EPA Office of Research and Development

Homeland Security Research Program

Stormwater Modeling: Case Studies to Support EPA's Homeland Security Research Program

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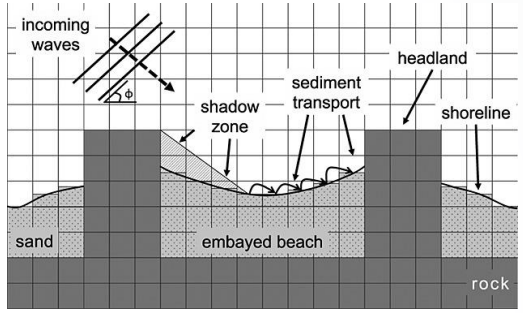
Office of Research and Development
Center for Environmental Solutions and Emergency Response

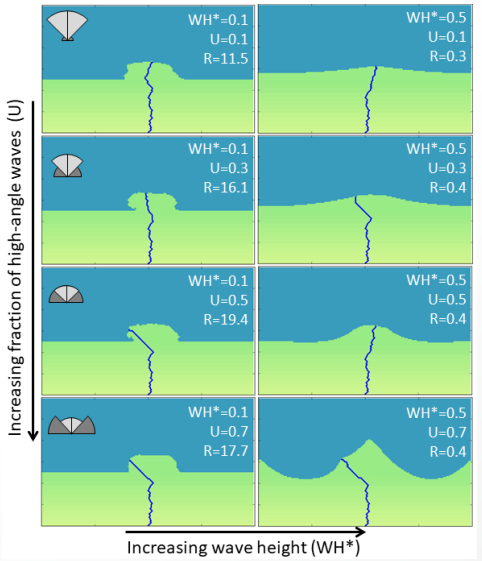
My Path to the EPA

- **B.A., Earth & Environmental Sciences**
  Vanderbilt University, Nashville, TN
- **Ph.D., Earth & Ocean Sciences**
  Duke University, Durham, NC
- **ORISE Postdoctoral Fellow, US EPA**
  National Homeland Security Research Center
- **Federal Postdoctoral Researcher, US EPA**
  Center for Environmental Solutions and Emergency Response

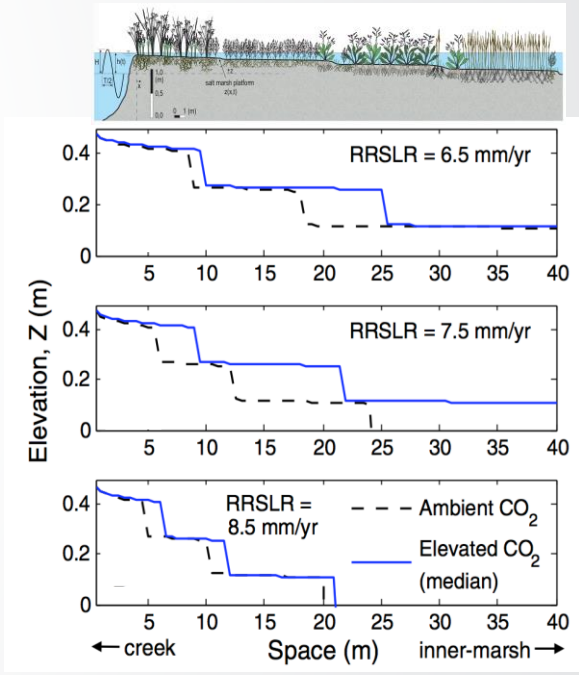
coastal sediment transport



river delta morphology



marsh resilience to sea-level rise



U.S. Environmental Protection Agency

Office of Research & Development

↳ Center for Environmental Solutions & Emergency Response (CESER)

↳ Homeland Security Materials Management Division (HSMMD)

↳ Wide Area Infrastructure Decontamination Branch (WAIDB)

<u>EPA Homeland Security Research Program (HSRP) Mission:</u>

to conduct research and develop scientific products that improve the capability of the Agency to carry out its homeland security responsibilities

EPA Homeland Security Responsibilities

Authorities

Bioterrorism Act

Presidential Directives

Executive Orders

National Response Framework

Elements of:

- Comprehensive Environmental Response, Compensation and Liability Act
- Emergency Planning and Community Right-to-Know Act
- Clean Water Act
- Safe Drinking Water Act
- Oil Pollution Act
- Clean Air Act
- Resource Conservation and Recovery Act

Responsibilities

- **Support water systems to prepare for and recover from attacks and other disasters**

  by leading efforts to provide States and water utilities guidance, tools and strategies. ***EPA is the federal government Sector Specific Agency lead for water infrastructure***.

- **Clean up buildings and outdoor areas**

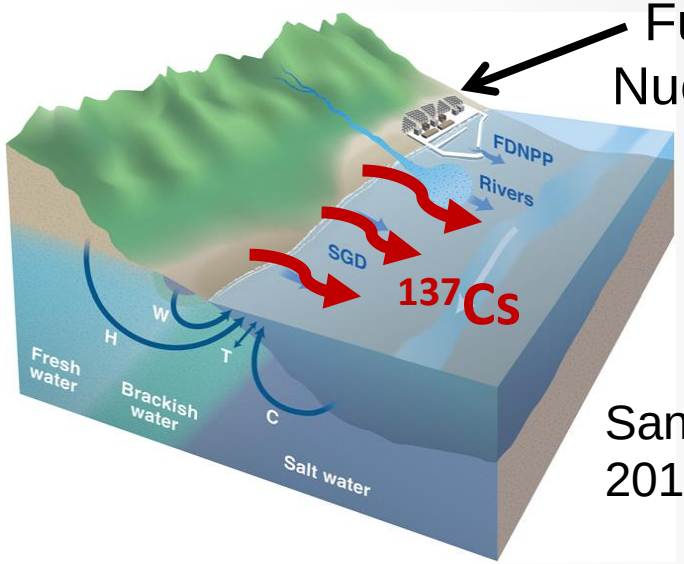
  impacted by a terrorist attack or other disaster by leading efforts to establish clearance goals and clean up.

- **Develop a nationwide laboratory network**

  with the capability and capacity to analyze for chemical, biological and radiological (CBR) agents for routine monitoring and in response to a terrorist attacks.

Fate & Transport Modeling

- Goal: to better understand impacts of wet weather and human intervention (e.g., power washing) on fate & transport of particulate contaminants (e.g., spores, radionuclides) in urban areas
- Challenges:
  - Contamination can be hard to detect
  - Dynamic systems (rain, wind, human and vehicle traffic)
  - Incidents may take years to remediate



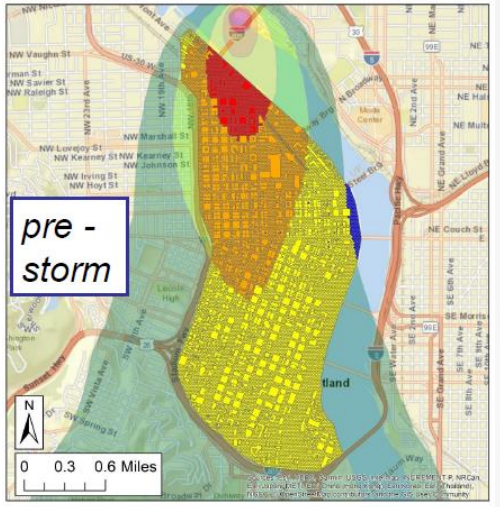
Sanial et al., 2017 *PNAS*

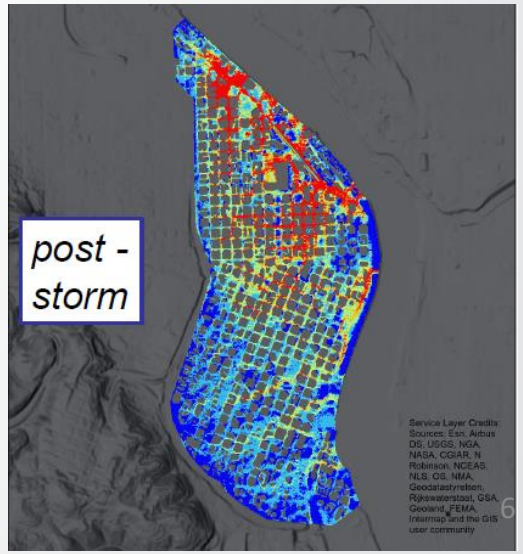
Amerithrax incident response

https://media.npr.org/assets/img/2011/02/15/anthrax-haz-mat_wide-d15256c9a2b55ef63fd426ccbd3dececc9e5c3dad-s700-c85.jpg

Focus: Stormwater Modeling

- Support contaminant mapping during emergency response and recovery
  - ✓Site characterization
  - ✓Developing sampling plans
  - ✓Determining waste staging areas
  - ✓Resource allocation
- Integrate air dispersion model results
- Surface & subsurface mapping
- Dynamic modeling capabilities that evolve over time (hours → years)
- Emergency planning

