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    - (646) 876-9923 or (408) 638-0986
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Supporting DoD Installation Sustainability Through Informed Stormwater Management

November 1, 2018

SERDP DOD • EPA • DOE | ESTCP

Welcome and Introductions

Jennifer Nyman, Ph.D., P.E.
Webinar Facilitator

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Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Jennifer Nyman, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Kurt Preston, SERDP and ESTCP
- **Linked Watershed Riverine Modeling System for DoD Installations** (25 minutes + Q&A)
  Dr. Billy Johnson, U.S. Army Engineer Research and Development Center
- **Optimization of Stormwater Modeling Approach** (25 minutes + Q&A)
  Ms. Heidi Howard, U.S. Army Engineer Research and Development Center
- **Final Q&A session**

In Case of Technical Difficulties

- Use a compatible browser (Firefox, IE or Edge)
- If material is not showing on your screen or if screen freezes
  - Key in Ctrl + F5 to do a hard refresh of your browser
- If connecting to computer audio
  - Click the arrow next to the "*Join Audio*" button
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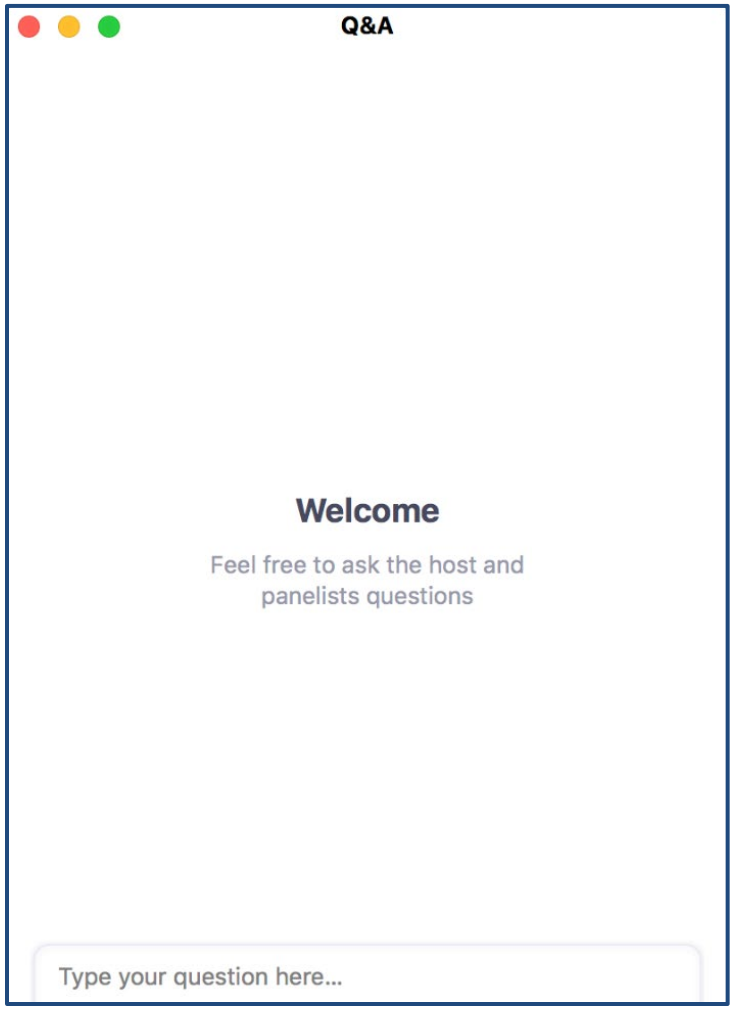
- Find the Q&A button on your control bar and type in your question(s)
- Make sure to add your organization name at the end of your question so that we can identify you during the Q&A sessions



SERDP and ESTCP Overview

Kurt Preston, Ph.D.
Resource Conservation and Resiliency Program Manager

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SERDP

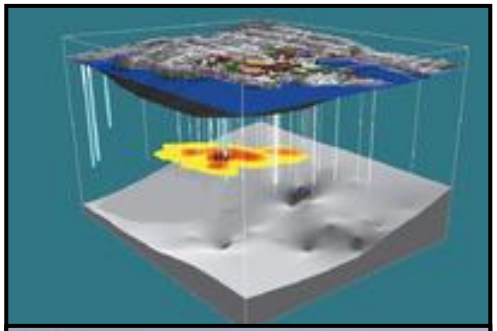
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

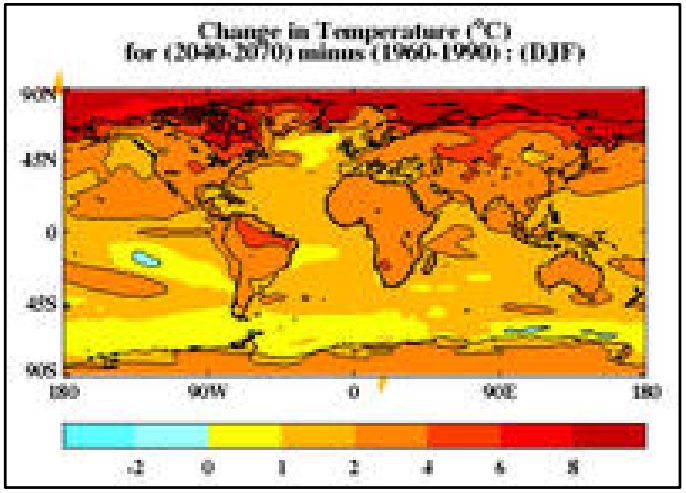
Program Areas

1. Environmental Restoration
2. Installation Energy and Water
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms



Resource Conservation and Resiliency

- Natural resources
  - Ecological forestry
  - Arid lands ecology and management
  - Cold regions ecology and management
  - Pacific island ecology and management
  - Coastal and estuarine ecology and management
  - Living marine resources ecology and management
  - Species ecology and management
  - Watershed processes and management
- Resilience
  - Vulnerability and impact assessment
  - Adaptation science
  - Land use and carbon management
- Air quality
  - Wildland fire dynamics
  - Fugitive dust



SERDP and ESTCP Webinar Series

Date	Topic
November 15, 2018	Stormwater Impacts on Sediment Recontamination
December 13, 2018	Installation Energy and Water Program Area Webinar

- *Stay tuned for the 2019 webinar program lineup*

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

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Save the Date!

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SYMPOSIUM
2018 | Enhancing DoD's Mission Effectiveness

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

November 27-29, 2018

Washington Hilton Hotel

Registration is open

Linked Watershed-Riverine Modeling System for Department of Defense (DoD) Installations

Billy E. Johnson
U.S. Army Engineer Research and Development Center

OPSEC A: "Public Release, Distribution Unlimited"

Agenda

- Project objectives and approach
- Water quality simulation modules
- Watershed and riverine models
- Demonstration sites and results
- Benefits to DoD
- Summary and conclusions

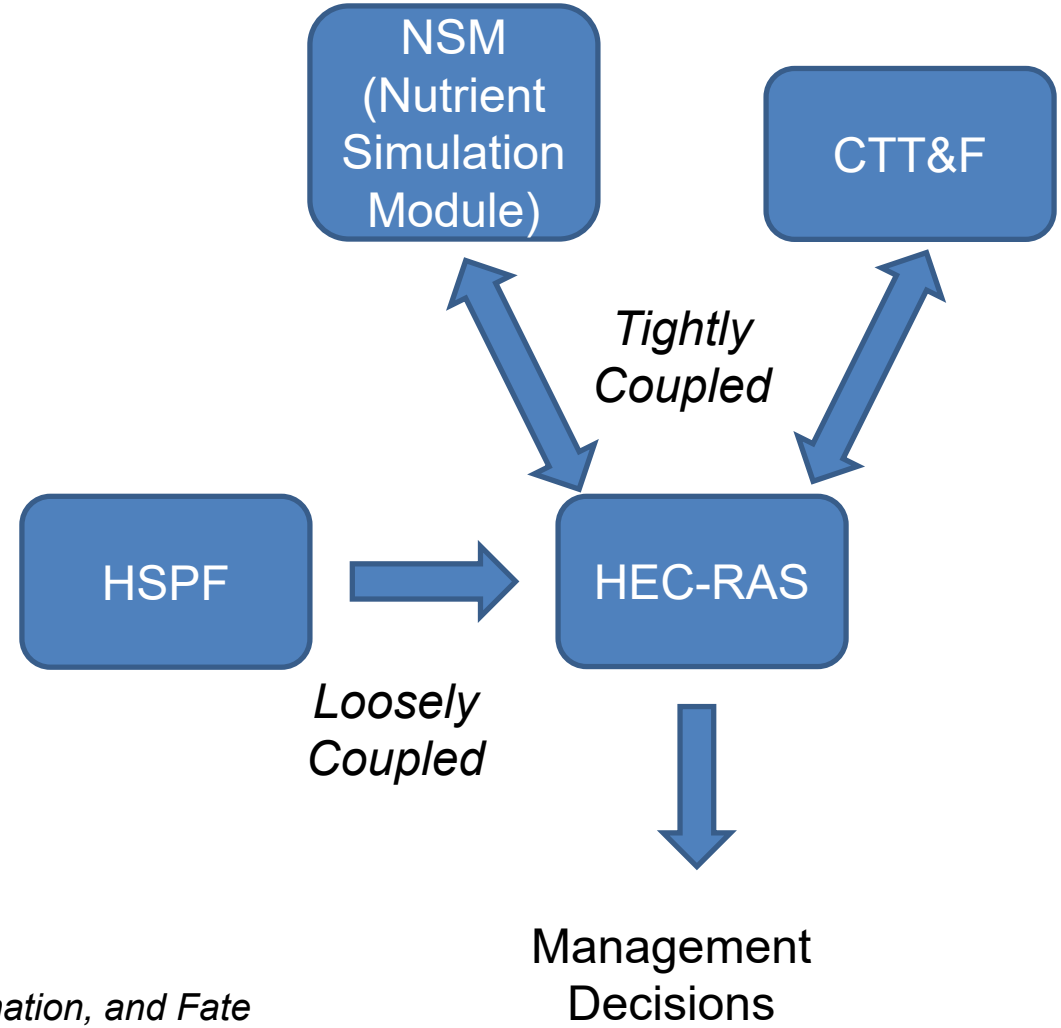
Project Objectives

- Demonstrate and validate an HSPF (Hydrological Simulation Program) HEC-RAS (Hydrologic Engineering Centers River Analysis System) linked watershed and riverine modeling system
- Assess outcomes resulting from military activities
- Support installation sustainability
- Informed watershed management of:
  - Water
  - Water quality
  - Contaminant
  - Land-use impacts
- Applicable to other climatic regions, hydrologic regimes
  - Demonstration sites vary across climatic zones

***Notes**: HSPF = Hydrological Simulation Program; HEC-RAS = Hydrologic Engineering Centers River Analysis System*

Project Approach

- HSPF model
  - Watersheds
  - Hydrologic processes
  - Soil erosion
  - Point / nonpoint sources
- HEC-RAS model
  - 1D river analysis
  - Steady flow
  - Unsteady flow
  - Sediment transport
  - Water quality analysis



***Note**: CTT&F = Contaminant Transport, Transformation, and Fate*

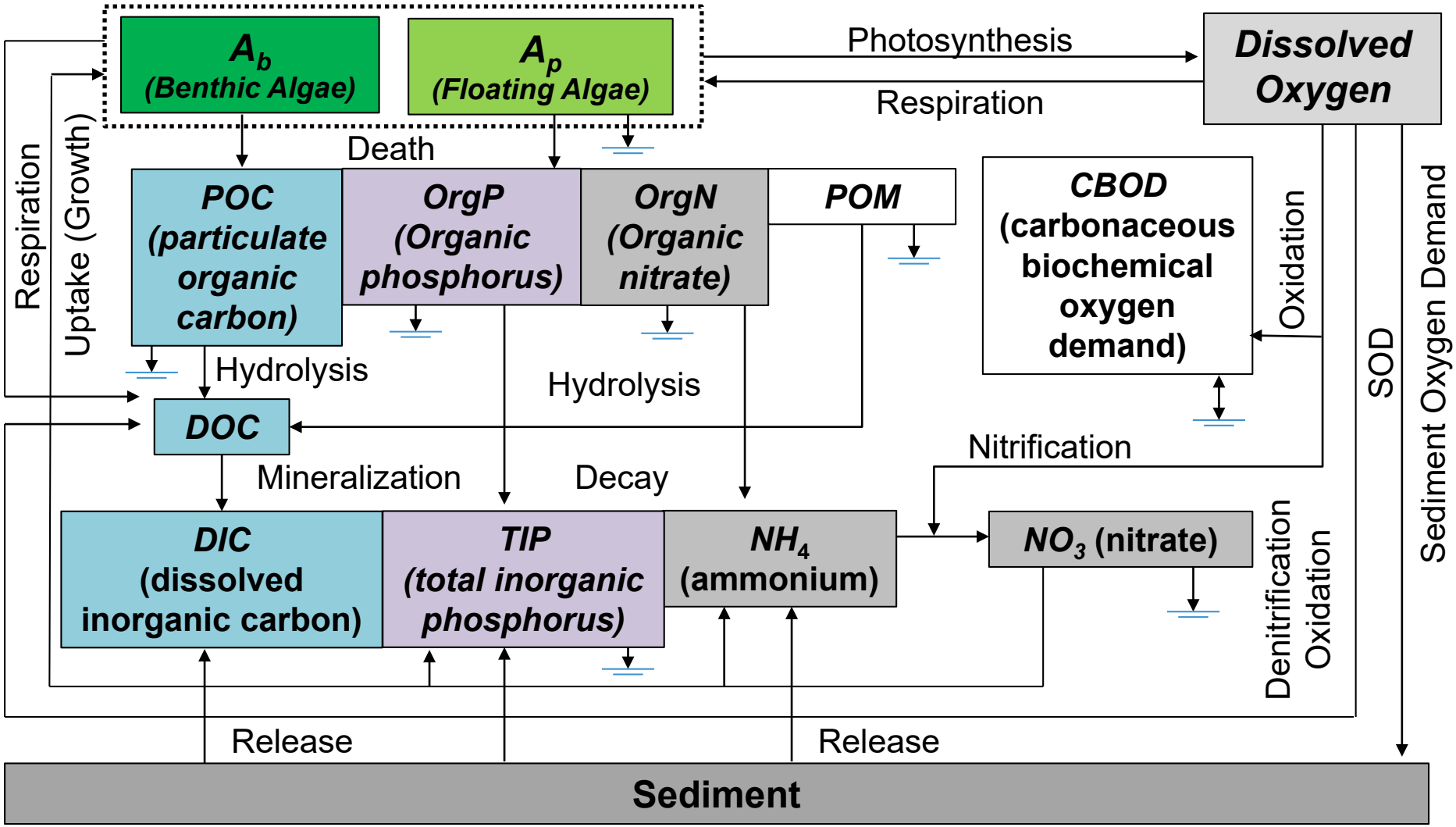
Water Quality Modules (DLLs)

