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User Manual and Instructions for

Metals Aquatic Life Criteria and Chemistry Map

(MetALiCC MAP)

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U.S. Environmental Protection Agency
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Office of Science and Technology
Health and Ecological Criteria Division
Ecological Risk Assessment Branch
Washington, D.C.

Project Team:

Luis Cruz, Office of Water, Office of Science and Technology, Health and Ecological Criteria, Ecological Risk Assessment Branch Division, Washington, DC (Lead)*

Mike Elias, Office of Water, Office of Science and Technology, Health and Ecological Criteria Division, Ecological Risk Assessment Branch Division, Washington, DC

Kathryn Gallagher, Branch Chief, Office of Water, Office of Science and Technology, Health and Ecological Criteria Division, Ecological Risk Assessment Branch Division, Washington, DC

***Please contact Luis Cruz at Cruz.luis@epa.gov for any questions or feedback on this Beta version tool and user manual**

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User Manual and Instructions for Metals Aquatic Life Criteria and Chemistry Map (MetALiCC Map) May 2022

Overview

This GIS application provides access to an interactive nationwide database to support states, tribes, and stakeholders with the derivation of bioavailability-based 304(a) freshwater aquatic life criteria values when site-specific water chemistry data are not available. Specifically, this map-based application provides access to 1) water chemistry parameter values necessary for the derivation of bioavailability-based criteria values for metals, 2) aquatic life criteria values for selected metals (currently copper and aluminum), 3) USGS NWIS water quality monitoring station locations, and 4) Major National Pollution Discharge Elimination System (NPDES) discharges for the conterminous United States.

Data used in this application were obtained from the United States Geological Service (USGS) National Waters Information System (NWIS) and Integrated Compliance Information System (ICIS) National Pollution Discharges Elimination System (NPDES) facilities databases. The database includes concurrent measurements of 11 water chemistry parameters from 43,718 samples, collected at 753 NWIS sampling stations distributed across the continental U.S. This GIS application presents data as selected percentiles (5th, 10th, 20th, 25th) of the measured water chemistry parameters at different spatial scales (USGS-NWIS station, Ecoregion Level III and Strahler Stream Order within ecoregions). Water chemistry data were additionally used as inputs into the National Recommended Copper Aquatic Life Criteria (2007) and National Recommended Aluminum Aquatic Life Criteria (2018) models to provide access to calculated criteria values for these chemicals, at the selected percentiles and spatial scales noted above. All water chemistry values used in the criteria calculations for copper and aluminum were concurrently measured to ensure representation of actual conditions present in the environment.

GIS Application Instructions

The GIS application presents data using two primary interfaces:

- 1) Map layers with water chemistry parameters and aquatic life criteria displayed at selected levels of organization (Site specific NWIS station, Level III Ecoregion, and Strahler Stream Order range within ecoregion),
- 2) Heat maps presenting the distribution of pH, DOC and water hardness in the conterminous U.S.

The following sections describe how to access each data interface.

Water Chemistry and Aquatic Life Criteria Layers.

Users can access maps and information contained within the water chemistry and aquatic life criteria layers by activating/deactivating each with the click of the mouse. The layers can be accessed via a dropdown menu appearing under the “Layers” icon at the top of the screen (Figure 1). Selecting features on a layer will open a pop-up window with associated information and each layer will have a legend indicating point location and/or ecoregion names (Figures 1 and 2).

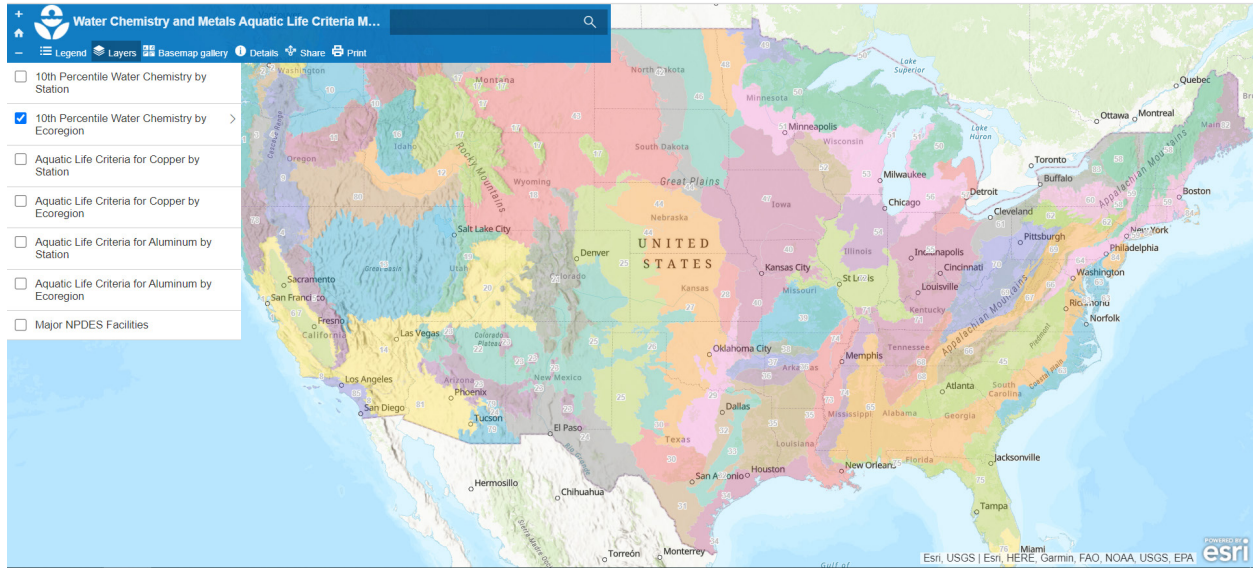


Figure 1. General map displaying Level III Ecoregions and the drop-down menu of “Layers”.

