



# An Overview of the HAWQS and BenSPLASH Tools: Development and Use

**A Community on Ecosystem Services (ACES 2024)**

Tools and Approaches for Measurement and Valuation;

EPA's HAWQS and BenSPLASH Models

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# Outline

- EPA's HAWQS-  
BenSPLASH Water  
Quality Integrated  
Assessment Model
- HAWQS
- BenSPLASH
- Future Work

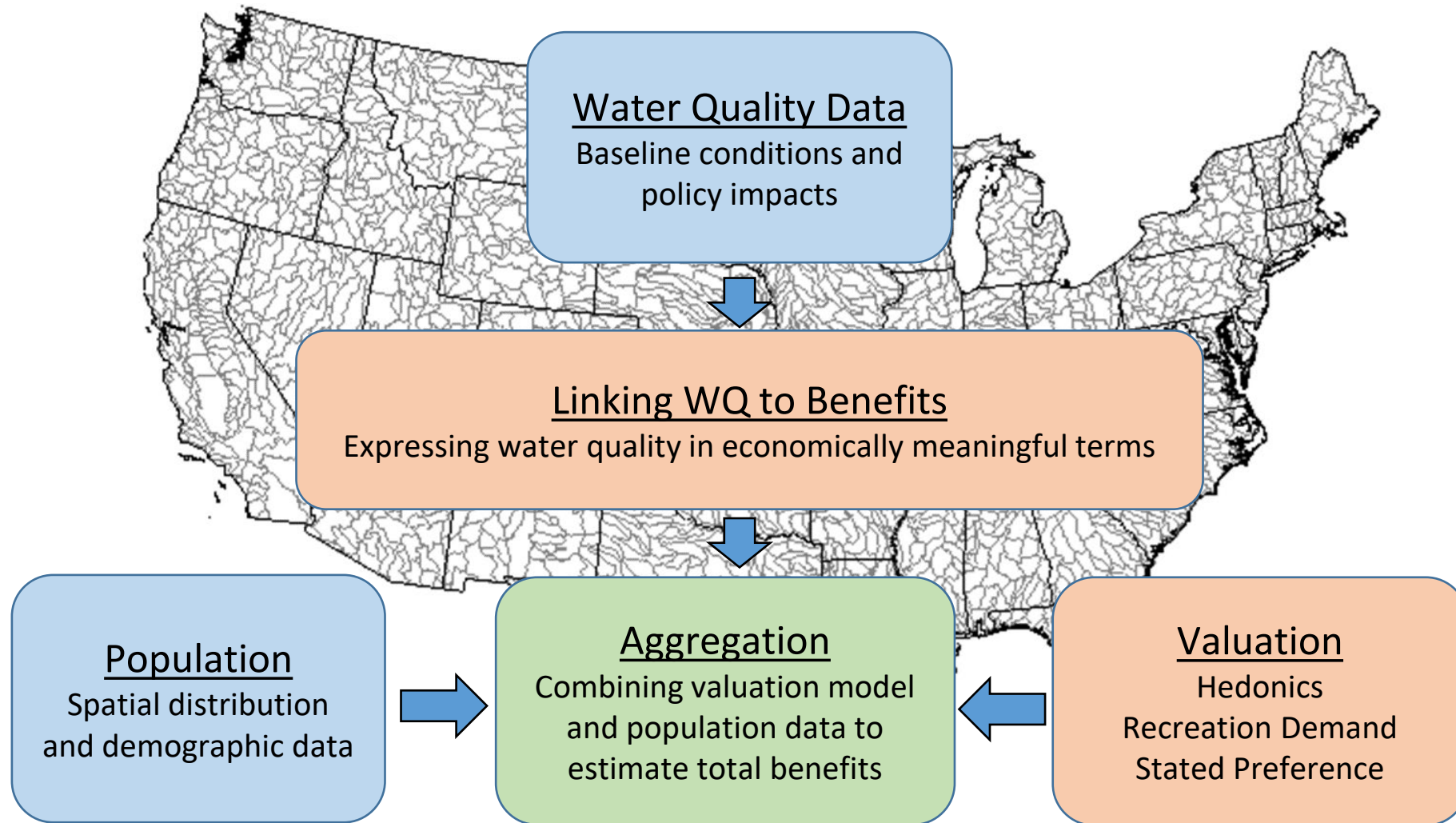


# HAWQS-BenSPLASH Integrated Assessment Model

- Develop a modeling framework to quantify the economic benefits of aquatic environmental changes nationwide
  - Open source
  - National, spatial
  - Freshwater rivers/streams, lakes, (coasts, wetlands)
- Two models
  - Hydrologic and Water Quality System (HAWQS) – Water Quality Model
  - Benefits Spatial Platform for Aggregating Socioeconomics and H<sub>2</sub>O Quality (BenSPLASH) – Economic Benefits Model



# Stylized Approach to Valuing Water Quality

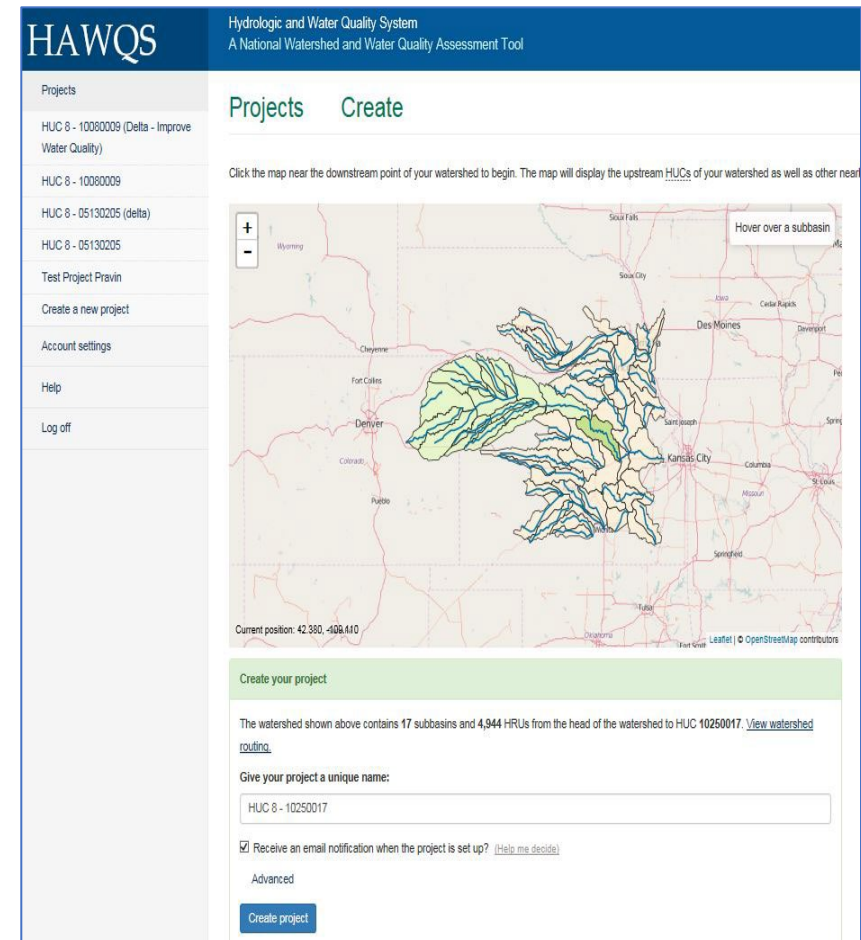


# HAWQS Overview

## Hydrologic and Water Quality System (HAWQS)

- **A national watershed and water quality assessment system**
  - Web-based user interface
  - National data layers
  - SWAT as core engine
- Cooperative project of the:
  - USEPA
  - USDA-ARS Grassland Soil and Water Research Lab
  - AgriLIFE Research, Texas A&M University
- HAWQS 2.0 available in beta

