ORNL/TM-2022/2389

NPD Classification Tools – User Guide
NPD Explorer and NPDamCAT Apps

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March 2022

OAK RIDGE National Laboratory

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Environmental Sciences Division

NPD CLASSIFICATION TOOLS – USER GUIDE
NPD EXPLORER AND NPDAMCAT APPS

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Prepared by
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1. ABOUT NON-POWERED DAM EXPLORATION AND CLASSIFICATION

1.1 BACKGROUND

The existing infrastructure at non-powered dams (NPDs) presents a variety of opportunities from generating electricity and economic value to the myriad services they provide. However, it also presents a significant challenge because aging structures must be maintained, and changes to the ecosystems and river systems by NPDs must be managed. The various stakeholders interested in these opportunities and challenges require varying information about NPDs; in many cases, interest in NPDs can extend across the entire population of dams. Even when interest is more narrowly focused on an individual dam or a small subset of dams, understanding how these dams relate to the broader context of NPD infrastructure can be important.

As noted in TM 2021/2155, "Each NPD has unique characteristics describing its design, operation, environmental impacts, social impacts, and economic potential. The large number of dams, the diversity of interests related to dams, the variety of dam characteristics, and the types of data required to describe dams all pose major challenges to an analysis of the entire dam population" [1].

This user guide describes two web-based tools that facilitate exploration of dams from a variety of perspectives: the NPD Explorer and the NPD Custom Analysis and Taxonomy (NPDamCAT). These tools facilitate access to information about dams and help users interact with the information, making small- to large-scale analyses more convenient for a broad set of stakeholders.

NPD exploration and classification tools facilitate understanding and analysis of NPDs in ways that accommodate diverse stakeholder interests.

Hydropower developers, researchers interested in dam safety or opportunities to retrofit or remove dams, and energy and water resource system modelers often need to filter the large population of dams into smaller subsets based on unique objectives or geographic interest. These stakeholders may need to explore variability among a subset or between groups of dams. The NPD Explorer and NPDamCAT apps lead these various stakeholders to information that helps them make decisions. For example, stakeholders can use the apps to identify dams that meet criteria for various opportunities, determine bounds of characteristics for certain dams, or identify representative dams for detailed analysis.

1.2 TOOL DESCRIPTIONS

The NPD Explorer tool is accessible via the HydroSource platform and the NPDamCAT tool can be accessed as a widget within NPD Explorer. Each tool serves a specific purpose by providing distinct avenues for the user to explore and interact with NPD data. The Venn diagram in Figure 1 highlights unique features of each tool and summarizes areas of overlap between the tools and the HydroSource Data Explorer app.

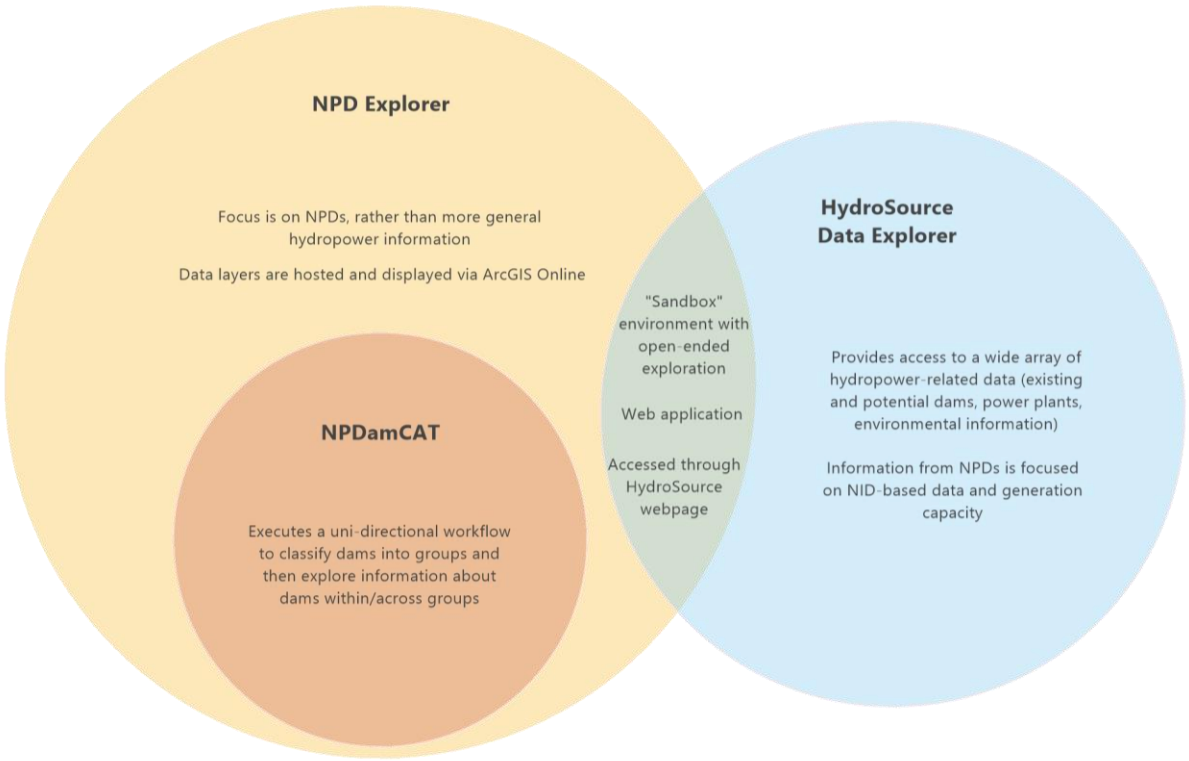


Figure 1. Tools that facilitate exploration and understanding of NPDs.

Clear areas of significant overlap exist between the tools: the HydroSource Data Explorer and NPD Explorer apps both provide an open-ended sandbox environment in which the user can easily sift through data layers, build up visualizations, deconstruct those visualizations, and explore something new. These apps are meant to be open ended in terms of features and ways in which a user interacts with the data. However, these two apps differ starkly in their scope: the HydroSource Data Explorer app is geared specifically toward hydropower and includes data sets such as operational/retired hydropower plants, whereas the NPD Explorer app is focused more narrowly on NPDs (not necessarily the other power-related data sets), taking a comprehensive, or holistic approach to NPDs, targeting a broader audience beyond hydropower development.

Although the NPD Explorer and the NPDamCAT apps share a similar focus (NPDs) and have similar scopes, they provide distinctly unique experiences for the user. The NPD Explorer app emphasizes the interactive mapping interface, and data are primarily viewed from a spatial perspective. Although the NPDamCAT app provides some limited geo-visual capabilities, it emphasizes completing a specific workflow (not open-ended exploration) to group dams and to analyze those groups.

Because the NPDamCAT app offers a focused avenue for exploring NPD data, it is considered one of several tools offered to users through the NPD Explorer app. Both apps use the same version of NPD data (see Appendix A for more details on the data and sources included) and offer some limited communication. For example, subsets of data downloaded from the NPDamCAT app can be ingested and viewed in the NPD Explorer app, though there are currently some constraints on which NPD Explorer functions can be applied to user-uploaded data.