To search for a specific place, type the location name or a zip code in the space near the magnifying glass. The “-” or “+” buttons to the left of the top screen banner and/or the mouse scroll wheel can be used to zoom in or out to a specific location of interest in the map.

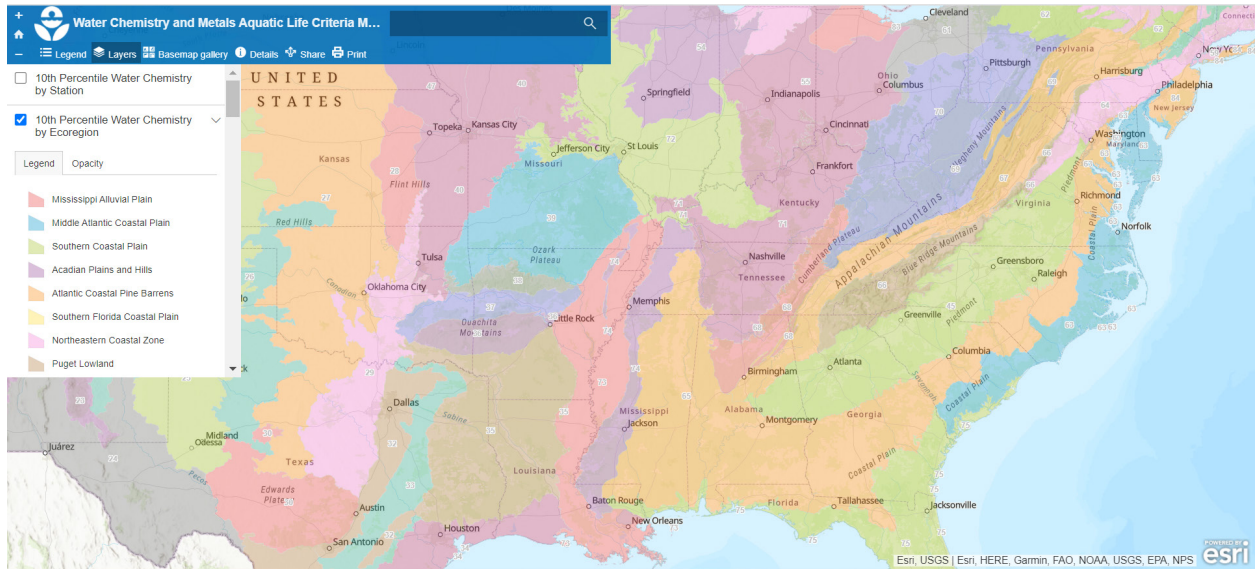


Figure 2. General map displaying Level III Ecoregions layer and the legend.

Activating layers for ecoregions will make all ecoregions visible on the map. After activating a layer, a user can access more detailed information by clicking on specific ecoregions to show a pop-up screen containing information for that ecoregion. Upon clicking on an ecoregion the borders of the ecoregion will highlight. For example, with a water chemistry layer active, users can point and click on a location and a pop-up screen will open with location information and water chemistry 10th percentile data. A user can then scroll down within the pop-up screen to access additional chemistry information and links to data (Figure 3).