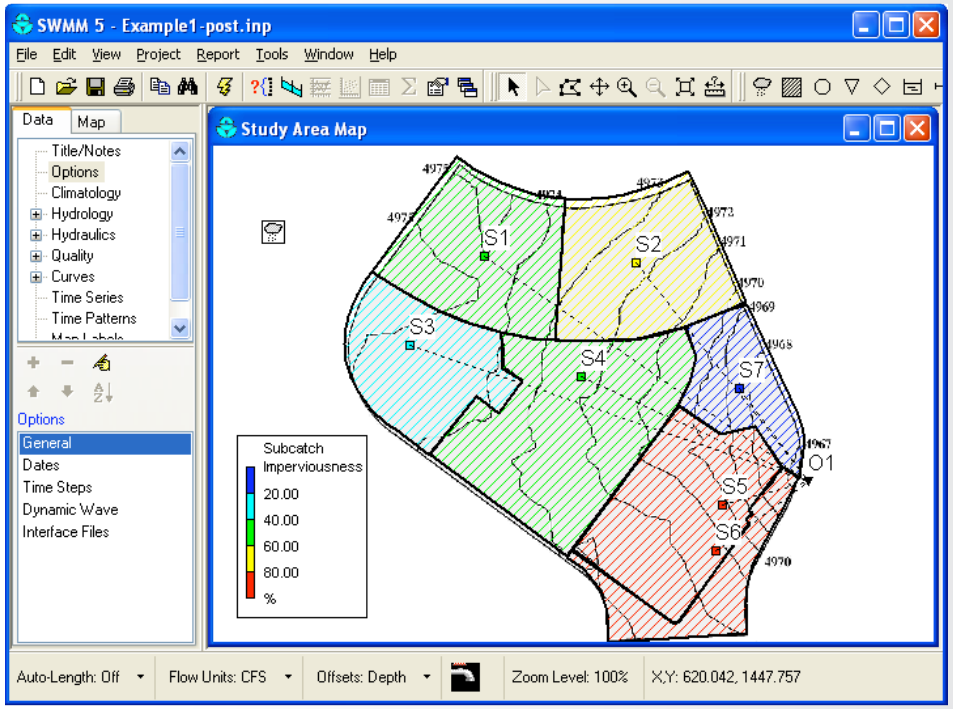




Adapting SWMM for HSRP Needs

- US EPA SWMM5 engine selected after comprehensive model survey (EPA Report: EPA/600/R-18/282)
- Need additional functionality for pollutant tracking and control
  - Open Water Analytics SWMM5 API & PySWMM Python wrapper
  - pyswmm.readthedocs.org

https://github.com/OpenWaterAnalytics



SWMM5 Graphical User Interface

Adapting SWMM for HSRP Needs

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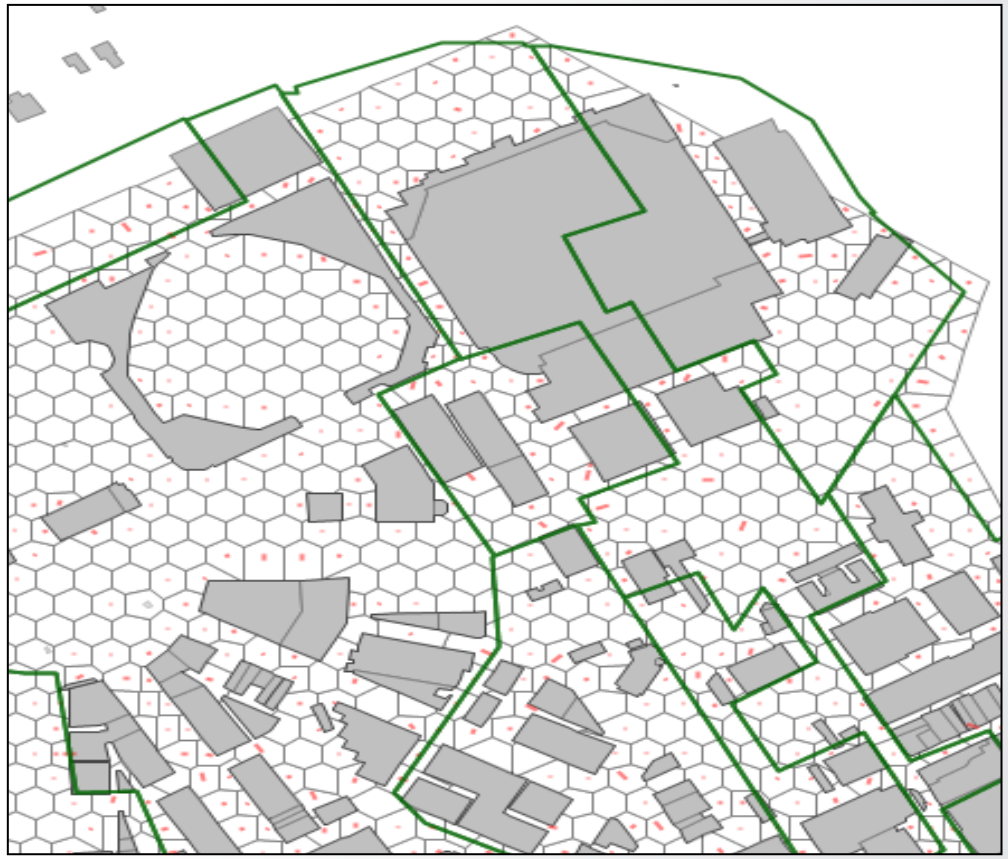
- Need additional functionality for pollutant tracking and control
  - Open Water Analytics SWMM5 API & PySWMM Python wrapper
  - pyswmm.readthedocs.org
- Finer spatial resolution for overland flow
  - PCSWMM '2D' modeling

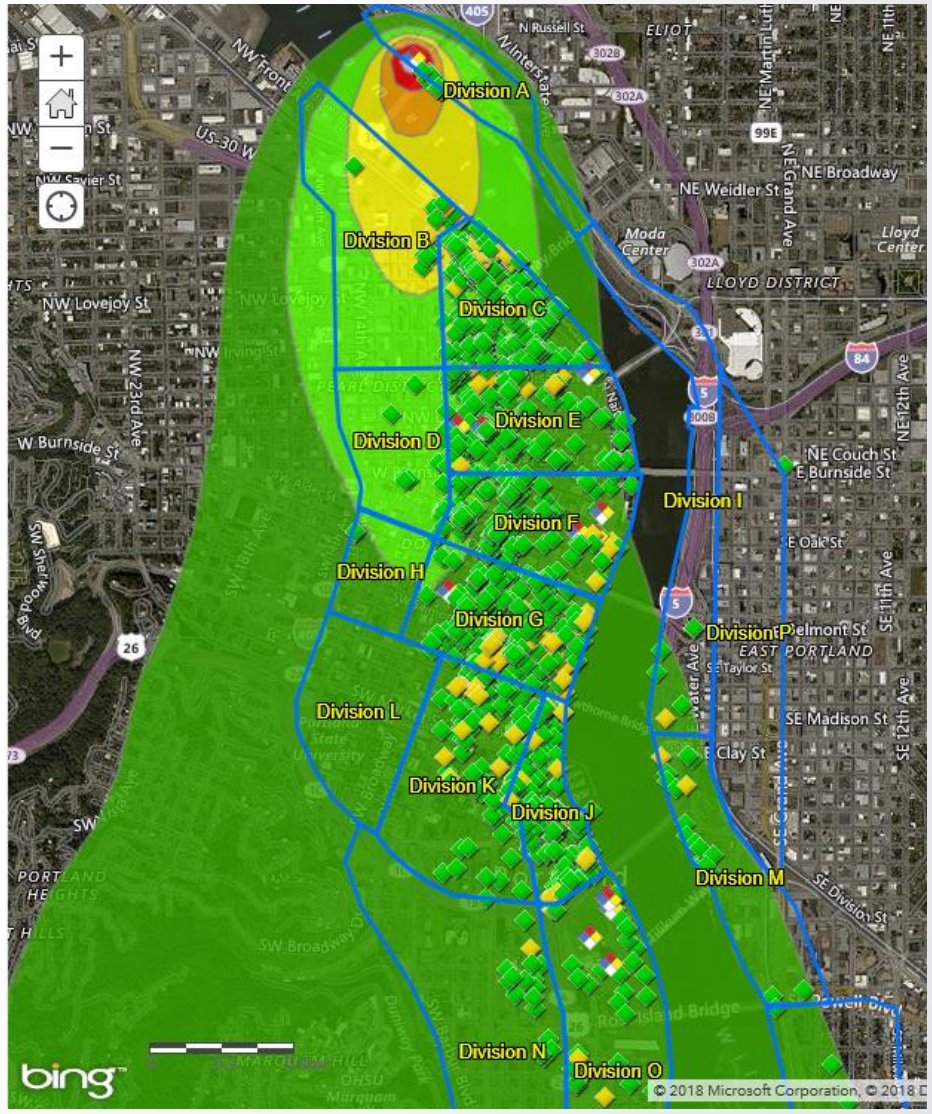


Example of 2D overland flow mesh

Case Study: Portland Asbestos Fire

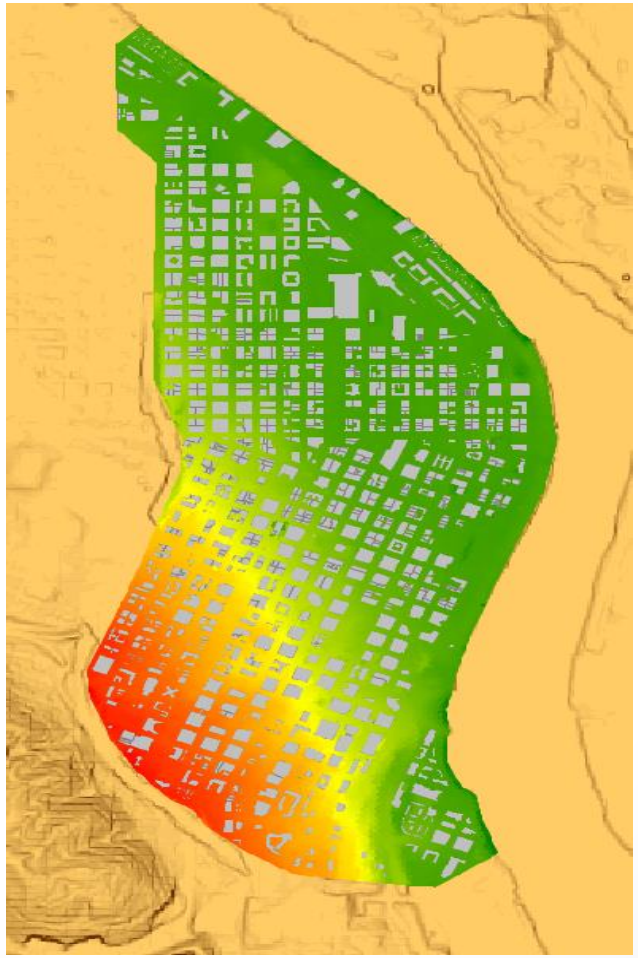
Case Study: Portland Asbestos Fire

- Building materials contained asbestos
- Recognized asbestos-containing ash had spread far from site of fire
- EPA provided support to Oregon Department of Environmental Quality
- FEMA's Interagency Modeling and Atmospheric Assessment Center (IMAAC) generated HPAC air plume model
- Demonstrated challenges of a wide-area contamination incident