- Water Temperature Simulation Module (TEMP)
- General Constituent (GC) Simulation Module
- Solid Simulation Module (SOLID)
- Nutrient Simulation Module I (NSMI + SedFlux)
- Nutrient Simulation Module II (NSMII + SedFlux)
- Contaminant Simulation Module (CSM)
- Mercury Simulation Module (HgSM)

***Note**: DLLs = Dynamic Linked Libraries*

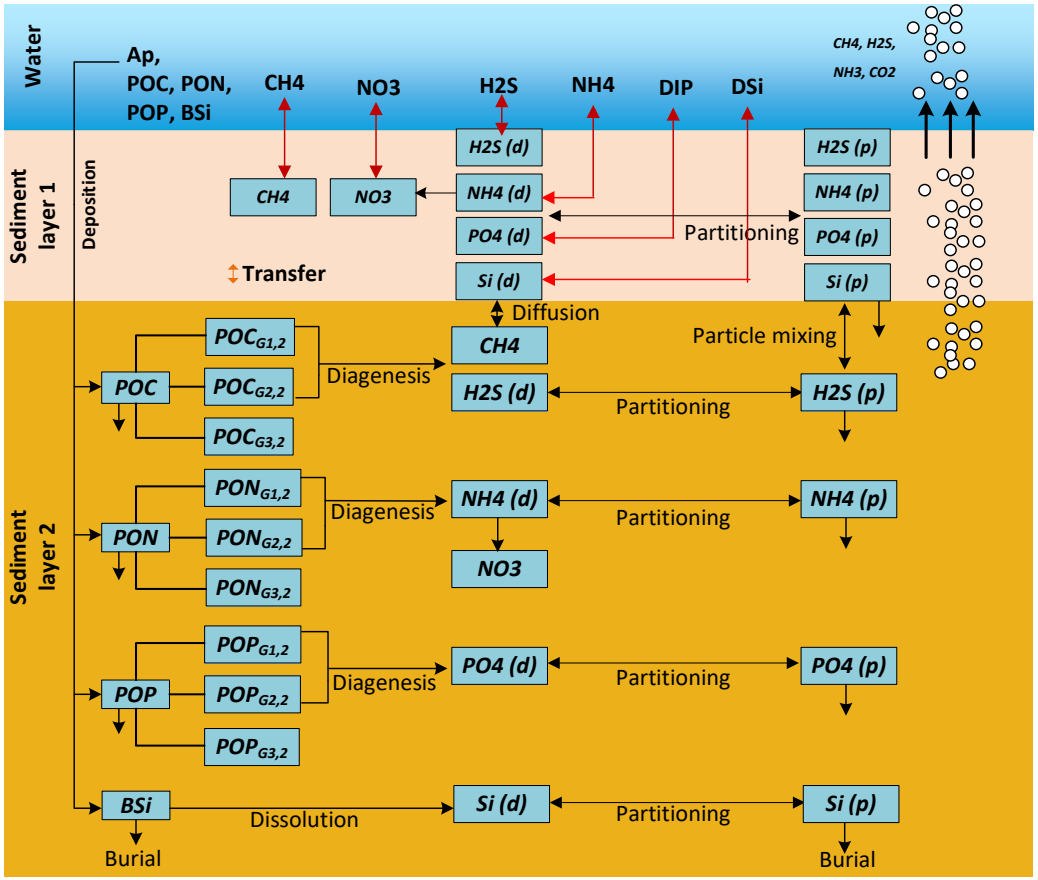
Water Quality Simulation Modules

Nutrient Simulation Modules (NSM)



Water Quality Simulation Modules

NSM - Sediment Diagenesis Module



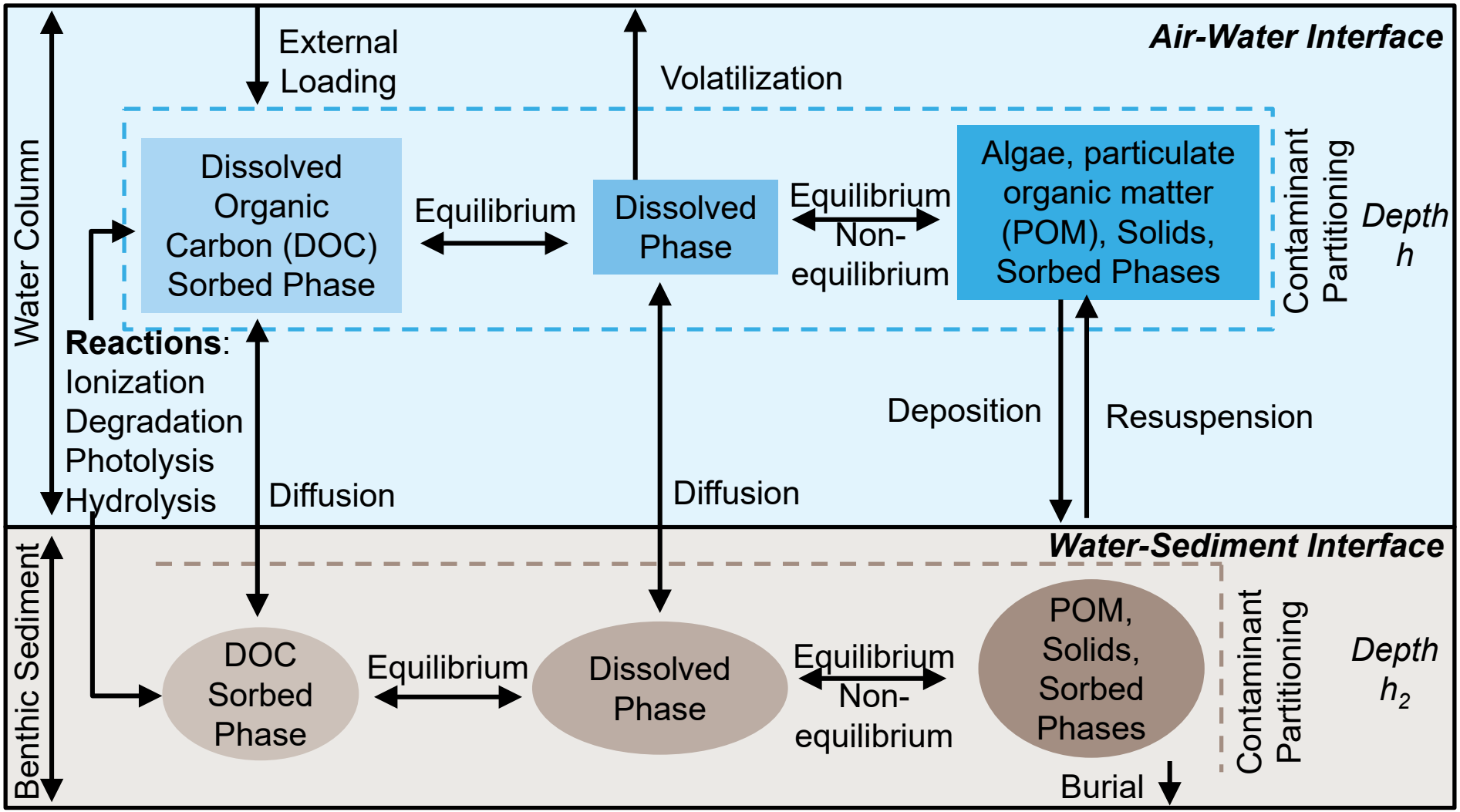
d = dissolved
p = particulate

Notes:
PON = particulate organic nitrogen
POP = particulate organic phosphorus
BSi = Biogenic Silica

PO_4 = phosphate
H_2S = hydrogen sulfide
DIP = dissolved inorganic phosphorus

Water Quality Simulation Modules

Contaminant Simulation Module (CSM)



Watershed and Riverine Models

HSPF

- Most complete, defensible process-based watershed model
- Used worldwide 20+ years
- Sponsored by U.S. Environmental Protection Agency and U.S. Geological Survey
- Continuous refinement / enhancement

HEC-RAS

- 1D steady / unsteady flow river
- Sediment transport-mobile bed modeling
- Water temperature analysis
- Water quality / contaminant kinetics sub-models
- Four major versions since 1995

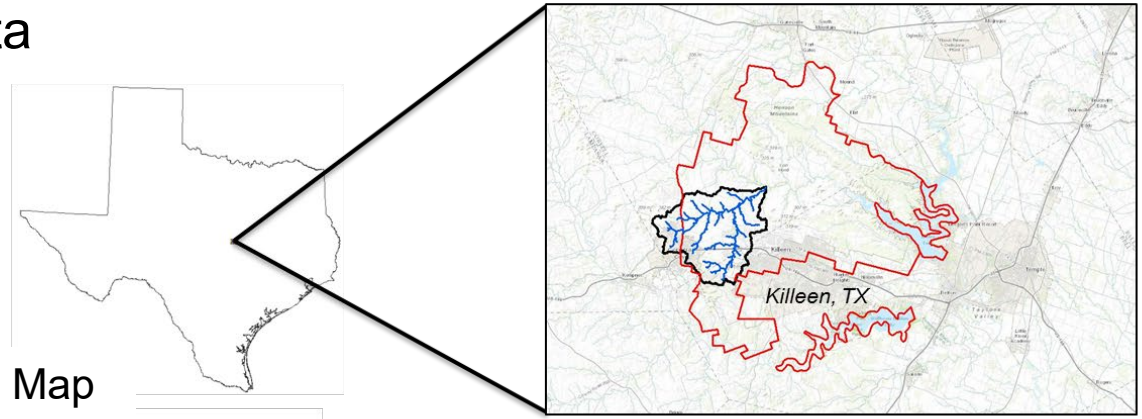
Demonstration Sites and Results

- Demonstration Site #1:
  - Fort Hood, TX
  - House Creek Watershed
- Demonstration Site #2:
  - Naval Base Ventura County, CA
  - Calleguas Creek Watershed
- Demonstration Site #3:
  - Fort Meade, MD
  - Patuxent River Watershed

Demonstration Site #1

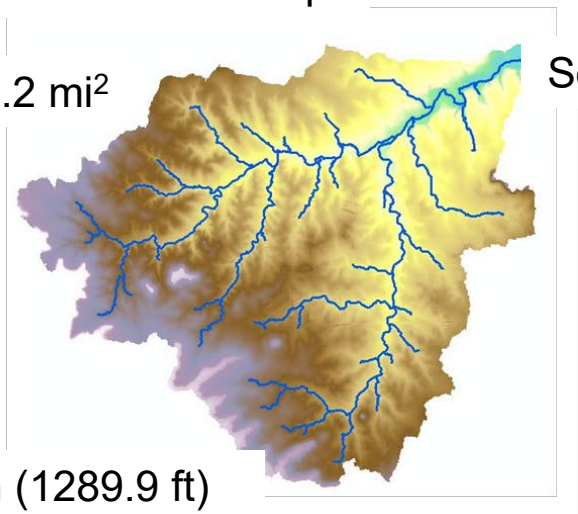
Fort Hood, Texas

GIS data



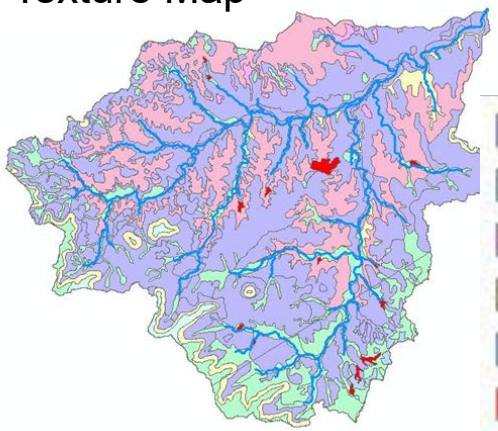
Digital Elevation Map

D.A. 66.2 mi^2



Highest: 393.3m (1289.9 ft)
Lowest: 199.7 m (655 ft)
Average: 293.7 m (963.2 ft)

Soil Texture Map

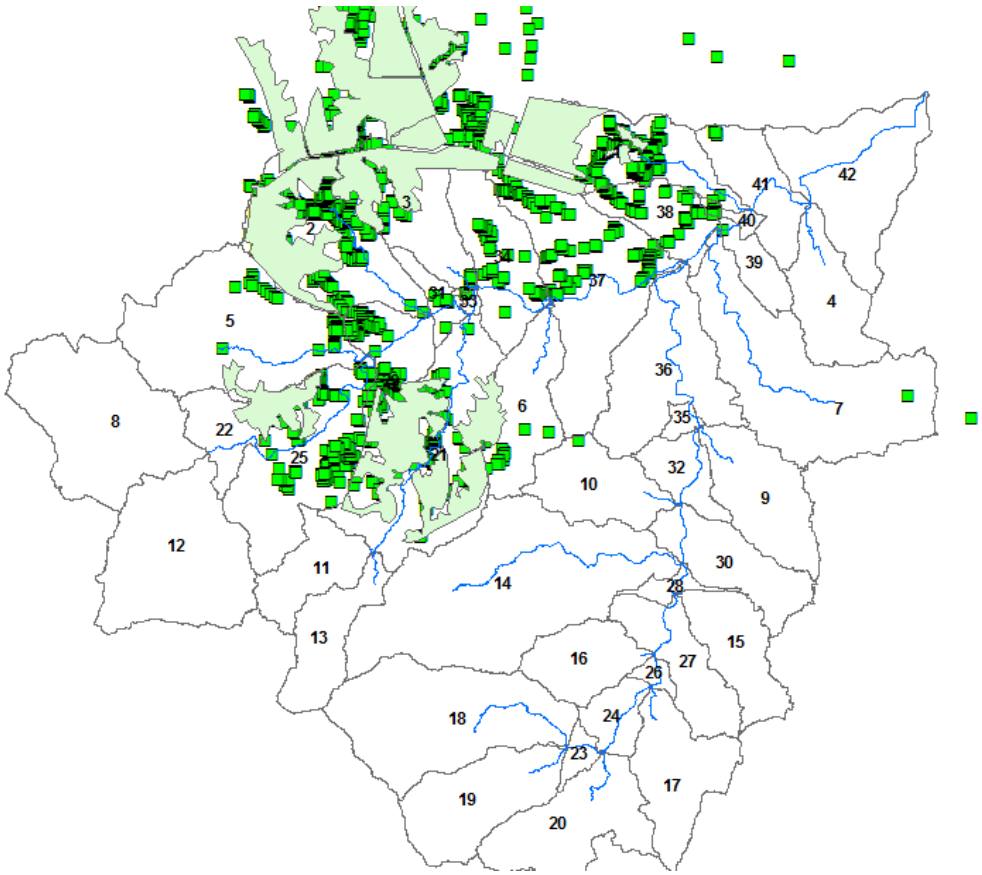


- Clay loam
- Cobbly silty clay
- Fine sandy loam
- Gravelly clay loam
- Gravelly silty clay
- NA
- Silty clay
- Very stony silty clay loam