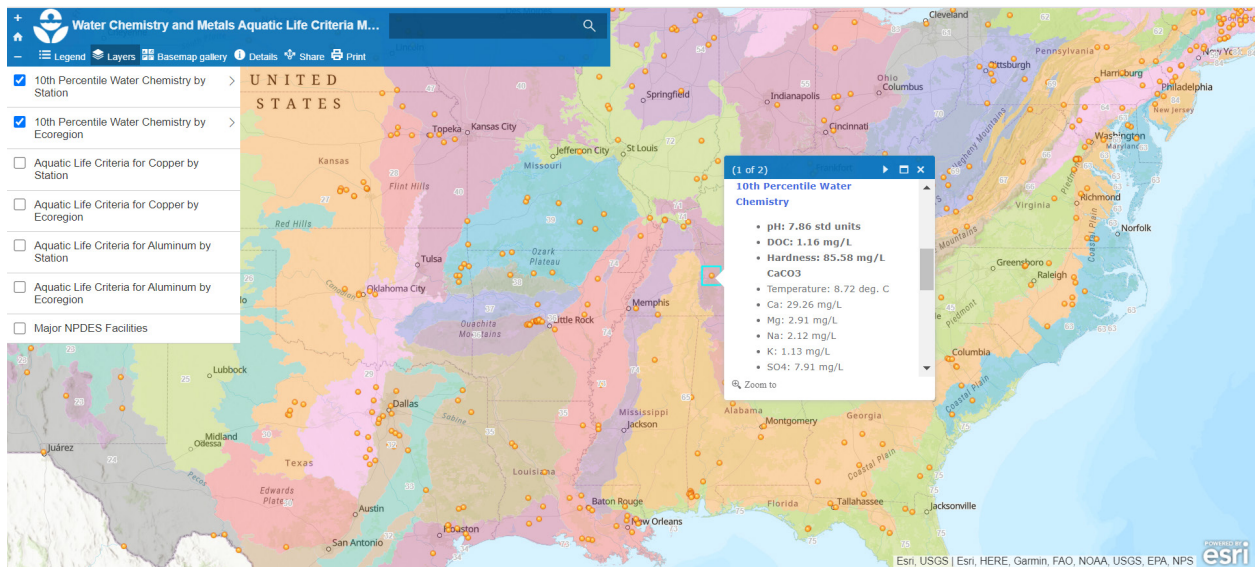


Figure 3. Map displaying Level III Ecoregions and NWIS locations. Pop-up window shows water chemistry 10th centile values for the selected NWIS location.

Users can similarly click on an ecoregion and a pop-up screen will display water chemistry information at an ecoregional level. Users can scroll down within the pop-up screen to access additional information (Figure 4).

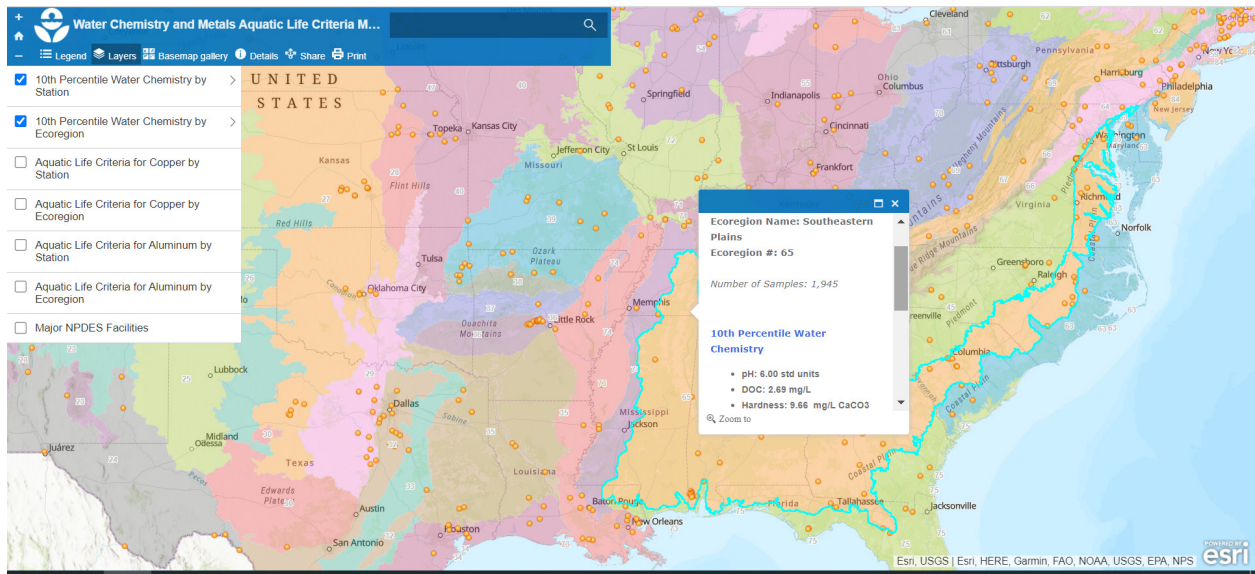


Figure 4. Map displaying Level III Ecoregions and NWIS locations. Upon clicking an ecoregion the borders of the ecoregion will highlight. Pop-up window shows water chemistry 10th centile values for the selected ecoregion.

Similar to the chemistry layers discussed above, there are layers for National Recommended Aquatic Life Criteria for aluminum and copper at the site location and Level III Ecoregion levels. The derived Cu criteria units are reported as dissolved fraction of the metal. The derived Al criteria are total aluminum. Users can again scroll down within the pop-up screen to access additional information (Figures 5 and 6).

