

User Guide

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Salinity Information Management System (SIMS)



One Water Solutions Institute

Colorado State University

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EXECUTIVE MESSAGE

Catena Analytics offers powerful platforms for building accessible and scalable analytical tools and simulation models that can be accessed via desktop or mobile devices. Our team has spent that last decade developing the Environmental Resource Assessment and Management System (eRAMS), an open-source technology that provides cloud-based geospatially-enabled software solutions as online services and a platform for collaboration, development, and deployment of online tools. Our services are used to assist with strategic and tactical decision making for sustainable management of land, water and energy resources. Thank you for choosing Catena Analytics and the eRAMS platform to meet your data, modeling, analysis and geospatial needs.

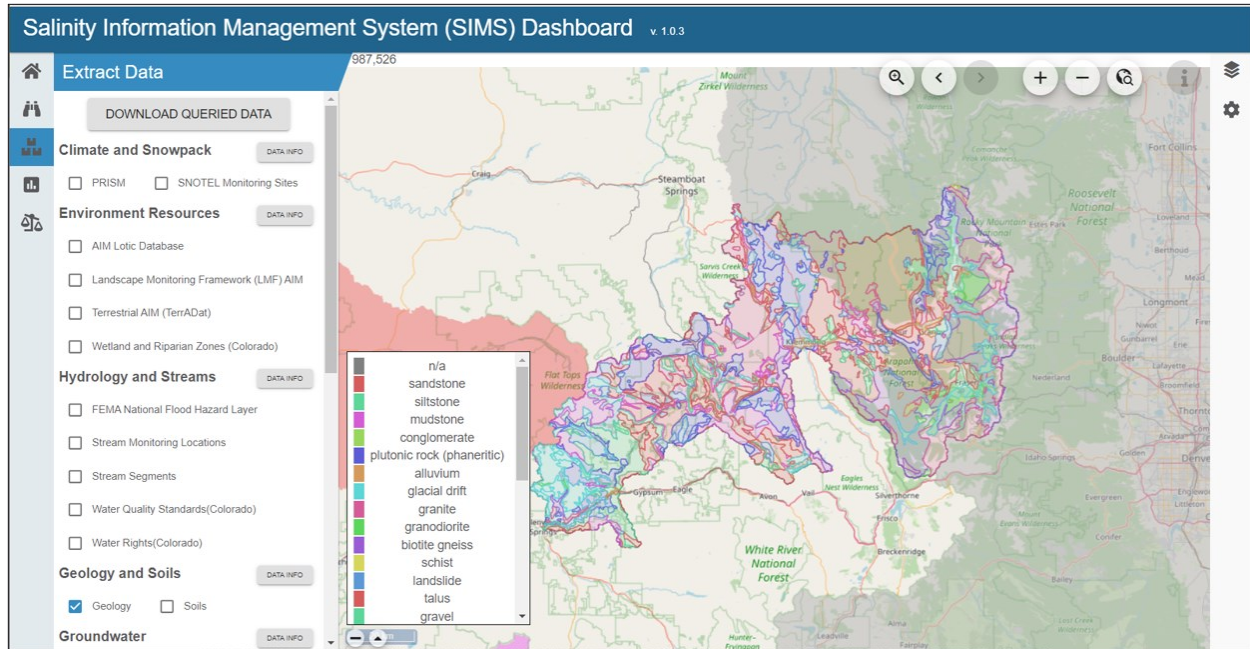
WHO SHOULD USE THIS GUIDE

This guide is a tutorial to get you started using eRAMS and the [Salinity Information Management System](#). The guide provides instructions for commonly performed tasks and uses of the tool. This tool is intended for use by water planners and managers, academic groups, regulatory officials, consultants as well as state, local and federal agencies planning for the future of water resources.

NEED HELP?

After reviewing the guide if you need additional assistance we are here to help! This guide is designed to provide instruction on commonly performed operations and answers to many frequently asked questions. If you find any aspect of the tool challenging or missing information from this guide, please engage an eRAMS expert to guide you through any hurdles. Contact us at: eramsinfo@gmail.com

INTRODUCTION



PURPOSE

The Salinity Information Management System (SIMS) is an interactive platform providing access to salinity data and results from our research in the Colorado River Basin.

DESCRIPTION

Our team examined the issue of high salinity in the Colorado River Basin, a factor that significantly impacts the region's agricultural productivity and infrastructure through corrosion. The study investigates both the natural and human-driven causes of salinity.

The dashboard includes three unique modules:

- Extract Data allows users to extract and summarize contextual data for a user-defined area within the CRB, offering interactive charts, tables, and maps across several contextual and salinity-related datasets.
- APEX-MODFLOW Analysis summarizes targeted modeling performed across the CRB, particularly utilizing the APEX-MODFLOW models for selected sub-watersheds, allowing users to extrapolate salt transport behaviors to the larger CRB.
- Salinity Balance Results presents a comprehensive salinity summary per component within the CRB, including surface water, subsurface, soils, and atmospheric deposition.

METHODS

To forecast salinity levels in the Colorado River Basin, a comprehensive model was constructed, which utilizes data from various sources, including land use, soils, climate, and hydrography. The model's primary soil data was derived from the Soil Survey Geographic (SSURGO) database, managed by the United States Department of Agriculture (USDA). Despite the comprehensiveness of the database, gaps in soil data, particularly in remote or under-studied areas, were present. To address these gaps, a hybrid point-disaggregation predictive soil property mapping strategy (Nauman & Duniway, 2020), was implemented to enhance the sample size, and improve prediction accuracy across the entire CRB.