1.3 HOW TO ACCESS THE TOOLS

The NPD Explorer can be accessed through the HydroSource Tools web page. This web page contains a collection of data exploration and analysis tools and can be found at hydrosource.ornl.gov/tools. The NPD Explorer app is hosted through ArcGIS Online and can be found at NPD Explorer beta (arcgis.com). The NPDamCAT app is included as a widget within the NPD Explorer but can also be found at https://npd-data.ornl.gov/.

1.4 LIMITATIONS FOR TOOL FUNCTIONS, DATA AND USER APPLICATIONS

There are several notable limitations to current tool functionalities that may constrain how users interact with and analyze information within these tools. These limitations include:

- While the NPD Explorer allows users to upload their own datasets, including outputs of the NPDamCAT app, there are size limits on custom datasets uploaded for visualization and exploration in the NPD Explorer. Currently, user-provided layers are limited to a maximum of 1000 individual features.
- The NPDamCAT app includes options for visualizing summaries of characteristics within groups of dams. However, groups with large numbers of dams will not be able to display all individuals and users may need to select smaller subsets of dams to display.

The tools described in this user guide are built to display an extensive array of characteristics for NPDs in the US. The underlying data may be subject to issues related to spatial accuracy of the source data (National Inventory of Dams [NID]; [1]). As dam location information and operational status are updated in future versions of the NID, the information reflected in the tools may need to be updated. Users are encouraged to reference the latest version of the user guide and refer to Appendix A for versions of sources used in assembly of the NPD data and Appendix B for explanations about any adjustments, quality checks, and transformations to the NPD data.

These tools are intended to provide opportunities for preliminary exploration of NPDs and NPD-related information. The information contained in these tools are not intended to supplant detailed site-specific analysis or final decision making. Neither Oak Ridge National Laboratory (ORNL) nor the US Department of Energy (DOE) approves of the use of these results in support of site-specific permit applications to the Federal Energy Regulatory Commission (FERC).

2. NPD EXPLORER

2.1 APP OVERVIEW

The NPD Explorer tool is a sandbox-type platform where the user can interact with and explore NPD characteristics and spatial data from across the United States. The basic functionality of NPD Explorer falls into three categories: data layers, selections and filters, and data interactivity.

- Data layers provide geospatial information about different NPD and landscape characteristics. NPD Explorer includes 12 data layers or layer groups, each with numerous attributes that provide valuable context.

- The user filters and spatial selection functions allow the user to input specific search criteria, visualize results, and download data summaries. Currently, NPD Explorer has more than 120 NPD attributes that the user can query.

- The user can interact with data by performing common tasks, such as selecting and identifying spatial features and creating dynamic heatmaps, infographics, and charts that summarize query results and key NPD attributes.

2.1.1 Customizable User Interface

The NPD Explorer user interface (Figure 2) consists of common map interface tools that allow the user to search for places, zoom in or out, and select features of interest to obtain feature attribute information. The following map widgets (Figure 3) allow the user to customize the mapping application to meet their needs:

- **Basemap Gallery.** Presents a gallery of basemaps and allows the user to select one from the gallery for their web map.

- **Layer List.** Provides a list of operational layers and their symbols and allows the user to turn individual layers on and off. Each layer in the list has a checkbox that allows the user to control its visibility. Some layers contain sublayers or subtypes. The order in which layers appear in this widget corresponds to the layer order in the map; the user can change the order of layers in the map by changing the order of layers in the widget.

- **Legend.** Displays labels and symbols for layers in the map. The legend automatically updates when the visibility of a layer or sublayer changes. The order in which layers appear in the **Legend** widget corresponds to the layer order in the map.

- **Add Data.** Allows the user to add data to the map by searching for layers in ArcGIS online content (includes thousands of data layers), entering URLs, or uploading local files. The user can temporarily add or remove layers but cannot save the layers to the map. This widget also allows the user to add data layers downloaded from the NPDamCAT app to view and interact with them on the map.

- **Bookmark.** Stores a collection of map view extents (i.e., spatial bookmarks).

- **Draw.** Allows the user to draw simple graphics and text on the map, providing basic sketching and markup functionality to a web app.

- **Measurement.** Allows the user to measure the area of a polygon or length of a line or to find the coordinates of a point.

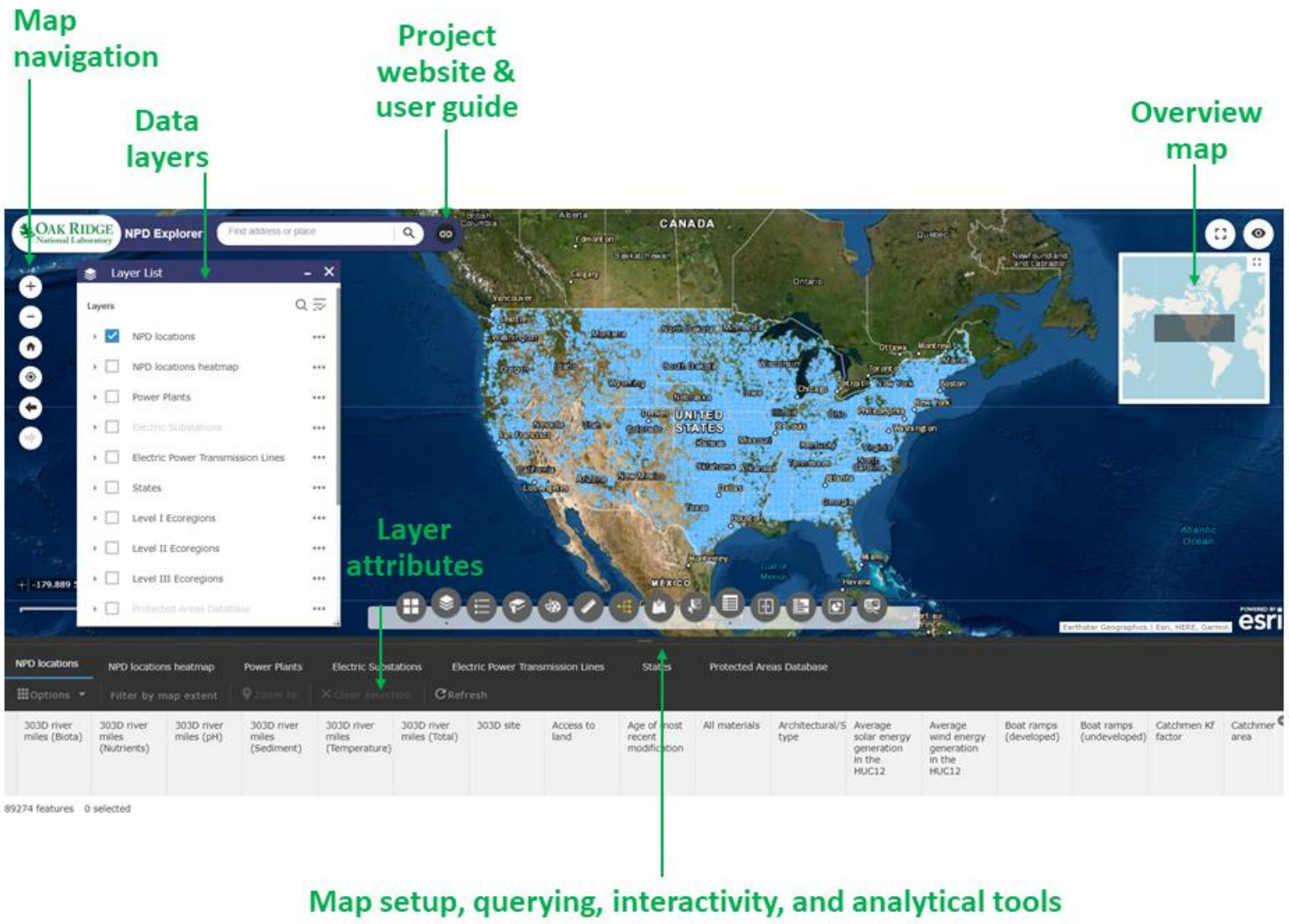


Figure 2. User interface of NPD Explorer.

