# River Basin Export Reduction Optimization Support Tool (RBEROST)

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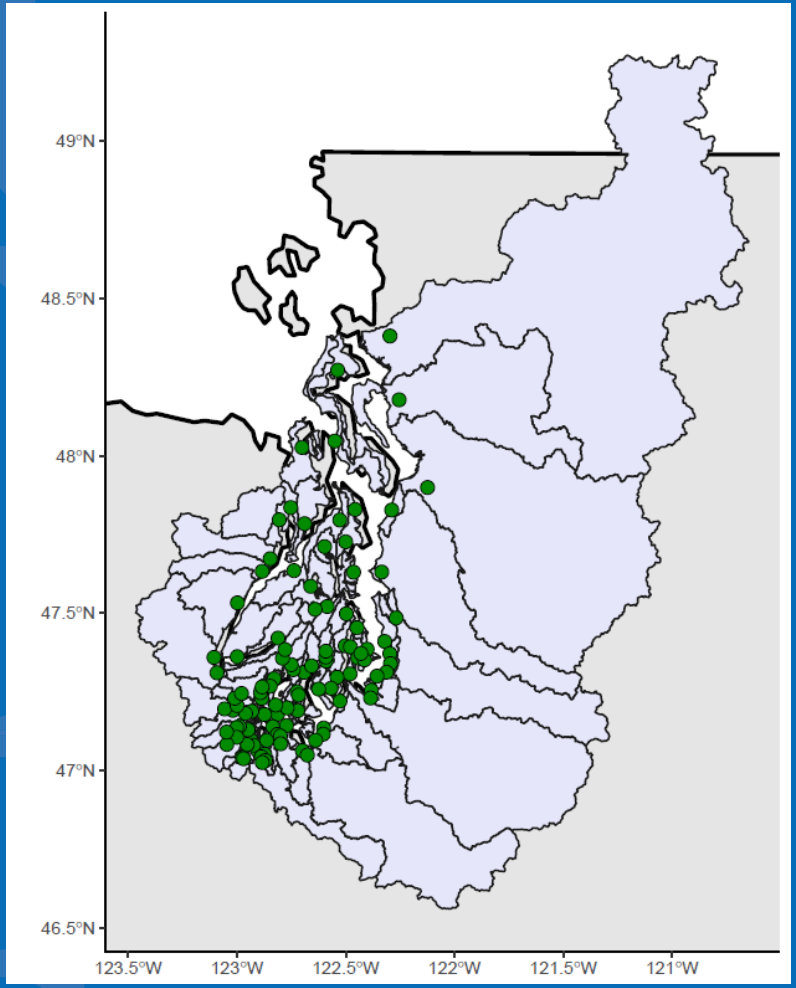



Virtual EPA Region 10 Technical Roundtable on Nutrients

EPA United States Environmental Protection Agency

# Goal

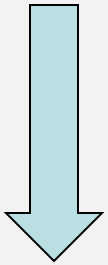
- Refine for PNW and demonstrate a regional optimization tool to allow stakeholders to find the least-cost solution to meet nutrient loading targets for Puget Sound Basin
  - Screening tool to complement existing optimization tool (Watershed Management Optimization Support Tool, WMOST) for HUC12-HUC10 scale
  - Considers wastewater, stormwater, and agricultural management practices
  - Extensible – built on national and regional datasets
  - User-friendly (R package prepares inputs for optimization program run online on NEOS server)

# Optimization components

- Objective – what you want to minimize (or maximize)
  - minimize cost
- Constraints – restrictions on solution
  - downstream loading target for N delivery
  - intermediate P or N loading targets
- Decision variables – choice of management actions, level of implementation, and location of implementation
  - Wastewater treatment plant upgrades
  - Agricultural conservation practices (BMPs)
  - Urban stormwater BMPs
  - Riparian zones

# Calculation of delivered load to watershed mouth (or intermediate point of interest) in SPARROW

Incremental delivered load for each NHDPlus catchment = sum(source * fraction delivered to water * fraction delivered through reach or reservoir)



attenuate as you continue to route downstream

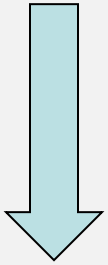
Delivered load from catchment to mouth of watershed = contribution from that catchment