Demonstration Site #1

Best Management Practices – Gully Plugs

- Period of record: 2006-2008
- House Creek Watershed
- Gully plugs and contour ripping best management practices (BMP's)
- Added BMP at each affected reach
- 90% removal rate for sediment based on Texas A&M AgriLife field observations
- Critical bed shear stress calibrated to obtain final sediment reduction



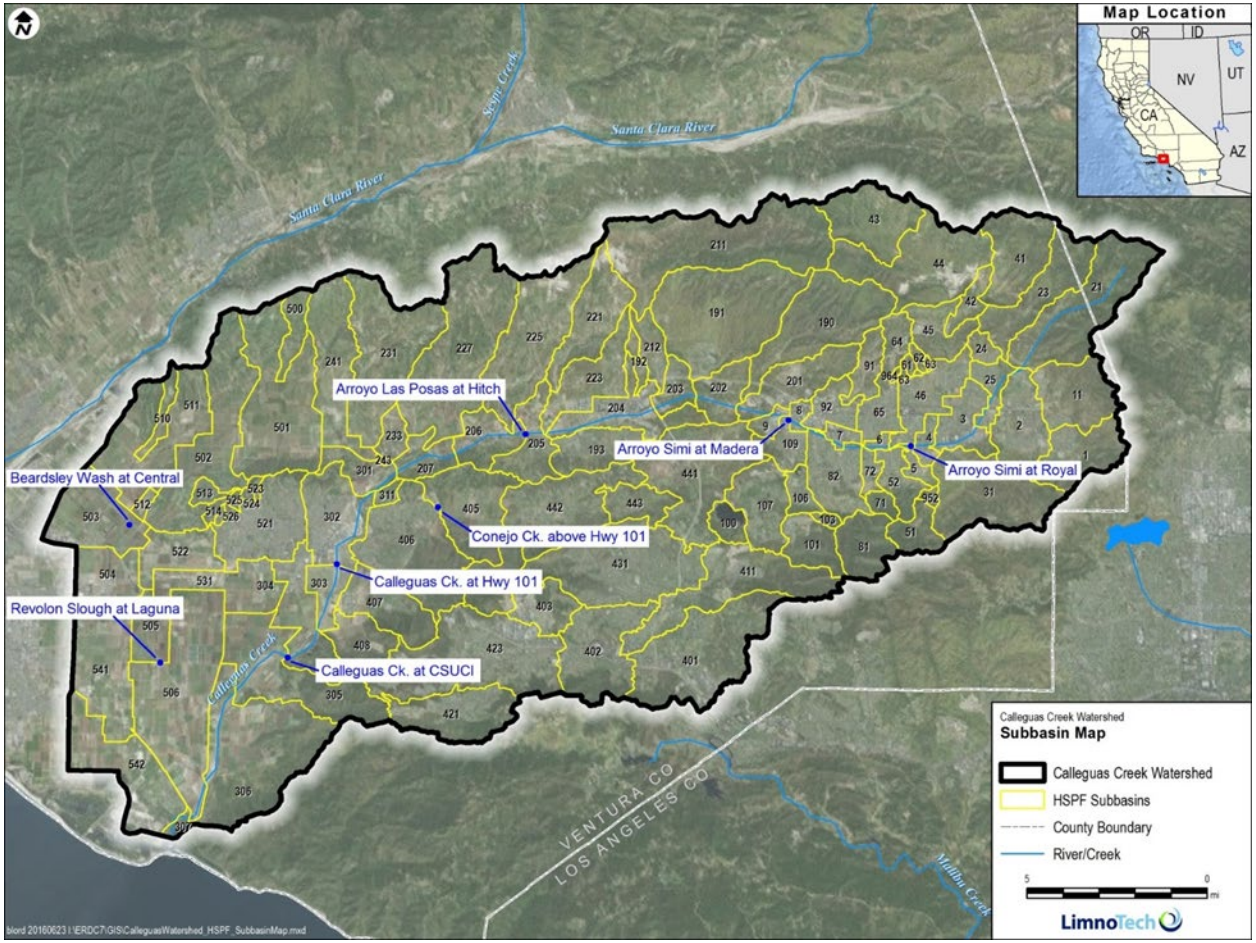
Demonstration Site #1

Summary and Conclusions

- Sufficient flow data for storm period events statistics
  - Issues with model matching low flows from wastewater plant
- More investigations needed to quantify surface subsurface interactions within channel network
  - Amount of exfiltration into stream during low flow?
  - Amount of channel transmission losses?
- More storm and grab samples needed to use USGS LOADEST
  - Not enough samples for House Creek Watershed to refine LOADEST statistics

Demonstration Site #2

Calleguas Creek Watershed, CA

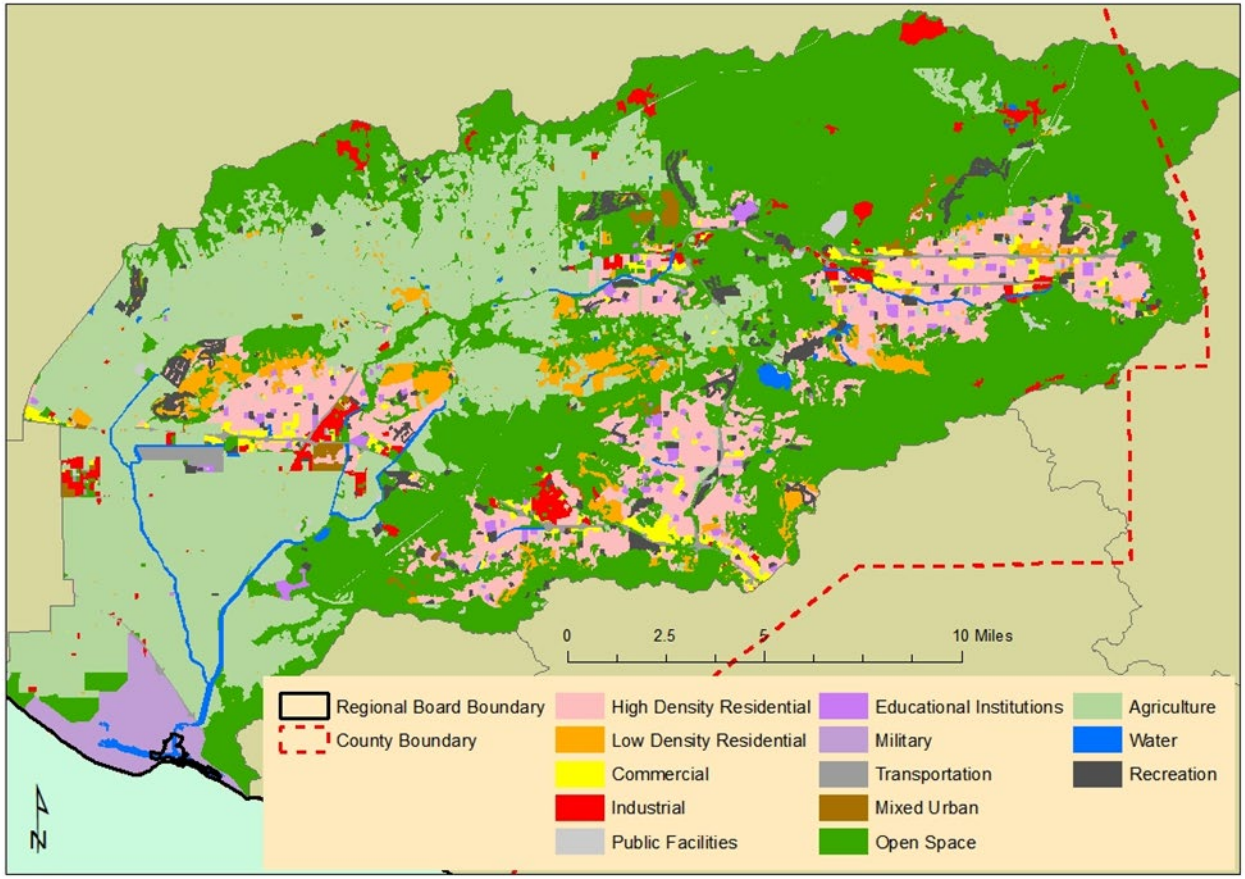


Drainage Area = 343 square miles

Demonstration Site #2

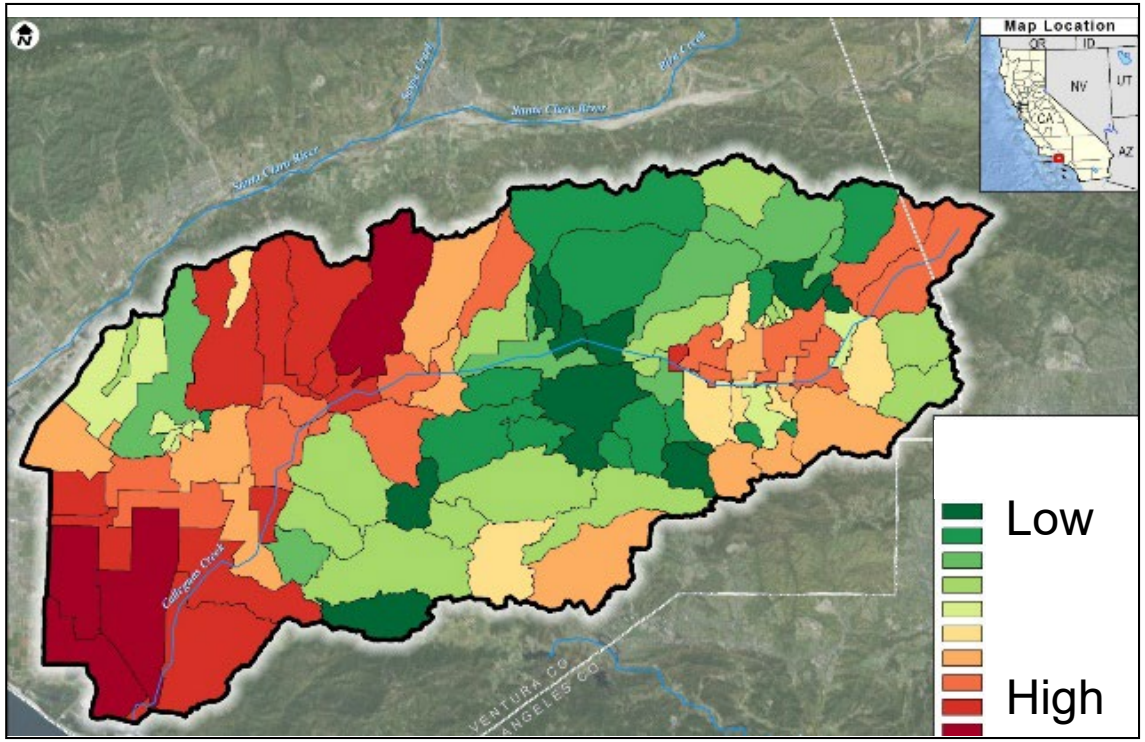
Calleguas Creek Watershed, CA

Land Use in the Calleguas Creek Watershed



Demonstration Site #2

Calleguas Creek Watershed, CA



Simulated Subbasin Total Mercury Yields (pounds/acre/year)

- Additional simulated parameters:
  - Sediment
  - Total phosphorus
  - Total nitrogen
  - Total copper

Sufficient modeling of water quality processes to support DoD decisions

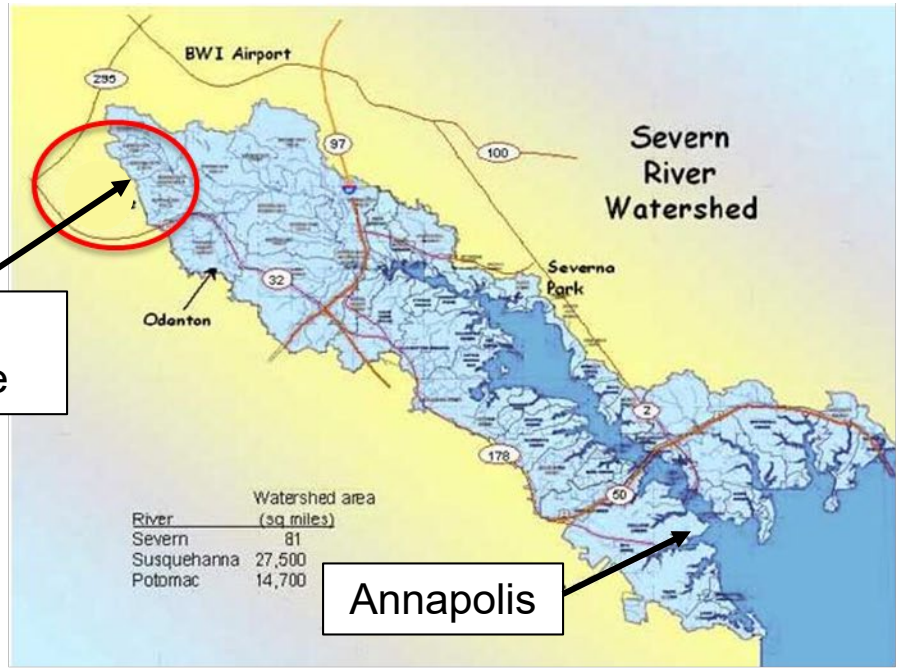
Demonstration Site #2

Summary and Conclusions

- Sufficiently simulated flow, sediment, nutrient, contaminant results
- Better mass loading estimations would improve models
- Base at mouth of watershed
  - Mitigation will not benefit most of watershed
  - Modeling shows DoD impacts compared to other stakeholders