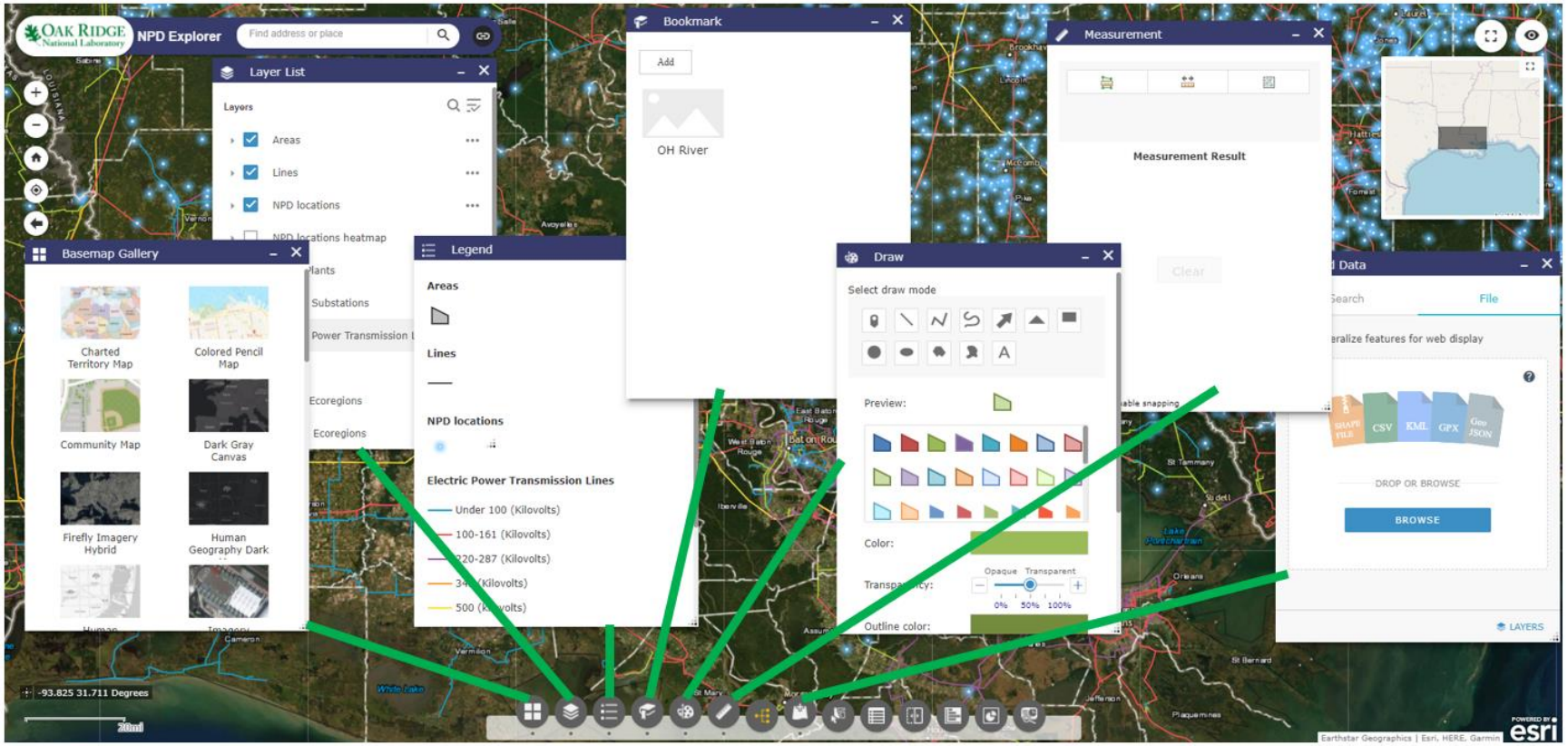


Figure 3. Map tools. (From left to right: **Basemap Gallery**, **Layer List**, **Legend**, **Bookmark**, **Draw**, **Measurement**, and **Add Data** tools).

2.1.2 Widgets for Selecting or Querying Data and Creating Infographics

The NPD Explorer user interface also includes widgets (Figure 4) that give the user the ability to select, filter, and interact with dynamic infographics and heatmaps. An overview of these widgets follows, and the functionality of these widgets is further explored following the overview.

- **Select.** Allows the user to interactively select features on the map and take actions on the selected features. The selected features can be saved in the app as a layer and can also be exported and saved locally for desktop analysis. The infographics dynamically respond to selections made with the **Select** widget.

- **Filter and View Attributes.** Displays a tabular view of operational layer attributes at the bottom of the screen that can be resized or closed. When attribute tables for more than one are displayed, multiple tabs are generated, allowing the user to switch among the attribute tables. The user can use an expression builder to filter and create subsets of NPD features with any combination of more than 120 NPD attributes and can export selected features, filtered features, or entire attribute tables to comma-separated value (CSV) files. All infographics use the NPD locations layer as their source data, so any filters or selections made in the attribute table view will be applied to the infographics.

- **Infographics by Theme.** Allows the user to visualize and monitor attributes and statistical data in the map for NPD features. The visualization graphs generated by this widget are dynamic; they refresh when the map extent or data source changes via filtering or selections, and they are interactive with the map. The user can view and interact with infographics through seven NPD data themes. From left to right in the app, these themes are design, climate, geology, hydrology, landscape, water quality, and hydropower opportunity and operations.

- **Power Potential, Head, and Flow Infographic.** Allows the user to pan the map and dynamically view a chart of generation potential (for NPDs with generation potential greater than 1 MW), hydraulic head, and flow characteristics for NPDs in the map view. This widget is a dynamic infographic linked to selection and filtering tools.

- **NPD Locations and Heatmap Swipe.** Allows the user to easily compare the content of the **NPD locations** or **NPD locations heatmap** layers to other layers in the app. The user can slide the swipe tool or move the mouse to reveal the content of another layer.

- **Summarize Nearby Grid Features.** Allows the user to define an area of interest (AOI) and summarize AOI overlap with existing power plants, transmission lines, and substations. The AOI can be defined by performing a place name search, by drawing on the map, by uploading a shapefile, or by entering a traverse with coordinate and distance pairs. Analysis results can be inspected in the widget or shared via a printed report, CSV file download, or feature download.