The methodology for hydrologic and water quality modeling was bifurcated into two primary approaches: process-based models and machine learning models. Process-based models, namely APEX-MODFLOW and SWAT+ national model, were used to simulate hydrology, salinity, and predict streamflow in specific watersheds in the CRB and across the entire basin, respectively.

For machine learning models, a diverse set of eleven algorithms was implemented, including linear regression, decision tree, support vector machine, random forest, gradient boosting, extreme gradient boosting, k-nearest neighbors, Gaussian process, Bayesian model, ridge regression, and neural network. Each model was trained to predict river salinity using available data and evaluated using a rigorous cross-validation technique.

DATA

Developing a reliable model for predicting salt levels in the CRB requires the integration of multiple types of data, each of which offers distinct insights into the complex dynamics of the Basin. The data assembled for this project, spanning diverse domains such as land use, soils, climate, hydrography, stream and river discharge, water quality, groundwater levels, and point sources, has been instrumental in training the model and enhancing its predictive accuracy. Each category of data contributes a piece to the puzzle, creating a comprehensive picture of the CRB's ecosystem and informing the prediction of salt levels at any point in the stream.

- **Land Use:** Moderate Resolution Imaging Spectroradiometer Irrigated Agriculture Dataset for the United States (MirAD-US)
- **Soils:** Soil Survey Geographic (SSURGO)
- **Terrain:** National Elevation Dataset
- **Land Cover:** 2019 National Land Cover Database (NLCD)
- **Climate:** Parameter elevation Regressions on Independent Slopes Model (PRISM)
- **Water Quality, Stream and River Discharge:** Flow and salinity data from the USGS Streamgaging Network dataset spanning from 2000 to 2020 were incorporated in this study.
- **Groundwater:** Groundwater level data from the USGS was sourced for this study, with around 5000 wells selected across the Colorado River Basin

- **Point Sources:** US EPA Enforcement and Compliance History Online (ECHO) database, focused on wastewater treatment facilities
- **Hydrography:** Digital elevation model (DEM) was employed for delineation of catchment boundaries around the selected USGS gauges

SOFTWARE AVAILABILITY

Domain

<https://sims.erams.com/>

Documentation URL

<https://erams.com/catena/tools/river-basin-planning/sims/>

AUTHORIZED USE PERMISSION

The information contained in the Watershed Rapid Assessment Program (the "Service") is for general information purposes only. Colorado State University's One Water Solutions Institute ("CSU-OWSI") assumes no responsibility for errors or omissions in the contents of the Service. In the Service (www.erams.com/wrap), you agree to hold neither the creators of the software platform nor CSU-OWSI liable for any action resulting from use or misuse of the Service. In no event shall CSU-OWSI be liable for any special, direct, indirect, consequential, or incidental damages or any damages whatsoever, whether in an action of contract, negligence or other sort, arising out of or in connection with the use of the Service or the contents of the Service. CSU-OWSI reserves the right to make additions, deletions, or modification to the contents of the Service at any time without prior notice.

GETTING STARTED

QUICK START

The [Salinity Information Management System \(SIMS\)](#) is an interactive platform providing access to salinity data and results from project research on the Colorado River Basin. Follow the simple workflow below to get started:

1. [Define Area of Interest](#)
2. [Extract Data](#)
3. [Access APEX-MODFLOW Metadata](#)
4. [Analyze Salinity Balance](#)
5. [Visualization and Graphing Features](#)

SYSTEM REQUIREMENTS

A modern web-browser is required to connect and run the WRAP. Browser options include: Google Chrome v.69, Mozilla Firefox v.62, Safari v.11.1, and Microsoft Edge v.17.