Demonstration Site #3

Patuxent Watershed, Maryland

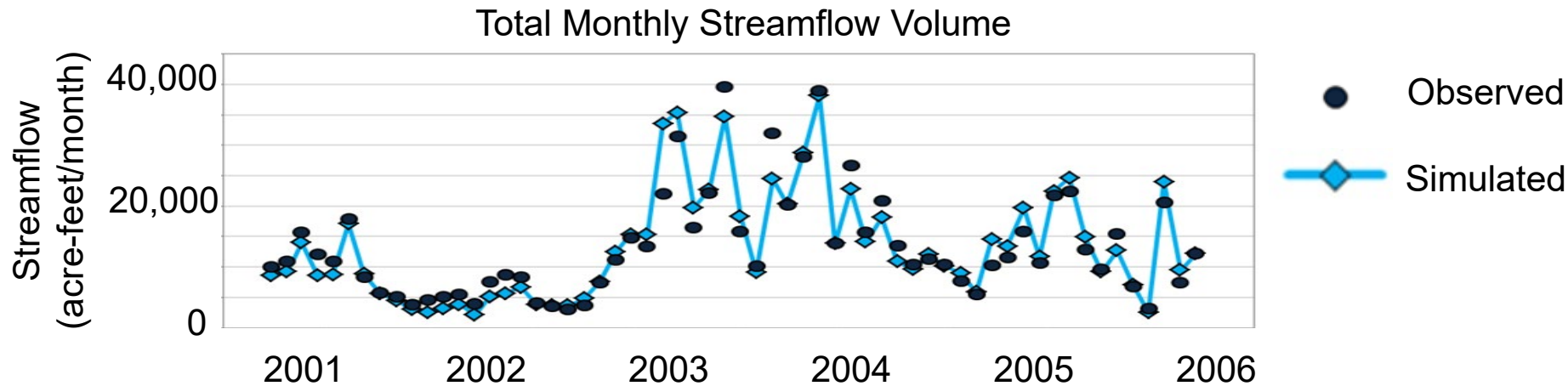


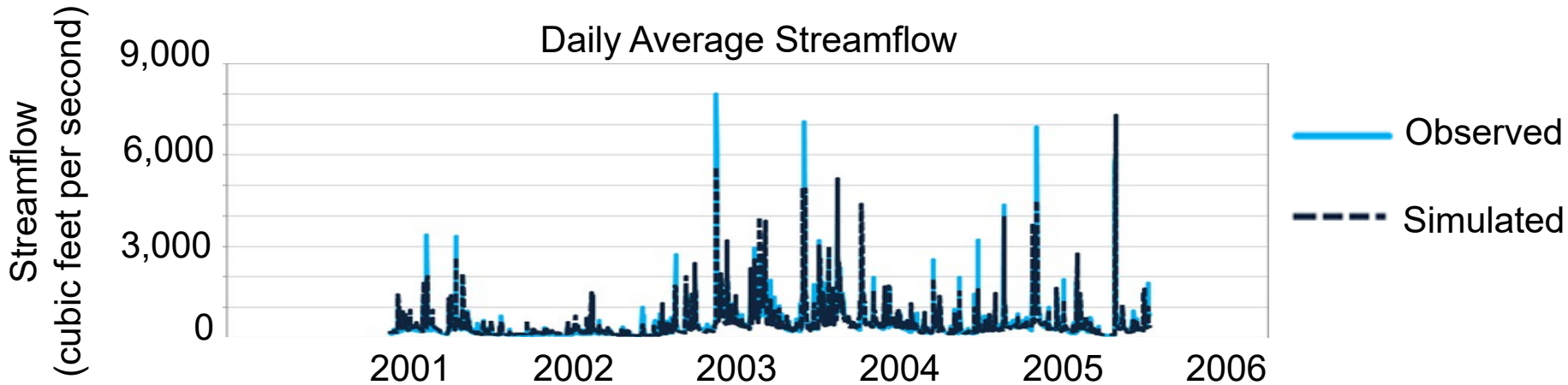
Naval Air Station

Drainage Area = 927 sq. mi.

Demonstration Site #3

Patuxent River near Bowie, Maryland

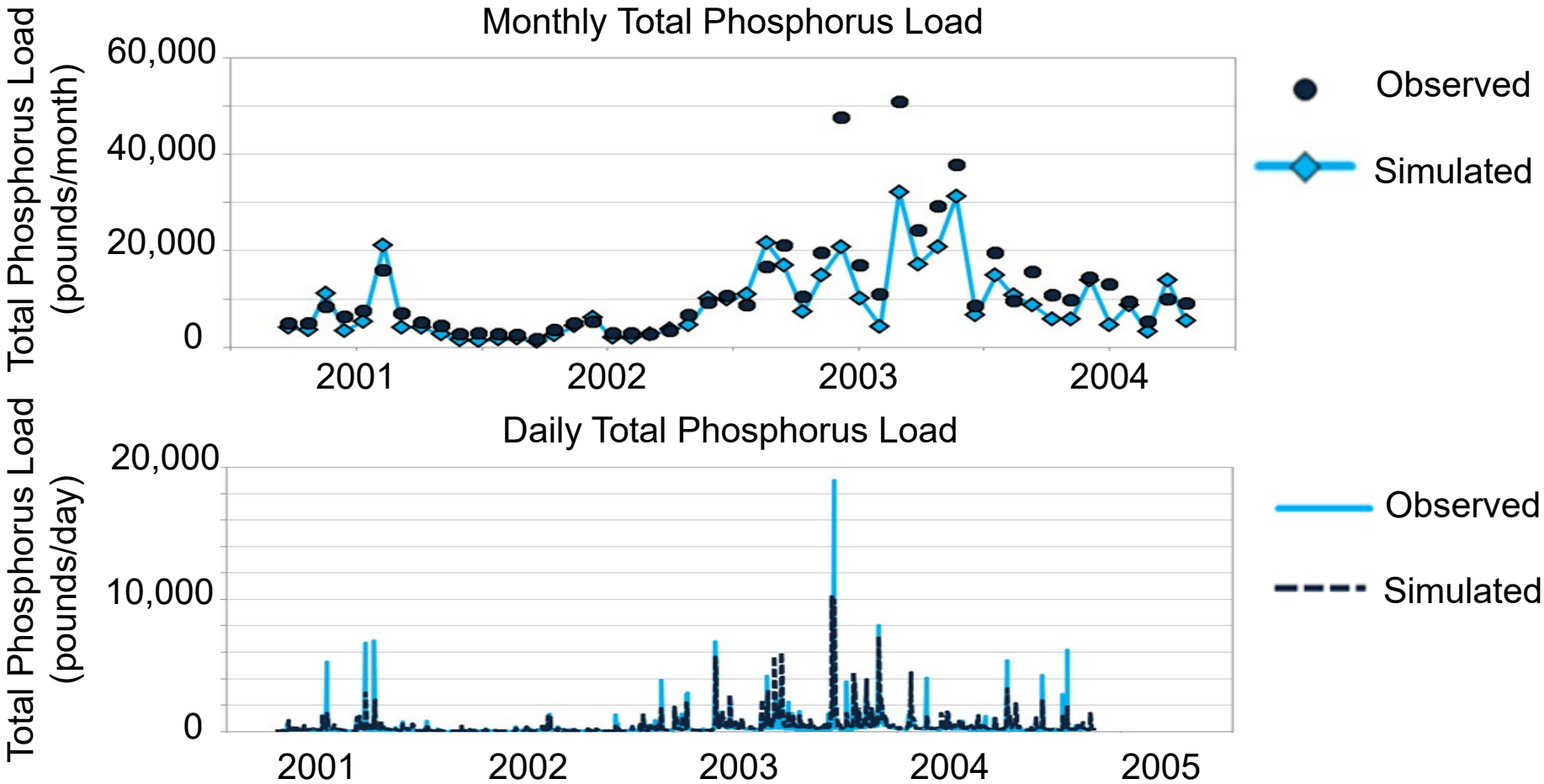




Sufficient flow modeling for DoD decision making

Demonstration Site #3

Patuxent River near Bowie, Maryland



Sufficient water quality modeling for DoD decision making

Demonstration Site #3

Summary and Conclusions

- Sufficiently simulated flow, sediment, nutrient, contaminant results
- Low Impact Development (LID) Projects at Fort Meade
  - Management scenarios within HSPF model in progress
  - Assess reduction in constituent loading from installation
- Load reductions part of Chesapeake Bay Total Maximum Daily Load (TMDL)
  - Modeling can show DoD compliance

Benefits to DoD

- Comprehensive assessment of impacts of constituent fate and transport on and off installation
- Detailed flood forecasting
- Complex channel sedimentation assessments as a result of DoD activities and surrounding lands.
- Results suitable to show that DoD is meeting/mitigating regulatory requirements
- Models can be used in varying climates

Conclusions

- Sufficient flow and meteorological data being collected
- Need more sediment, water quality data for model calibration / validation
- Sufficient modeling of flow, sediment, water quality processes to support DoD decisions
- DoD contractors, not installation personnel, to set up and run models
- Models can assess:
  - Future land use changes
  - Climate change
  - Urban encroachment to installations

For additional information, please visit https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Watershed-Processes-and-Management/RC-201302

Speaker Contact Information

Billy.E.Johnson@usace.army.mil; 601-415-4247

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Q&A Session 1

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Optimization of Stormwater Modeling Approach

Heidi R. Howard
U.S. Army Engineer Research
and Development Center

OPSEC A: "Public Release, Distribution Unlimited"

Agenda

- Benefits to DoD
- Project objectives
- Modeling approaches
- Demonstration sites and results
- Usefulness and LID applications
- Conclusions

***Note**: LID = low impact development*

Project Objectives

- Demonstrate and validate SMOT
  - Integrates factors that contribute to BMP size differences
  - Appropriate modeling approach for stormwater management
- Stress test SMOT using:
  - Multiple climate regions
  - Soil heterogeneity
- Validate recommendations with full modeling
- Demonstrate simplified tool for DoD decision making

Notes: *SMOT = Stormwater Management Optimization Toolbox; BMP = best management practices*

Benefits to DoD

- Documents DoD compliance to EISA 438
  - Storm Water Runoff Requirements for Federal Development Projects[1]:
    - Meet pre-hydrologic and hydraulic conditions post construction
    - Utilize LID BMPs
    - Disturbance > 5,000 square feet (new or retrofit)
- Paradigm shift to LID BMPs solutions[2]
  - Must track and report pre-post results
- Inform end-users on best modeling approach
  - Documentation for the modeling approach selected
- Significant savings for modeling efforts,
  - Right sizing of BMPs

Notes: EISA = Energy Independent Security Act of 2007

(1) Title 42, USC, Chapter 52, Section 17094, Section 438 Energy Independence and Security Act, December 2007; (2) Army Stormwater Management LID Guidance 9/201

Modeling Approaches

- EPA-approved for EISA 438 compliance
  - 95th Design Storm Event
  - Continuous Simulation, i.e., SWMM
  - Continuous Simulation with Optimization, i.e., SUSTAIN
- Difference in cost/time /design results

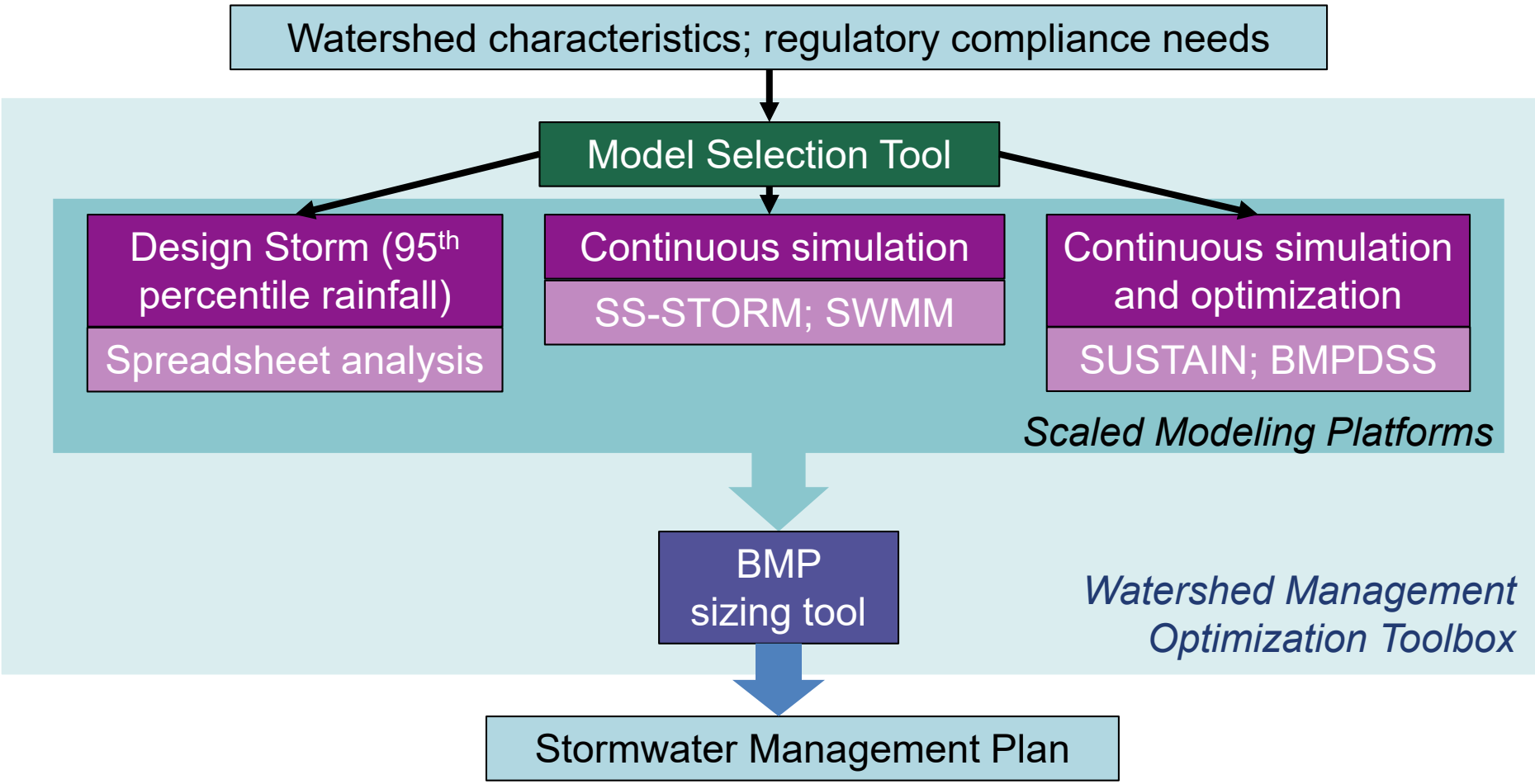
***Notes**: EPA = United States Environmental Protection Agency; SWMM = Stormwater Management Model ; SUSTAIN = System for Urban Stormwater Treatment and Analysis Integration*