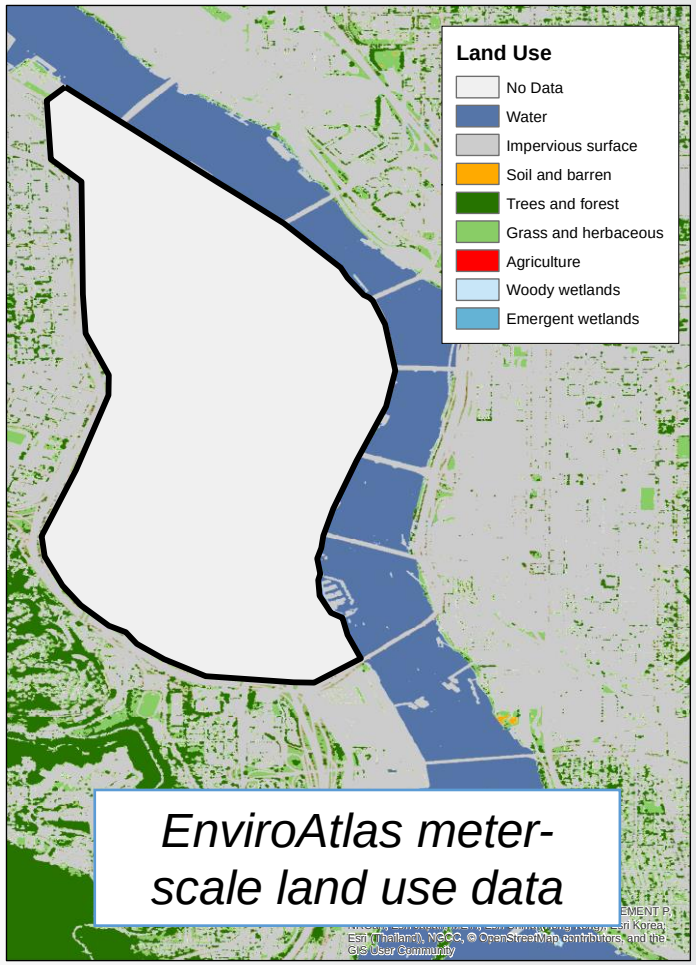


Developing Overland Flow Model

- Define model boundary
- Cell shape/resolution
- GIS data needed:
  - ✓land use/land cover
  - ✓building footprints
  - ✓roads
  - ✓critical infrastructure
- Digital elevation model
- Washoff equations and parameterization

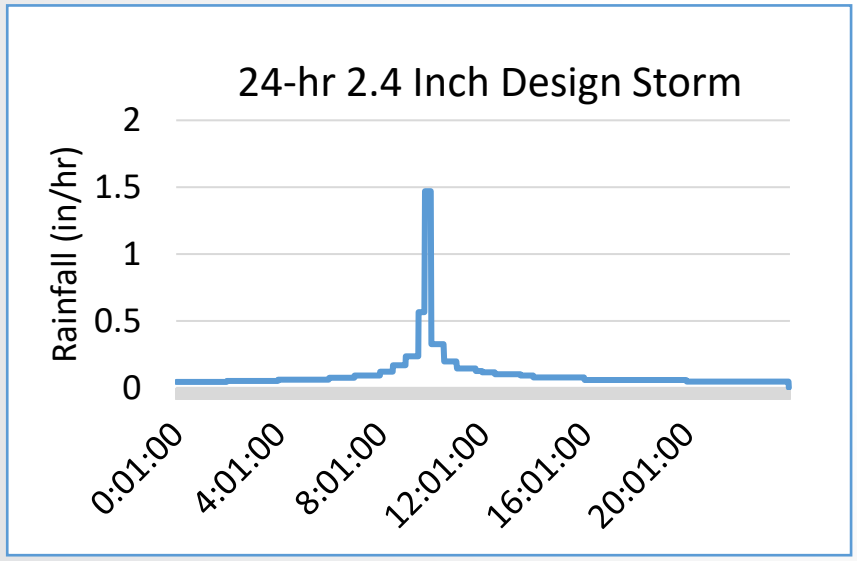


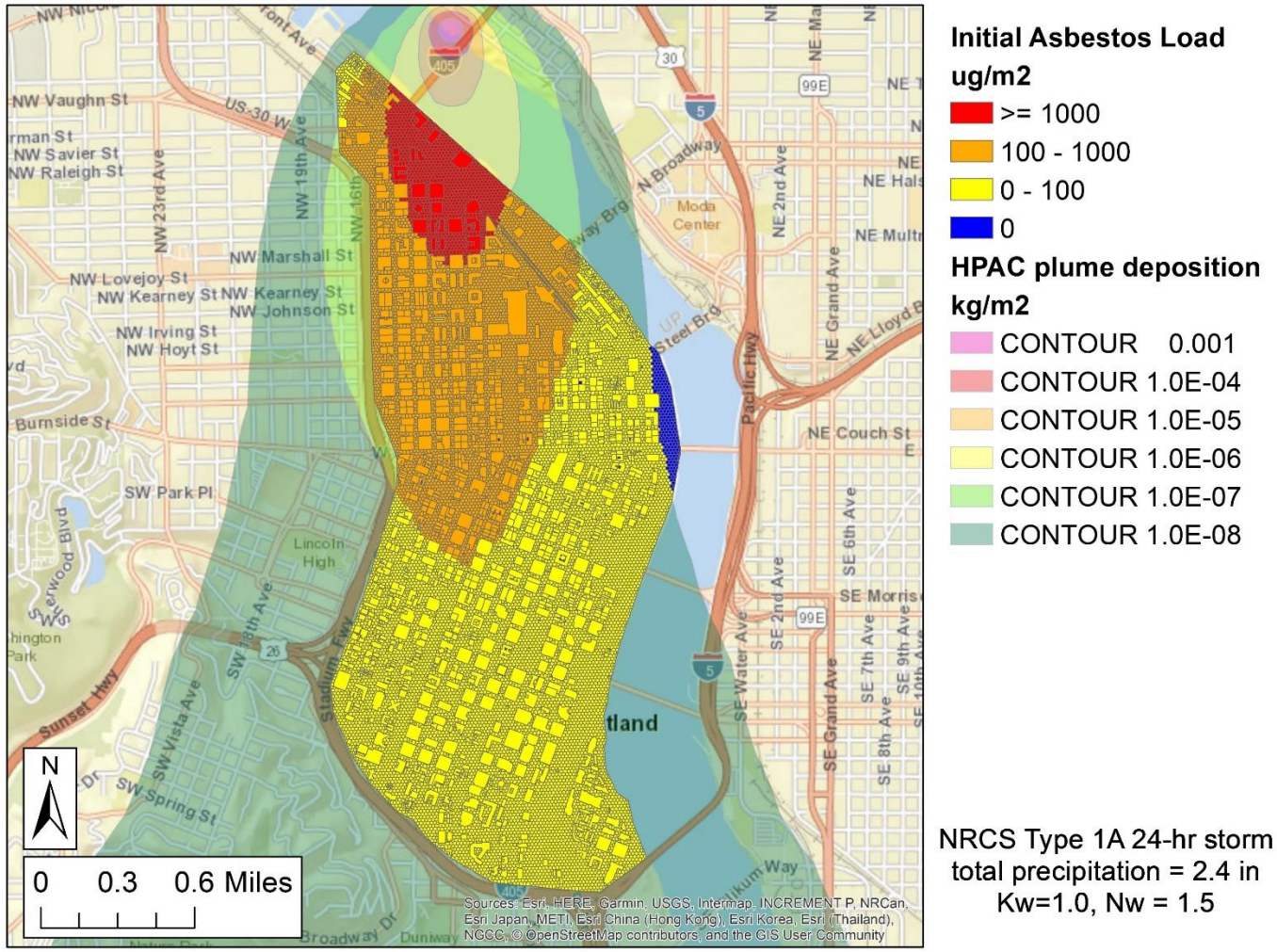
2D model cell elevations



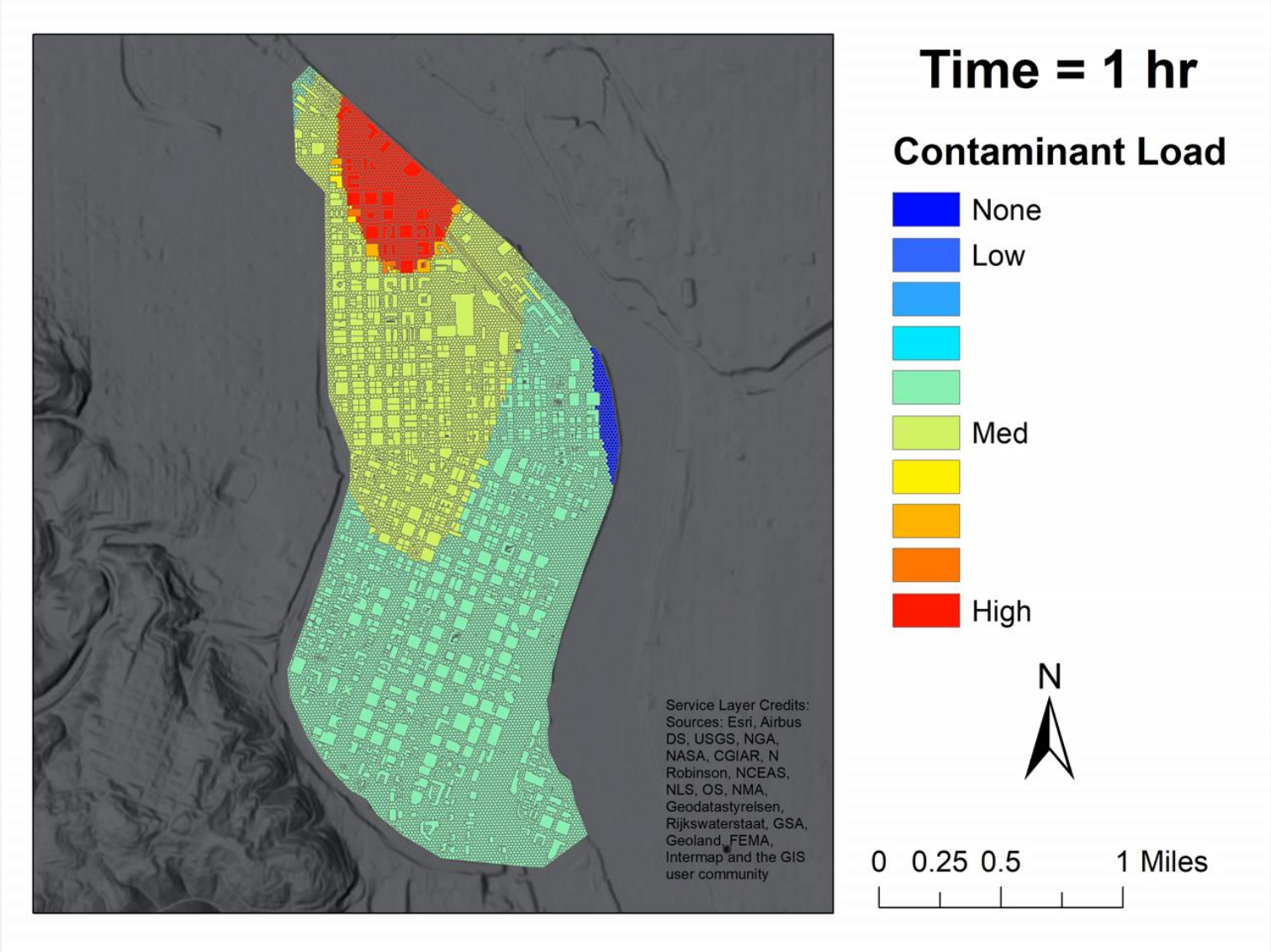
Initial Model Conditions

- Overlay IMAAC plume
- Exponential washoff equation (must define parameter values)