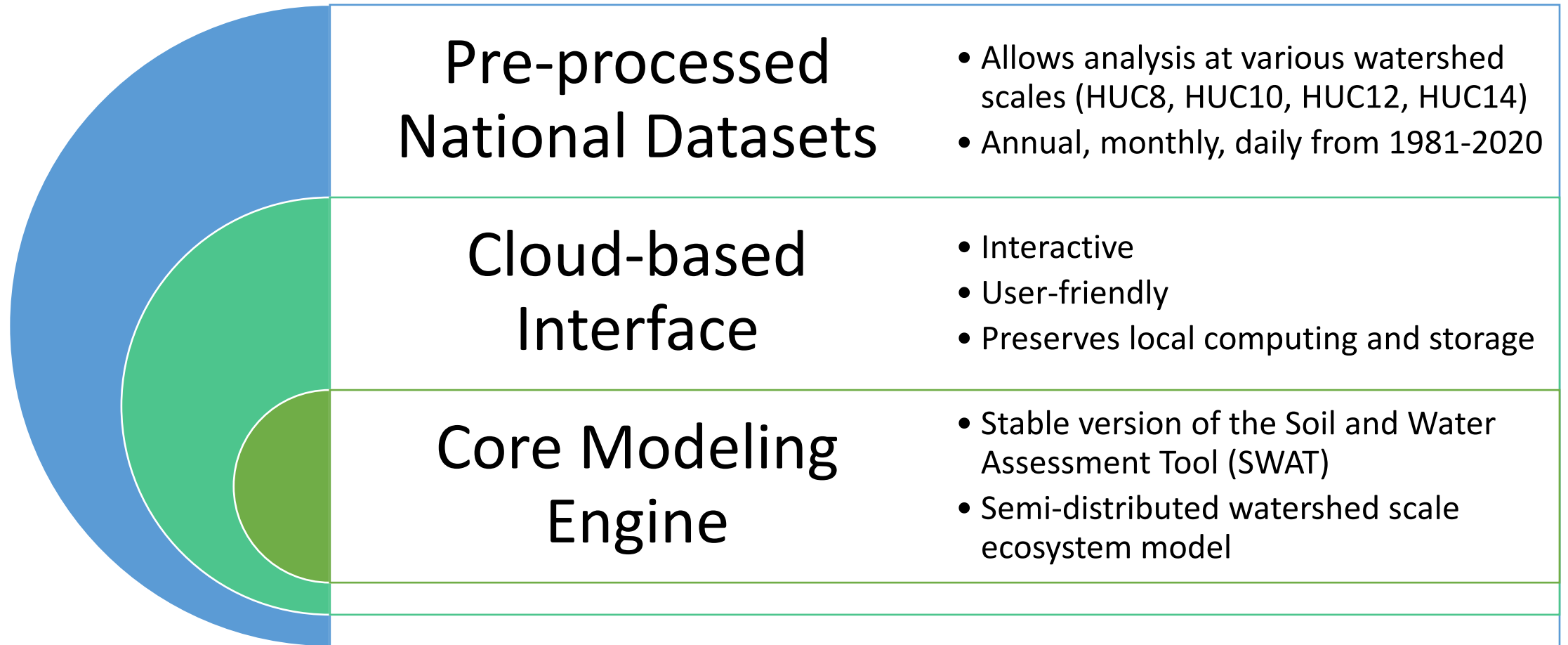
<https://hawqs.tamu.edu>



The screenshot displays the HAWQS web interface. The header includes the logo and the text "Hydrologic and Water Quality System A National Watershed and Water Quality Assessment Tool". A sidebar on the left lists navigation options: Projects, HUC 8 - 10080009 (Delta - Improve Water Quality), HUC 8 - 10080009, HUC 8 - 05130205 (delta), HUC 8 - 05130205, Test Project Pravin, Create a new project, Account settings, Help, and Log off. The main content area is titled "Projects Create" and contains a map of a watershed in the central United States. Below the map, there is a form to "Create your project" with the following fields and options:

- Text: "The watershed shown above contains 17 subbasins and 4,944 HRUs from the head of the watershed to HUC 10250017. [View watershed routing.](#)"
- Text: "Give your project a unique name:"
- Text input field: "HUC 8 - 10250017"
- Checkbox: "Receive an email notification when the project is set up? [\(Help me decide\)](#)"
- Text: "Advanced"
- Button: "Create project"

# What is HAWQS?



**Reduces SWAT model set-up time and effort by 90%**

# Login or Register

[hawqs.tamu.edu](http://hawqs.tamu.edu)

Log in using **existing credentials** or **register** for a new account

The screenshot shows the HAWQS website interface. At the top left, the logo 'HAWQS' is displayed next to the text 'Hydrologic and Water Quality System' and 'A National Watershed and Water Quality Assessment Tool'. In the top right corner, there are links for 'Log in' and 'Documentation & Support'. The main content area features a paragraph describing HAWQS version 2.0 as a web-based interactive water quantity and quality modeling system that employs the Soil Water Assessment Tool (SWAT). Below this, there are two columns of text. The left column describes how HAWQS enhances the usability of SWAT by simulating the effects of various management practices. The right column explains that HAWQS users can select from three watershed sizes (8-digit, 10-digit, and 12-digit) and that the system allows for aggregation and scalability of water quality estimates across large geographic areas. Overlaid on the right side of the page is a 'Log in' form. The form has a title 'Log in' and contains two input fields: 'User name' and 'Password'. Below these fields is a green 'Log in' button. At the bottom of the form, there are two links: 'Forgot your password?' and 'Don't have an account? Register now.'. A red box highlights the 'existing credentials' text in the slide, with a red arrow pointing to the 'User name' field in the form. A purple box highlights the 'register' text in the slide, with a purple arrow pointing to the 'Register now.' link in the form.

HAWQS version 2.0 is a web-based interactive water quantity and quality modeling system that employs as its Water Assessment Tool (SWAT), an internationally-recognized public domain model. HAWQS provides users with pre-loaded input data; outputs that include tables, charts, and raw output data; a user guide, and online development modeling projects.

HAWQS substantially enhances the usability of SWAT to simulate the effects of management practices based on an extensive array of crops, soils, natural vegetation types, land uses, and other scenarios for hydrology and the following water quality parameters:

HAWQS users can select from three watershed sizes (HUCS) – 8-digit ~700mi<sup>2</sup>; 10-digit ~227 mi<sup>2</sup>; and 12-digit ~70,000 mi<sup>2</sup> to run simulations. HAWQS allows for further aggregation and scalability of daily, monthly, and annual estimates of water quality across large geographic areas up to and including the continental United States.