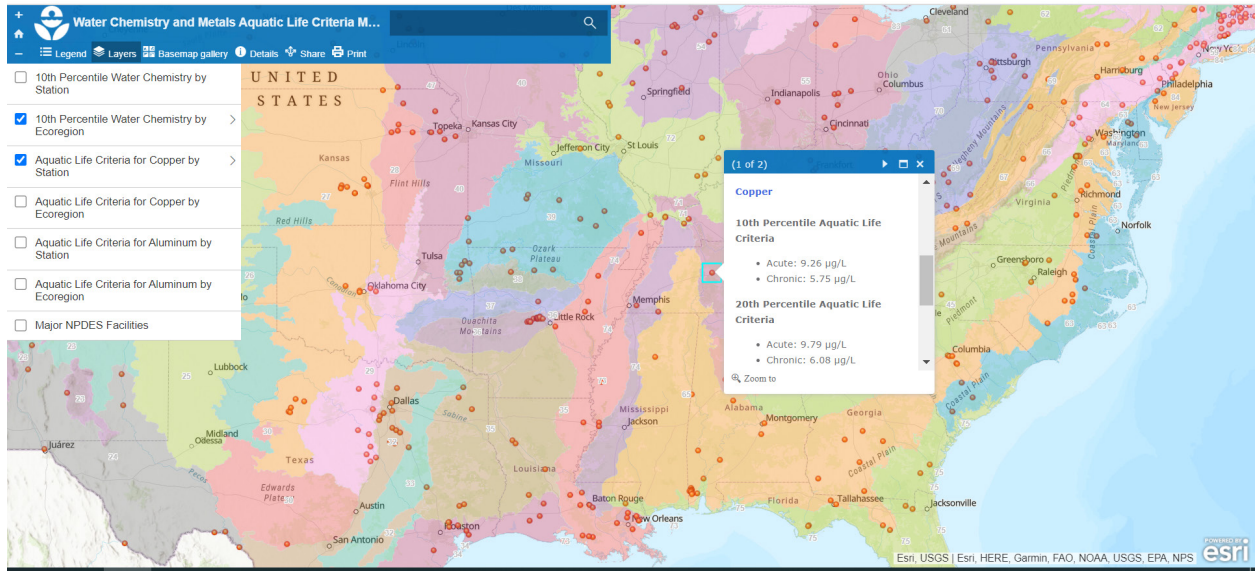


Figure 5. Map displaying Level III Ecoregions and NWIS locations. Pop-up window shows 10th centile aquatic life criteria values for the selected NWIS location.

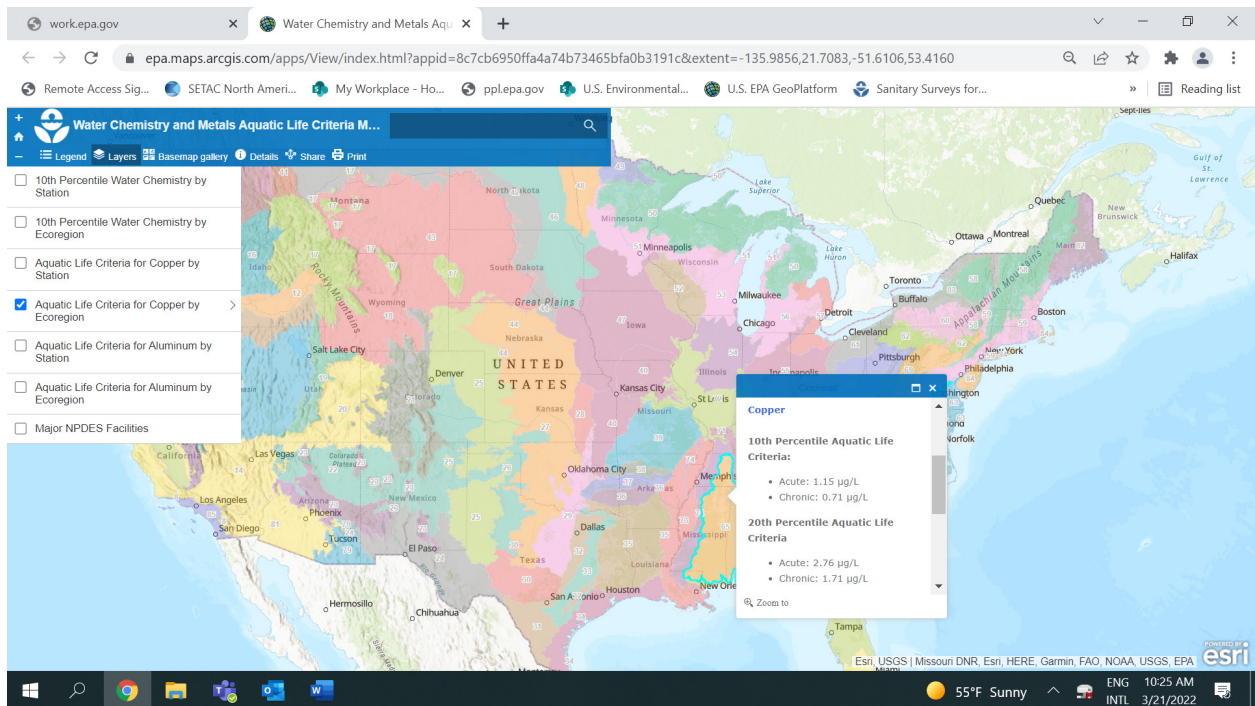


Figure 6. Map displaying Level III Ecoregions. Pop-up window shows 10th centile aquatic life criteria values for the selected ecoregion.

Users have the option to select the specific type of data they would like to access. There is information on water chemistry (temperature, pH, DOC, hardness, Ca, Mg, Na, K, SO₄, alkalinity, Cl) and aquatic life criteria for copper and aluminum at the 10th percentile level for each location. Similarly, there is water chemistry and aquatic life criteria information at the ecoregion level. Water chemistry and aquatic life criteria data are calculated at other

percentiles (5th, 20th, 25th) by stream order within ecoregions, and are accessible to download by clicking on links provided when you scroll down in the pop-up screen.

This application has information on two main features: water chemistry (WC), and aquatic life criteria (ALC). Each one of these features are further organized into geographical categories: by NWIS stations, and by Level III ecoregions. In the application there is the capability to activate different layers, but it is recommended to only simultaneously activate layers for different geographical categories. For example, the two water chemistry layers can be activated at the same time since these two layers represent different geographical categories (by station and by ecoregion), the pop-up windows will display the correct information. Similarly, when searching the aquatic life criteria layers it is again recommended to only simultaneously activate layers for different geographical categories (stations and ecoregion).