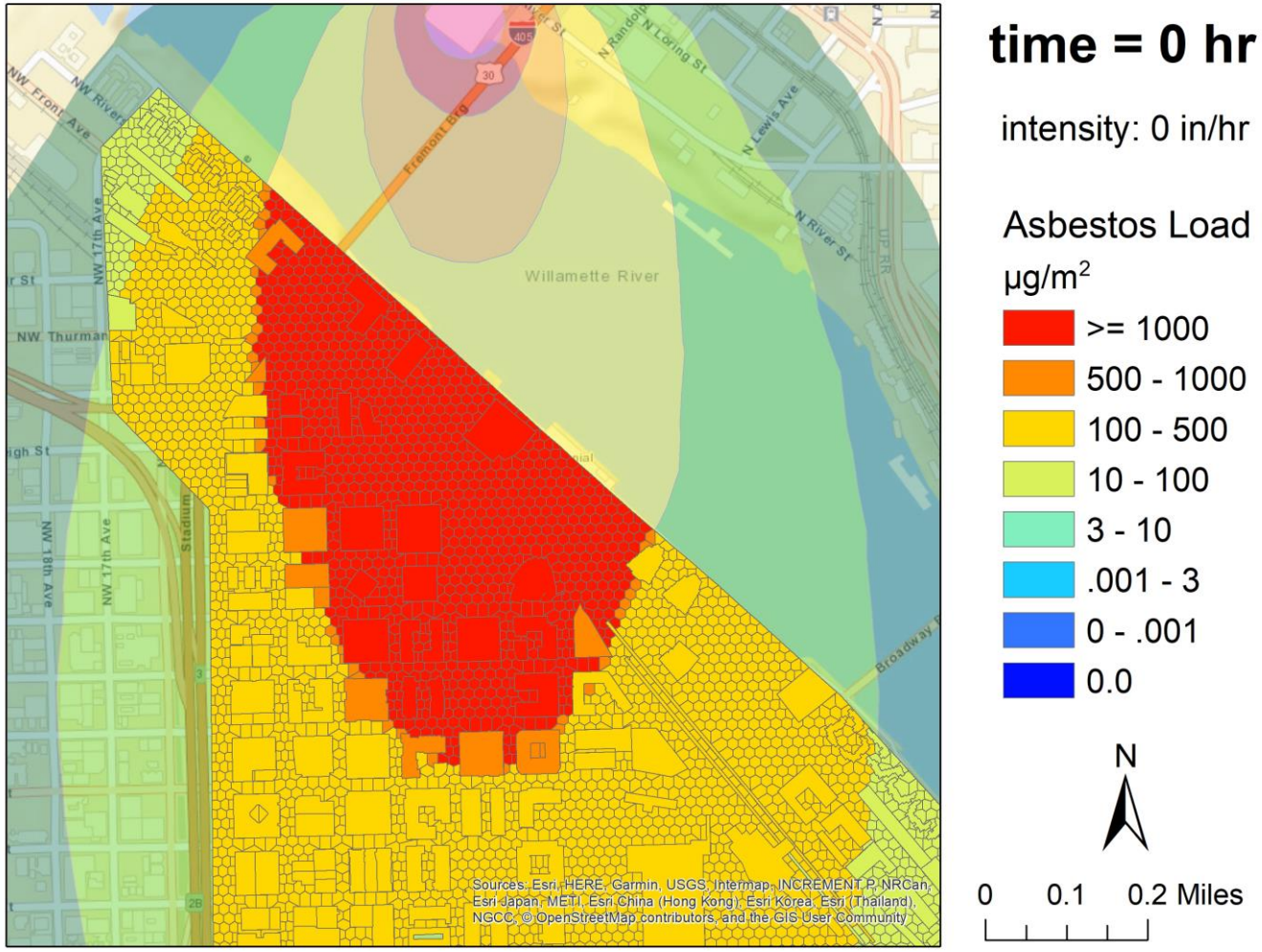




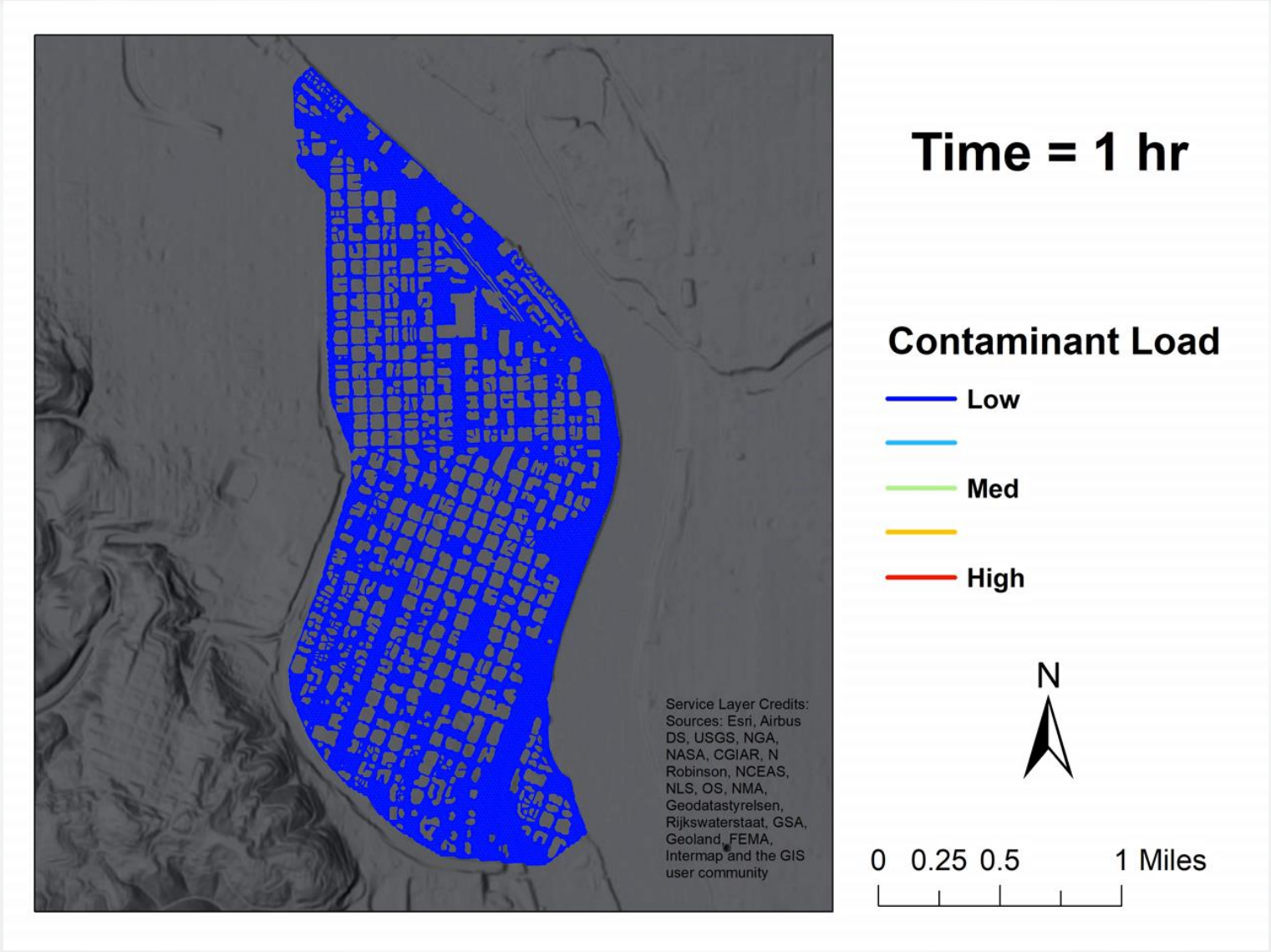
Surface Contamination



Surface Contamination

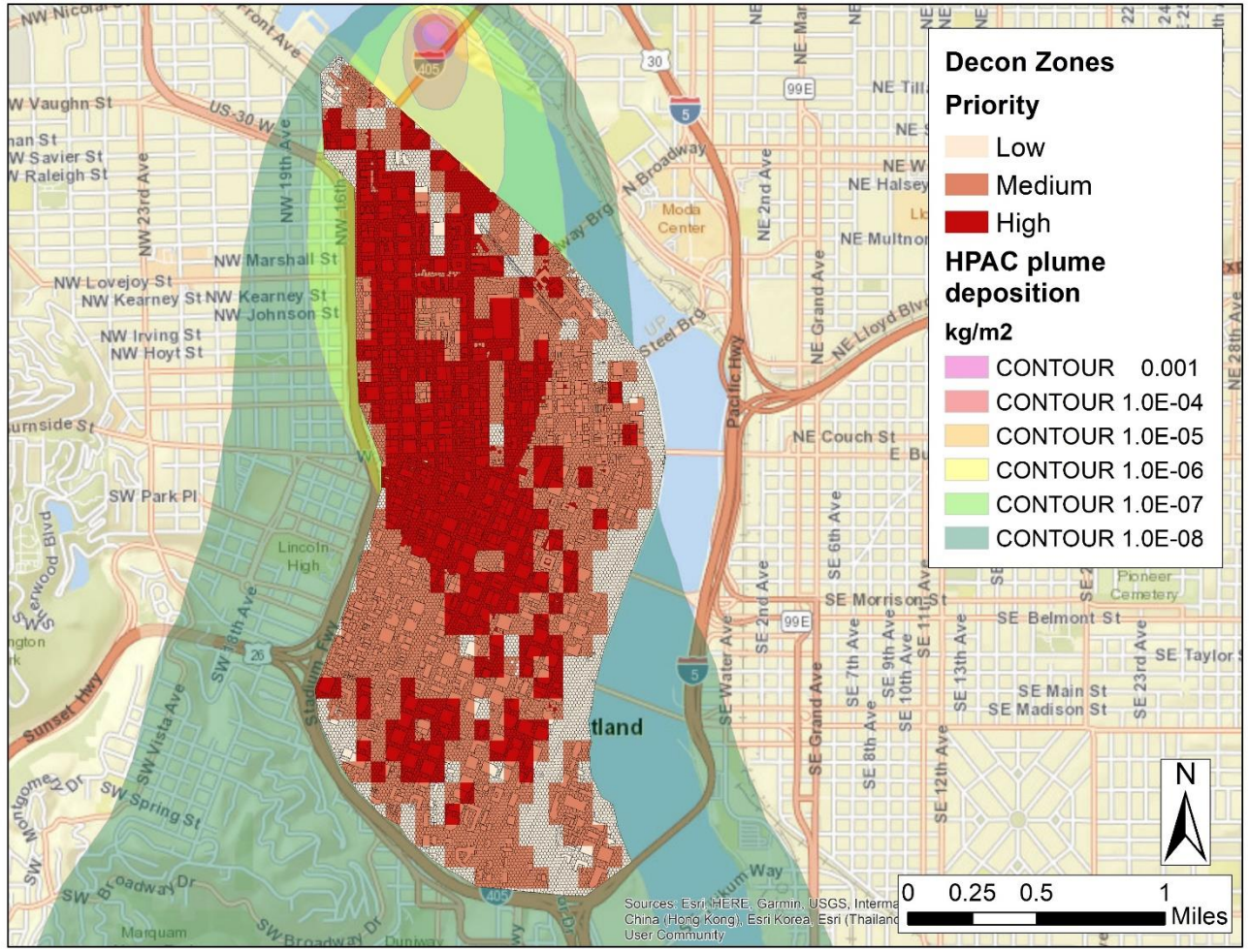


Overland Flow Contamination



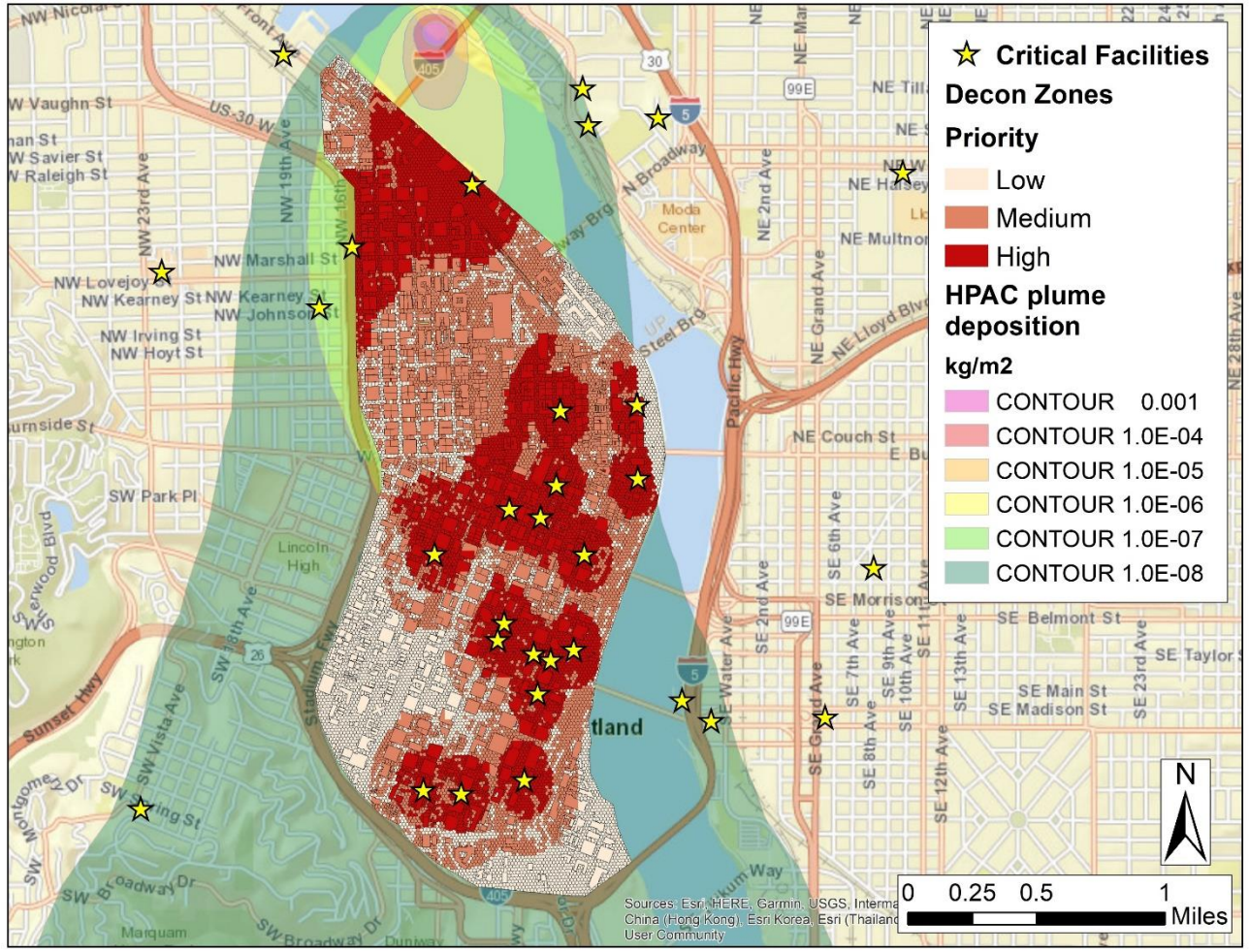
Planning for Response & Recovery

- Combine contamination maps with additional data for planning and prioritization
  - ✓Population data



Planning for Response & Recovery

- Combine contamination maps with additional data for planning and prioritization
  - ✓Population data
  - ✓Critical facilities
- Dynamic, flexible support that can evolve over time
- Model different clean up scenarios and strategies