**\*\*Tier I access upon registration - request for higher Tier access to run larger projects**



Recent Activity

Projects

Group Projects

**+ New Project**

### HAWQS Dataset

HUC8

#### HAWQS Version 2

**HUC8**

HUC10

HUC12

HUC14

#### HAWQS Version 2 Calibrated

HUC12 Flow Calibrated

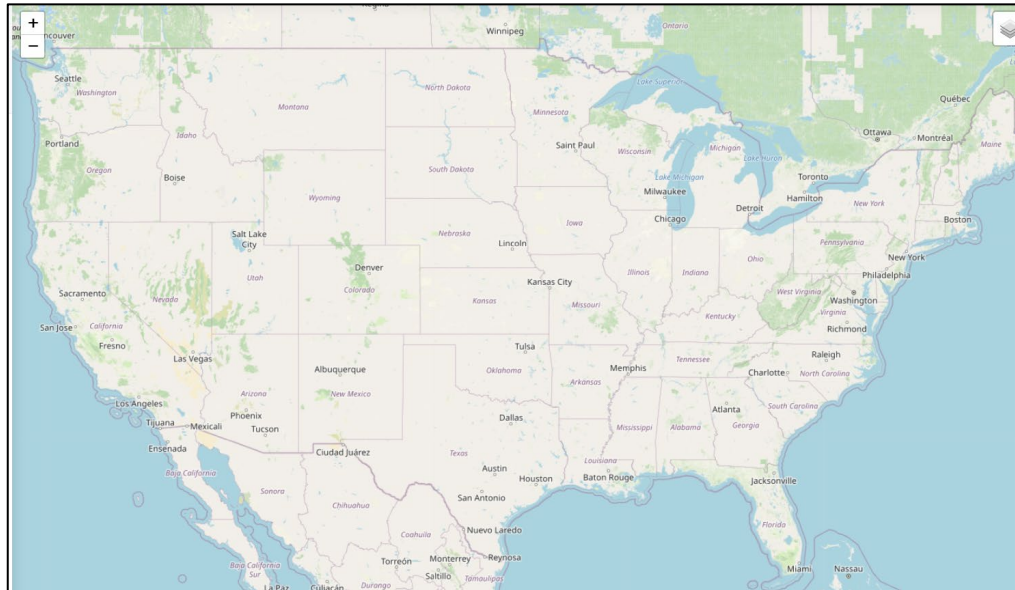
#### HAWQS Version 2 Use Cases

HUC10

HUC12 Agricultural Practices

HUC12 Climate Change

HUC14



### Downstream subbasin

031502

03150201

03150202

03150203

**03150204**

# Create a Project

### HAWQS Dataset

HUC8

### Downstream subbasin

03150204

▶ Advanced options

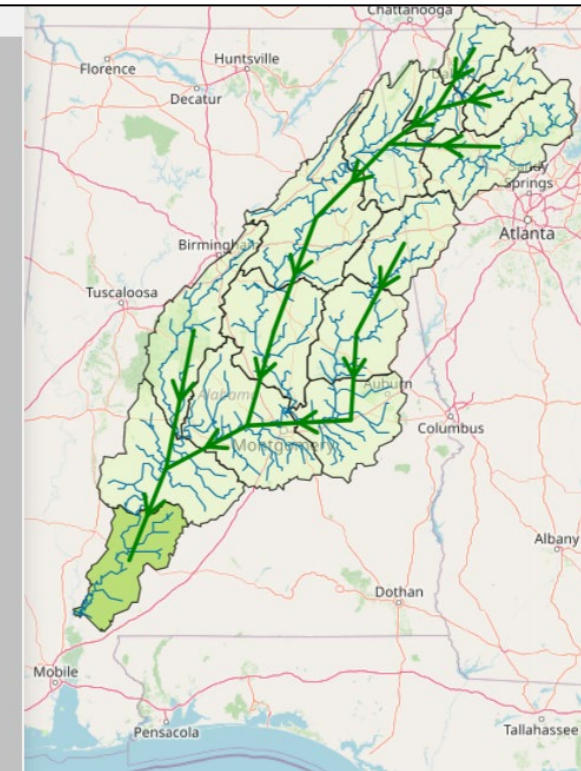
The selected watershed contains 14 subbasins and 54,152 HRUs. [View routing table.](#)

Show routing on map

Give your project a name

HUC8 - 03150204

**Create Project**











## SUMMARY

Name	HUC8 - 03150204
Subbasins	14
HRUs	54,152
Total area	58,893.17 km <sup>2</sup>
Watershed	HUC8, 03150204





## SET-UP

-  Set HRUs
-  Create scenario

## DATA

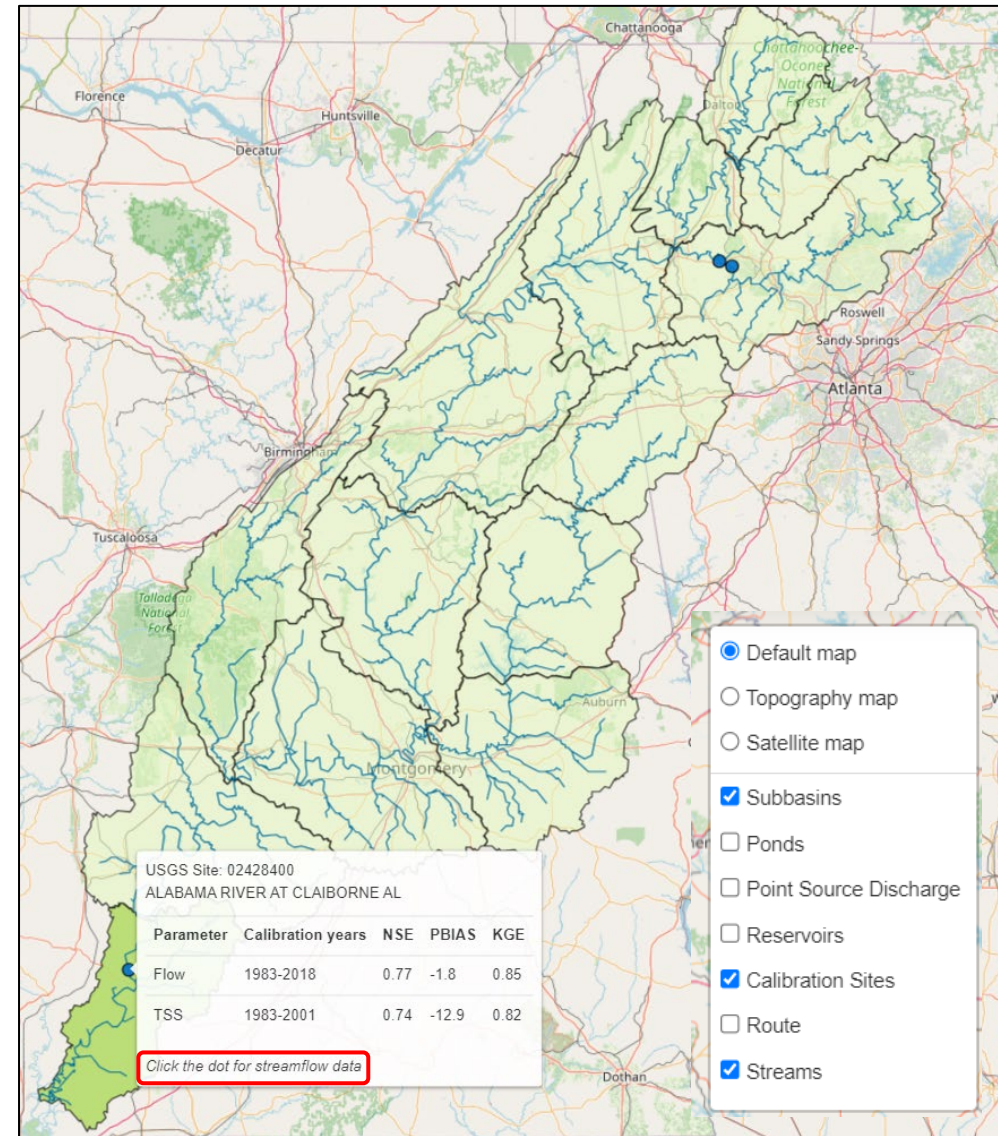
-  Metadata
-  Project downloads
-  Uploaded documents
-  Feedback and error reports