USING THE TOOL

STEP 1 – DEFINE AREA OF INTEREST

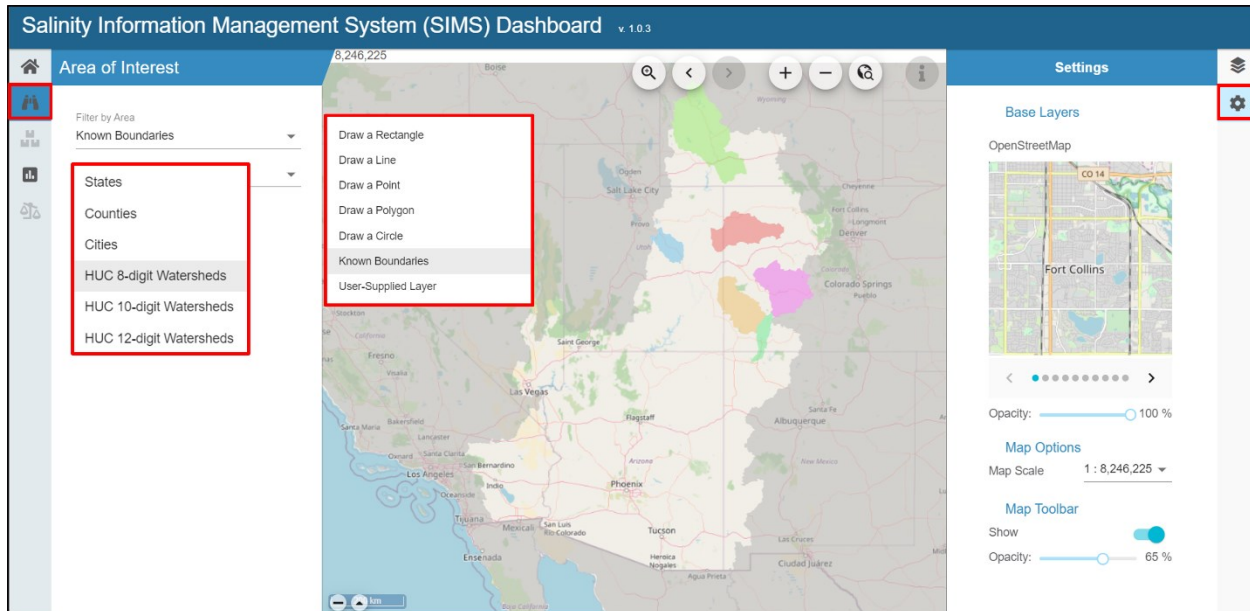


Figure 1 Define area of interest and modify base map (optional).

Select Base Layer (optional)

With the SIMS interface open, click the “Settings” tab located on the right dashboard

1. Select the desired base layer and modify map settings including opacity and scale.
 - Base layer options include: OpenStreets, USGS National Maps, Google, None.

Define Watershed Boundary

With the WRAP interface open, click the “Select Area of Interest” (binoculars) tab from the left dashboard. Define your watershed boundary by performing one of the following operations:

Draw Boundary

The options for manual selection of the geographic region of interest include the area within a desired radius of a point (point buffer); area within a buffer of a line; area within a rectangle; or area within a free-hand polygon.

1. Select boundary type
 - Enter desired buffer radius (point or line)
2. Place point(s) on desired map location
3. Name the watershed

Select Known Boundary

Users can select a region from known boundaries such as states, counties, or hydrological unit codes (HUCs).

1. Select "Known Boundary"
2. Select predefined boundary from drop down list (states, counties, cities, HUC-8, HUC-10 or HUC-12 watersheds).

Upload Boundary Layer

Users can upload a layer (shapefile) by performing the following operations:

1. Select "Upload a Boundary"
2. Select a shapefile for upload from your device
 - All files associated with a shapefile can be zipped into a ZIP archive (*.zip) then uploaded, or multiple files can be uploaded at the same time outside of a ZIP archive
 - Depending on the size of your file(s), it may take a few minutes to process

Upload Layers

Users can upload files (Figure 2) and add their own information under the "Layers" tab located on the right dashboard:

1. Upload geospatial user layers
2. Import data from public sources such as U.S. Geo Data, U.S. Hydro Data and U.S. Environmental Protection Agency water data.

Map Features

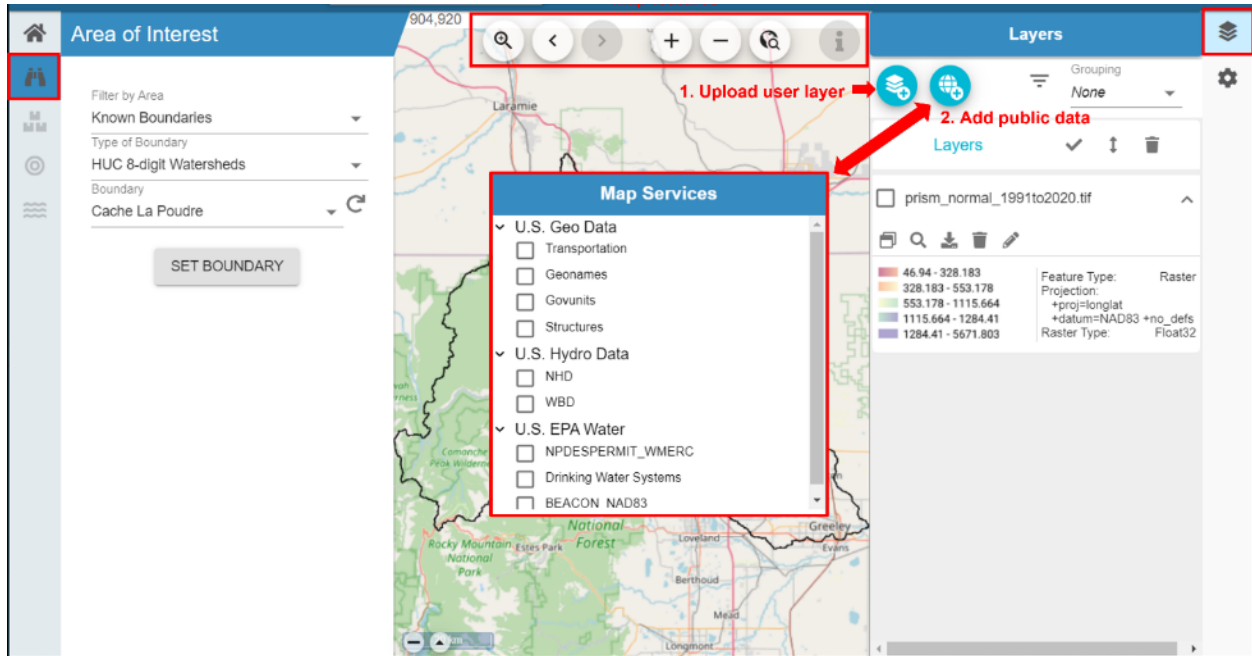


Figure 2 Add user layers, import public data, and navigate map features.

The dashboard also allows users to navigate basic mapping features from the toolbar located on top of the map canvas (search location, zoom in/out/to specific place, enter location, layer attributes).

