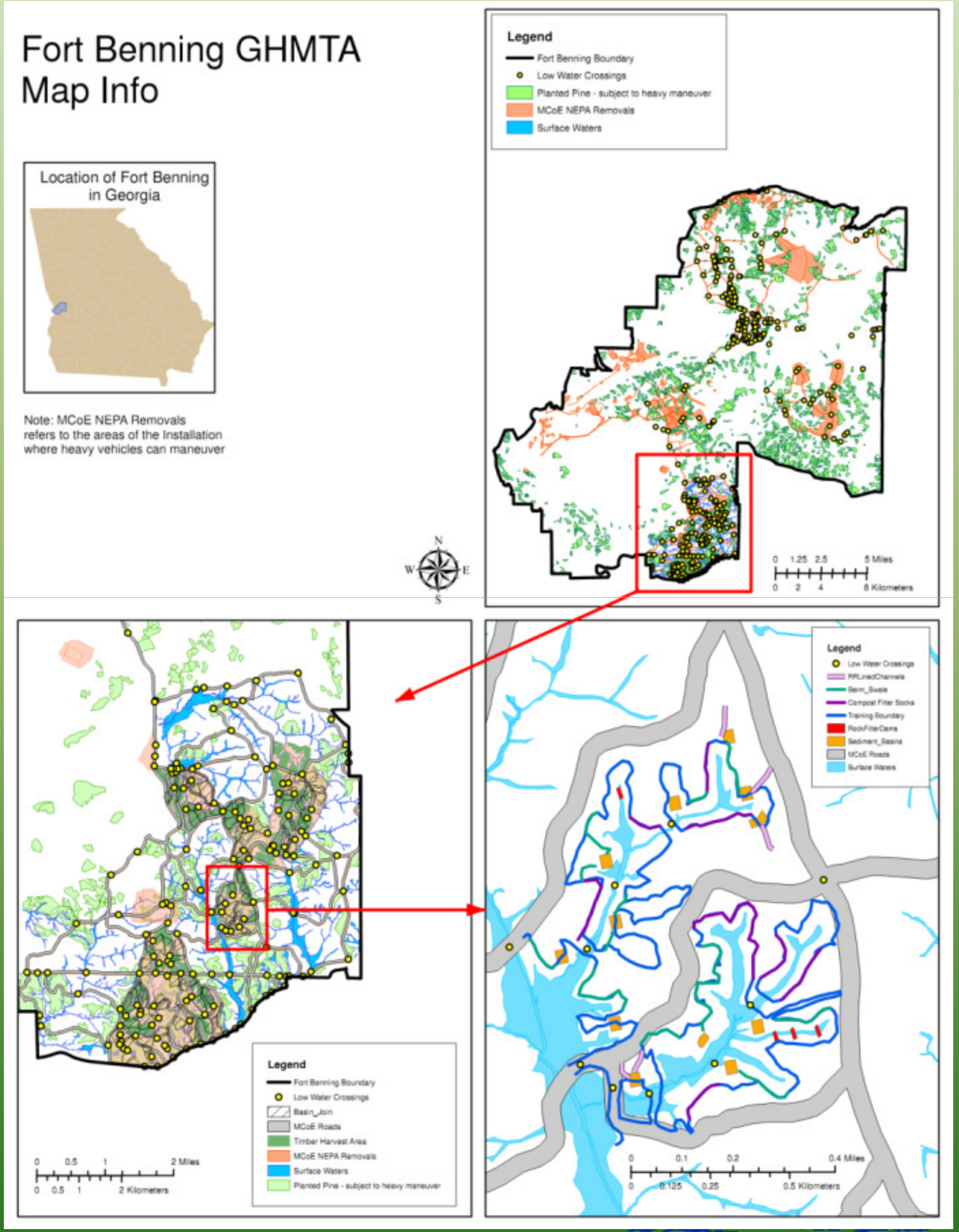
Conclusions and Implications for Future Research/Implementation

Project Outcomes

- Watershed modeling system immediately available to Fort Benning to support management and funding decisions (i.e., a GIS-based capability within a watershed management framework)
- Components of the newly enhanced modeling system are directly transferrable to other installations (i.e., model enhancements, and military training intensity methodology and related model parameters)

Results – BRAC Good Hope MTA Condition Scenario Best Management Practice Impact



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HSPF- WEPP Linkage

- WEPP simulation for each HSPF unpaved road segment (14 runs) using shared meteorological data
- Output from 14 WEPP simulations processed to get daily loads (kg/m^2) at the edge of the fill slope
- Daily loads imported to WDM file and units converted from kg/m^2 to tons/acre
- Daily loads distributed to hourly using input precipitation pattern (with 0.2 inch abstraction/depression storage)
- Hourly loads used as input to each HSPF stream reach (and multiplied by acres of unpaved roads), in place of HSPF simulated loads from unpaved road segments

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