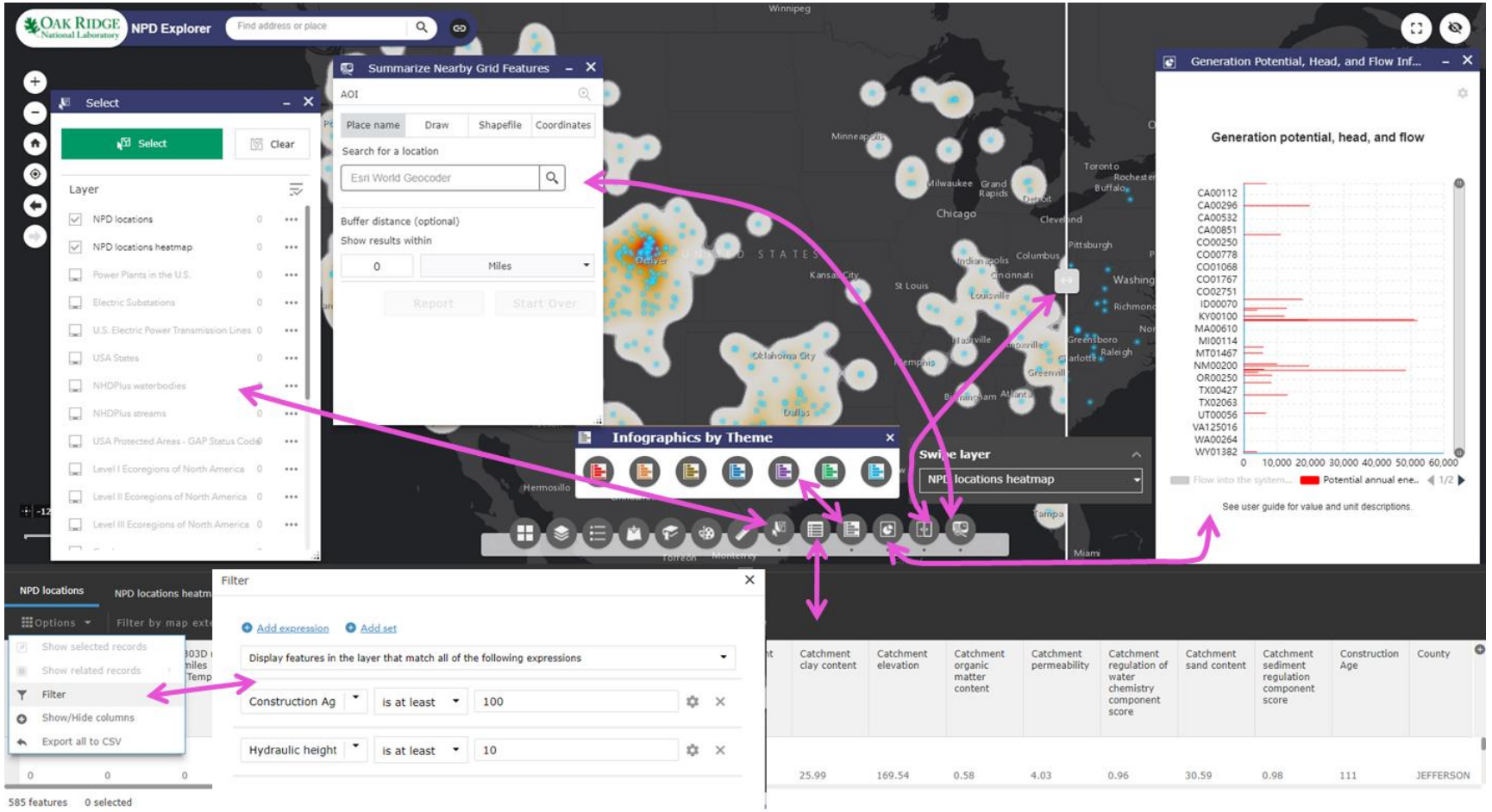


Figure 4. Select, filter, infographics, and swipe tools. (From left to right: **Select**; **Filter and View Attributes**; **Infographics by Theme**; **Generation Potential, Head, and Flow Infographic**; **NPD Locations and Heatmap Swipe**; and **Summarize Nearby Grid Features**).

2.2 VIEWING INFORMATION IN THE NPD EXPLORER

2.2.1 Displaying Basemaps and Available Data Layers

The user can change the background basemap (e.g., aerial imagery, topographic, street map) and overlying data layers using the **Basemaps Gallery** and **Layer List** widgets, respectively. The data layers included in NPD Explorer are as follows:

- **NPD locations.** Provides locations of NPDs based on the NID. These dams have been geo-enriched by the US Department of Energy's ORNL with many attributes deemed relevant for the user to explore NPD characteristics and patterns across the United States.

- **NPD locations heatmap.** Shows NPD density; a filter can be applied to layer an attribute table, which updates the heatmap density calculation.

- **Hydropower Dams.** Shows locations and installed capacities of dams identified in the NID as having hydropower generation capabilities or those that are co-located with a hydropower plant (as detailed in the Existing Hydropower Assets dataset [2]).

- **Power Plants.** Uses data from the Energy Information Administration (EIA) and depicts all operable US electricity-generating plants by energy source.

- **Electric substations.** Represents electric power substations primarily associated with electric power transmission. . In this layer from the Homeland Infrastructure Foundation-Level Data (HIFLD) catalog, substations are considered facilities and equipment that can switch, transform, or regulate electric power at voltages equal to or greater than 69 kV. Substations with a maximum operating voltage less than 69 kV may be included, depending on the availability of authoritative sources, but coverage of these features should not be considered complete. This layer is unavailable (grayed out) unless the map is sufficiently zoomed in.

- **Electric power transmission lines.** Represents electric power transmission lines from the HIFLD catalog. Transmission lines are the system of structures, wires, insulators, and associated hardware that carry electric energy from one point to another in an electric power system. Lines are operated at relatively high voltages ranging from 69 up to 765 kV and can transmit large quantities of electricity over long distances. Underground transmission lines are included when sources were available.

- **States.** Shows the boundaries of the 50 US states.

- **Level I, II, and III Ecoregions of North America.** Divides North America into 15 broad, level I ecological regions, 50 level II regions nested within the level I regions, and 182 level III regions nested within level III regions. These regions highlight major ecological areas and provide the broad backdrop to the ecological mosaic of the continent, providing context on global or intercontinental scales.

- **Protected Areas Database.** Shows a comprehensive map of lands protected by government agencies and private landowners. This layer is from the Protected Areas Database of the United States. This database combines federal lands with information on state and local government lands and conservation easements on private lands to create a powerful resource for land-use planning.

- **NHDPlus V2.1 - Flowlines.** Shows streams and rivers from the National Hydrography Dataset Plus version 2.1

- **NHDPlus V2.1 - Waterbodies.** Shows lakes and ponds from the National Hydrography Dataset (NHD) Plus version 2.1

- **NHDPlus V2.1 - Catchments.** Shows polygons representing the unique area draining to each NHDPlus stream reach.