Heat Maps Presenting pH, DOC, and Water Hardness Data.

Users have access to individual heat maps with information on the distribution of pH, DOC, and hardness in surface waters of the conterminous U.S. These maps provide a visual representation of the three water chemistry parameters most important to modifying the bioavailability (and toxicity) of various metals in the environment and that are the most important inputs to the multiple linear regression (MLR) model for the derivation of the aluminium acute and chronic criteria. The heat maps present interpolations of these surface water parameters measured at NWIS locations across the continental U.S., which provide the user with information on the range of pH, DOC, and hardness values within their area of interest.

The maps can be accessed via a dropdown menu appearing under the “Layers” icon at the top of the screen. Selecting a layer will display the map for a given parameter (pH, DOC or hardness; Figure 7).

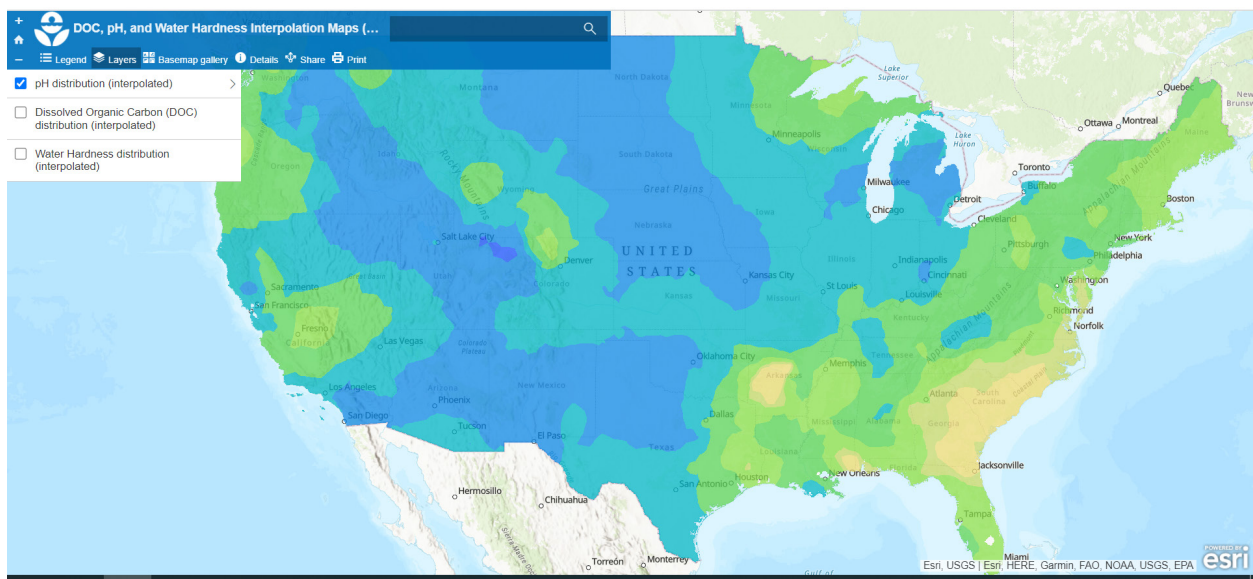


Figure 7. General map displaying heat maps and the drop-down menu of "Layers" (pH, DOC, and water Hardness).

Selecting an interpolation area on a map opens a pop-up window with the associated information for that parameter and selected area. Selecting an interpolation area opens a pop-up window showing the minimum and maximum values for the parameter, and the total area covered for that parameter in the selected interpolation area. The following figures represent heat maps for pH (Figure 8), DOC (Figure 9), and water hardness (Figure 10).