Identical model construct across SPARROW regions

# Calculation of delivered load to watershed mouth (or intermediate point of interest)

Incremental delivered load for each NHDPlus catchment = sum((source * fraction delivered to water * (**1-fraction removed by mgt action**) **– retention by riparian buffers**)* fraction delivered through reach or reservoir)



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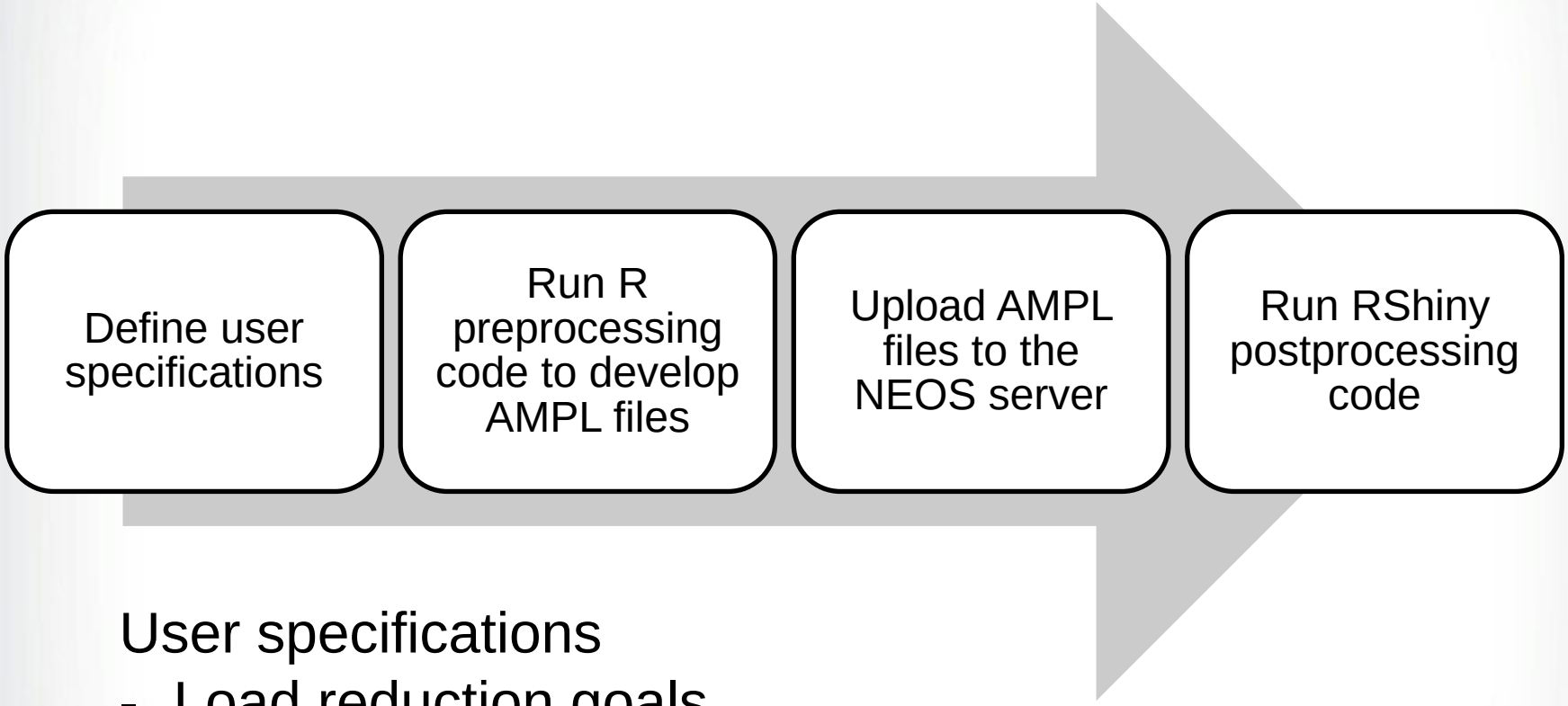
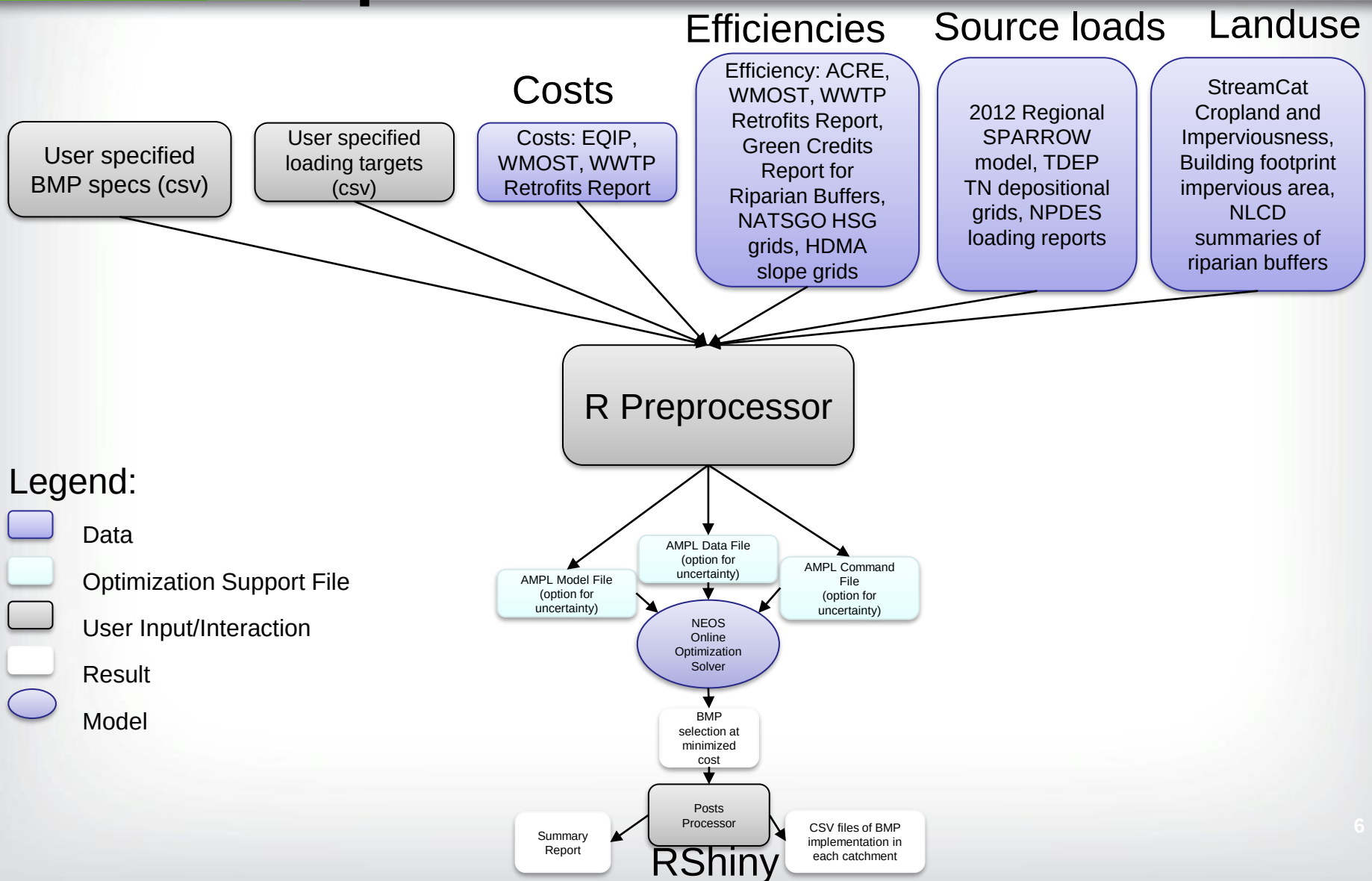
# Sequence for solving optimization problem with RBEROST