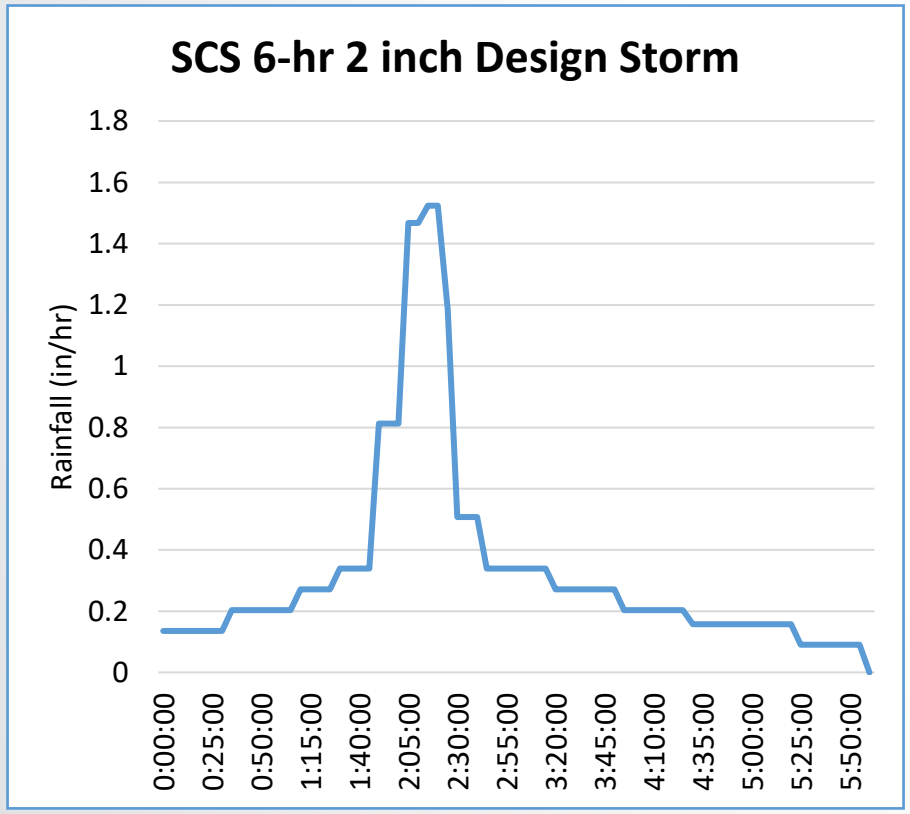


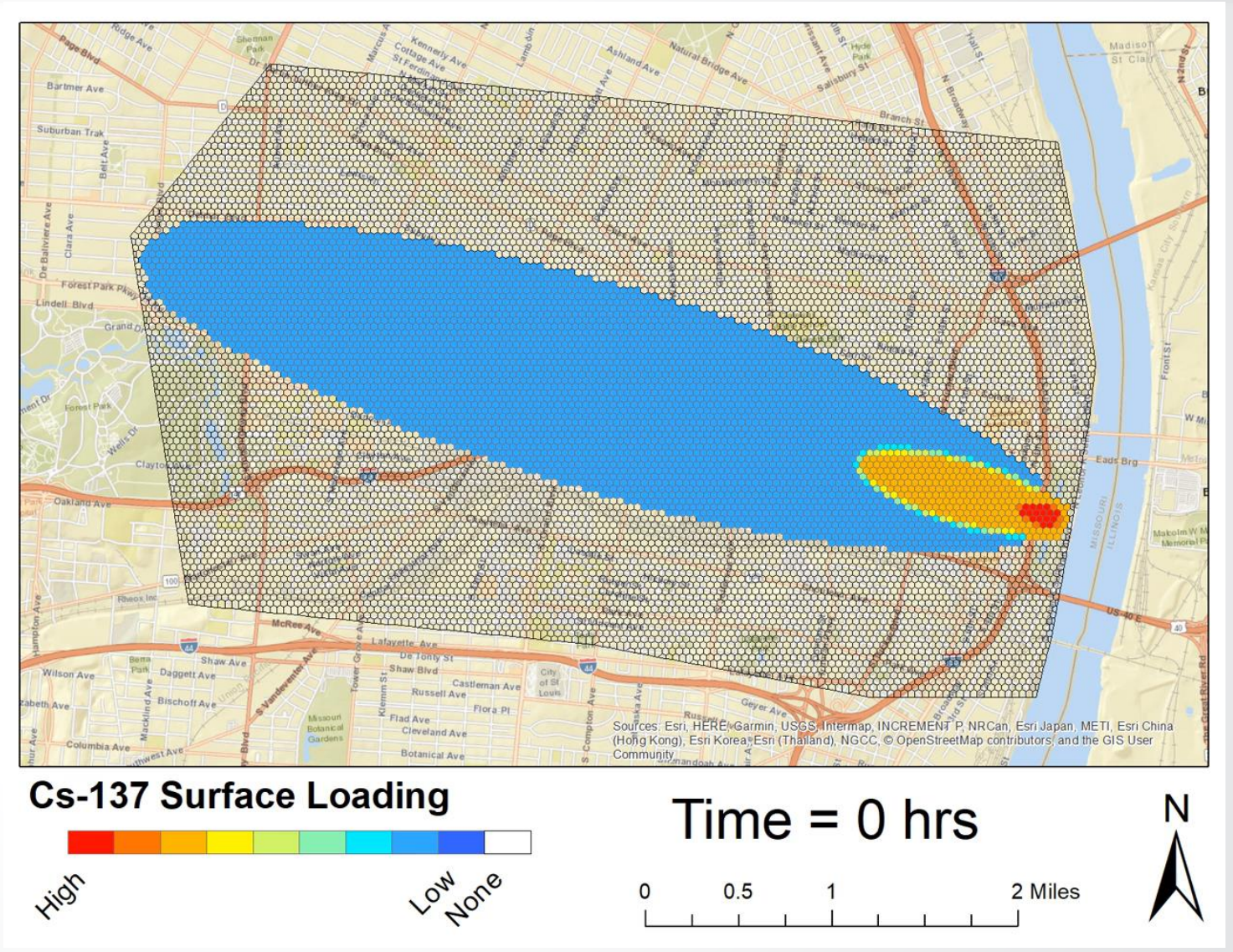
Case Study: St. Louis

- Large-scale hypothetical radiological incident resulting from a radiological dispersal device (RDD)
- RDD contained 2,300 curies of cesium-137 (as cesium chloride)