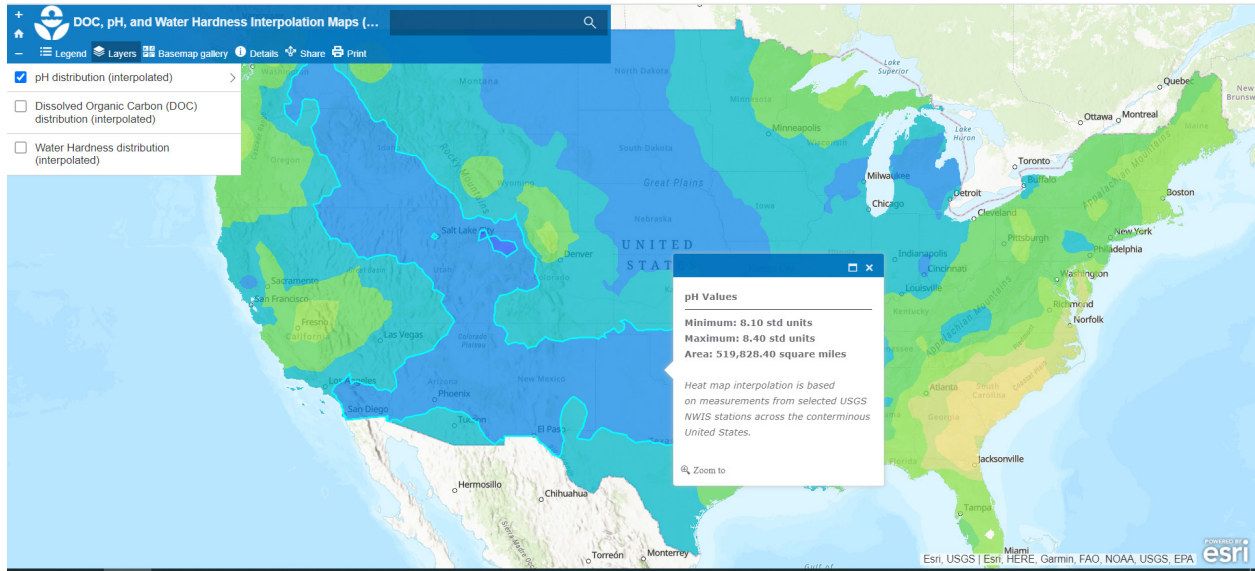


Figure 8. Map displaying the surface waters pH distribution across the conterminous U.S. Pop-up windows shows the minimum, and maximum pH values in the selected interpolation area. Clicking on an area of interpolation the borders of the area will highlight.

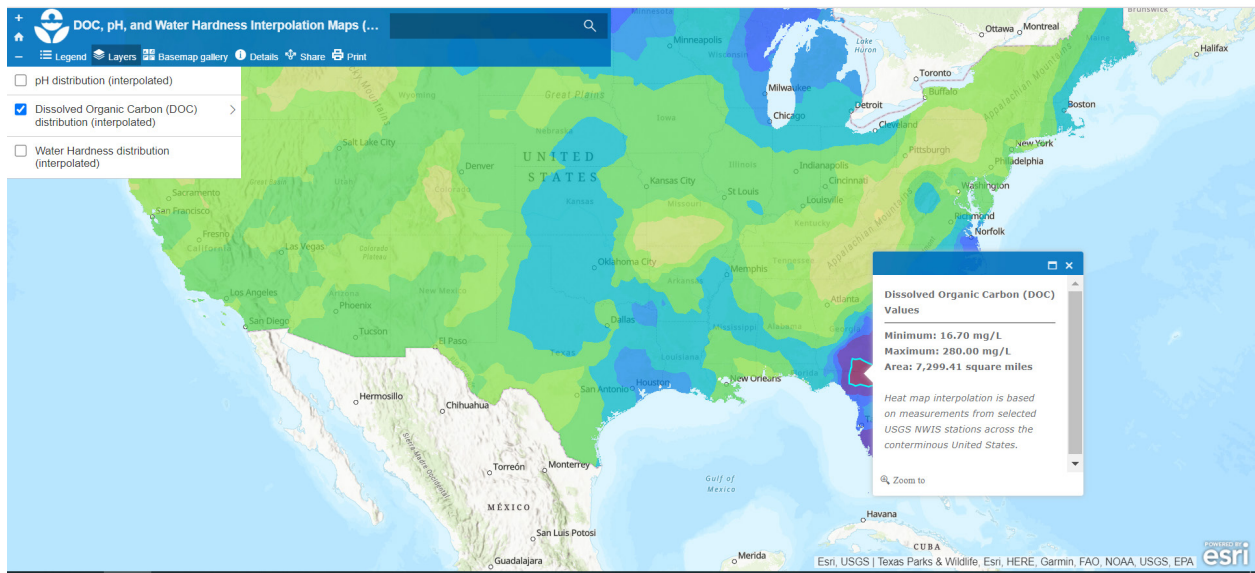


Figure 9. Map displaying the surface waters DOC distribution across the conterminous U.S. Pop-up window shows the minimum and maximum DOC values in the selected interpolation area.

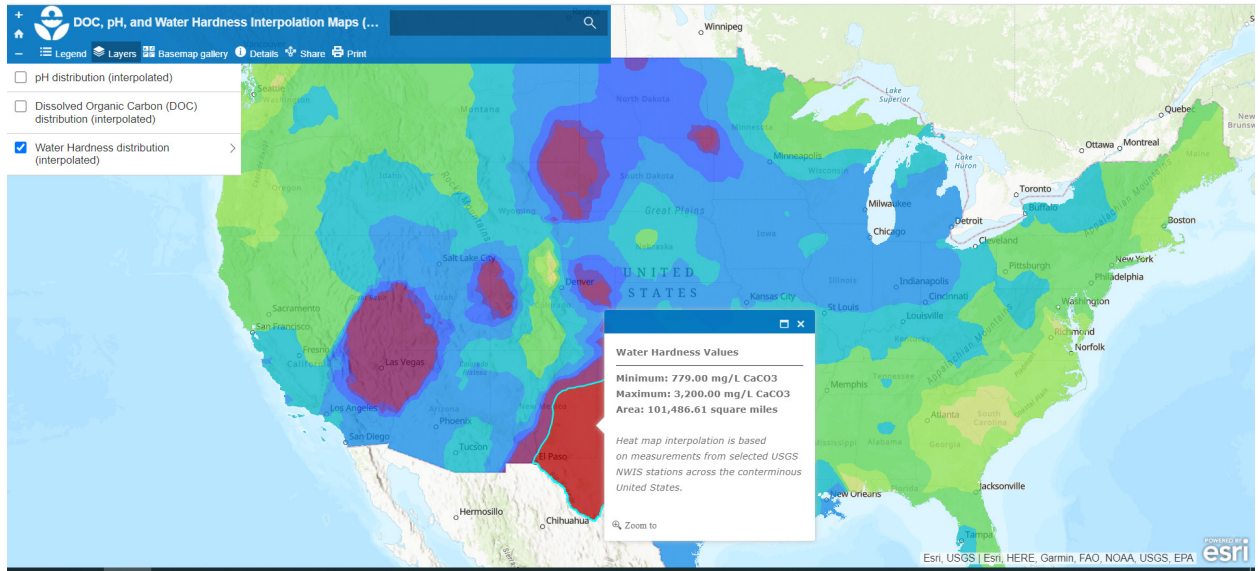


Figure 10. Map displaying the surface waters hardness distribution across the conterminous U.S. Pop-up window shows the minimum and maximum water Hardness values in the selected interpolation area.