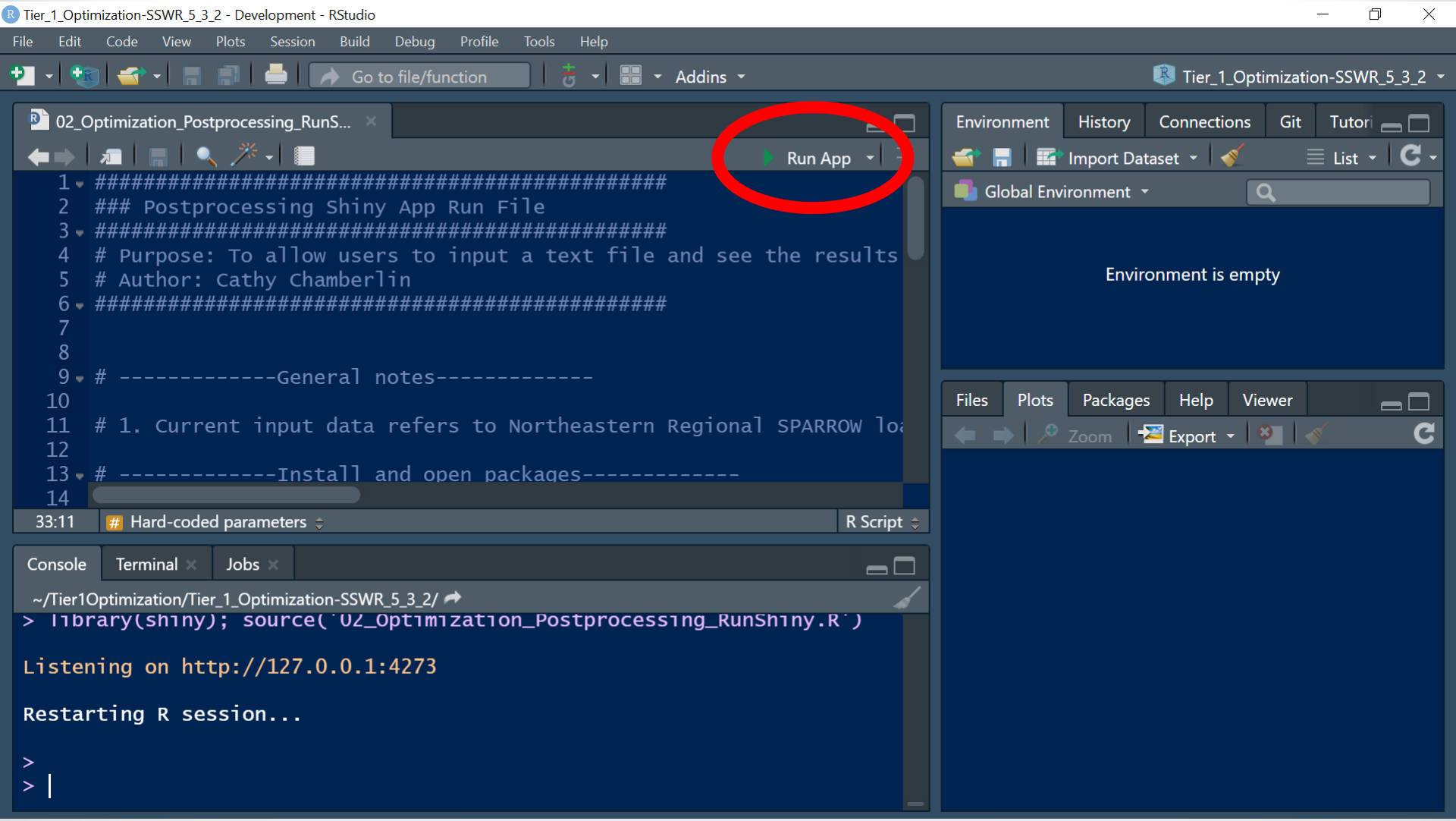

User specifications

- Load reduction goals
- BMPs to include
- Planning horizon
- Interest rate

# Schematic of Scaled-Up RBEROST Optimization Model Framework



# RBEROST Rshiny Postprocessor



# Uncertainty analysis

- Costs, efficiencies, and base loading in the model are ***estimates***, and have ***uncertainty*** around their values (e.g. $5.72/sq ft ± $1.00)
- Originally the model displays only one estimate for cost, and assumes one estimate for total loading after BMP implementation (and that loading is less than the targets)
- Given the suite of BMPs the model suggests implementing, there will be a range of probable costs, and a range of total loading
- Bootstrapping approach