## ACTIONS

-  Share project
-  Copy project
-  Change project name
-  Delete project

# Project Summary

- Details of watershed
- HRU set-up
- Scenario creation
- Download project
- Upload documents
- Share projects
- Calibration statistics
- Streamflow data
- Point Sources/Reservoirs/Ponds



SET-UP

☰ Set HRUs

⚙️ **Create scenario**

## Create a new scenario

Scenario name

Default

Weather data

PRISM

Simulation start date

01/01/1998

01/01/1981 or later

Simulation end date

12/31/2020

12/31/2020 or earlier

Set-up/warm-up years

2

SWAT output print setting

Daily

SWAT model version to run

SWAT 2012 rev. 692

SWAT 2012 rev. 636

SWAT 2012 rev. 659

SWAT 2012 rev. 670

SWAT 2012 rev. 681

SWAT 2012 rev. 682

SWAT 2012 rev. 683

SWAT 2012 rev. 685

SWAT 2012 rev. 688

SWAT 2012 rev. 692

# Create a Scenario

## Default Scenario

Overview

Customize SWAT Inputs

Weather dataset

PRISM

Starting simulation date

1/1/1998

Ending simulation date

12/31/2020

Set-up/warm-up years

2

SWAT output print setting

Daily

SWAT model version

SWAT 2012 rev. 692

Run Scenario

Edit/Copy Settings

Back

# Default Scenario

Overview

Customize SWAT Inputs

## General watershed inputs and databases

Calibration data

Basin input data

Fertilizers

Nutrient efficiency

Urban input data

Land use update

## Weather data

Climate sensitivity/variability analysis

Weather generator

## SWAT output to print

HRU variables to print

HRUs to print

## Subbasin inputs

Curve number

Pothole variables

Sediment routing method

Point source

## Ag management/BMPs/Conservation practices

General parameters

Operations management

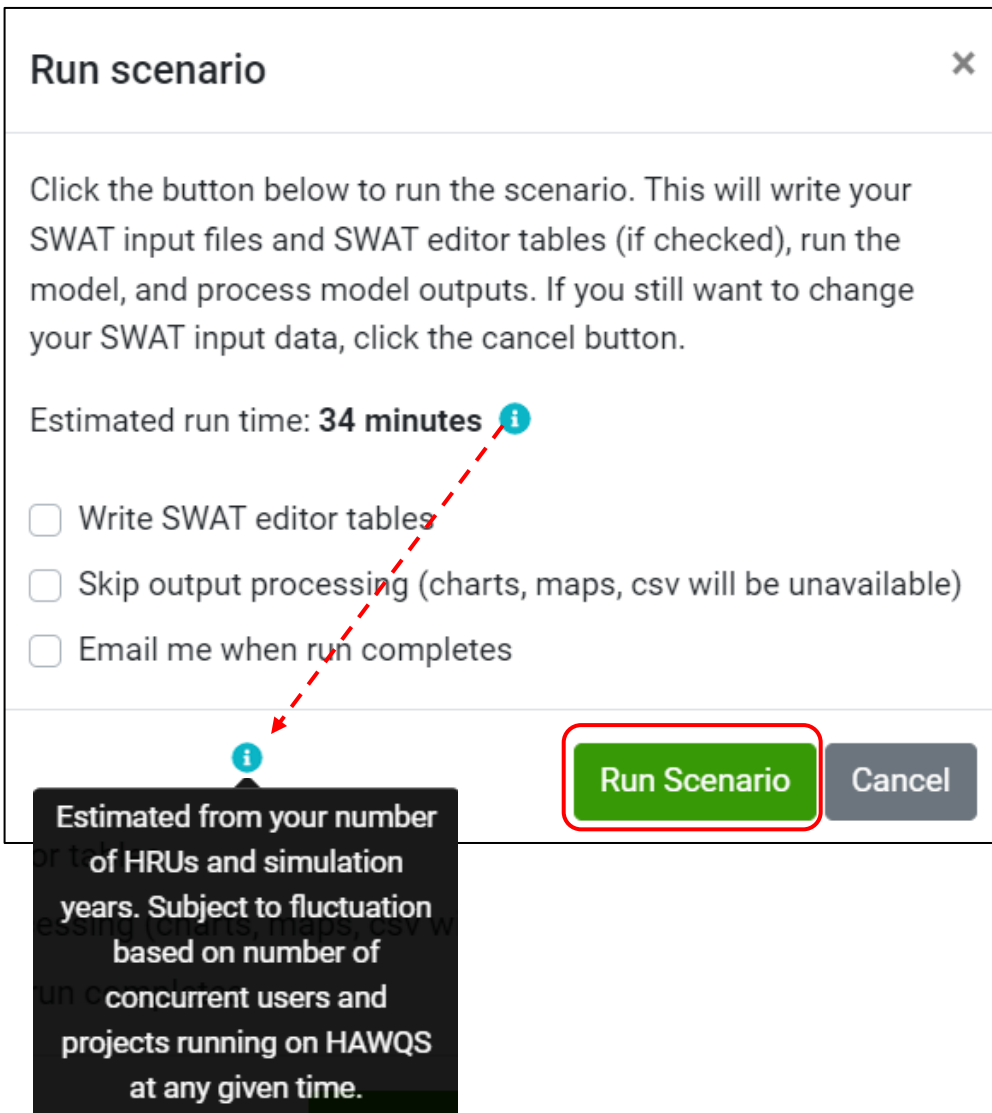
# Customize SWAT Inputs

## Calibration data

HAWQS uses the following calibrations for this watershed by default. Toggle the input below to run your model with or without these calibrations. Please note that any customizations you make to these inputs will override the calibrations. Visit the [documentation and support](#) page for more information about the calibrated data.

Parameter	Calibration years	NSE	PBIAS	KGE
Flow	1983-2018	0.77	-1.8	0.85
TSS	1983-2001	0.74	-12.9	0.82