- **Watershed Boundaries.** Shows the perimeter of drainage areas formed by the terrain and other landscape characteristics. This layer is from the National Watershed Boundary Dataset (WBD). The drainage areas are nested within each other, so a large drainage area (e.g., hydrologic unit code-2 [HUC-2]) will be composed of multiple smaller drainage areas (e.g., HUC-4, 6, 8, etc.). Each of these smaller areas can be further subdivided into successively smaller drainage areas (e.g., HUC-10, 12).

Each data layer has numerous attributes of potential interest to NPD stakeholders. The user can turn layers on or off and move layers up or down using the layer list widget to change the layer display order. Once layers of interest are turned on, the user can select features of interest to view their attributes in a pop-up window (Figure 5). If the user selects overlapping features, then multiple overlapping pop-up windows will be displayed. The user can toggle through these windows using the left/right arrows in the pop-up window to see the different feature attributes. The ellipsis on the bottom right corner of the pop-up window offers the option to view the feature attributes in the attribute table across the bottom of the app window. The user can also export feature attributes to a CSV file that can be imported to Microsoft Excel or other programs that can read text files. These text files can also be imported as spatial data into spatial analysis/mapping platforms using the latitude and longitude coordinates.

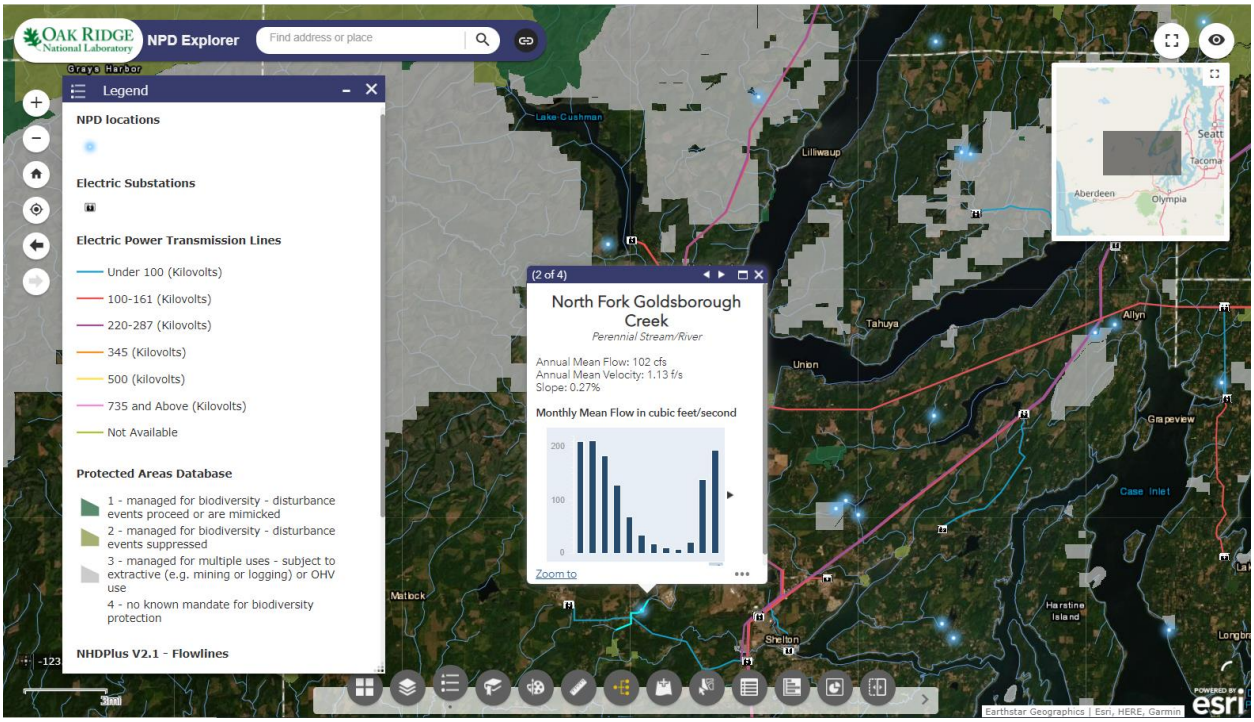


Figure 5. Layer interactivity. (In this example, the user turned on the **Electric substations**, **Electric Power Transmission Lines**, **NPD locations**, **NHDPlus V2.1 - Flowlines**, and **Protected Areas Database** layers, zoomed in to northeast Washington state, and selected **NHDPlus stream** at an NPD location to view a monthly mean flow graph for the stream reach).

The user can select features (Figure 6) in all layers included in NPD Explorer. This action is best accomplished by launching the **Layer List** and **Select** widgets, turning on the layers of interest, activating the **Select** button in the **Select** widget, and dragging a polygon on the map to select features within an area of interest. By going to the ellipsis next to a layer in the **Select** widget, the user can create a new layer in the map of the selected features, zoom to the selection, export data as a CSV or GeoJSON, and view the selected features in the attribute table.