STEP 2 – EXTRACT DATA

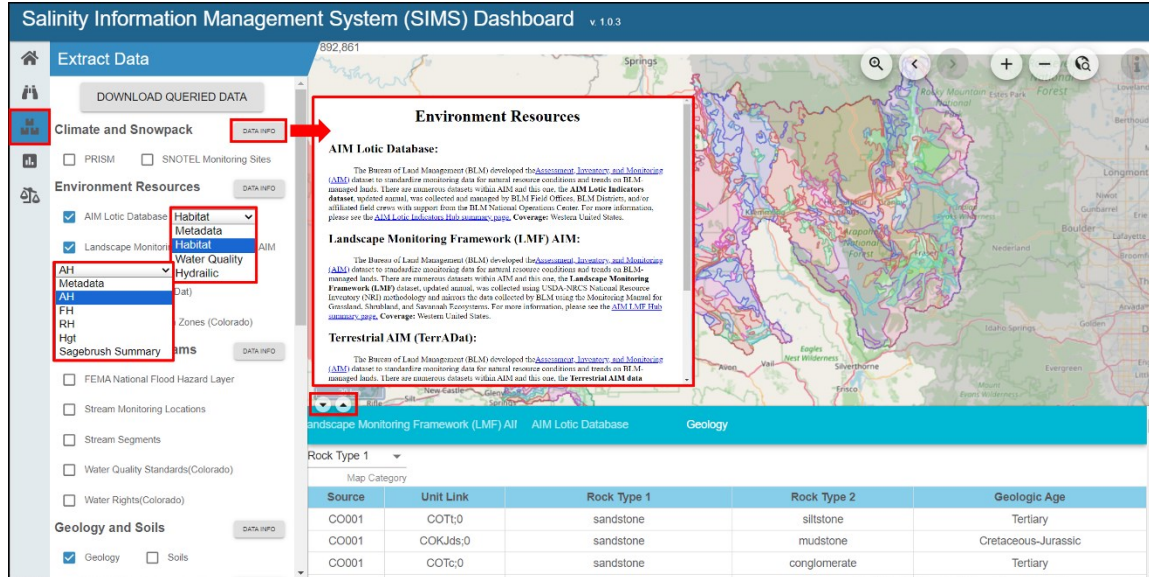


Figure 3 Select and extract desired data, help text available.

Select Datasets

The eRAMS platform retrieves live data for the prepopulated categories described in further detail below. Therefore, the processing time may take a few minutes after you have selected the desired dataset(s) to complete the extraction. Inline help and links to the data sources are available in the SIMS interface by clicking the “DATA INFO” button next to each data category (Figure 3) which are also described below. Users can download the queried data using the gray button at the top of the module.

To select and extra data:

1. Check the box next to the desired data set
 - Each dataset and source is described in further detail below
2. A summary will populate in the table below the map canvas once the data has been extracted

Climate and Snowpack Data

Gridded Datasets

Parameter-elevation Regressions on Independent Slopes Model (PRISM) is a set of gridded data products for average, minimum, and maximum temperature and average precipitation. For more information please see the [PRISM Climate group's data page](#). **Coverage:** Conterminous United States (Lower 48 States).

Observed Historic/Current Climate

Snow Telemetry (SNOTEL) stations within the provided area of interest are also extracted from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service database. The precipitation data for these stations are summarized separately from the GHCN-Daily data. For more information please see the [SNOTEL data page](#). **Coverage:** Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington, and Wyoming.

Environmental Resources Data

AIM Lotic Database

The **Bureau of Land Management (BLM)** developed the [Assessment, Inventory, and Monitoring \(AIM\)](#) dataset to standardize monitoring data for natural resource conditions and trends on BLM-managed lands. There are numerous datasets within AIM and this one, the **AIM Lotic Indicators dataset** (updated annually) was collected and managed by BLM Field Offices, BLM Districts, and/or affiliated field crews with support from the BLM National Operations Center. For more information, please see the [AIM Lotic Indicators Hub summary page](#). **Coverage:** Western United States.

Landscape Monitoring Framework (LMF) AIM

The **Bureau of Land Management (BLM)** developed the [Assessment, Inventory, and Monitoring \(AIM\)](#) dataset to standardize monitoring data for natural resource conditions and trends on BLM-managed lands. There are numerous datasets within AIM and this one, the **Landscape Monitoring Framework (LMF)** dataset (updated annually) was collected using USDA-NRCS National Resource Inventory (NRI) methodology and mirrors the data collected by BLM using the Monitoring Manual for Grassland, Shrubland, and Savannah Ecosystems. For more information, please see the [AIM LMF Hub summary page](#). **Coverage:** Western United States.

Terrestrial AIM (TerrADat)

The **Bureau of Land Management (BLM)** developed the [Assessment, Inventory, and Monitoring \(AIM\)](#) dataset to standardize monitoring data for natural resource conditions and trends on BLM-managed lands. There are numerous datasets within AIM and this one, the **Terrestrial AIM data (TerrADat)** dataset is a point dataset (updated annually) was collected by the BLM using the Monitoring Manual for Grassland, Shrubland, and Savannah Ecosystems. For more information, please see the [AIM LMF Hub summary page](#). **Coverage:** Western United States.

Wetlands and Riparian Zones

Colorado Natural Heritage Program (CNHP) has performed a state-level wetlands assessment including potential conservation areas and networks of conservation areas. For more information please see the [CNHP data page](#). **Coverage:** Colorado.