- Dispersed over approximately 4 square miles via a 3,000 lb truck bomb

Case Study: St. Louis

Model domain larger than initial deposition plume





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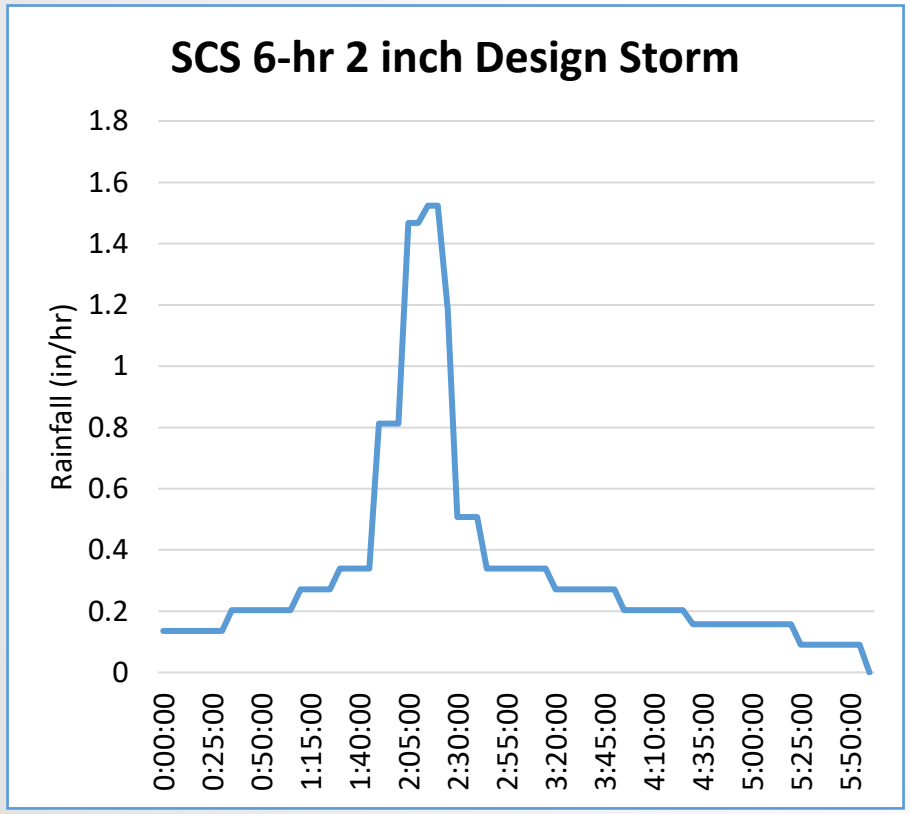
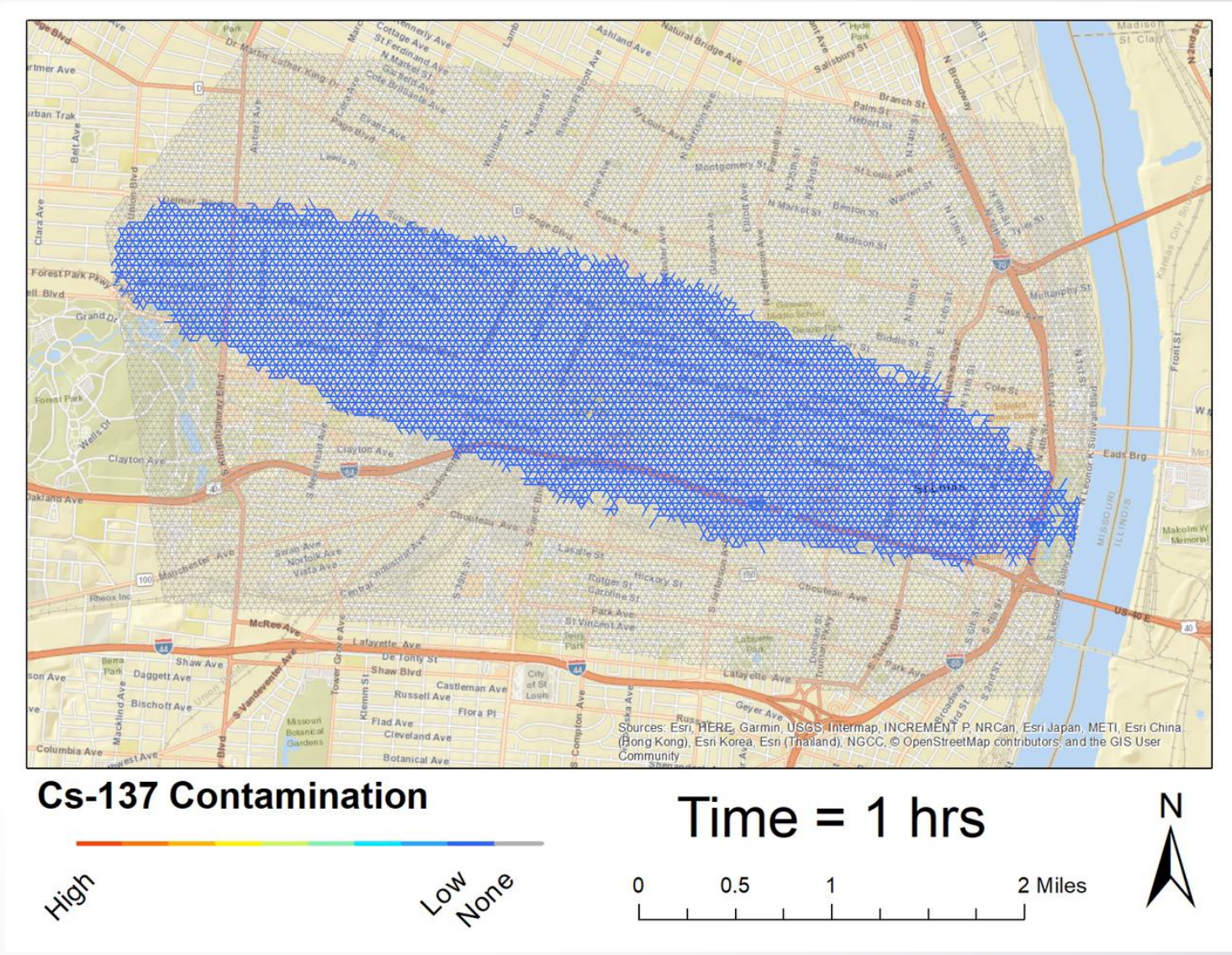
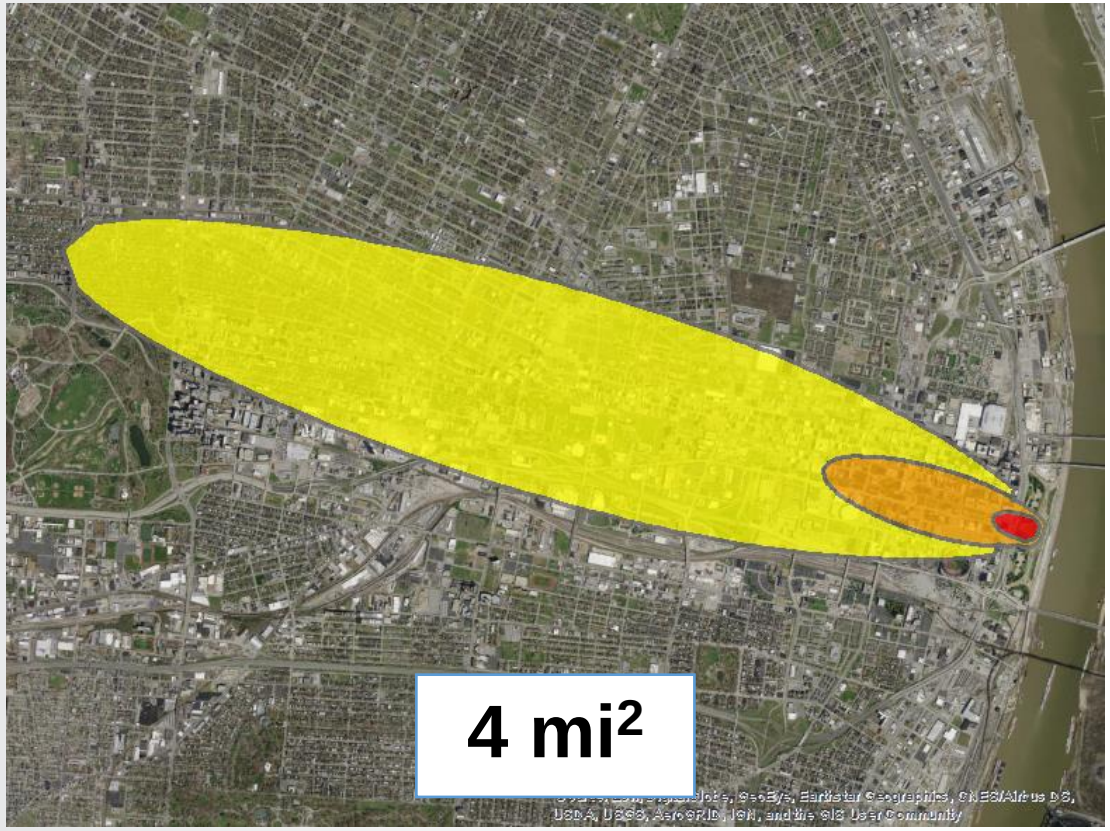