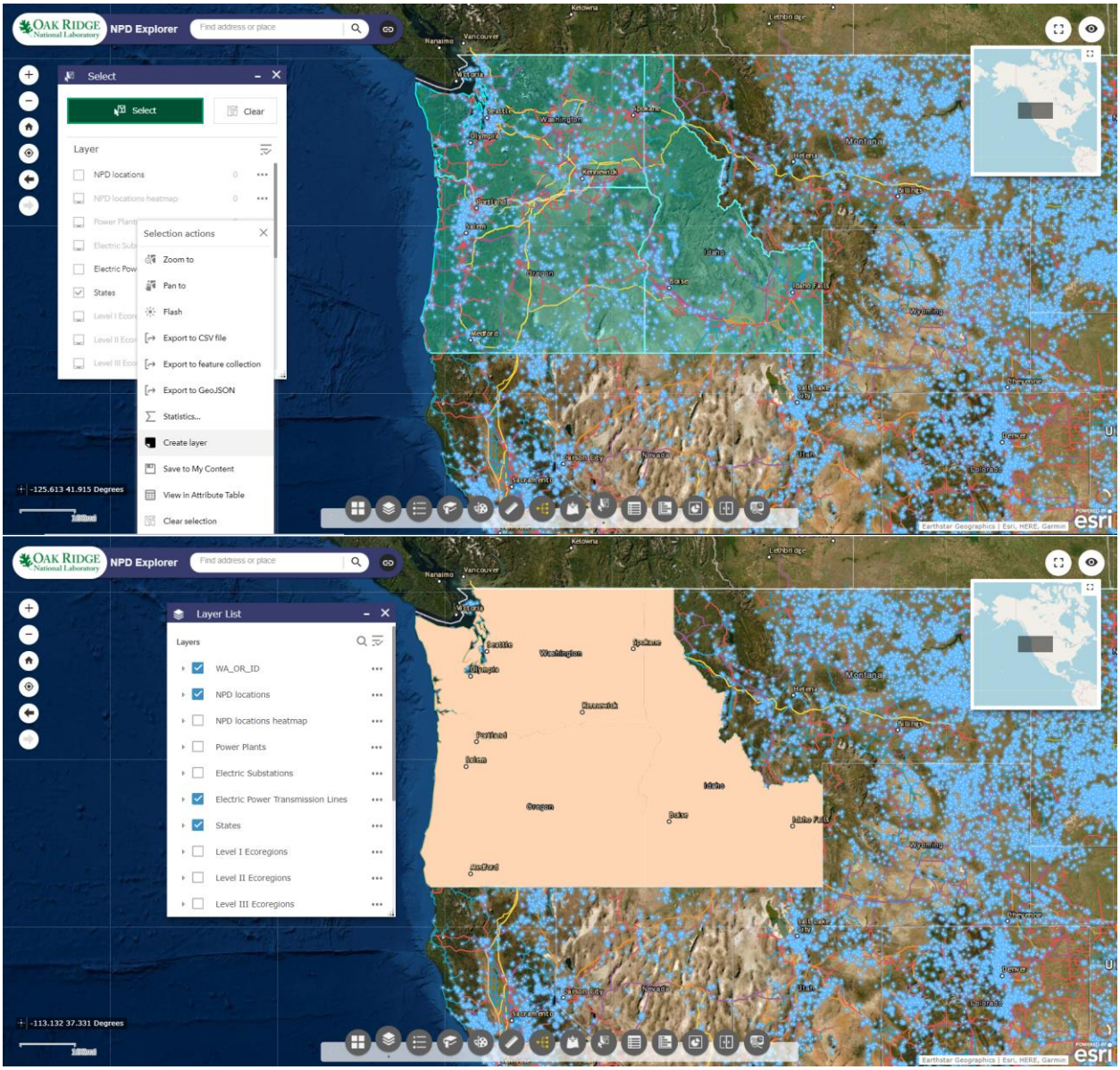


Figure 6. Feature selections. (In this example, the user turned on the **NPD locations**, **States**, and **Electric Power Transmission Lines** layers, used the **Select** widget to select Oregon/Washington/Idaho, and created a new layer in the map called the **WA_OR_ID layer**).

2.2.2 Swiping to display NPD locations and NPD density heatmap

Another feature for viewing NPD locations is the ability to dynamically swipe between displaying locations and viewing the underlying geographic features (i.e., other layers, features visible on the

basemap). With the **NPD Locations and Heatmap Swipe** widget, users can drag an overlay layer across the interface to either display all features or hide and view underlying layers (Figure 7). To swipe with a particular layer (either NPD locations or the NPD locations heatmap), the respective layer needs to be turned on in the layer list.

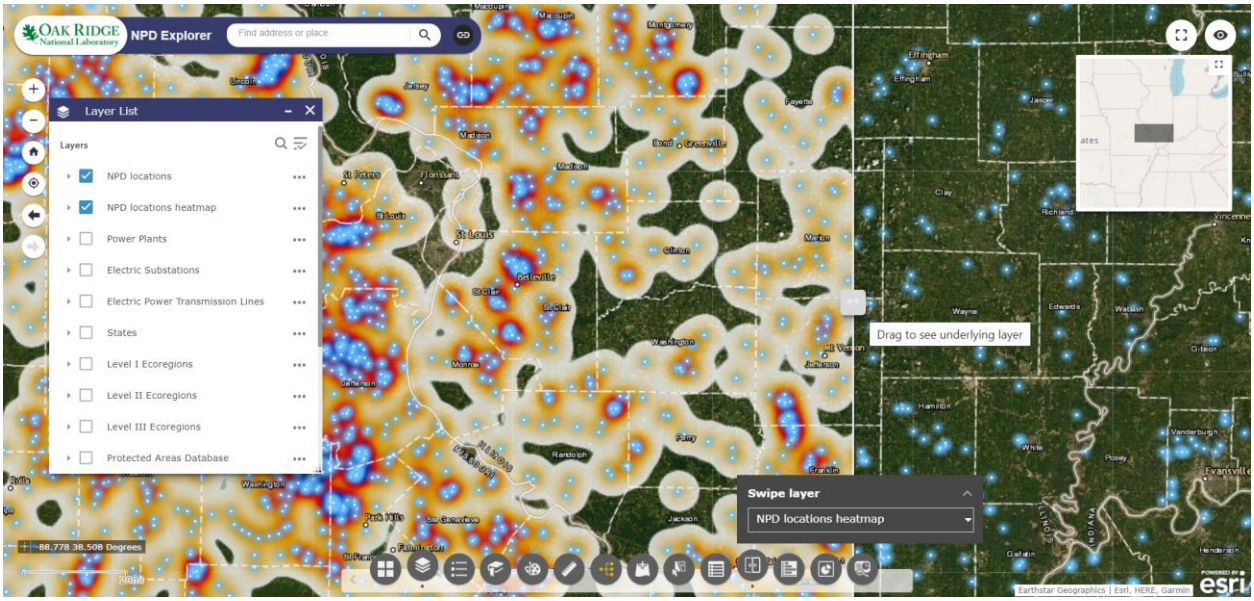


Figure 7. Swiping to dynamically view locations of NPDs, the heatmap, and underlying features. (Here, the user has made both the **NPD locations** and **NPD locations heatmap** layers visible and they have selected the NPD location heatmap for swiping. All NPD locations are displayed, but the vertical swiping line can be dragged across the interface to reveal or hide the features in the heatmap layer).

2.3 FILTERING OR CREATING SUBSETS OF DATA – BUILDING A QUERY EXPRESSION IN THE ATTRIBUTE TABLE

To filter or create subsets of NPD or other data layers, the user can launch the **Filter and View Attributes** widget to open attribute tables for all layers currently turned on in the map. Then the user can select **Options** and then **Filter** (Figure 8) to filter a layer by any of its attributes. Filter expressions can also be applied to the **NPD locations heatmap** layer to dynamically recalculate NPD density based on applied filters (Figure 9).