Hydrology and Streams Data

FEMA Flood Plain Maps

Federal Emergency Agency (FEMA) National Flood Hazard Layer (NFHL) dataset (S_Fld_Haz_Ar) are used by FEMA to designate the Special Flood Hazard Area (SFHA) and for insurance rating purposes. These data are the regulatory flood zones designated by FEMA. For more information, please see the FEMA page for their [Flood Insurance Rate MAP \(FIRM\) Database Technical Reference](#). **Coverage:** United States.

Stream Monitoring Locations (Historical/Current Stream Discharge and Water Quality)

The U.S. Geological Survey (USGS) National Water Information System (NWIS) database of stream monitoring locations (average daily discharge and water quality) within the provided area of interest will be extracted. For more information please see the [USGS NWIS home page](#). **Coverage:** United States.

The U.S. EPA STORET database of stream monitoring locations (average daily discharge and water quality) within the provided area of interest will be extracted. For more information please see the [STORET Central Warehouse data page](#). **Coverage:** United States.

The Colorado Division of Water Resources (CDWR) database of stream monitoring locations (average daily discharge) within the provided area of interest will be extracted. For more information please see the [Colorado DWR data page](#). **Coverage:** Colorado.

Stream Segments (Impaired and Use-Limited Waterbodies (EPA 303d) and Waterbody Classification (EPA 305b))

The U.S. Environmental Protect Agency (EPA) Impaired and Use-Limited Waterbodies (2014) within the provided area of interest will be extracted and summarized. For more information please see the [U.S. EPA Impaired Waters and TMDL home page](#). **Coverage:** United States.

The U.S. Environmental Protect Agency (EPA) National Water Quality Inventory Report (2012) of streams and waterbodies and their designated uses within the provided area of interest will be extracted and summarized. For more information please see the [U.S. EPA 305b home page](#). **Coverage:** United States.

Colorado Department of Public Health and Environment (CDPHE) Impaired and Use-Limited Waterbodies (2016) for areas in Colorado only will be extracted and summarized instead of the U.S. EPA data. For more information please see the [CDPHE GIS Maps page](#). **Coverage:** Colorado.

Colorado Department of Public Health and Environment (CDPHE) Waterbodies (2016) for areas in Colorado only will be extracted and summarized instead of the U.S. EPA data. For more information please see the [CDPHE GIS Maps page](#). **Coverage:** Colorado.

Geology and Soils

Soil type and other attributes are extracted from the **Soil Survey Geographic (SSURGO)** database from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). For more information please see the [USDA-NRCS Soil Data home page](#). **Coverage:** United States.

Groundwater Data

Principal Aquifer Extent

The U.S. Geological Survey (USGS) Groundwater Atlas of principal aquifer extent. For more information please see the [USGS Aquifer home page](#). **Coverage:** United States.

Historical/Current Groundwater

The U.S. Geological Survey (USGS) National Water Information System (NWIS) database of groundwater monitoring locations (water table elevation) within the provided area of interest will be extracted. For more information please see the [USGS NWIS home page](#). **Coverage:** United States.

Land Surface Data

Dry-land Irrigated Agriculture The dry-land agricultural field layer shown was developed by combining multi-year NLCD cultivated cropland data and intersecting it with public land survey units (PLSS), erasing out irrigated field coverage from the [Colorado Decision Support System \(CDSS\) website](#). **Coverage:** Colorado.

Irrigated Agriculture is a set of irrigated field boundaries for the state of Colorado available from the [Colorado Decision Support System \(CDSS\) website](#). **Coverage:** Colorado.

Land Use

The National Land Cover Database (NLCD) of Percent Developed Imperviousness is an impervious surface summary by the U.S. Geological Survey (USGS). These assessments began in 2001 nationwide. For more information please see the [USGS NLCD home page](#). **Coverage:** Conterminous United States (Lower 48 States).

The National Agricultural Statistical Service (NASS) is a land use summary by the U.S. Department of Agriculture (USDA) with an emphasis on crop type. These assessments began in 1997 at the state level with nationwide coverage by 2008. For more information please see the [USDA NASS home page](#). **Coverage:** Conterminous United States (Lower 48 States).

The National Land Cover Database (NLCD) is a land use summary by the U.S. Geological Survey (USGS). These assessments began in 1992 nationwide. For more information please see the [USGS NLCD home page](#). **Coverage:** Conterminous United States (Lower 48 States).

The land use trends analysis extracts a subset of land use cover layers from either NASS (2014, 2012, 2010, 2008) and NLCD (2011, 2006, 2001, 1992) and then displays them side by side for comparison. **Coverage:** Conterminous United States (Lower 48 States).

Population

Decennial U.S. Census (2010 and 2000) population for blocks or block groups (depending on the size of the area of interest) extracted and analyzed. **Coverage:** United States.

American Community Survey population for counties are extracted and analyzed. **Coverage:** United States.

Topography

30-meter Digital Elevation Maps (DEMs) of topography are extracted from the **National Hydrography Dataset (NHDPlus Version 2)**. For more information please see the [NHDPlus Version 2 home page](#). **Coverage:** Conterminous United States (Lower 48 States).

Other Data

Abandoned Mine Lands (Colorado)

Colorado Abandoned Mine Land features from [numerous agencies](#) will be extracted and summarized. For more information please see the [Colorado Abandoned Mine Lands Metadata page](#). **Coverage:** Colorado.

Atmospheric Deposition

National Atmospheric Deposition Program (NADP) National Trends Network atmospheric deposition monitoring stations are also extracted for the provided area of interest. Data for these stations are summarized separately from the GHCN-Daily data. For more information please see the [NADP data page](#). **Coverage:** United States.