# RBEROST Postprocessor

E.g. scenario 1:

Preprocessing Step | Optimization Step | Postprocessing Step

RBEROST Results Postprocessing Step

File Preview | View Results

View available scenarios

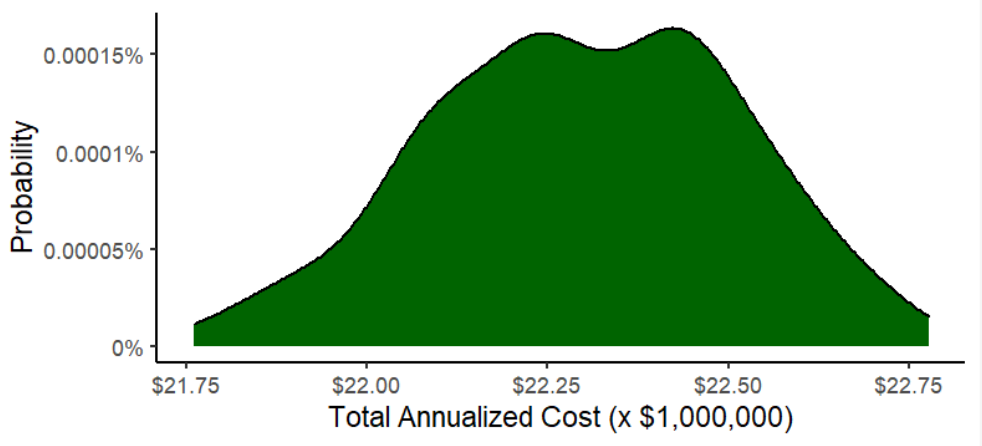
1

Scaled-up Optimization Results

Your model has successfully solved.

The total cost to reduce loads to the limit you provided is $22,250,300.23.

Estimates of Total Annualized Cost ranged from $21,885,755.71 to $22,684,894.97. RBEROST costs are usually most influenced by the amount of retrofitting necessary to install urban BMPs. More retrofitting leads to higher costs.