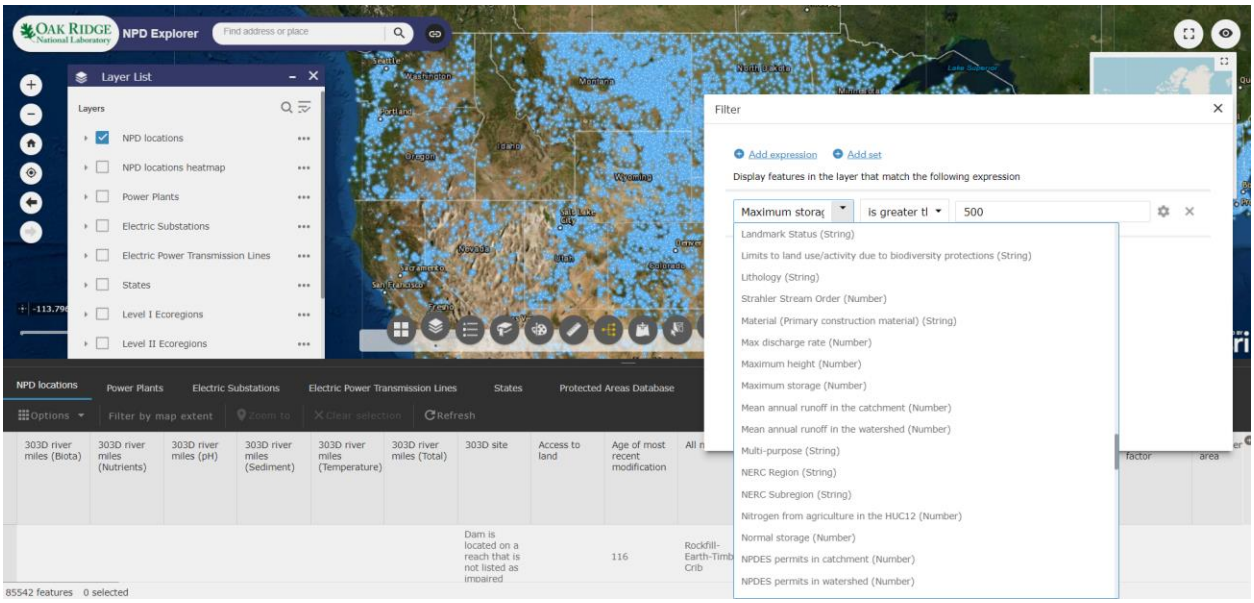


Figure 8. Applying filter expression. (In this example, the user selected the **Filter** option with the **NPD locations** attribute table highlighted. The **Filter** window opens, allowing the user to filter numeric and categorical attributes from the data set using a variety of expressions. This user set up a filter based on impoundment storage volume).

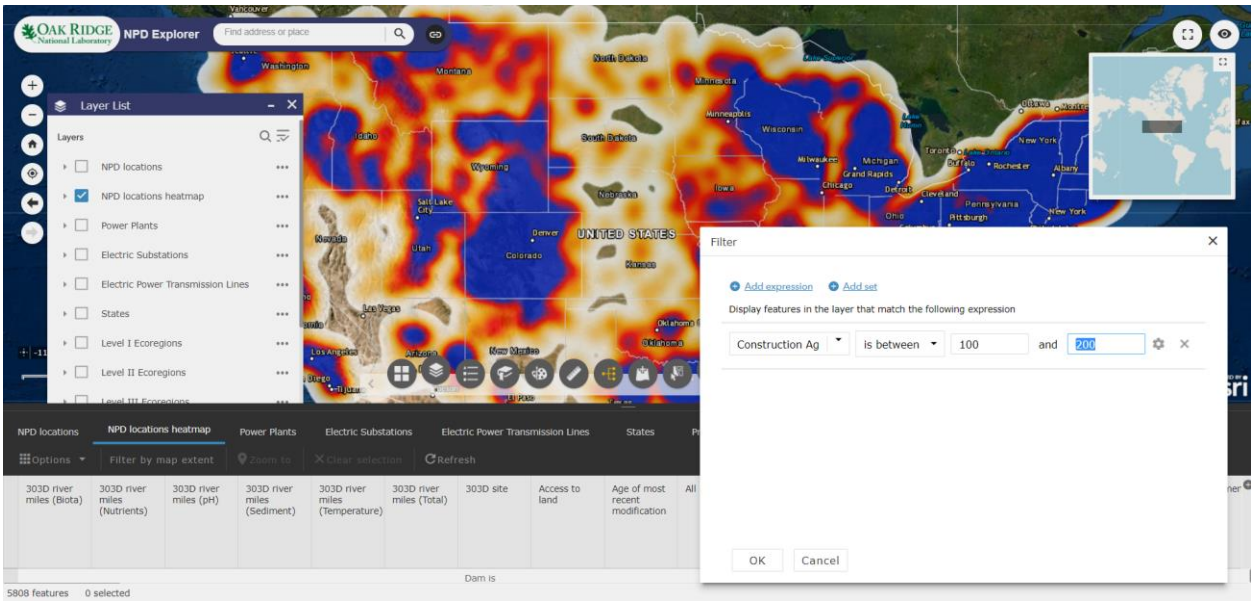


Figure 9. Applying SQL filter to heatmap. (In this example, the user selected the **Filter** option within the **NPD locations** attribute table. This user is setting up a filter for dams between 100 and 200 years old. The interactive display is updated by the app to reflect the filter applied by the user).

2.3.1 Creating Infographics to View Distributions of Values for Selected Attributes

After a user applies filter expression(s) based on the attribute(s) of interest, one or more of the themed infographics (Figure 10) can be launched, allowing the user to interact with the data via dynamic bar charts. An infographic is provided for each NPD attribute theme: design, climate, geology, hydrology, landscape, water quality, and hydropower opportunity and operations. The user should toggle off all attributes not of interest before exploring an infographic. This action is accomplished by choosing the attribute field names across the bottom of the graphic to turn them on or off. The user can start learning how the infographic works by initially exploring a single attribute. The *x*-axis values can vary widely for different attributes, so choosing and exploring a single attribute ensures that the user will see relevant data values. Additional attributes can be added to the infographic, but if the data ranges are quite different, then the infographic will probably not display visually discernible values for the attribute with smaller values. Note that the infographics have zoom in/out capability to allow the user to zoom in on NPDs of interest to see more detail. The sliders on the right side of the infographics can also be used to focus on a part of the data range. The infographics are all sorted by NID ID, which always begins with the two-character state abbreviation indicating the dam's location.