Canals and Ditches

Canals and Ditches from USGS National Map Viewer's Hydrography database of flow lines are provided for the area of interest. For more information please see the [USGS National Map Viewer help page](#). **Coverage:** United States.

Roadways

Roadways from USGS National Map Viewer's Geo Data database of national transportation datasets are provided for the area of interest. For more information please see the [USGS National Map Viewer help page](#). **Coverage:** United States. This is missing from inline text

Colorado Transbasin Diversions

Colorado transbasin (transmountain) diversions are important alterations to natural hydrography. Ditch and tunnel structures along with associated monitoring gages within the provided area of interest will be extracted and summarized. **Coverage:** Colorado.

Wastewater Treatment Plants

Colorado Department of Public Health and Environment (CDPHE) Regulation 85 nutrient management data for wastewater treatment plants within the provided area of interest will be extracted and summarized. For more information please see the CDPHE Regulation 85 nutrient home page. **Coverage:** Colorado.

National Pollution Discharge Elimination System (NPDES) The NPDES permit program addresses water pollution by regulating point sources that discharge pollutants to waters of the united states [NPDES home page](#). **Coverage:** United States.

STEP 3 – APEX-MODFLOW METADATA

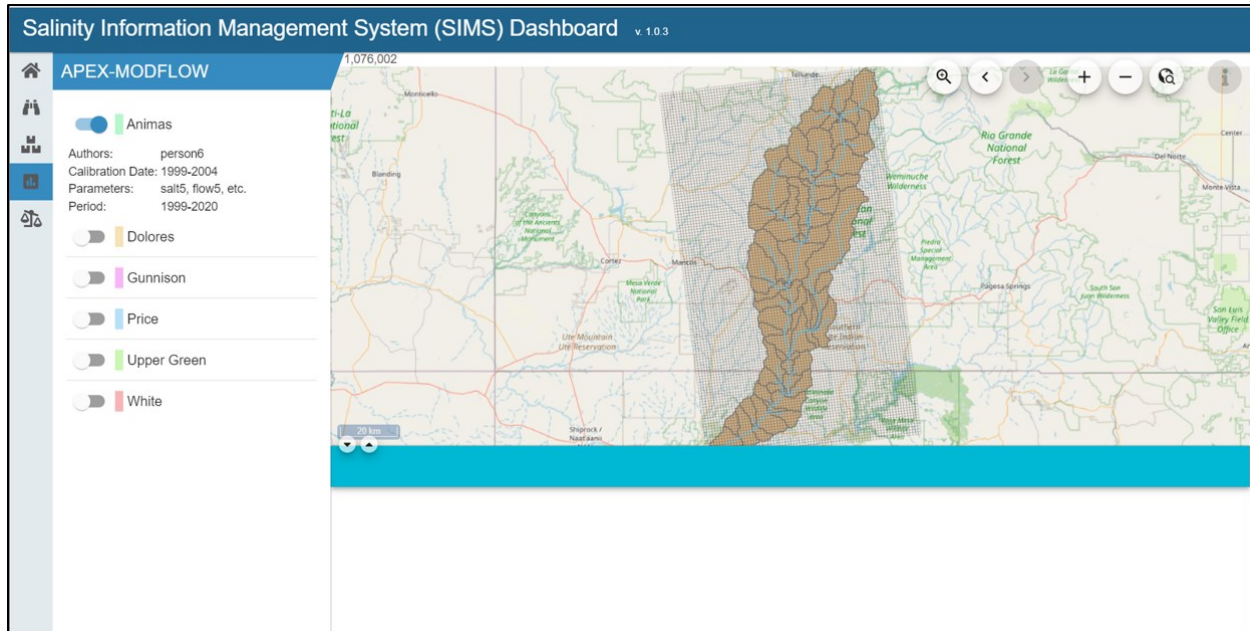


Figure 4 Metadata for APEX-MODFLOW Results

The methodology for hydrologic and water quality modeling was bifurcated into two primary approaches: process-based models and machine learning models. Process-based models, namely APEX-MODFLOW and SWAT+ national model, were used to simulate hydrology, salinity, and predict streamflow in specific watersheds in the CRB and across the entire basin, respectively.

For machine learning models, a diverse set of eleven algorithms was implemented, including linear regression, decision tree, support vector machine, random forest, gradient boosting, extreme gradient boosting, k-nearest neighbors, Gaussian process, Bayesian model, ridge regression, and neural network. Each model was trained to predict river salinity using available data and evaluated using a rigorous cross-validation technique.

This module provides an overview to users to view metadata associated with the APEX-MODFLOW models that were built to support this project. More details on the methods and purpose of these models can be found in the technical report on Hydrologic and Water Quality Modeling section “Process-based Models (APEX-MODFLOW)” subsection. Similarly, detailed results and conclusions from the modeling can be found in the Results and Discussion section in the APEX-MODFLOW Results subsection.