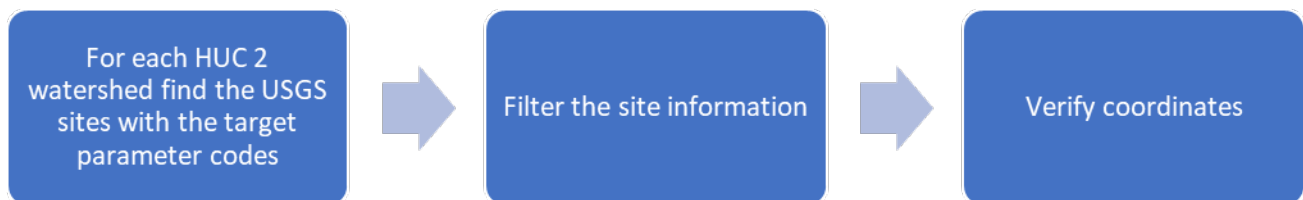
Background Information on Data Collection and Processing for Development of the EPA GIS Tool for Water Chemistry and Aquatic Life Criteria for Metals

Water chemistry data (pH, DOC, temperature, calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity, and hardness) for samples collected from rivers and streams within the conterminous United States between January 1, 1984, and February 1, 2022 were retrieved from USGS's NWIS for analysis. Water chemistry parameter concentrations are reported as dissolved fraction. Data collected prior to 1984 were excluded from analysis because several analytical methods used prior to that date have been replaced by methods with improved precision and lower detection limits.

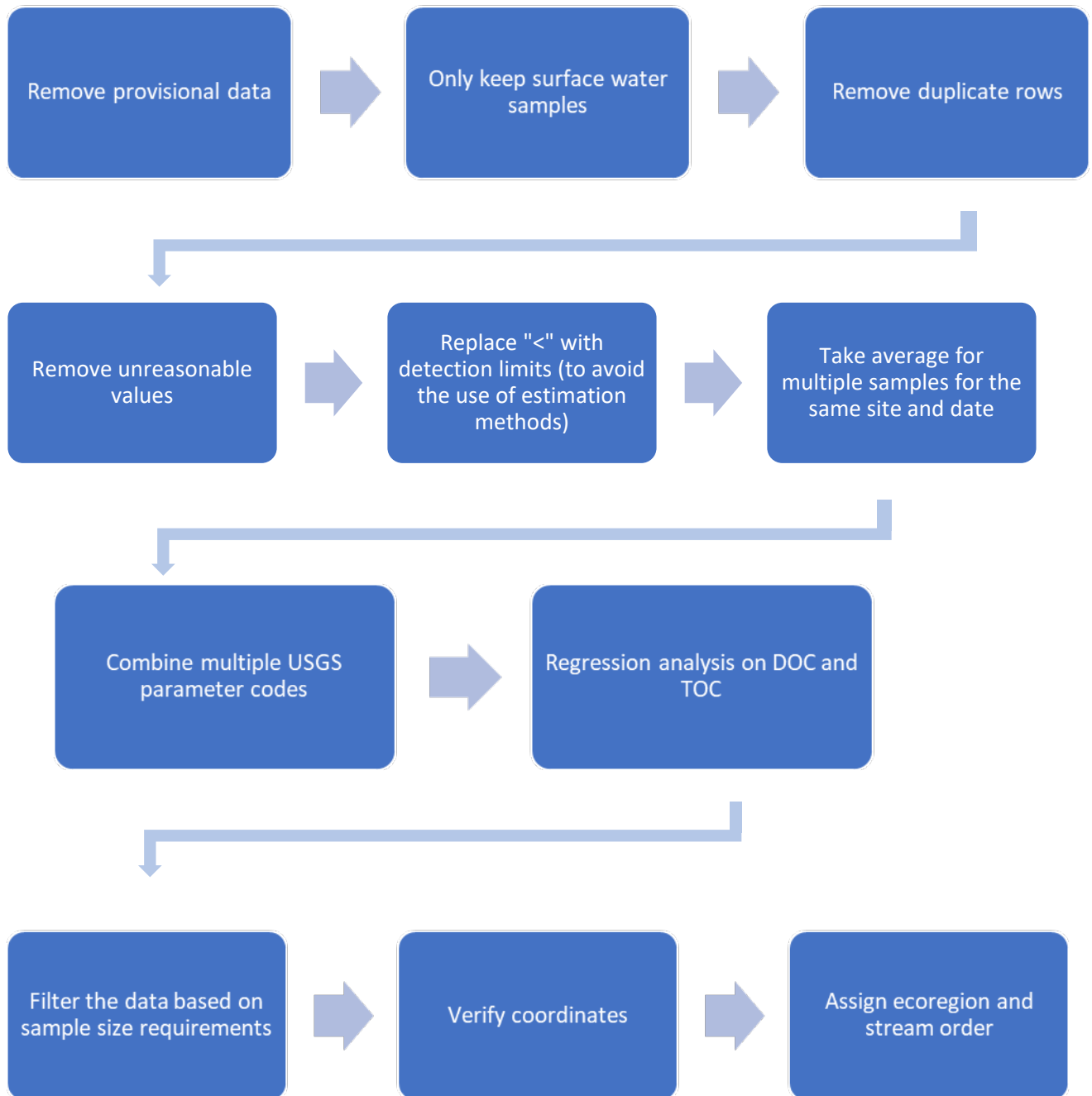
The retrieved data include concurrent measurements of all water chemistry parameters from 43,718 samples, collected at 753 NWIS sampling stations distributed across the continental U.S. At this time the application only covers the conterminous U.S. Later iterations of the application are expected to have data from states outside the conterminous U.S. (AK, HI) and territories (PR, USVI, Guam, Northern Marianas), where sufficient water chemistry data are available. The spatial coordinates (latitude and longitude) of each sampling station were also retrieved from NWIS. A geographic information system (GIS) program was used to confirm that the spatial coordinate data placed each sampling location within the continental United States. GIS was also used to determine the Level III Ecoregion (Omernik, 1987) for each sampling location, to assign the corresponding ecoregion and to determine the Strahler stream order (SO) of the 753 NWIS sampling locations. Three stream order ranges were defined: SO 1 – 3 (headwaters and small streams), SO 4 – 6 (intermediate streams), and 7 – 10 (large rivers).