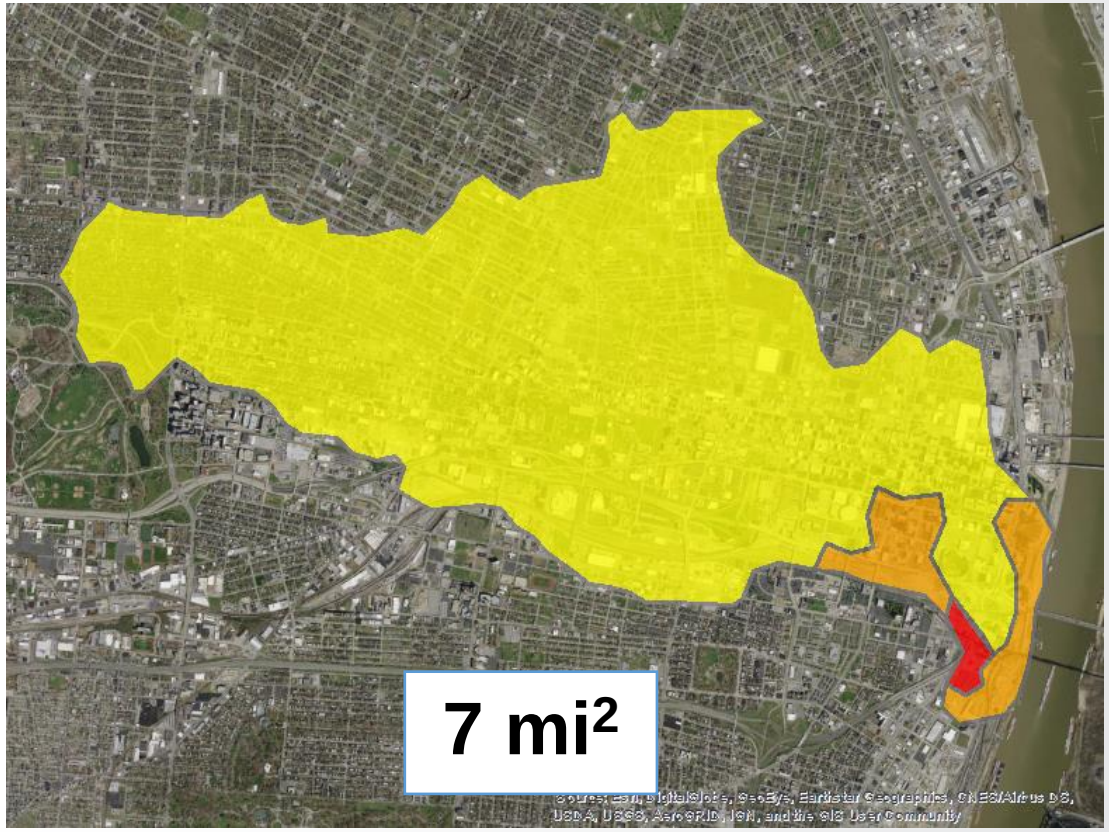


Case Study: St. Louis

Initial Deposition

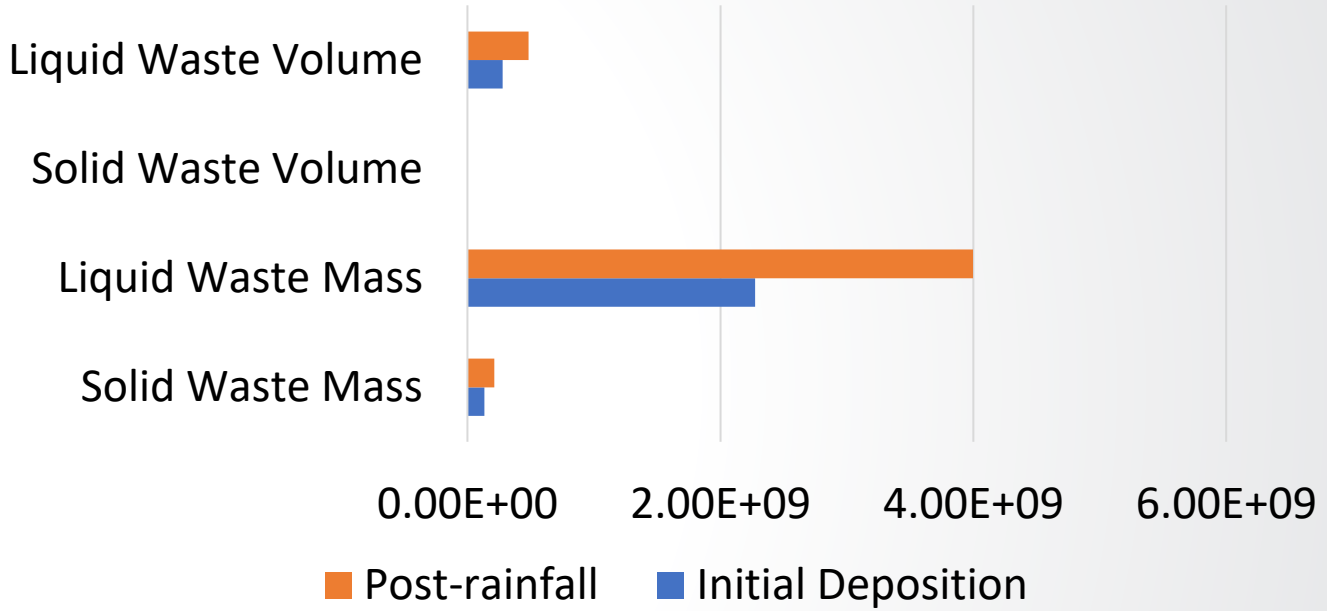


Post-Rainfall



Fate & Transport Impacts

- Waste Estimation Support Tool (WEST) is a GIS-based tool designed to assist in planning and preparedness
- Facilitates waste estimates, planning for staging and storage, assessing strategies

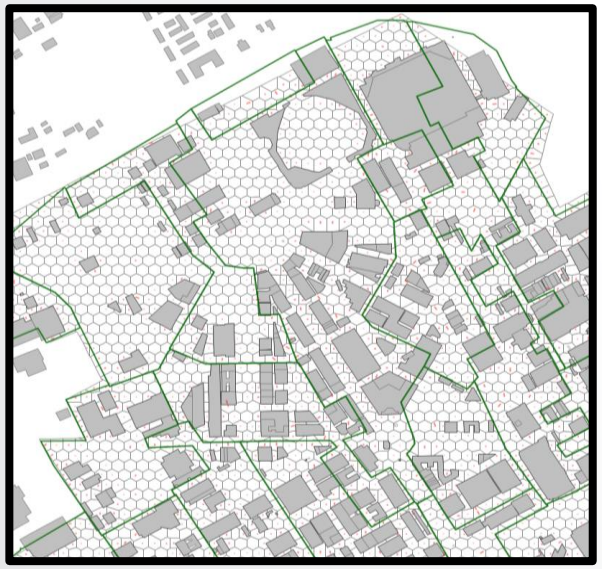


Results	Units	Initial Deposition	Post-Rainfall
Solid Waste Mass	lb	1.34E+08	2.11E+08
Liquid Waste Mass	lb	2.28E+09	4.00E+09
Solid Waste Volume	ft^3	1.69E+06	2.45E+06
Liquid Waste Volume	gal	2.79E+08	4.84E+08

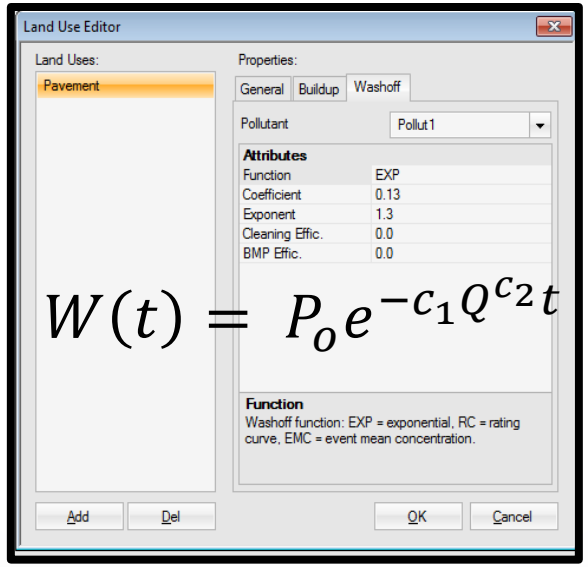
Washoff Modeling

Lab & field experiments determine what coefficients need to be used for modeling

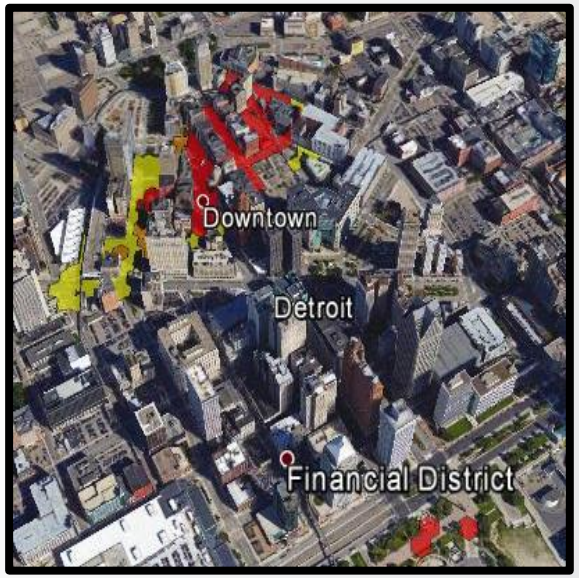
Define Land Use by Subcatchment
EPA's Stormwater Management Model (SWMM)