STEP 4 – SALINITY BALANCE SUMMARY

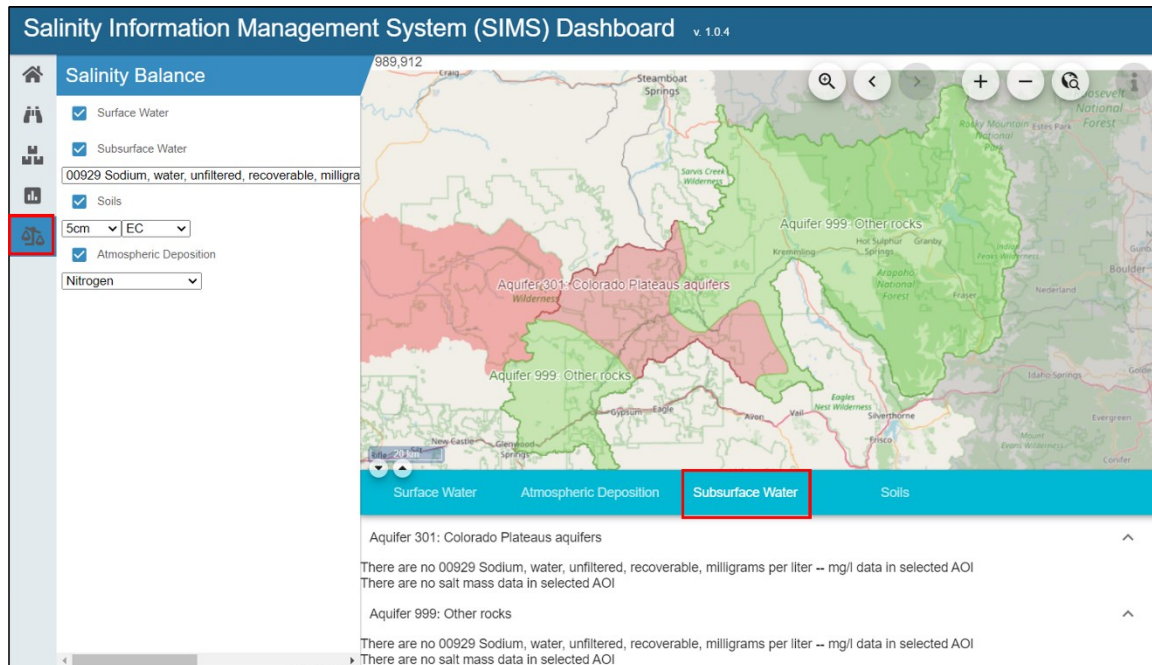


Figure 5 Salinity balance summary

The final module of SIMS is a summary section on salinity mass balance. It is here that efforts of the data collection and integration, section on soil properties, are combined with the detailed modeling results from APEX-MODFLOW, and summarized for the various components of the watershed system. Using the area selected in the earlier in [Step 1 – Define Area of Interest](#), users can interact with the detailed results for each of the categories of salt in a watershed system.

For the surface water category, SIMS includes a detailed data driven summary of salinity in surface water (instream salt loads) calculated using the USGS LoadEST model. This combines observed river discharges with observed salt concentrations for a combined total of salt loads over time at monitoring sites in the area of interest. Similarly, subsurface groundwater quality observations are summarized by salt constituent and regional aquifer unit for a summary of salinity in the wetted subsurface.

Additionally, summarized here are the SSURGO soil summaries for salt constituents and total electrical conductivity throughout the area of interest. Further details on the methodology used to develop the expanded SSURGO soils dataset for the Colorado River Basin are included in the SIMS technical report under the Methods-Soils section and Results and Discussion-Soil Properties section.

Finally, there is a specific section summarizing the salt content from atmospheric deposition (climate driven salt deposition), fed by summary of datasets generated by the National Atmospheric Deposition Program (NADP).

Together, these datasets and analysis summarize the presence and quantity of salts across and below the landscape and into the river system and were joined in analysis to inform the Trends in Salt Levels in Surface Water Bodies and Salt Level Along Streams and Rivers sections of the SIMS technical report.