The flow chart below illustrates how the downloaded data was screened for quality and processed prior to inclusion in the final database.

Data Download



Data Cleaning



Where direct measurements of DOC were not reported, a regression was constructed to determine DOC based on paired DOC and TOC measurements, to increase the number of NWIS locations with DOC measures in the database. The number of locations with DOC based on the developed regression amounted to < 6% of all the locations in the database.

Once all the data were compiled EPA:

1. Checked data to confirm that they contain numerical values without null (missing) records,
2. Removed zero values from parameters, except for water temperature,
3. Excluded data that were reported as averages for a period greater than one day,
4. Excluded data for samples that were not specifically identified as surface waters (surface waters samples were defined as streams, rivers, lakes, reservoirs, wetlands),
5. Excluded data from estuaries and coastal open waters,
6. Excluded “provisional” data (remark code P), which according to USGS “have not received the Director's approval ... and (are) subject to revision”,
7. Removed water temperature values greater than 100 degrees C, and
8. Replaced negative values for alkalinity with <0.1 mg/L, consistent with USGS procedures¹ for reporting hydroxide, carbonate, or bicarbonate concentrations.

Data Requirements

Once the data were downloaded and cleaned the resultant database was further processed to retain data from NWIS locations that met the following requirements:

1. All water chemistry parameters (Temperature, pH, DOC, Ca, Mg, Na, K, SO₄, Cl, Alkalinity and Hardness) are measured concurrently at each NWIS station,
2. All NWIS stations are located in the continental U.S.,
3. Data are one-day averages when multiple samples are taken from the same station and date,
4. All stations have data for 3 or 4 meteorological seasons with 2 or more sampled days per season, and
5. Each NWIS station was sampled 10 or more days.

In addition to the water chemistry parameters identified above, EPA included the following information in the database: sample date, season, state, EPA Region, ecoregion name, and location name.

¹ National Field Manual, Section 6.6, Alkalinity and Acid Neutralizing Capacity
(<https://water.usgs.gov/owq/FieldManual/Chapter6/section6.6/html/section6.6.htm>)

Ecoregions Without Sufficient Data

A total of 77 Ecoregion Level III areas are represented in the database. There were 8 ecoregions (9, 11, 16, 56, 66, 76, 78, 80) that did not have enough data to fulfill requirements for inclusion. There are non-concurrent measured water chemistry data available in the NWIS dataset that were substituted in for these ecoregions. For these ecoregions EPA collected measured water chemistry parameters values relaxing all data requirements imposed for inclusion in the database. Non concurrently measured water chemistry parameters values were collected from all NWIS locations within the aforementioned eight ecoregions. For each parameter, various percentiles (5th, 10th, 20th and 25th) were calculated and used for representation of each water chemistry parameter for each of these eight ecoregions.

GIS NWIS National Database

The resulting database includes concurrent measurements of all evaluated water chemistry parameters for 43,718 samples. Selected percentiles (5th, 10th, 20th, 25th) were derived for each water chemistry parameter from the concurrently measured data and arrayed into three categories: Site-specific NWIS stations, Ecoregion level III, and Stream Order range within ecoregion. The concurrent water chemistry measurements were used as inputs into the National Recommended Aquatic Life Criteria for copper (2007) and aluminum MLR (2018) to derive acute and chronic criteria. Selected percentiles (5th, 10th, 20th, 25th) were calculated from the criteria outputs and arrayed into the three categories listed.

References

U.S. EPA Office of Water (2007). Aquatic Life Ambient Freshwater Quality Criteria – Copper 2007 Revision. EPA 822-R-07-001.

U.S. EPA Office of Water (2018). Final Aquatic Life Ambient Water Quality Criteria For Aluminum 2018. EPA-822-R-18-001.