Click the dot for streamflow data



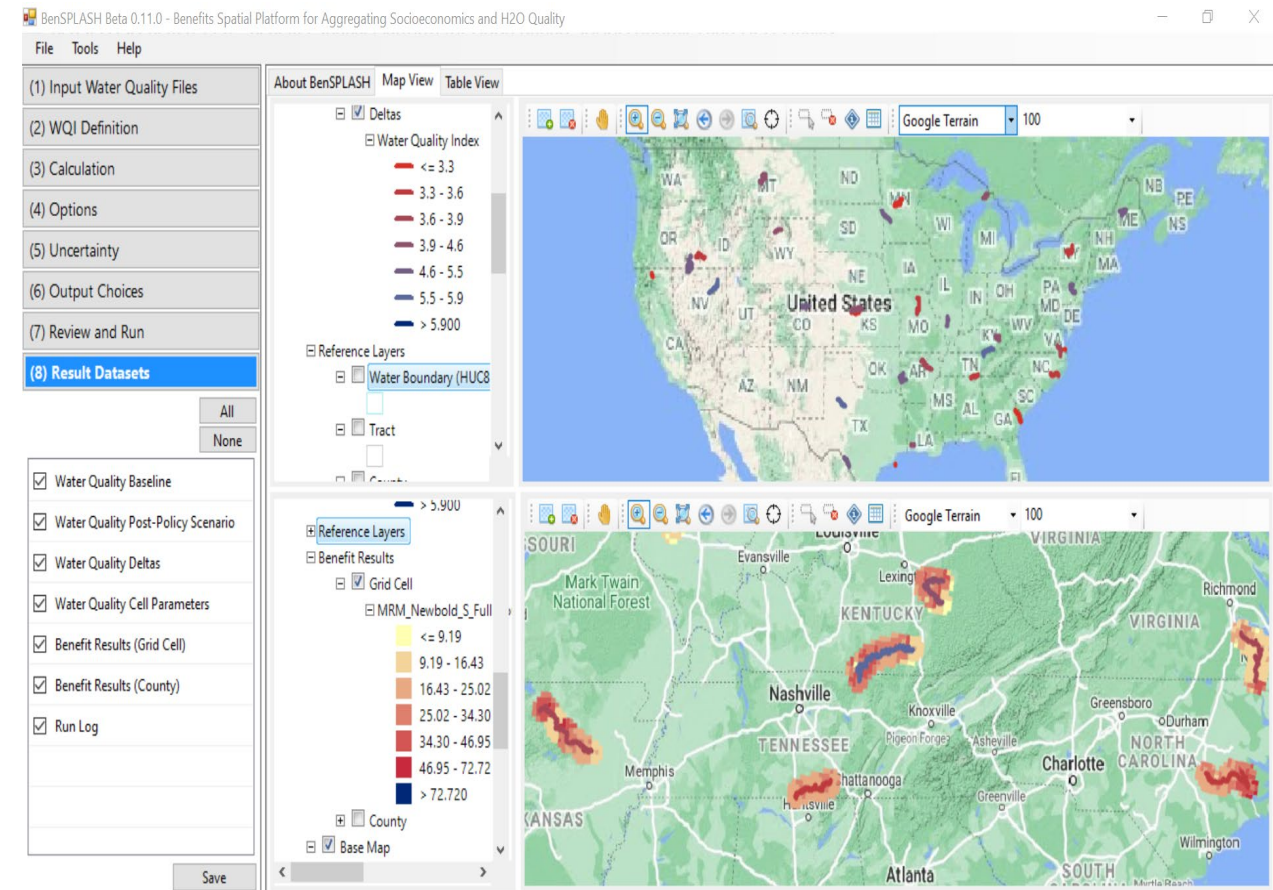
# Run Scenario

- Estimated run time
- Write SWAT editor tables (use offline)
- Reduce run time by skipping output processing
- Receive email when run is complete

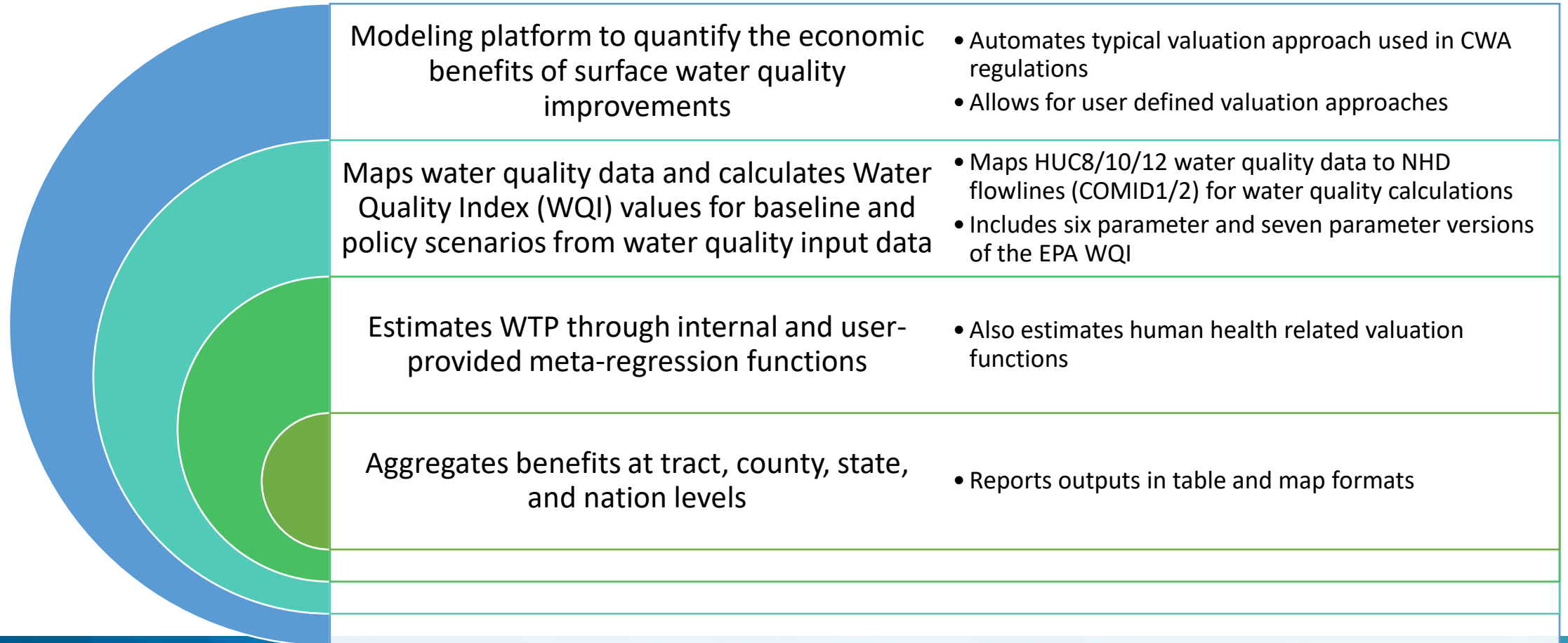
# BenSPLASH

- **Benefits Spatial Platform for Aggregating Socioeconomics and H<sub>2</sub>O Quality (BenSPLASH)**

- Currently under development
- Open source
- National coverage
- Accepts common water quality inputs
- Default valuation approaches + R window for user-defined applications
- EPA Science Advisory Board identifying panel to review model and methodology  
[https://sab.epa.gov/ords/sab/r/sab\\_apex/sab\\_advisoryactivitydetail?p18\\_id=2655](https://sab.epa.gov/ords/sab/r/sab_apex/sab_advisoryactivitydetail?p18_id=2655)



# What is BenSPLASH?



# BenSPLASH Input Files

BenSPLASH Beta 0.11.0 - Benefits Spatial Platform for Aggregating Socioeconomics and H2O Quality

File Tools Help

**(1) Input Water Quality Files**

File Type: WQBM (WQI or Concentrations)

Baseline: C:\Users\JCorona\OneDrive - Environn... Browse...

Scenario: C:\Users\JCorona\OneDrive - Environn... Browse...

HUC Mapping: High Strahler-1

Next >

(2) WQI Definition

(3) Calculation

(4) Options

(5) Uncertainty

(6) Output Choices

(7) Review and Run

(8) Result Datasets

About BenSPLASH Map View Table View

Welcome to **BenSPLASH 0.11.0**, the Benefits Spatial Platform for Aggregating Socioeconomics and H2O Quality. This open source application has been developed in coordination with the U.S. EPA to analyze, quantify, and monetize regional and national impacts on water quality.