Mathematically Describe Washoff



Build Sampling Maps
PySWMM & GIS



Washoff Studies: Bench to Field Scale

26 ft. Indoor Rainfall Simulator

Portable Rainfall Simulator

Autosamplers with cell phone activated sample triggering

CESER Washoff Field Studies

Spore Sampling/Washoff Field Study

March 2018 – April 2019

EPA Campus Edison, NJ

- Watershed Sensors
  - Soil moisture, runoff, rainfall
- Interactive Telemetry

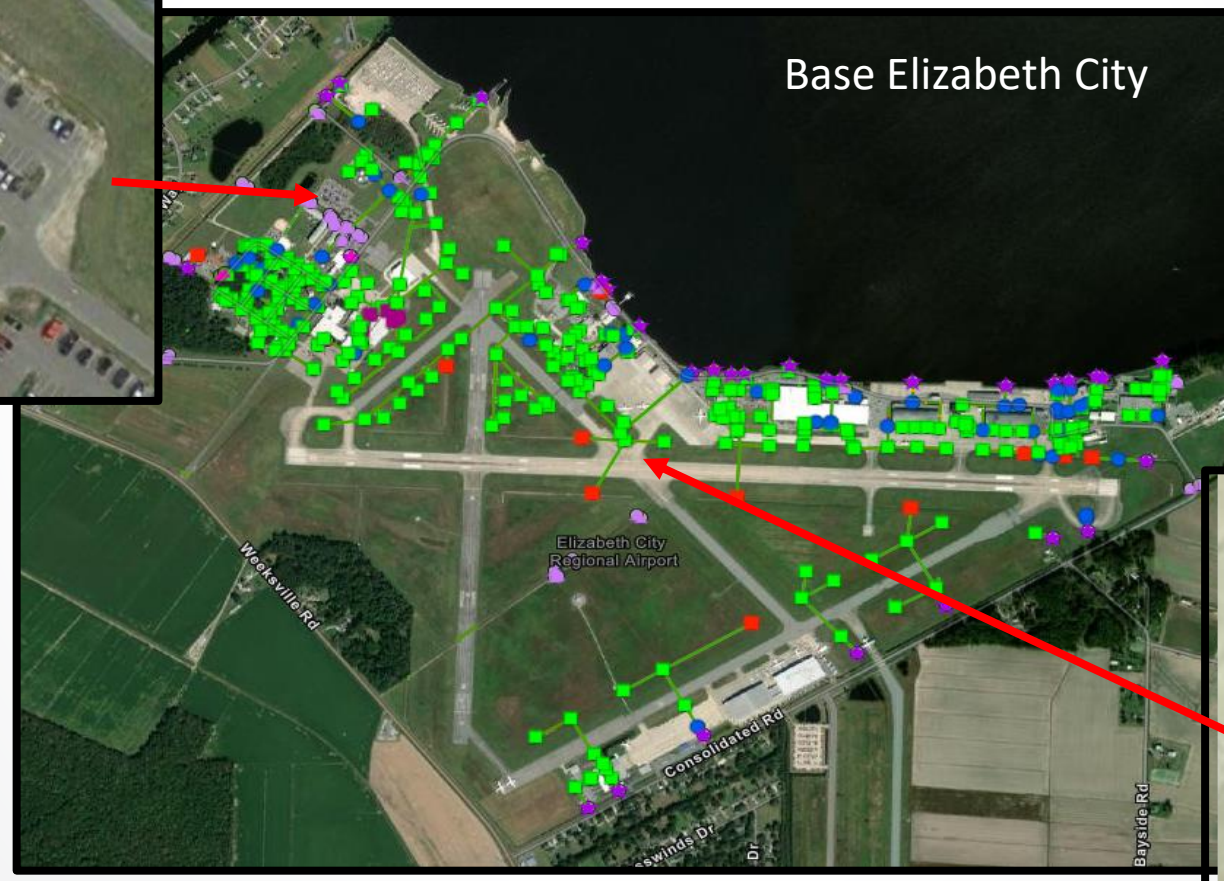
AnCOR Field Study

Summer 2021

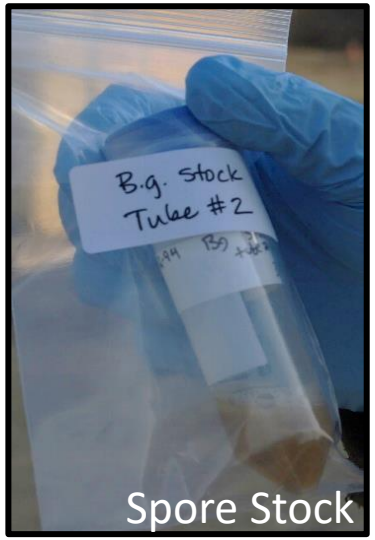
US Coast Guard Base Elizabeth City, NC

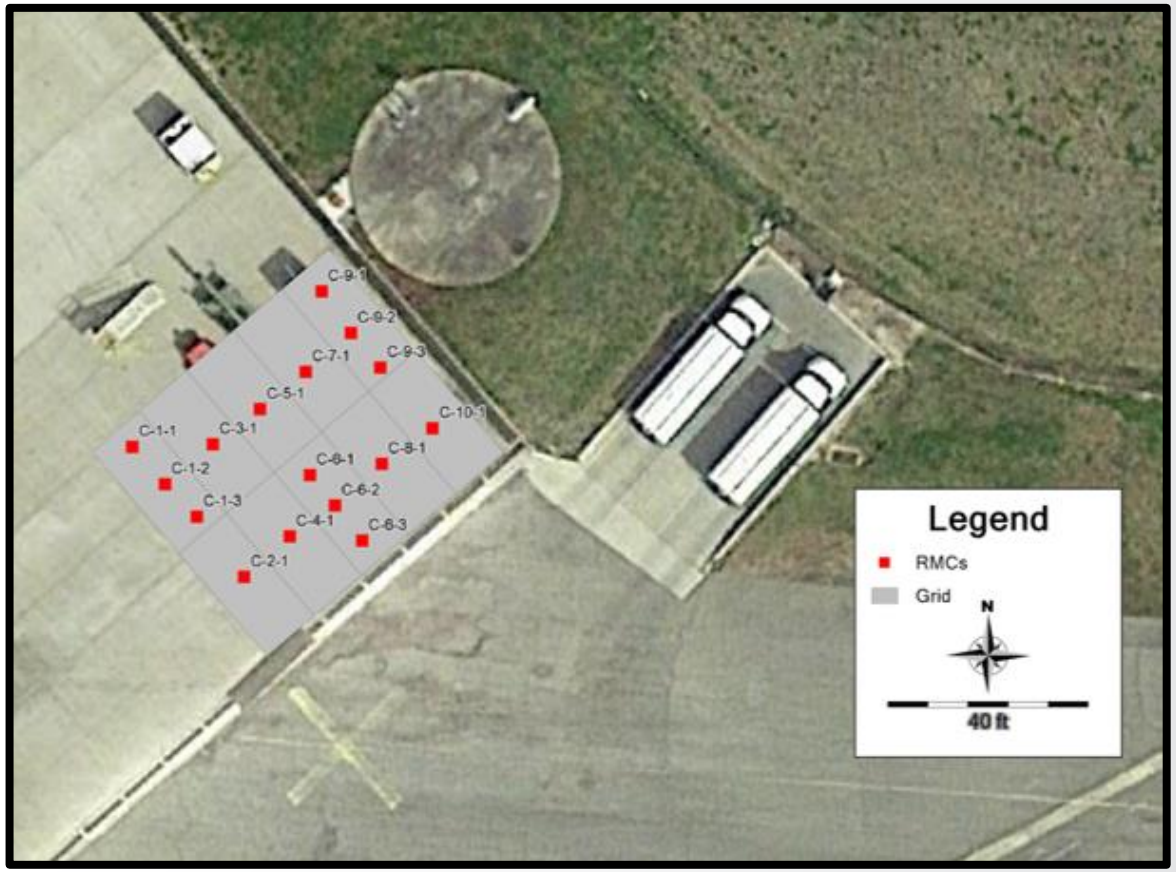
- Telemetry Pod Improvements
- Code Management (GitHub)
- Additional sensors

Stormwater System & Inoculation Locations



Inoculation Method





Stainless Steel Reference Material Coupons used to estimate CFU/ft^2

Sensors

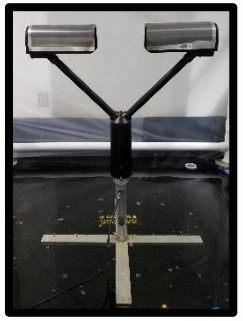
Runoff Velocity Measurement
Non-Contact Discharge Radar
(RQ-30A)

Telemetry Pod Circuitry

Rainfall

Moisture Sensor

Disdrometer



Tipping Bucket Rain Gauge

Soil Moisture Sensors

Runoff Autosamplers

Additional Resources

- https://www.epa.gov/water-research/storm-water-management-model-swmm
  - SWMM Reference Manuals
  - Tutorials
- https://www.openswmm.org
  - Code viewer, knowledge base, example models
  - SWMM-USERS list serv
- https://github.com/OpenWaterAnalytics
  - OWA SWMM Toolkit API
  - PySWMM

SWMM-Related Products

- PCSWMM – CHI (https://www.pcswmm.com/)
- InfoSWMM – Innovyze (https://www.innovyze.com/en-us/products/infoswmm)
- XPSWMM – Innovyze (https://www.innovyze.com/en-us/products/xpswmm)
- MIKE URBAN – DHI (https://www.mikepoweredbydhi.com/products/mike-urban)

Questions?
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