Project Approach and Model Selection

- Demonstrate MST and SMOT can determine best modeling approach for DoD
- Ensure that SMOT can evaluate EISA 438 compliance at the lowest cost
- Phase I: Model Selection Tool
  - Determine best approach to minimize cost/volume for compliance
- Phase II: SMOT
  - Demonstrate minimum cost/volume compliance strategy at two installations

***Notes**: MST = Model Selection Tool*

Project Approach



***Notes**: SS-STORM = Spread Sheet – Storage, Treatment, Overflow, Runoff Model; BMPDSS = Best Management Practice Decision Support System*

Modeling Approaches

Installation Data

- Soils
- Rainfall
- Regulations

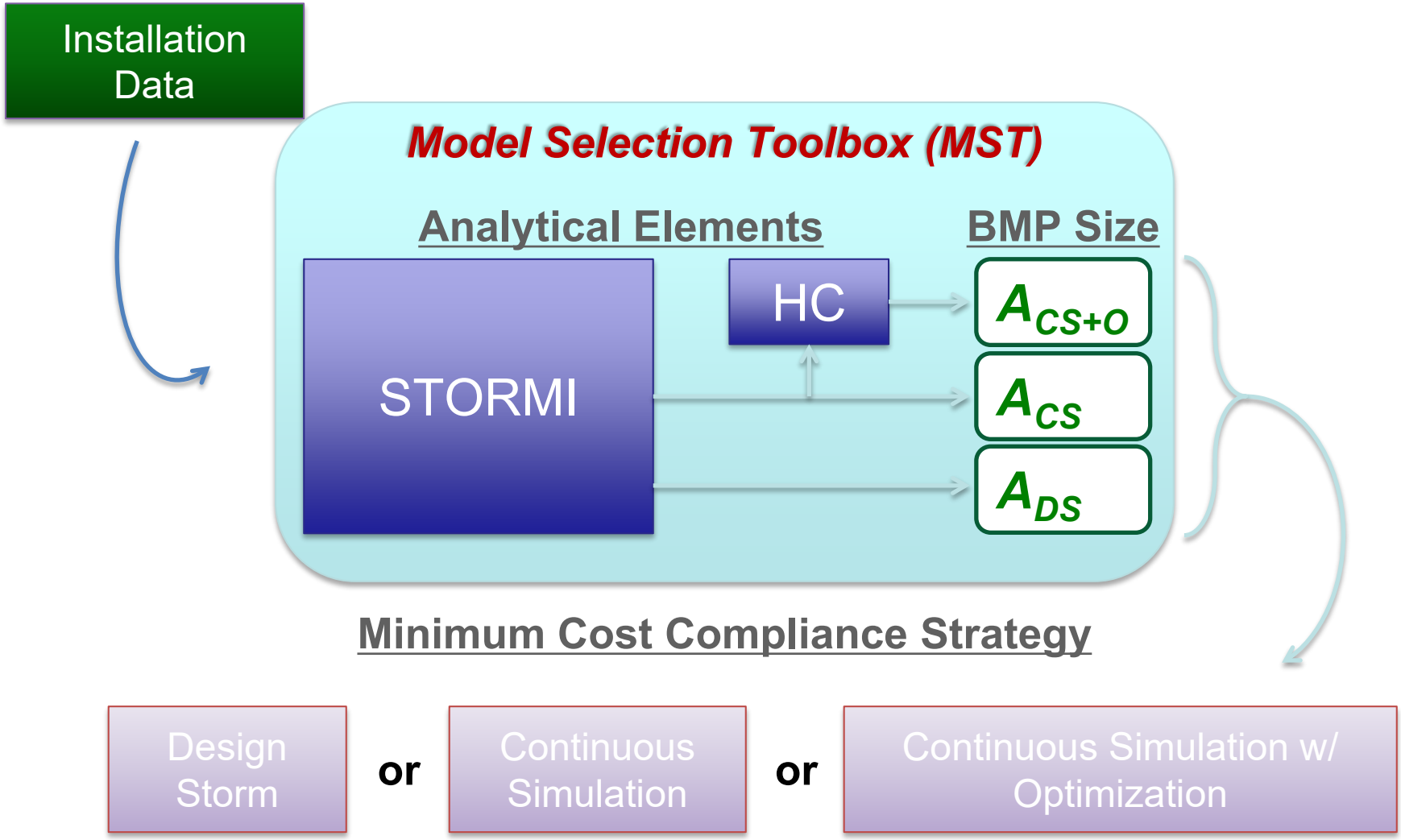
How can we determine which compliance strategy is best?

95th Percentile

Matching Pre-Development Hydrology (or Water Quality Objective)

Design Storm **or** Continuous Simulation **or** Continuous Simulation w/ Optimization

Modeling Approaches



***Notes**: STORMI = Spreadsheet Tool for Optimization Runoff Management & Infiltration*
HC = Heterogeneity Curve

MST Analytical Element: STORMI

U.S. AIR FORCE

SPREADSHEET TOOL FOR OPTIMIZING RUNOFF MANAGMENT & INFILTRATION

Project Setup

Precipitation

Initialize

BMP Solution Mode

(•) Automatic ( ) Manual

Simulation & Analysis

Simulate

View Watershed

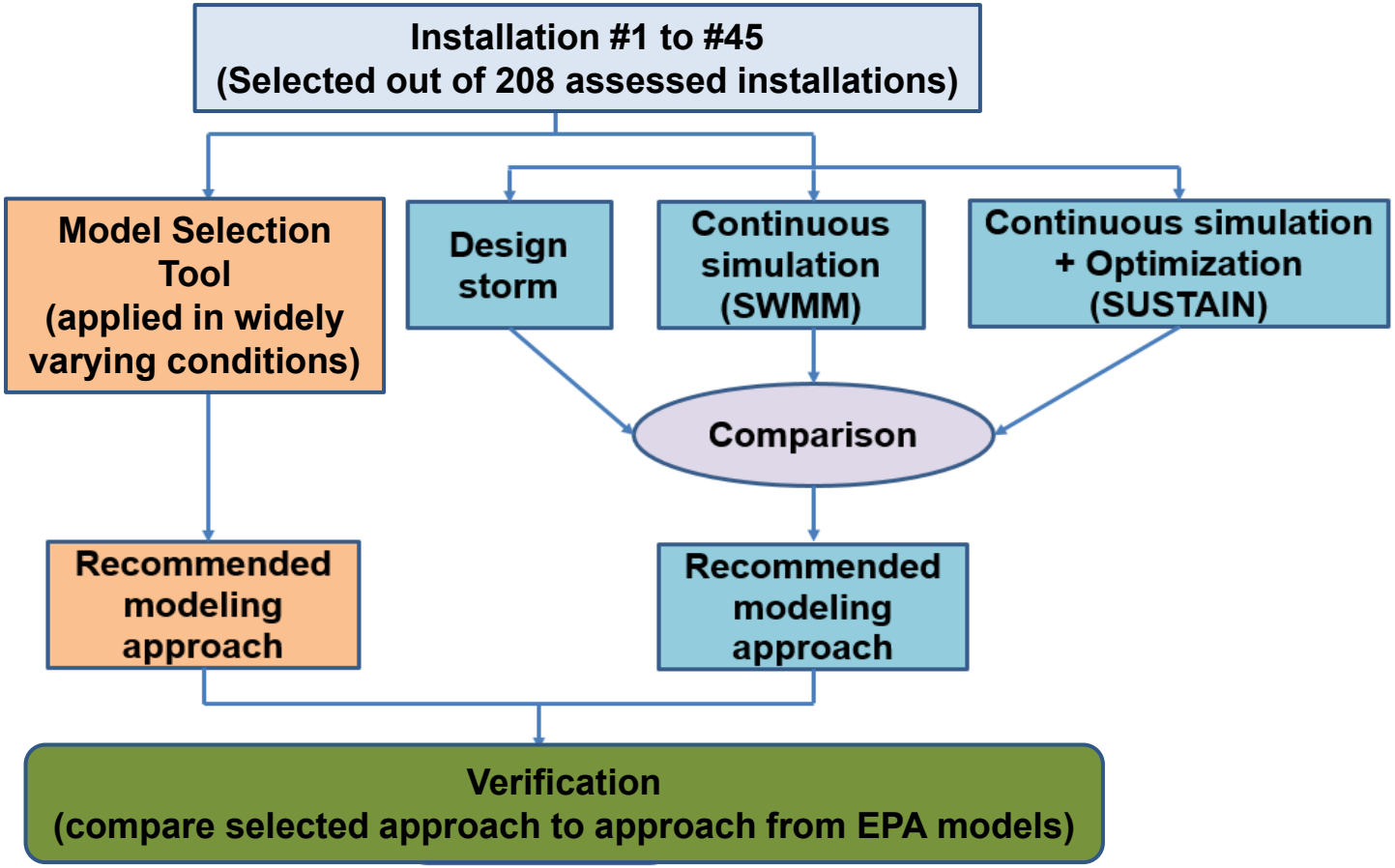
Watershed	Area of development (ft^2)	Depression Storage	
		Impervious (post-dev)	Pervious (pre-dev)
Watershed 1	5,000	0.05	0.15
Watershed 2	70,000	0.05	0.15

Horton Infiltration			BMP Depth (in)	BMP Infil (in/hr)
F_o (in/hr)	F_f (in/hr)	k_d (hr^{-1})		
6.0	0.3	4.14	21.0	0.2
5.0	0.15	4.14	21.0	0.2

Cost = (C) x $(Volume)^E$		BMP Solution	
C	E	Surface Area (ft^2)	Cost ($)
12.4	0.76	646	$ 2,593.33
12.4	0.76	6,823	$ 15,558.76

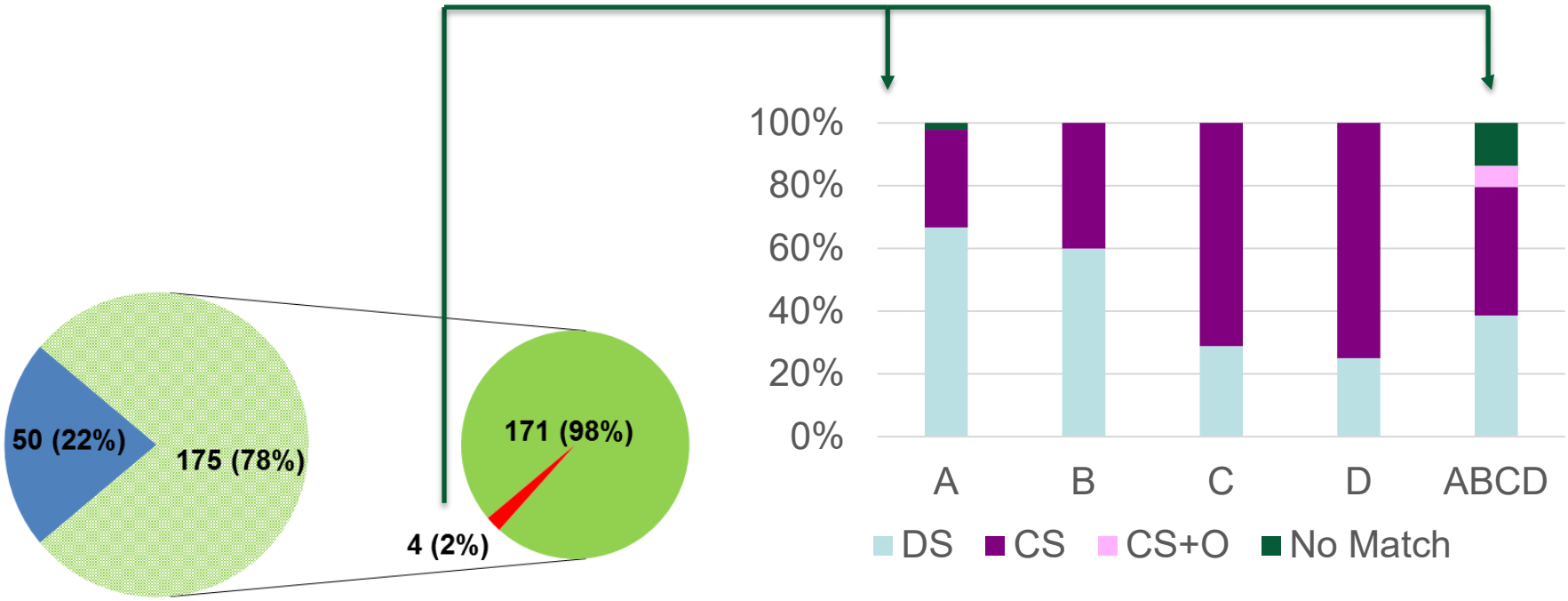
***Notes**: C = concentration, dev = development, ft^2 = square feet, hr^{-1} = per hour, in/hr = inches per hour, V = volume*