EPA Office of Water  
<https://www.epa.gov/aboutepa/about-office-water>

**Release Notes**

Release Version	BenSPLASH 0.11.0
Release Date	2020.12.16

1. Created Windows Installer Package for application and signed executable files for improved security and user experience.
2. Implemented several enhancements and fixes to the GIS mapping interface.
3. When viewing Cell Water Quality Inputs on the Table tab, you can now select a cell and click the "COMID Contributions" button at the top to get a better understanding of how each COMID in the cell's circular buffer has contributed to the cell values.
4. Added Tools/Reference Tables allowing the user to review and export the internal lookup tables used by the application.
5. Removed several unnecessary files from the embedded R distribution to reduce installation time and size.
6. Revised the main analysis loop to only run calculations for cells contained within the circular buffer surrounding each cell associated with the water quality inputs. This greatly improves performance for regional analyses and improves visibility for cells that were previously skipped due to lack of population or required water quality parameters.
7. Added min\_PctAg input variable to the MRM2, MRM2-S, and MRM\_Newbold\_S\_Full. Previously, this 0.1 constraint was hardcoded into the respective R scripts for these functions.
8. Implemented support for yearly outputs from benefit calculations.
  - a. Where available, you may enable yearly outputs in the output choices tab.
  - b. When you select a dataset on the table view that includes yearly outputs, the table will include one column for each year.
  - c. When viewing a dataset on the map that includes yearly outputs, you can choose to view the total output, or select a specific year. You will also notice a slider at the top of the map's table of contents that allows you to adjust the year.
9. Updated the contents of User Guide (available via the Help menu) and added the Technical Appendix to the Help menu. Selecting this will open the document in the system's default PDF viewer.
10. Updated descriptive text displayed when WQI6 or WQI7 are selected in the Water Quality Index panel.
11. Implemented several additional fixes and enhancements based on testing and user feedback.

# BenSPLASH- Water Quality Index

The screenshot displays the BenSPLASH Beta 0.11.0 interface. On the left, a vertical navigation pane shows steps from (1) Input Water Quality Files to (8) Result Datasets, with (2) WQI Definition selected. The main content area is titled 'About BenSPLASH' and includes a 'Map View' tab. It contains a welcome message, EPA Office of Water information with a link, and a 'Release Notes' section. The release notes list eight items, including the creation of a Windows installer, GIS interface enhancements, performance improvements, and support for yearly outputs.

BenSPLASH Beta 0.11.0 - Benefits Spatial Platform for Aggregating Socioeconomics and H2O Quality

File Tools Help

(1) Input Water Quality Files

(2) WQI Definition

Calculate 6-parameter WQI from TSS, DO, TN, FC, BOD, and TP

Output subindex values  Convert SSC to TSS

The **six**-parameter WQI will be calculated as described in Environmental impact and benefits assessment for final effluent guidelines and standards for the construction and development category (2009), Section 10.1.

Parameters are weighted as follows:

DO	0.24
FC	0.22
TP	0.14
TN	0.14
TSS	0.11
BOD	0.15

No adjustments are made to subindex values before applying WQI formula.

Next >

(3) Calculation

(4) Options

(5) Uncertainty

(6) Output Choices

(7) Review and Run

(8) Result Datasets

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# BenSPLASH- Valuation

BenSPLASH Beta 0.11.0 - Benefits Spatial Platform for Aggregating Socioeconomics and H2O Quality

File Tools Help

(1) Input Water Quality Files

(2) WQI Definition

**(3) Calculation**

Identifier	Notes
<input checked="" type="checkbox"/> MRM2	Household willingness to pay for single unit increase in WQI
<input type="checkbox"/> MRM2-S	Similar to MRM2 with added factor for magnitude of water qu...
<input type="checkbox"/> MRM_Newbold_S_Full	Household willingness to pay for single unit increase in WQI, S...

Next >

(4) Options

(5) Uncertainty

(6) Output Choices

(7) Review and Run

(8) Result Datasets

About BenSPLASH | Map View | Table View

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# BenSPLASH- Modeling Options

The screenshot displays the BenSPLASH Beta 0.11.0 application window. The title bar reads "BenSPLASH Beta 0.11.0 - Benefits Spatial Platform for Aggregating Socioeconomics and H2O Quality". The interface is divided into two main sections: a left-hand navigation pane and a right-hand content area.

**Left-hand navigation pane:**

- (1) Input Water Quality Files
- (2) WQI Definition
- (3) Calculation
- (4) Options** (highlighted in blue)
- (5) Uncertainty
- (6) Output Choices
- (7) Review and Run
- (8) Result Datasets

**Options section (4) Options:**

- Grid Size: 7290m
- Buffer Distance (km): 160
- Population Year: 2015
- Landcover Year: 2011
- Start Year: 2016
- End Year: 2022
- Benefits Year: 2022
- Discount Rate 1 (%): 3
- Discount Rate 2 (%): 7
- Waterbody Type: Rivers
- Result Aggregation:  State,  County,  Tract,  Block Group. Buttons for "All" and "None" are also present.

**Right-hand content area:**

Buttons: About BenSPLASH, Map View, Table View

Welcome to **BenSPLASH 0.11.0**, the Benefits Spatial Platform for Aggregating Socioeconomics and H2O Quality. This open source application has been developed in coordination with the U.S. EPA to analyze, quantify, and monetize regional and national impacts on water quality.