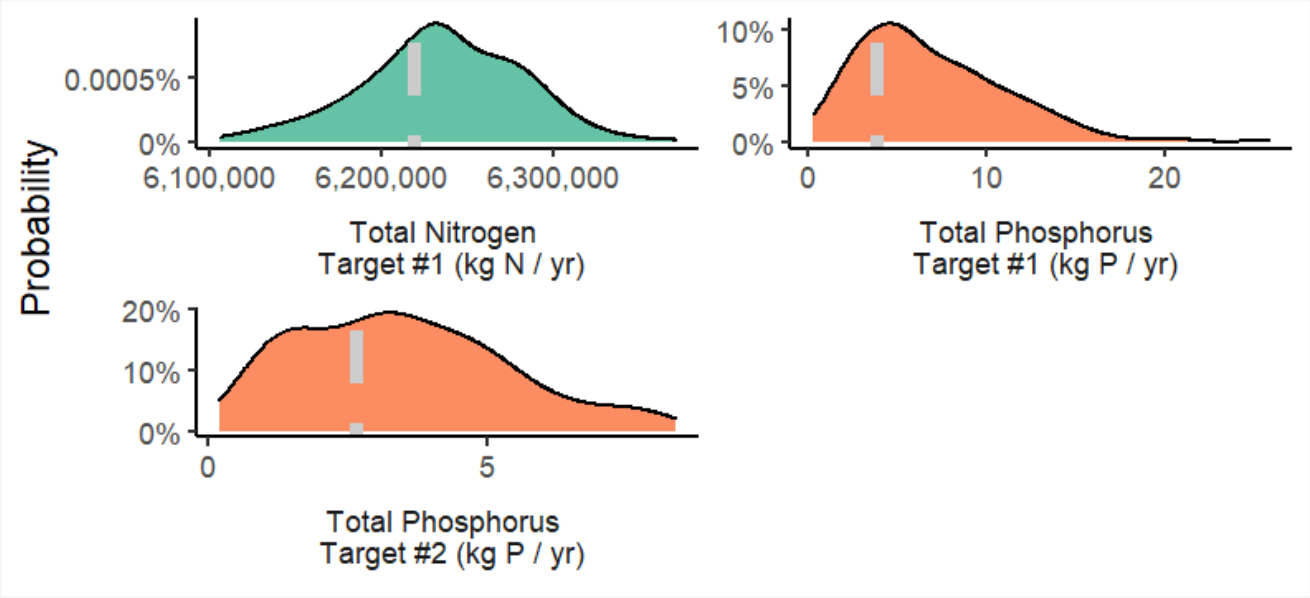


# RBEROST Postprocessor

E.g. scenario 1:

The model's suggested plan has an estimated 26% chance of meeting all loading targets.

| Loading Target | Your Specified Target Load | Estimated Annual Loading | Probability of Meeting Your Loading Target |
|---|---|---|---|
| Total Nitrogen Target #1: | 6,218,600.00 kg N/yr | 6,140,382.55 - 6,317,441.13 kg N/yr | 32% |
| Total Phosphorus Target #1: | 3.81 kg P/yr | 1.14 - 15.75 kg P/yr | 26% |
| Total Phosphorus Target #2: | 2.66 kg P/yr | 0.73 - 7.62 kg P/yr | 36% |



# RBEROST Postprocessor

Option to provide multiple scenarios. Here we show 3 scenarios for Upper CT R Basin that are ~1% different from each other.

10% implementation cap on agricultural ponds and no porous pavement with subsurface infiltration:

- Scenario 1: ***$22,250,300.23*** with ***32%*** chance of meeting TN target, 26% & 36% chance of meeting 2 TP targets
- Scenario 2: ***$28,747,815.07*** with ***93%*** chance of meeting TN target, 22% & 35% chance of meeting 2 TP targets
- Scenario 3: ***$37,062,233.49*** with ***100%*** chance of meeting TN target, 27% & 41% chance of meeting 2 TP targets

Reduction

10%

11%

12%

# RBEROST Postprocessor

E.g. scenario 1:

The model chose to implement WWTP retrofits at the following locations.

| Plant Name |
|---|
| Ludlow |
| Springfield |
| Claremont |
| Hanover |

WWTP upgrades to be applied

| Fert 20 (ac) | Filterstrip (ac) | MIN TILL (ac) | Ponds (ac) | Terrace Waterway (ac) | Waterway Only (ac) |
|---|---|---|---|---|---|
| 2,889.2 | 74,529.2 | 117.1 | 2,435.6 | 20.9 | 75.1 |

Download Agricultural BMPs by COMID

The model chose to implement the total area of the following urban BMPs.

| Gravel Wetland (ac) | Infiltration Basin (ac) |
|---|---|
| 136.1 | 106,213.9 |

Download Urban BMPs by COMID

The model chose to implement the total length of the following riparian buffer BMPs.

| Forested Buffer (ft of bank) | Grassed Buffer (ft of bank) |
|---|---|
| 19.7 | 34,000.1 |

Download Riparian Buffer BMPs by COMID

Acres of ag or developed land or riparian buffer length to be treated with specific BMPs