Verification of MST



Objective: 95% accuracy when cost differences >10%

Phase 1 Results

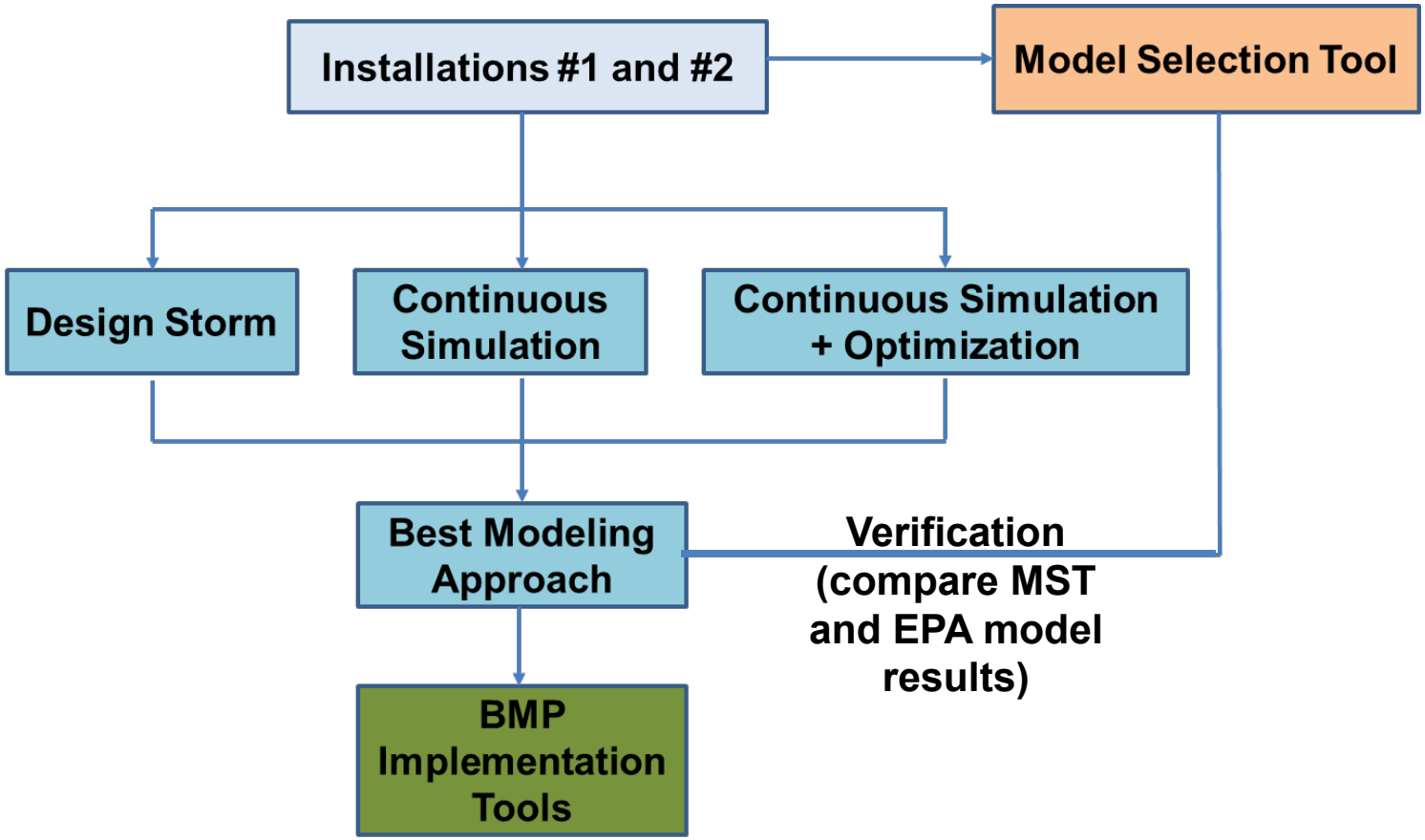


- Sites with cost differences < 10%
- Sites with cost difference > 10%, accurate MST prediction
- Sites with cost difference >10%, inaccurate MST prediction

Note: A, B, C, D are Hydrologic Soil Groups

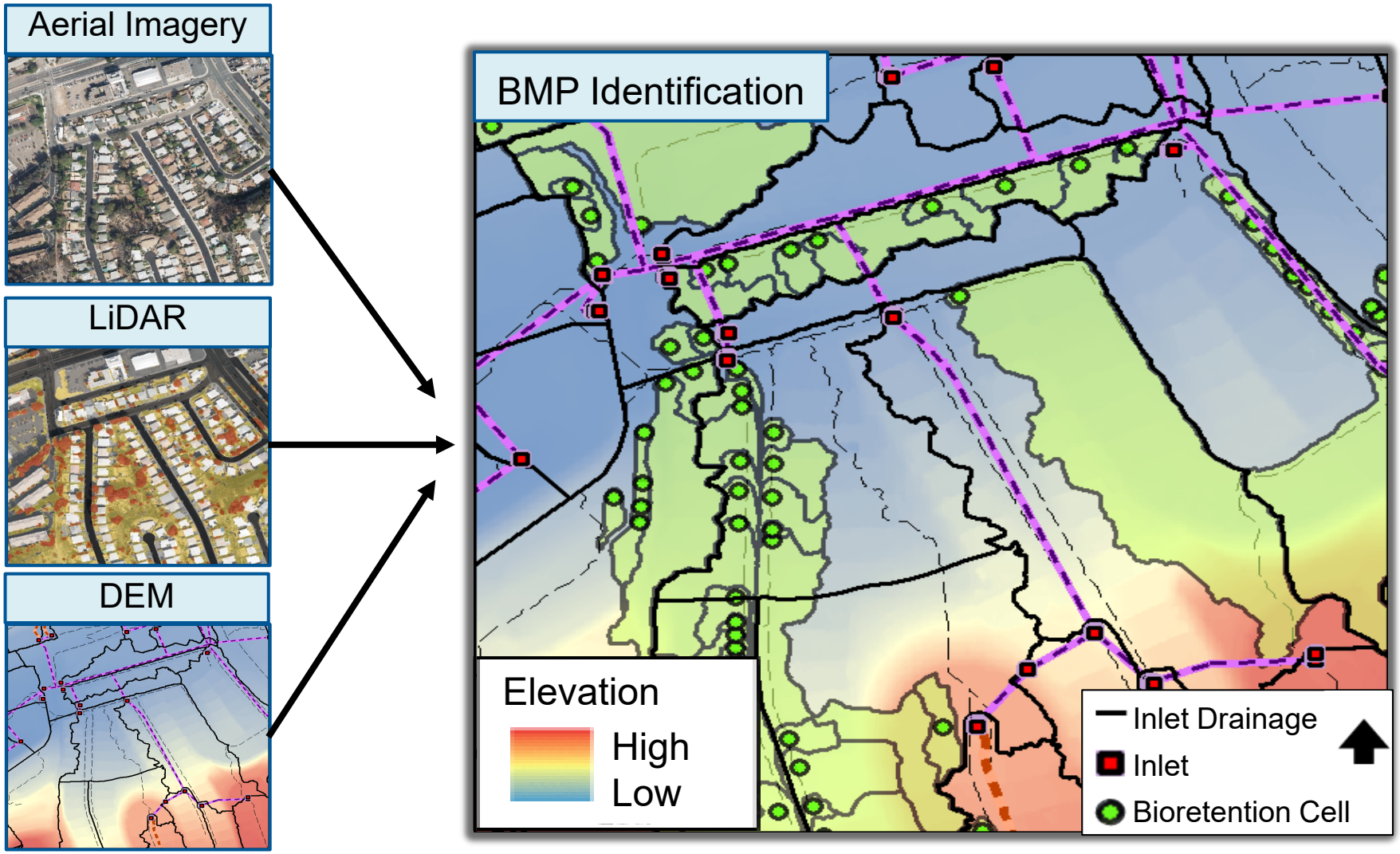
Technical Approach

Phase II Demonstration



Objective: Consistent model approach selected

Technical Approach – Phase II Detailed Modeling



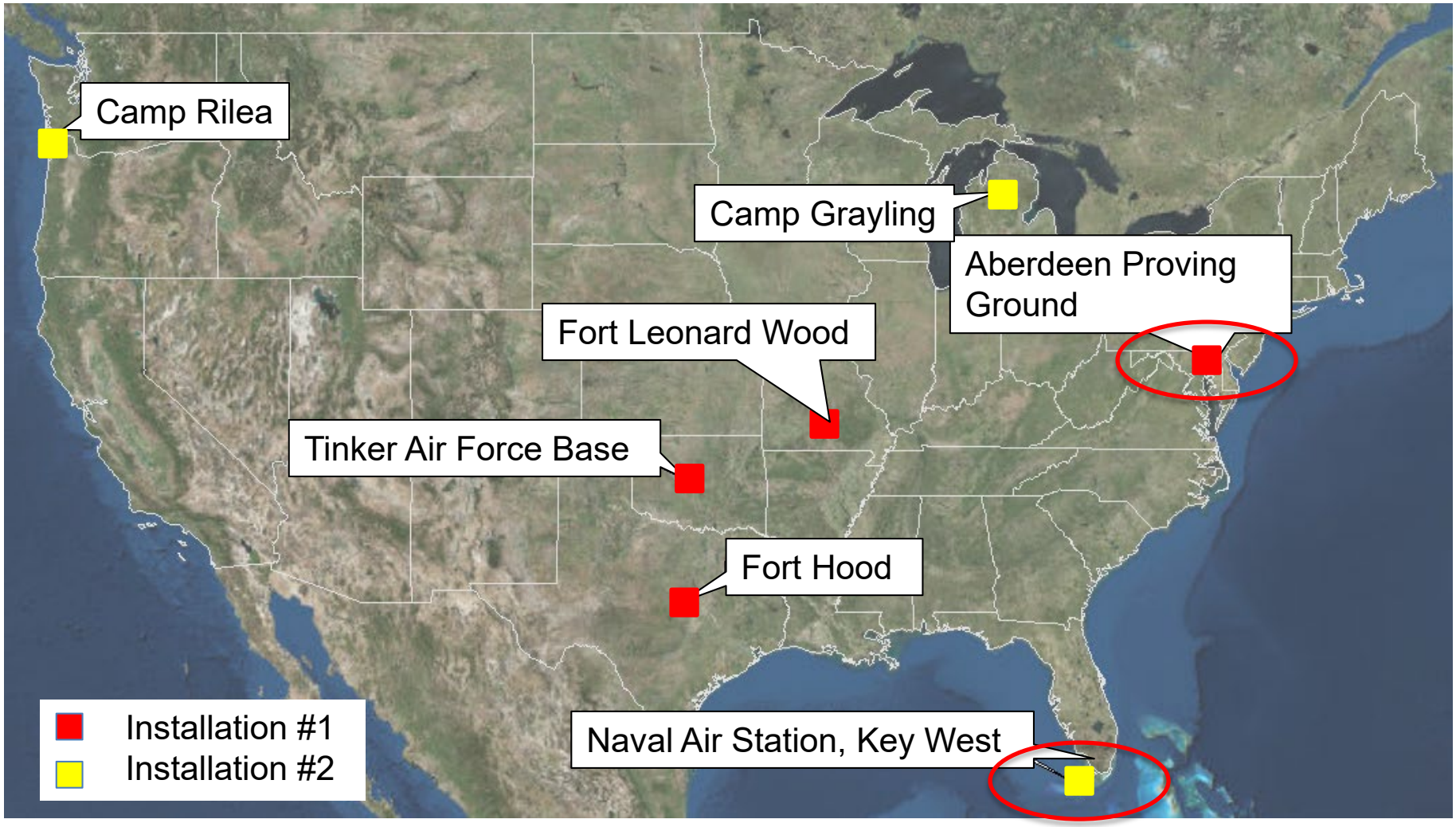
***Notes**: DEM = Digital Elevation Model*

Phase II Site Criteria

Selection Criteria	Parameter	Preferred Values	
		Installation #1	Installation #2
Primary	MST recommended model approach	Continuous simulation only	Continuous simulation coupled with optimization
	Cost savings potential	High (>10%)	
Secondary	Regulatory requirements	1 Installation with EISA only 1 Installation with EISA+TMDL	
	BMP retrofit requirement	n/a	High
	Master plan indicates future development	Yes	
	Willingness and data availability	High	
	CWASSC and ESTCP recommendations		

Notes: *CWASSC = Clean Water Act Services Steering Committee, TMDL = total maximum daily limit*

Phase II Candidate Sites



Data Utilized

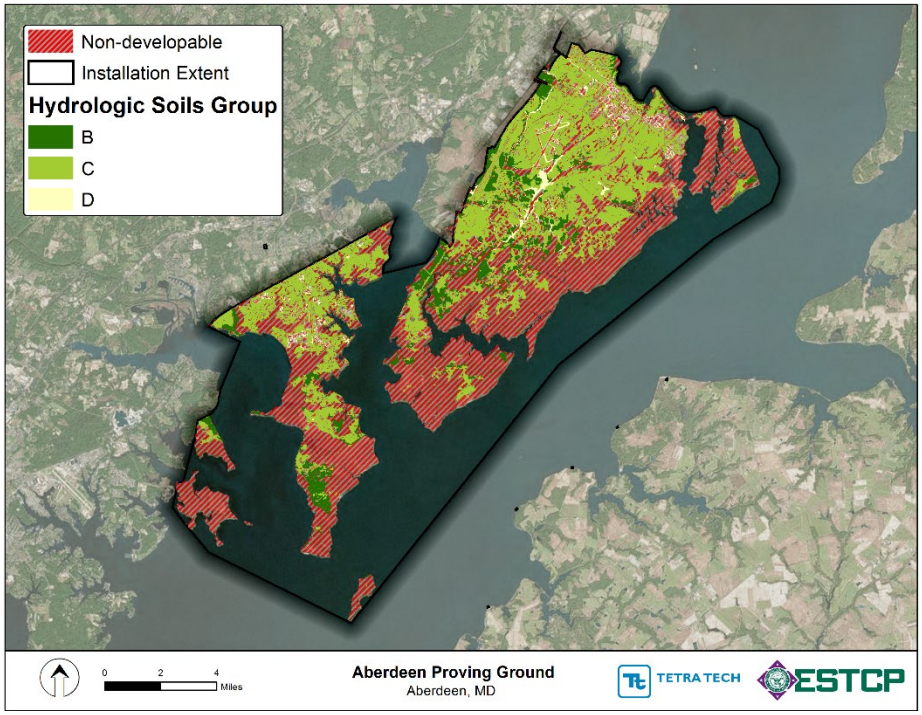
Data	APG	NAS Key West
Storm Drain Network	✓	✓
Land Use	✓	✓
Rainfall	✓	✓
Soils	✓	✓
Existing BMPs	✓	✓
Impervious Area	✓	✓
DEM	✓	✓
Inundation Confidence	✓	✓