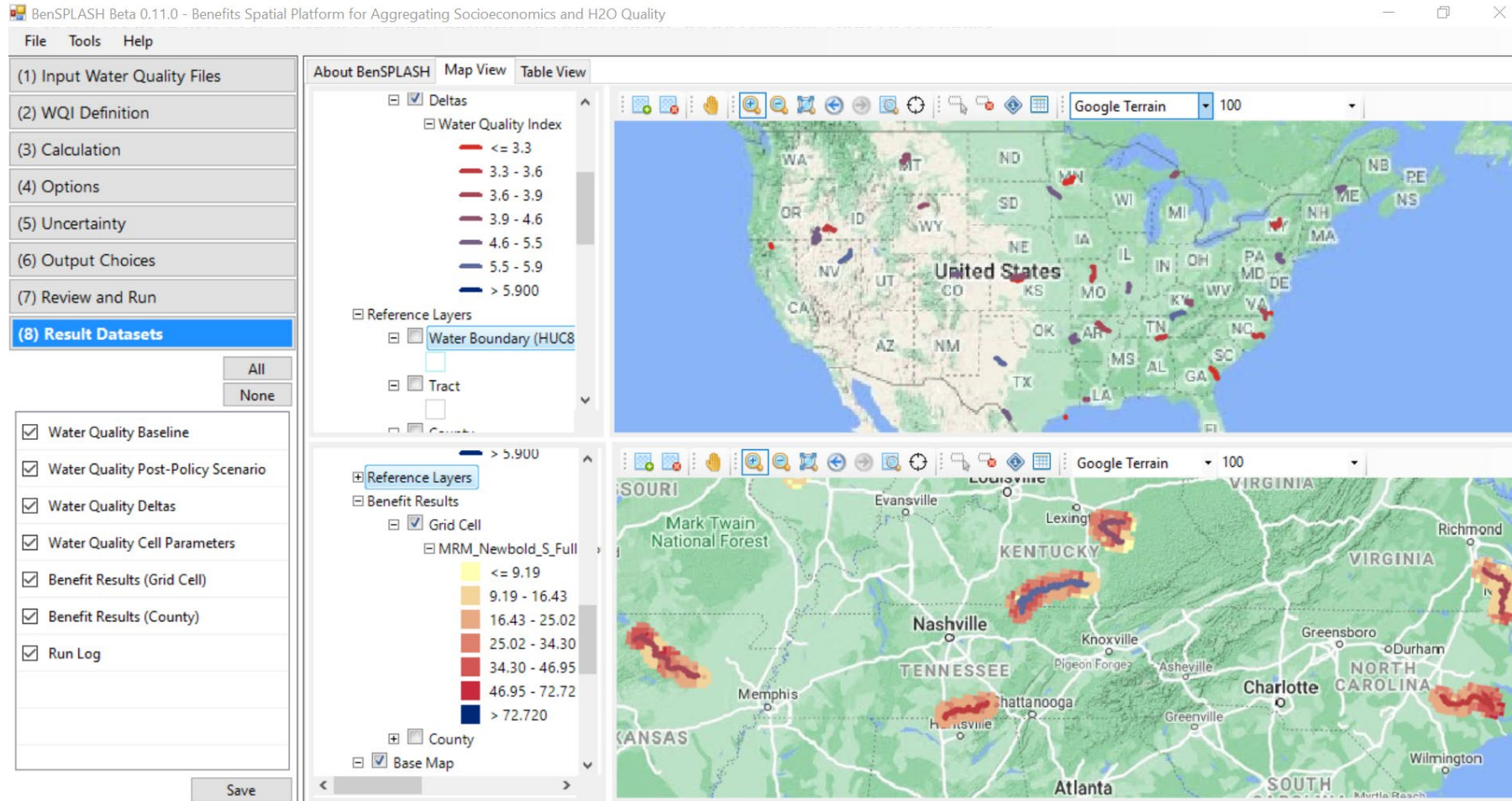
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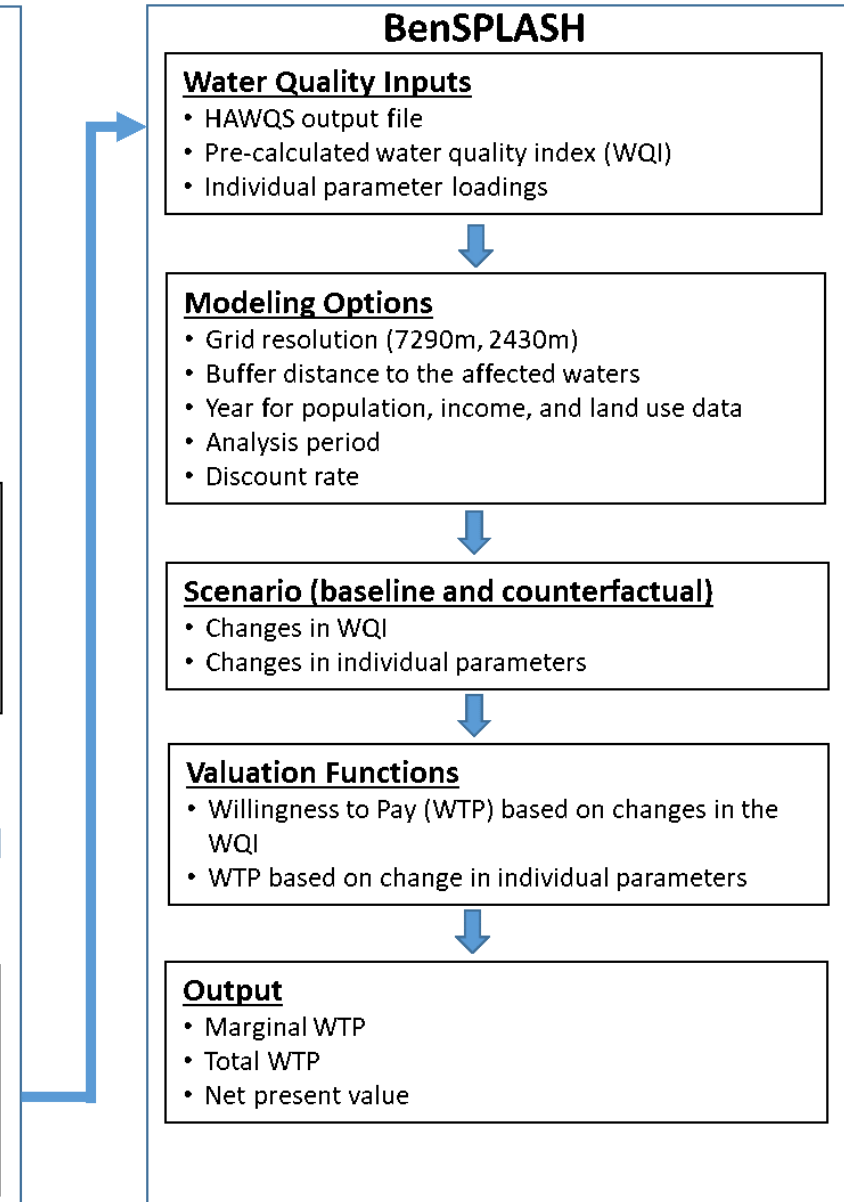
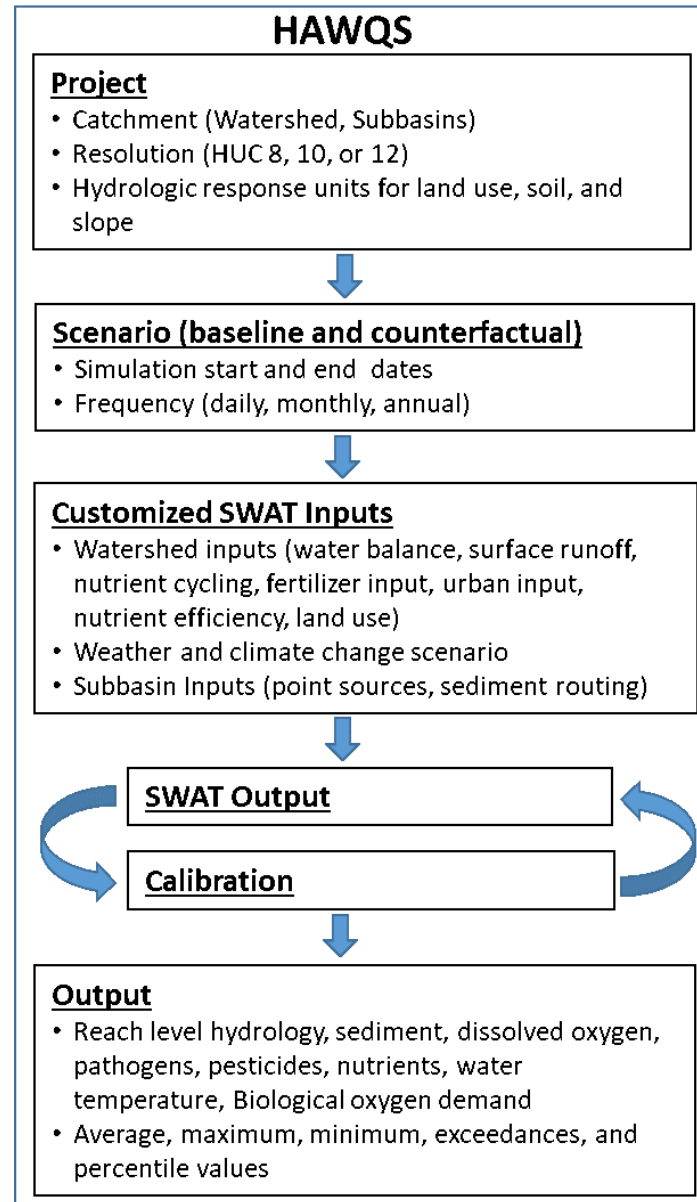
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# BenSPLASH- GIS Results



# HAWQS- BenSPLASH Flowchart



# HAWQS-BenSPLASH Future Work

## HAWQS 2.0

- Peer Review
- Update national (CONUS) data layers
- Continue calibrating CONUS for sediment, nitrogen, and phosphorus
- Explore expansion of geographic coverage (Alaska, Hawaii, Guam, Puerto Rico)
- Eventually migrate core model from SWAT to SWAT+ ???