# EstuarySAT: A Paired Estuarine Water Quality and Remote Sensing Database

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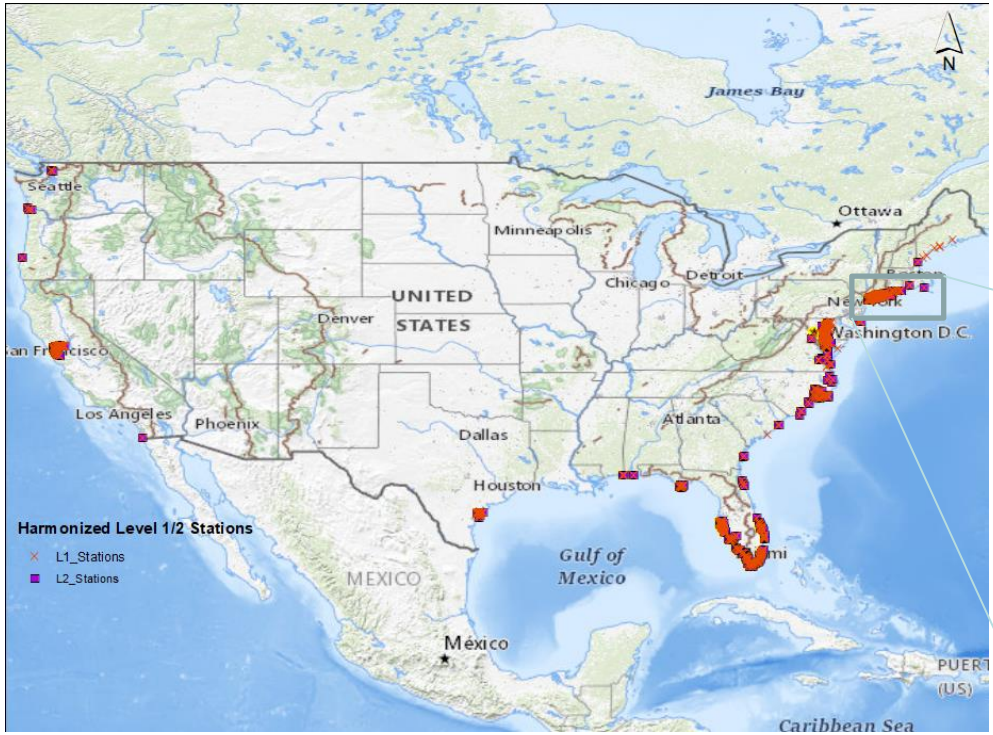
# Problem and Objectives

- The integration of remote sensing information and water quality information in tidal fresh and estuarine systems can provide enhanced datasets to develop new predictive models and algorithms for algal and cyanobacterial bloom events.
- To date – much of this work has focused on large lakes and freshwater bodies in the U.S.
- We have developed  a harmonized database of available water quality parameters for tidal fresh and estuarine systems using publicly available and published research data, integrated with Sentinel Level 1 & 2 satellite imagery from the European Space Agency (ESA).
- We are utilizing these data for developing algorithms and predictive models for harmful algal blooms in estuarine and riverine systems.

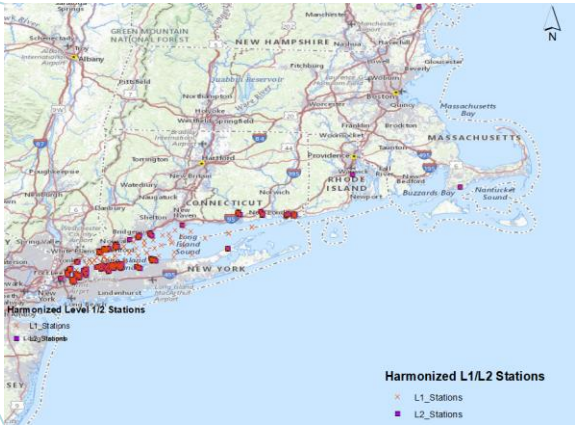
# EstuarySAT: Distribution of Stations




Some increases in station numbers and large increases in observations can be gained through the incorporation of Level 1 (uncorrected) imagery data. Open Source tools such as the ESA SNAP toolbox, AcoLite, and Polymer will be used to process and atmospherically correct Level 1 Sentinel imagery.

Sentinel Level 1 (N) = 8046

Sentinel Level 2 (N) = 1818



# For further information

- Contact Naomi Detenbeck (detenbeck.naomi@epa.gov)

- RBEROST github site (tool and user guide for version 1 (set up for Upper CT River Basin)
- https://github.com/USEPA/RBEROST