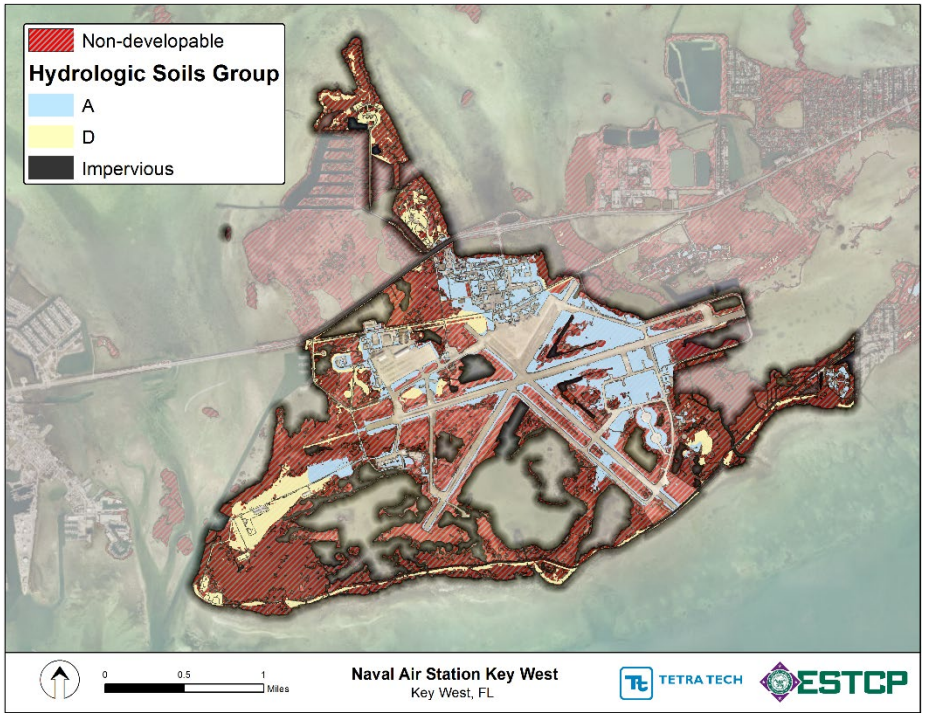
No development plans = “Developable Area Analysis”

***Notes**: APG = Aberdeen Proving Ground, DEM = digital elevation map, NAS = Naval Air Station*

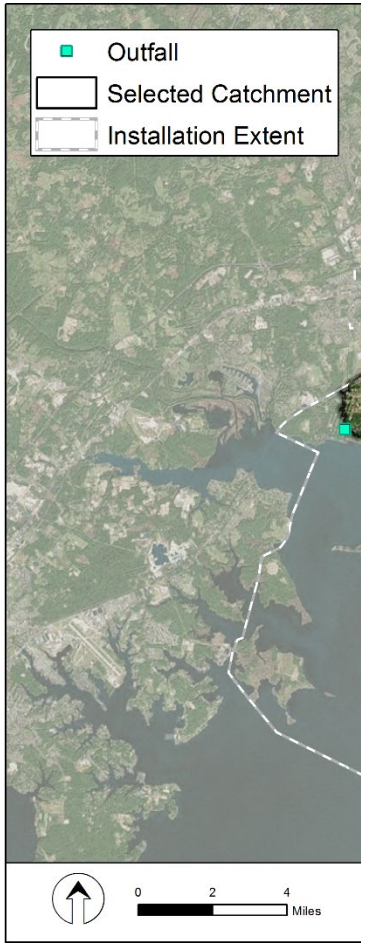
Developable Area Analysis

- Development scenarios (APG and NAS Key West):
  - 30% / 60% / 90% development of pervious area





Installation #1: APG



Installation #1: APG

Horton infiltration initialization

Recommended modeling method:

Based on the input data, the recommended modeling approach for the
APG Air Force Base is:

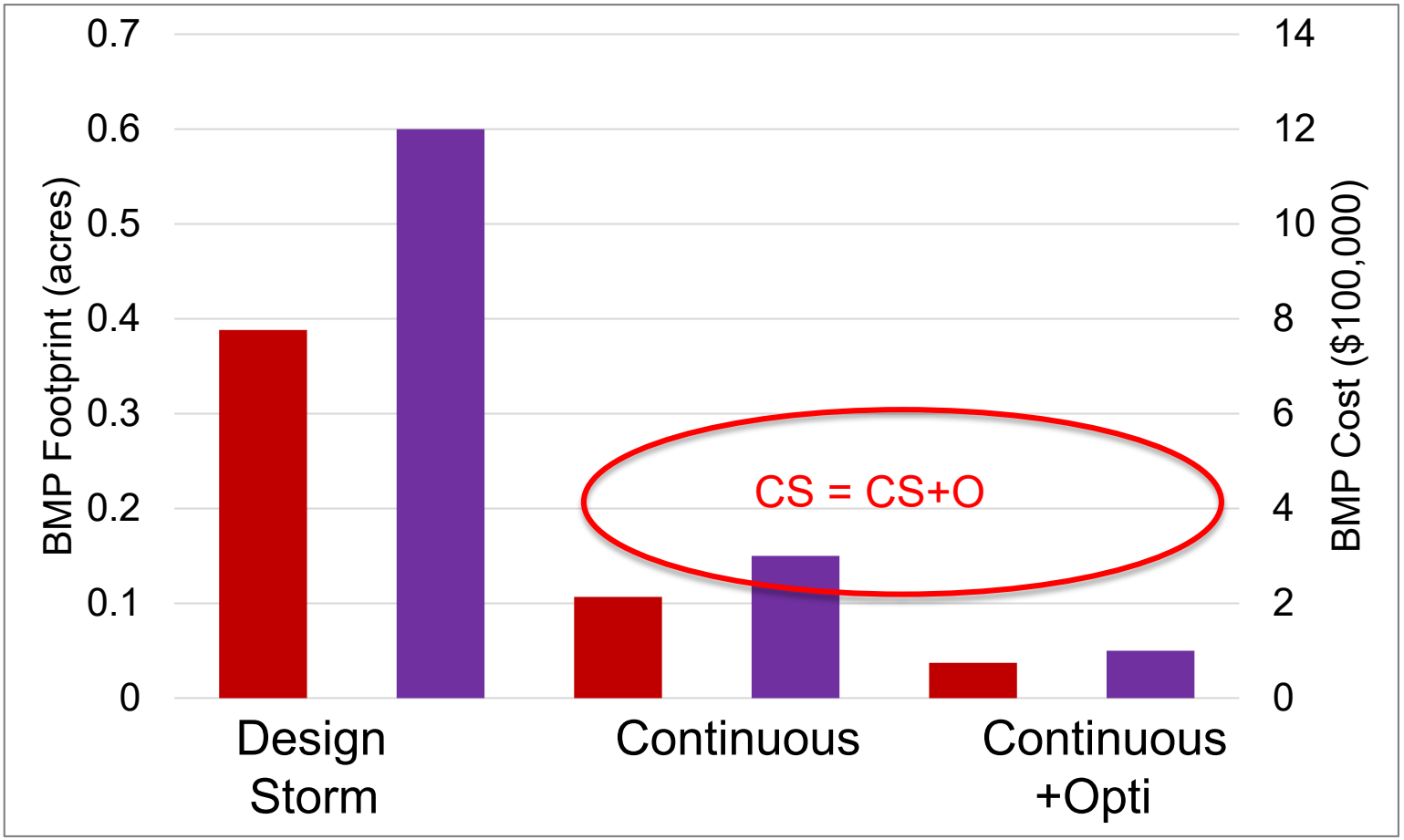
Continuous Simulation Only

The main reasons for this recommendation are:
- BMP size in Continuous Simulation < BMP size in Design Storm.
- The soils are not heterogeneous enough and the optimization result is not significant.

	Dry days	7.0	1 – 14 (UWRI 2012)
	Decay rate (1/hr)	4.0	3 (UWRI 2012)

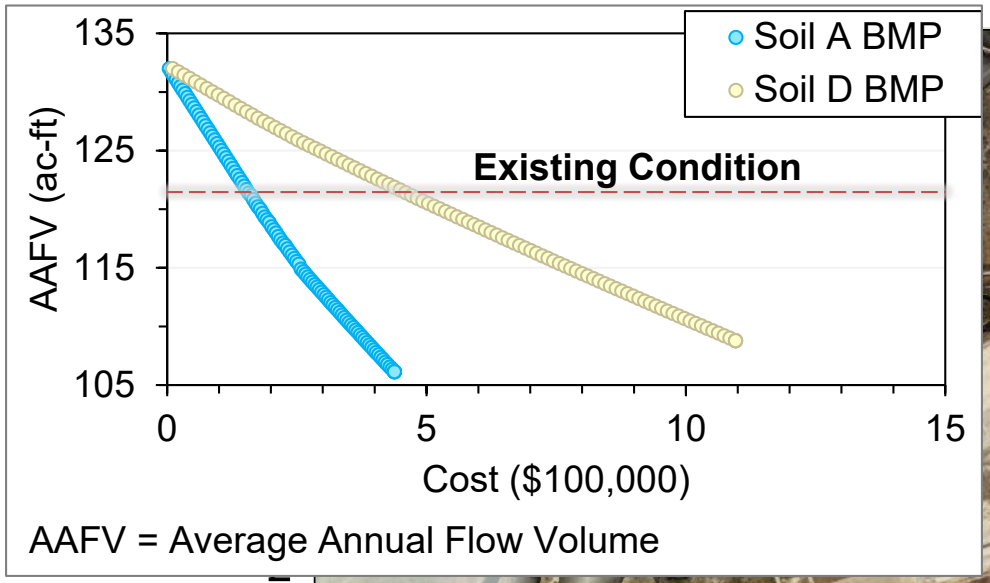
Validate inputs | Run the decision model | Reset inputs

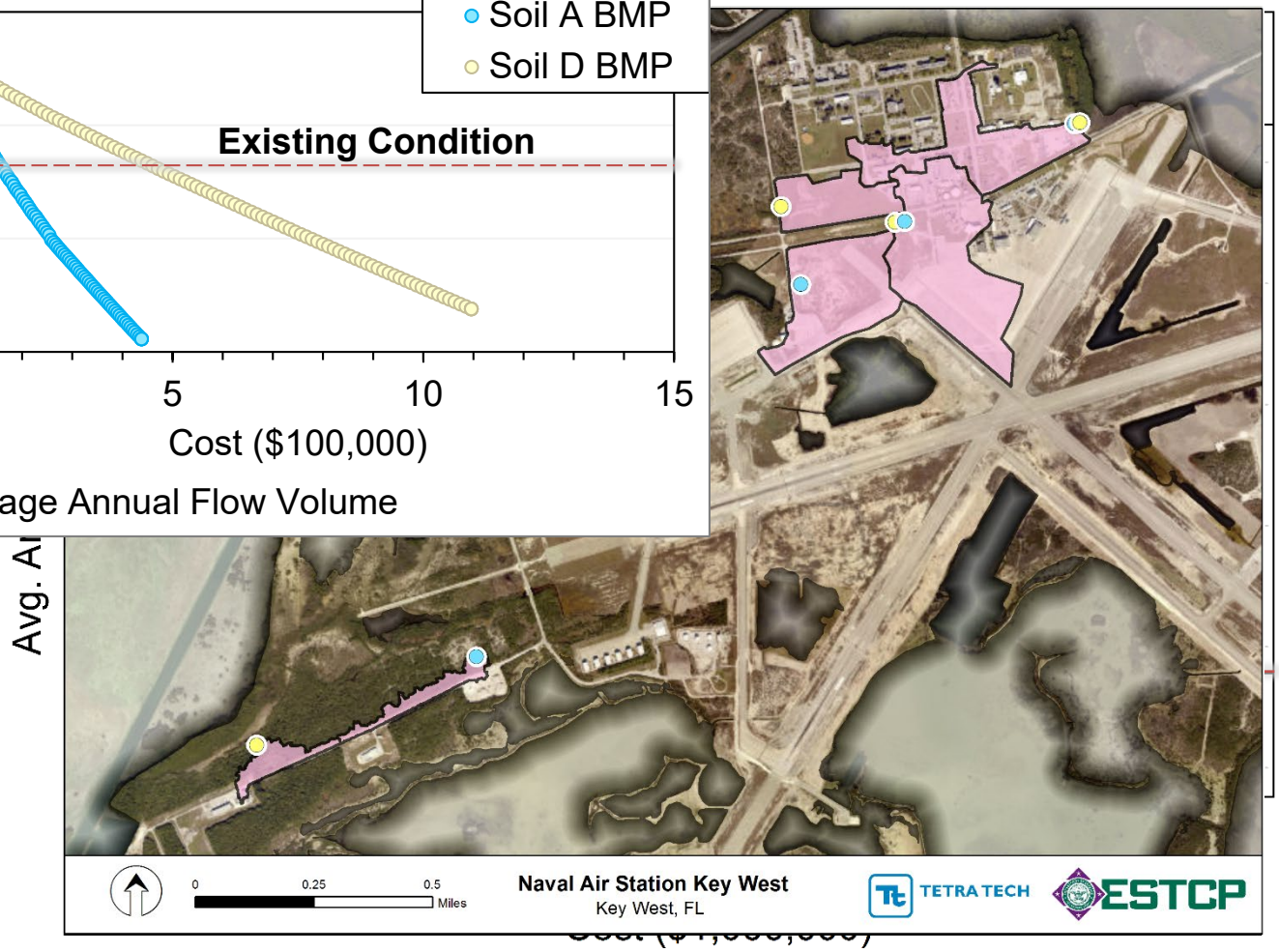
Installation #1: APG



Notes:
CS = continuous, O = Optimization

Installation #2: NAS Key West





***Notes**: AAFV = Average Annual Flow Volume*

Installation #2: NAS Key West

Horton infiltration initialization

Recommended modeling method:

Based on the input data, the recommended modeling approach for the Key West Air Force Base is:

Continuous Simulation Coupled with Optimization

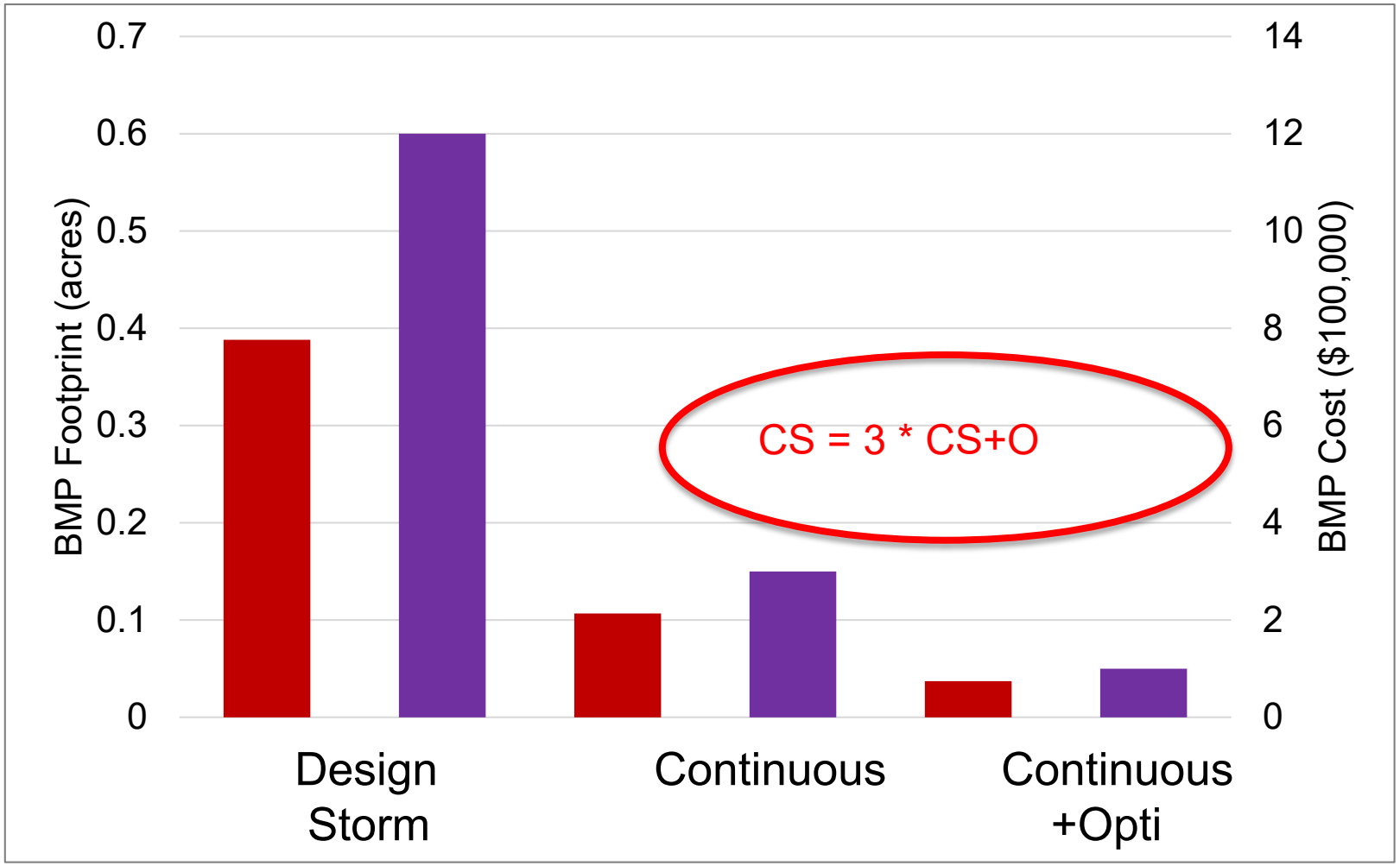
The main reasons for this recommendation are:

- BMP size in Continuous Simulation < BMP size in Design Storm.
- The soils are heterogeneous and the optimization result is significant.

	Dry days	7.0	1 – 14 (UWRI 2012)
	Decay rate (1/hr)	4.0	3 (UWRI 2012)

Validate inputs | Run the decision model | Reset inputs

Installation #2: NAS Key West



Scenario Summary

% Development Modeled	APG (MST)	APG (Models)

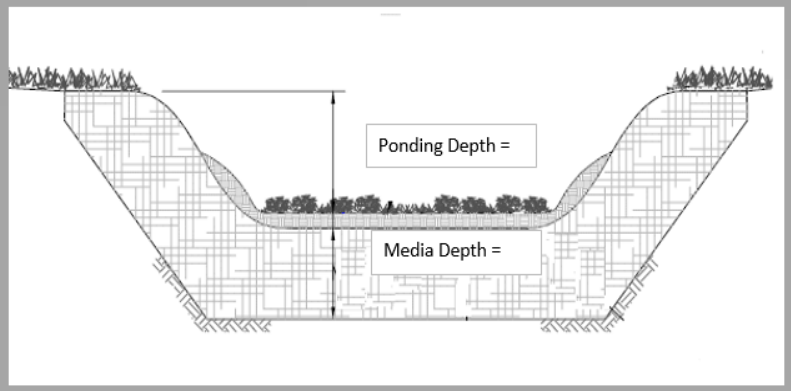
Technical Progress

BMP Implementation Tools

BMP Factsheet

BMP Selected	Bioretention		(From Select BMP page)
BMP Layer Definition for Conceptual Cross-sectional Design	Default Depth (inches)	Customized Depth (inches)	Recommended Design Range
Desired Ponding Depth	8		(1"-12")
Desired Media Depth	24		(1"-48")
Desired Stone Layer Depth	0		(1"-52")

19,379	Required BMP Size (ft^2)

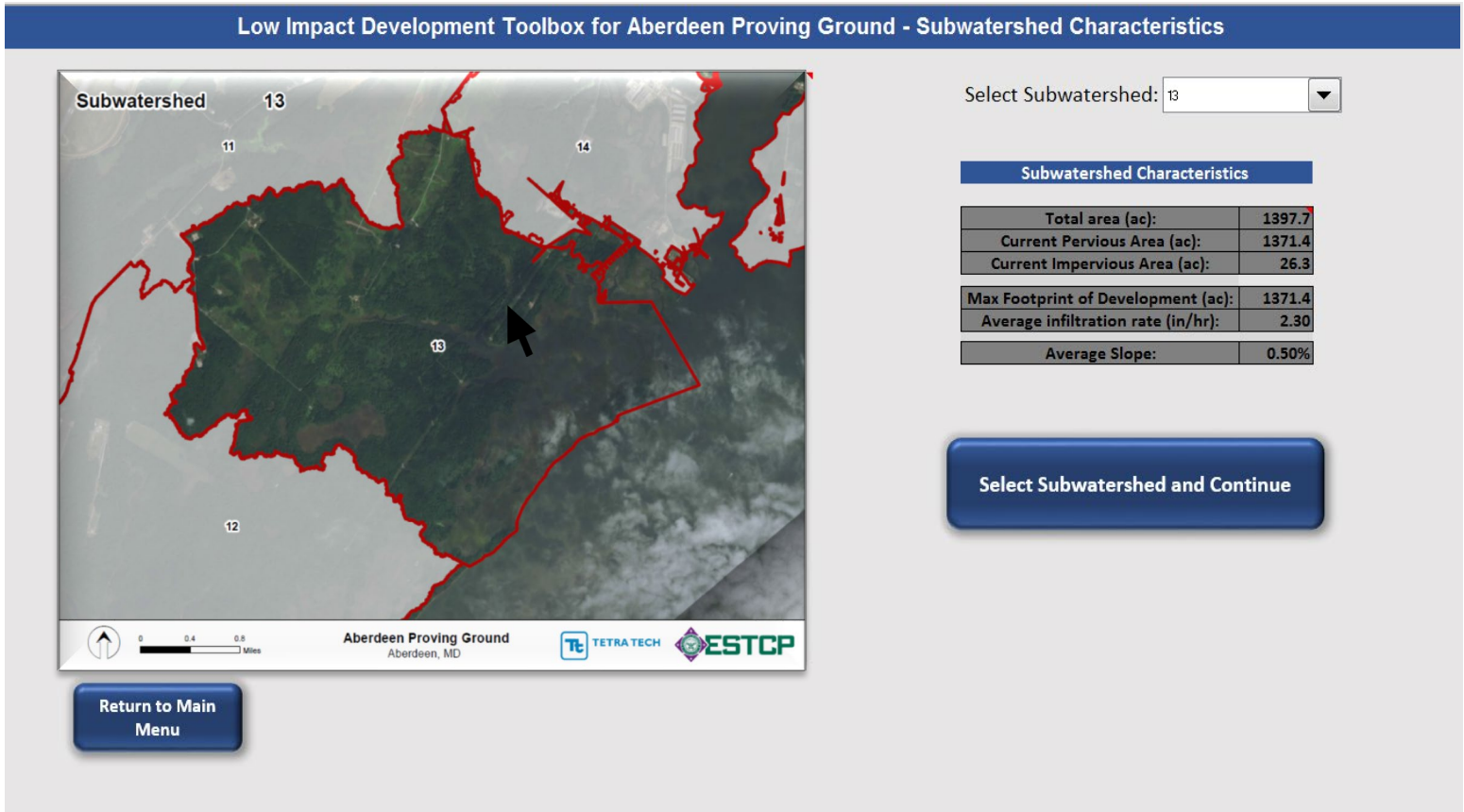


Return to Select and Develop BMPs

BMP Design Factsheet

Technical Progress

BMP Implementation Tools

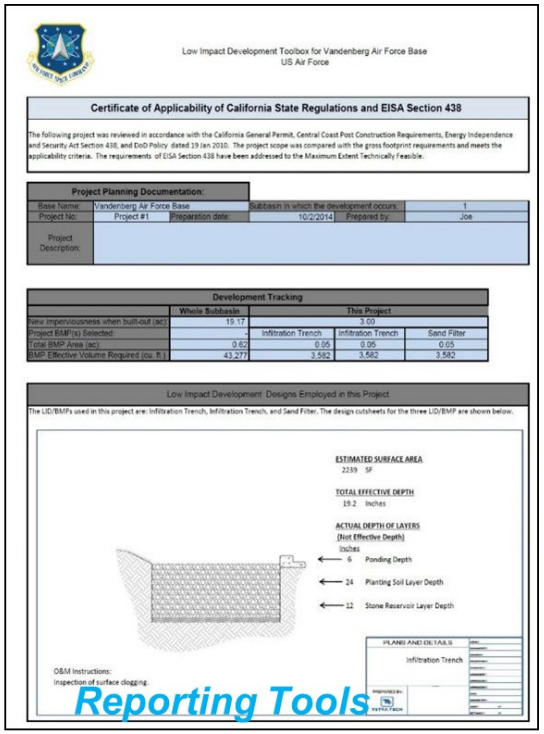


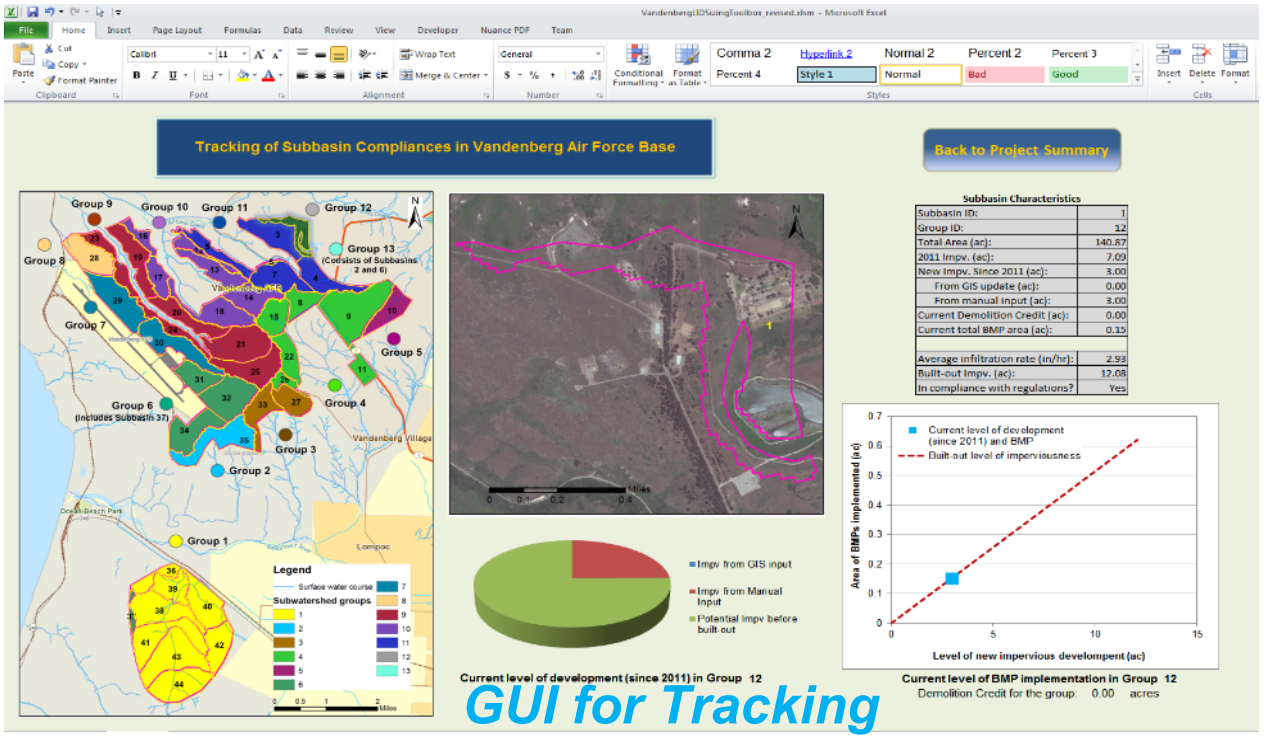
Graphical User Interface for Individual SWS Development

MST Usefulness and LID Applications

- "Appropriate" modeling approach, level of effort
  - Optimize BMP placement: >10% size savings
- Sizing, tracking, accounting tools
  - Excel environment
  - Seamless results integration
    - Size BMPs for new developments
  - Compliance reporting
    - BMP design, hydrologic benefits, cost information
- BMP planning tools
  - Conceptual design fact sheets/reports
  - BMP master planning
  - Linked to model output
    - Tracking / trading / BMP sizing
  - Project-scale prioritization and selection
    - Ranked by efficiency / effectiveness / multiple benefits

MST Usefulness and LID Applications





Conclusions

- Phase I
  - MST and SMOT work across varying climates and soil heterogeneity
- Phase II
  - Full hydrologic modeling when compared to SMOT outputs correctly identified cheapest modeling approach for both sites

For additional information, please visit https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Watershed-Processes-and-Management/RC-201305

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Q&A Session 2

SERDP
DOD • EPA • DOE

ESTCP

The next webinar is on November 15, 2018

Stormwater Impacts on Sediment Recontamination

SERDP DOD • EPA • DOE | ESTCP

Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends

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