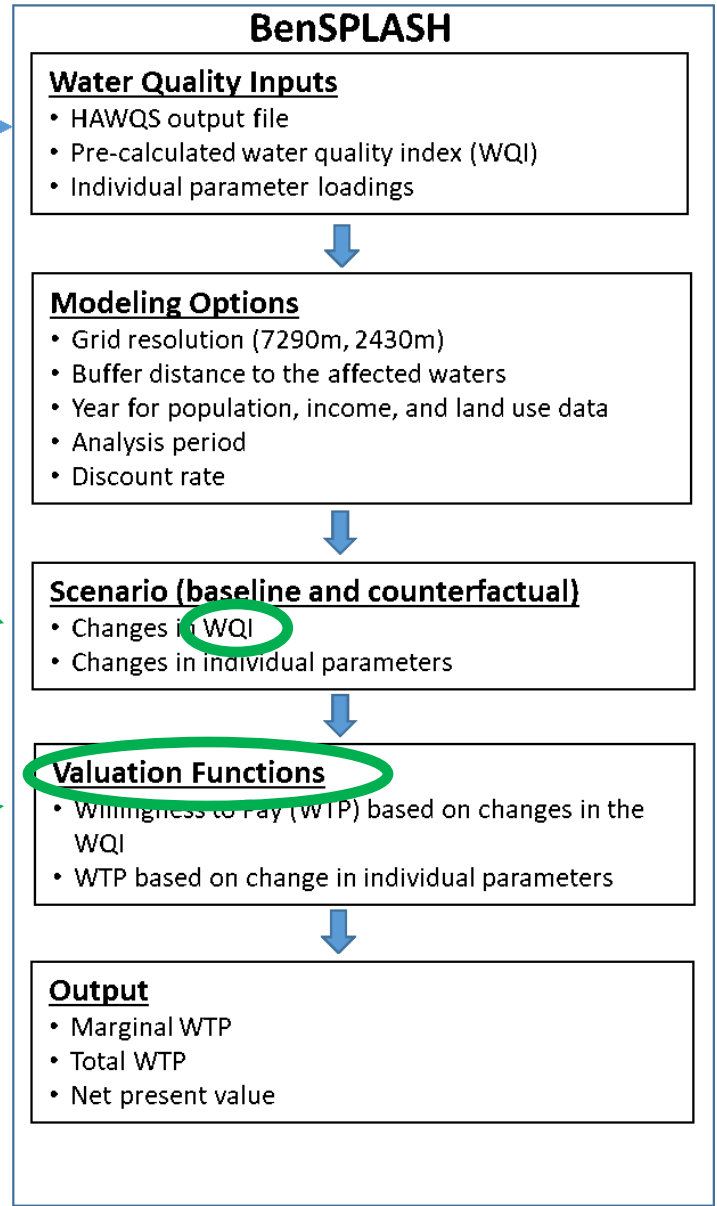
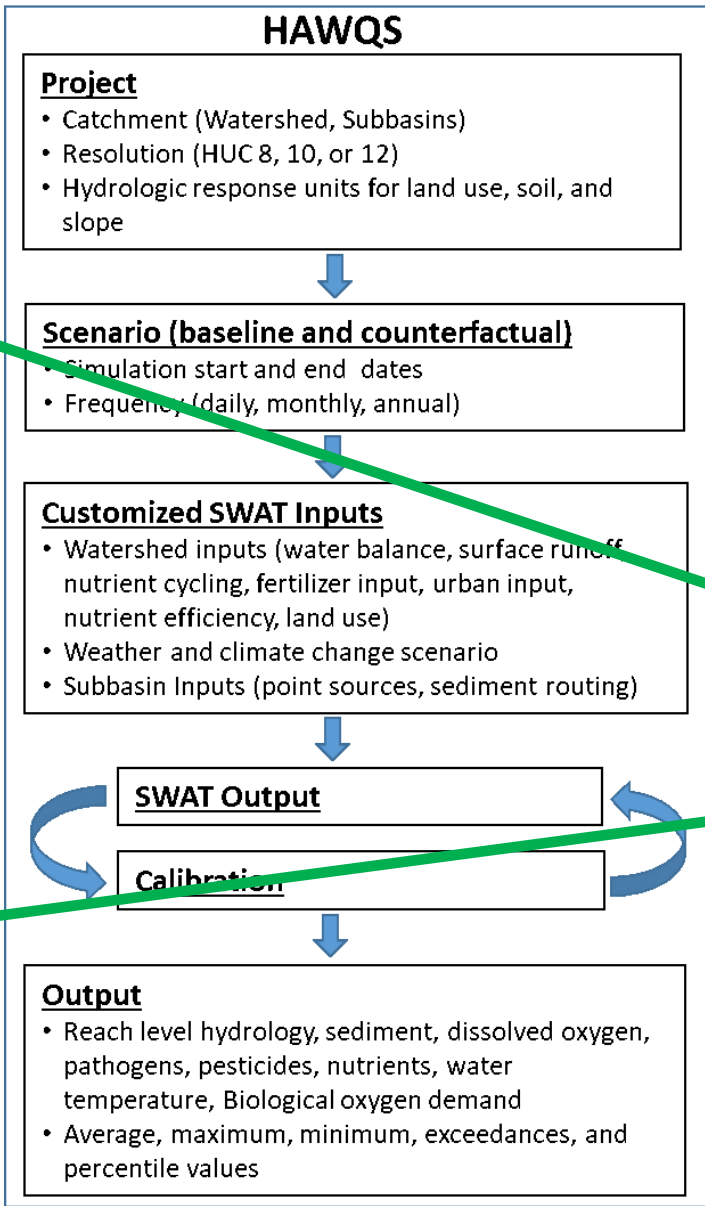
## BenSPLASH

- Peer review
- Update metadata
- Revisit methodology and default assumptions
- Add new valuation approaches (additional human health endpoints, avoided cost, hedonic property valuation)
- Add flexibility to WQI options

Changes to WQI,  
additional WQIs

How do the  
following  
presentations fit in?

Avoided drinking  
water treatment costs,  
valuing ecological and  
recreational  
improvements,  
property sales  
capitalization





**Contact Info:**

[Corona.Joel@epa.gov](mailto:Corona.Joel@epa.gov)

[Hewitt.Julie@epa.gov](mailto:Hewitt.Julie@epa.gov)

# Benefits of HAWQS

- Federally approved public domain databases
- Doesn't require expert water modeling experience or GIS skills
- Secure distributed collaborative modeling through shared storage and execution
- Helps to preserve institutional memory and reproducibility through transparency
- Helps to visualize spatial and temporal data as well as perform various analyses of water quantity and quality assessments such as LDC, flood frequencies
- Allows non-water quality modelers to estimate water quantity and quality benefits under various scenarios using a readily available calibrated water quality modeling system such as ecologists, environmentalists, and economists
- Users can perform both online or offline modeling using freely available tools for desktop exercises
- **More efficient – reduces SWAT model set-up time and effort by 90%**



# ADDITIONAL HAWQS PLATFORMS

## SUPPORT AND FUNDING

### State and Regional

*(##).hawqs.tamu.edu*

- Texas (TX)
- Oklahoma (OK)
- South Carolina (SC)
- Trinity River Authority (TRA)
- Tarrant Regional Water District (TRWD)
- Lower Colorado River Authority (LCRA)
- North Texas Municipal Water District (NTMWD)
- Meskwaki Nation (Meskwaki)



# INTERNATIONAL HAWQS PLATFORMS

## SUPPORT AND FUNDING

- South Africa (HAMSA)  
[[hamsa.hawqs.tamu.edu](http://hamsa.hawqs.tamu.edu)]

- Pernambuco Brazil (SUPer)  
[[super.hawqs.tamu.edu](http://super.hawqs.tamu.edu)]

- Hydrologic Unit Model for InDia (HUMID)  
[[bhuvan.nrsc.gov.in](http://bhuvan.nrsc.gov.in)]

- Global HAWQS  
[[global.hawqs.tamu.edu](http://global.hawqs.tamu.edu)]

- Coming Soon: Ukraine  