VISUALIZATION & GRAPHING FEATURES

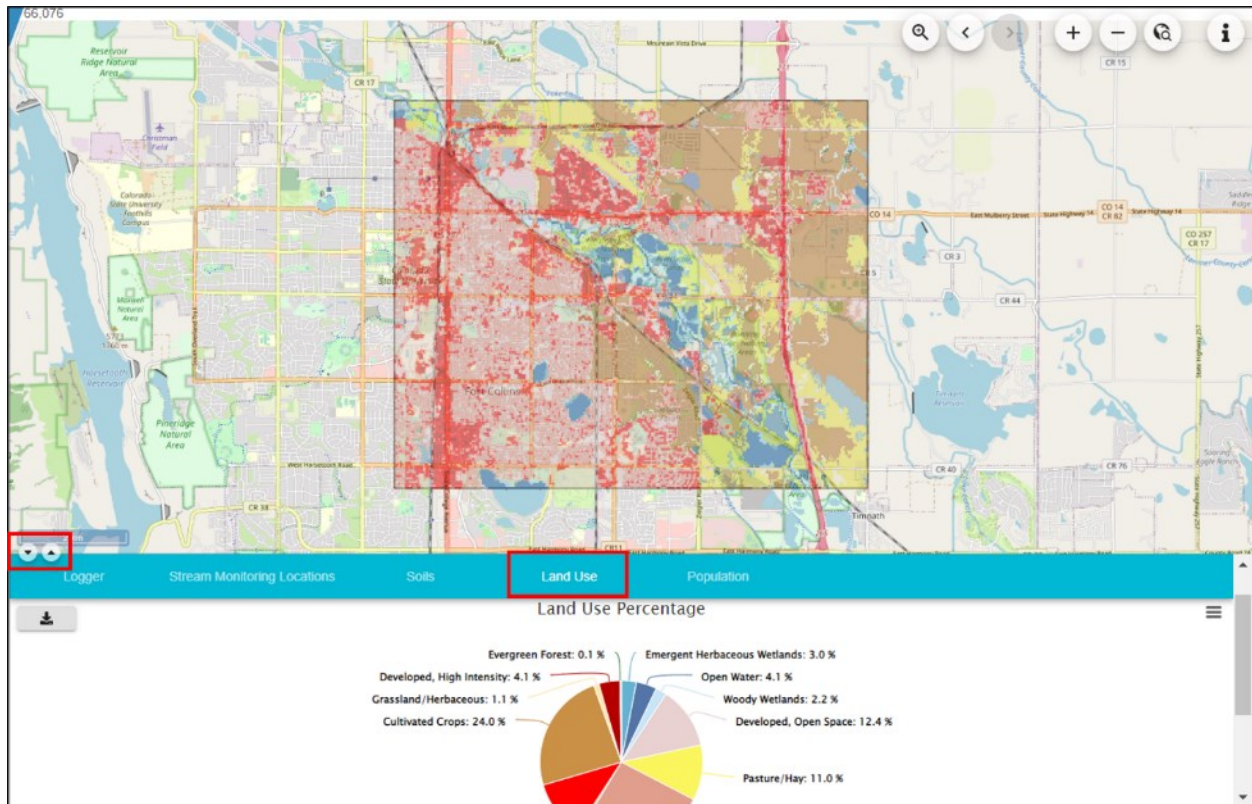


Figure 6 Analysis results example (land use) on map canvas and results table

The SIMS tool is intended to facilitate comparison of different watersheds. The tool summarizes various time series and spatial data in a consistent format to facilitate these comparisons.

Each data category is summarized using interactive maps and graphs which are accessible from the results tab(s) that automatically populate under the map canvas (Figure 6). The results tabs can be maximized or minimized and the map canvas can be hidden by clicking the arrows at the bottom left corner of the map canvas (Figure 6).

The graphs (png, jpeg, pdf, svg) as well as the raw data including time series (xls, csv) and raster maps can be downloaded from the dashboard (Figure 7). These figures are interactive and hovering your mouse over any section will reveal additional information.

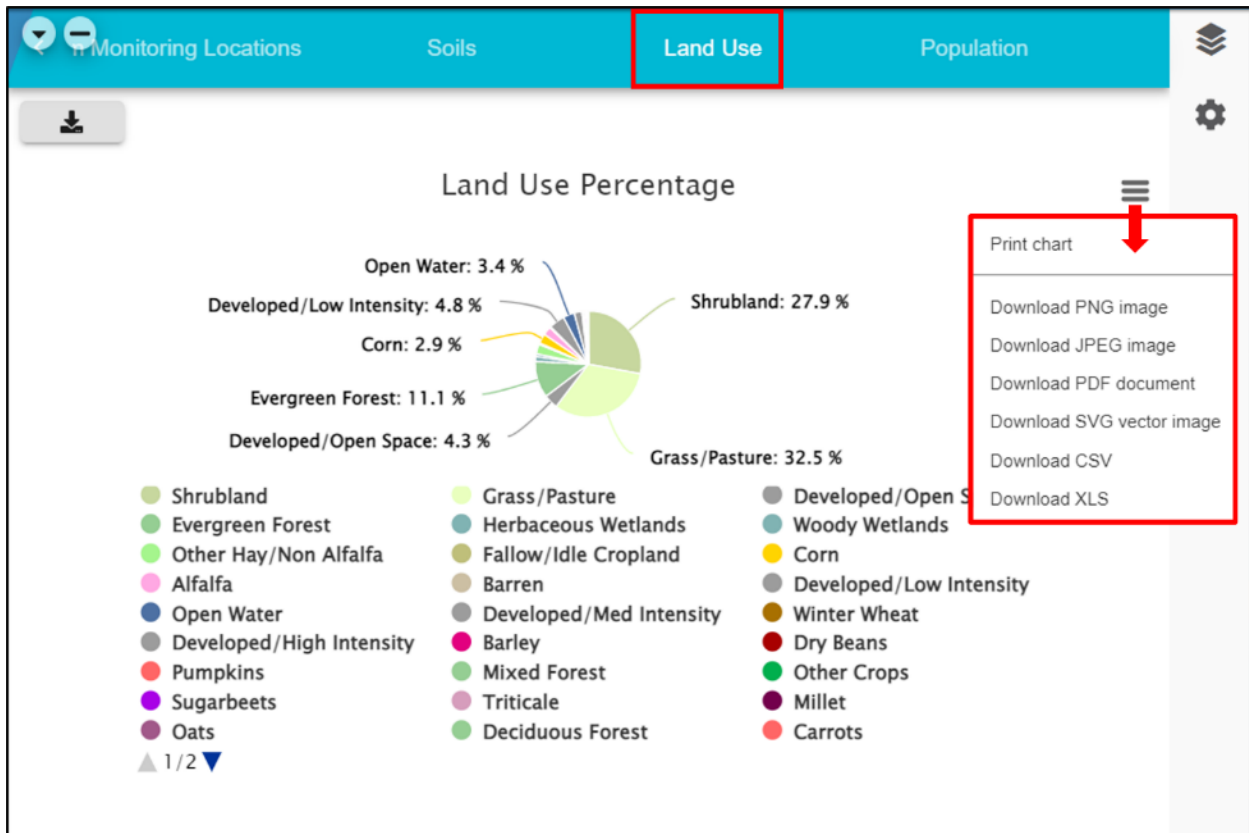


Figure 7 Example of land use analysis results and download features.