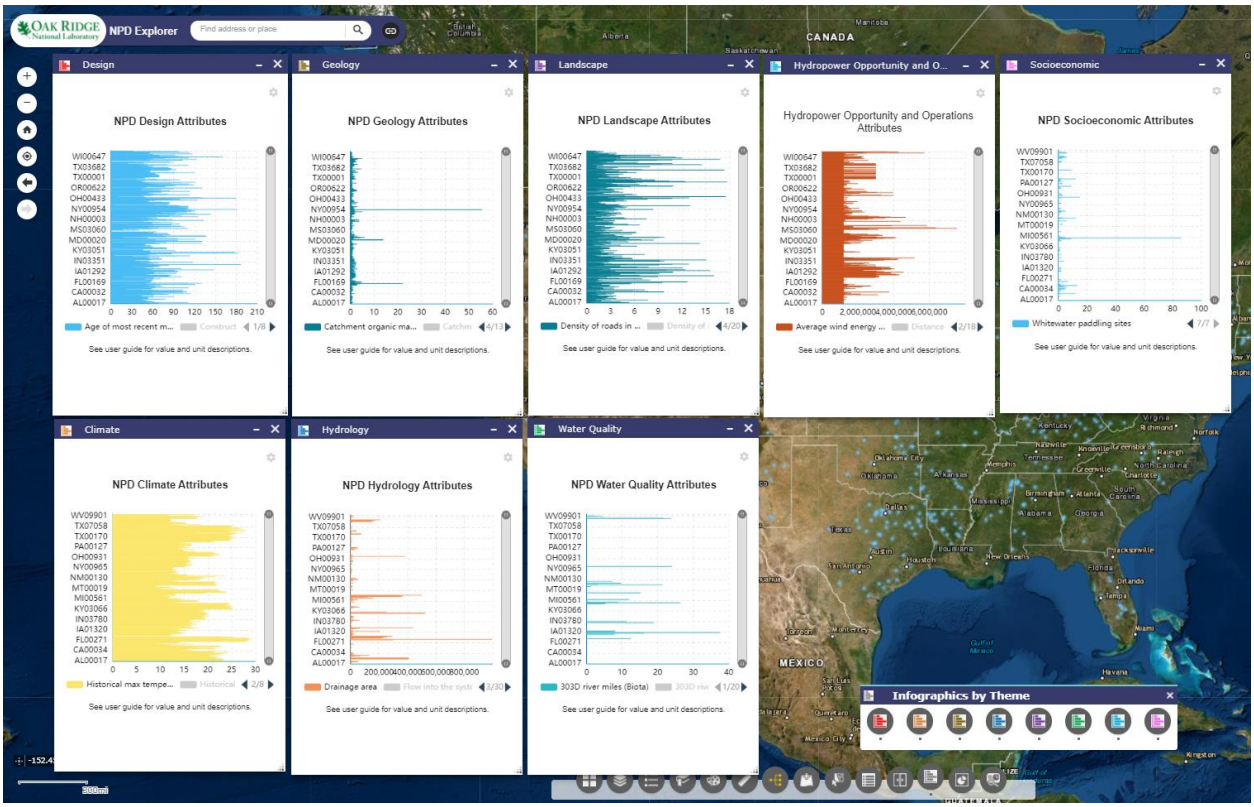


Figure 10. Infographics by theme. (In this example, the user applied a filter based on generation potential, opened infographics from all seven themes, selected an attribute of interest within each theme, and (4) used the sliders to ensure all features in the query result are displayed on each infographic).

2.3.2 Downloading Data

To access more detailed information on a particular NPD or set of NPDs, the user can select the NPDs, create a new map layer (Figure 11), and then download a CSV file of the attributes for closer examination on a desktop computer (Figure 12). This approach can reveal common characteristics of NPDs of interest

and can inform additional exploration of NPDs by enabling the user to perform actions such as building queries to find similar NPDs.

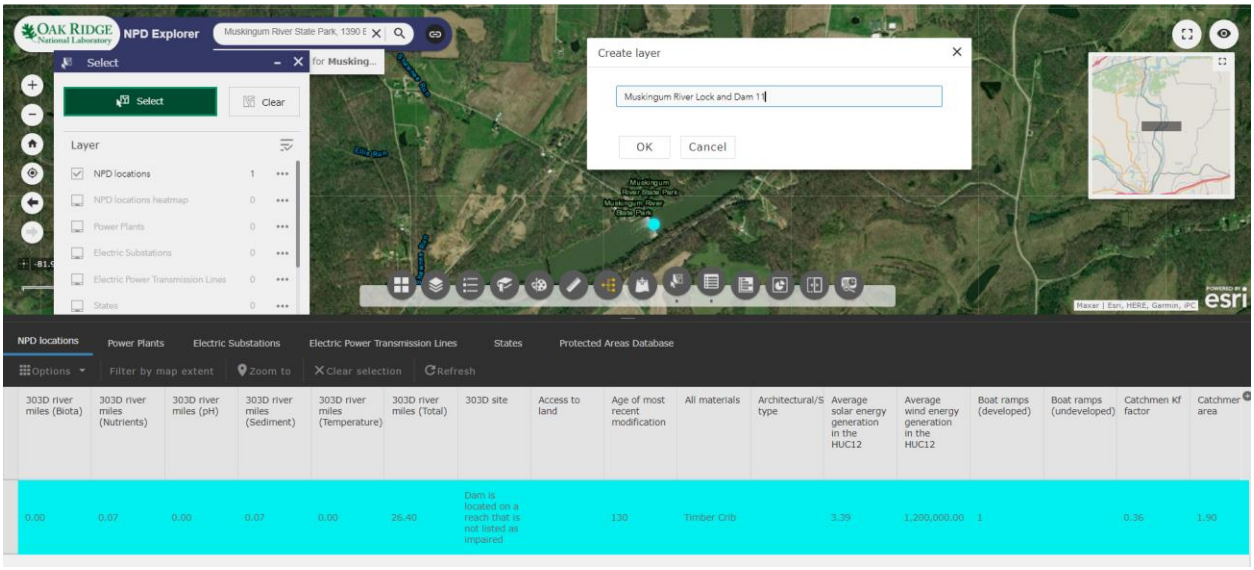


Figure 11. Create new layer from selected features.

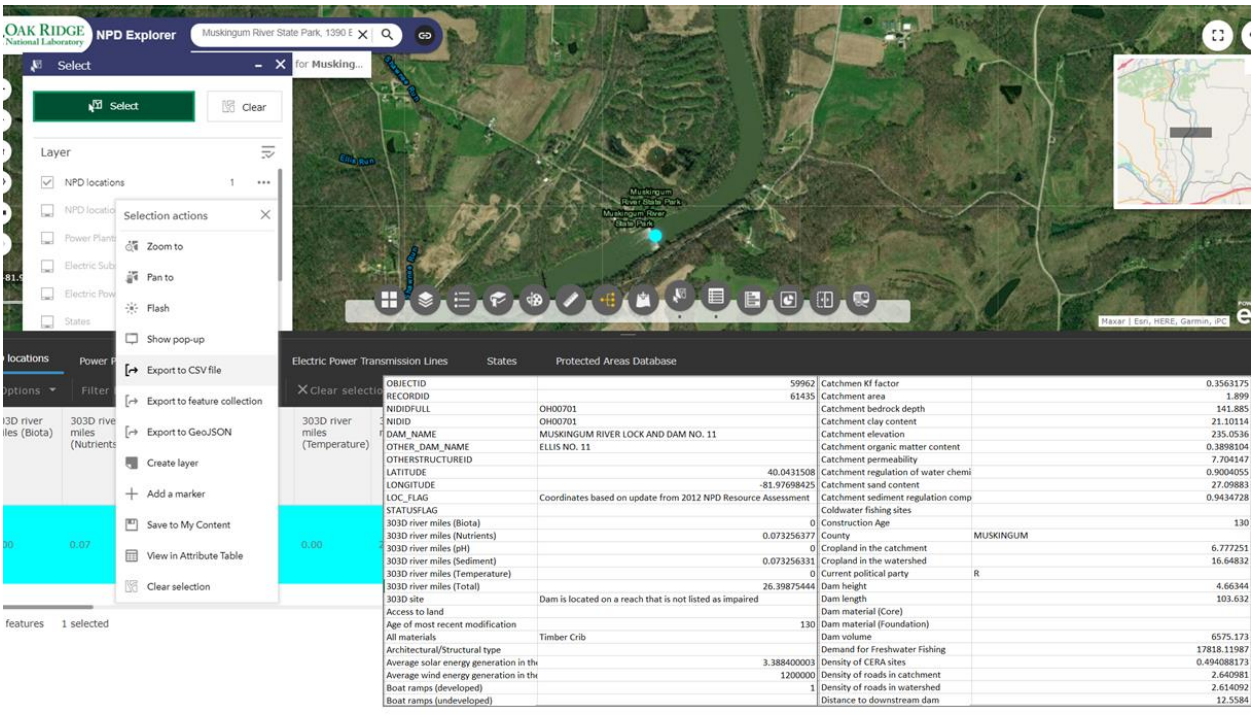


Figure 12. Download data for desktop exploration.

Another option for downloading data is the **Summarize Nearby Grid Features** widget. The user can specify an AOI, set an AOI buffer distance if desired, and then select grid features within the AOI to be downloaded as CSV files or in a report format (Figure 13). Reports, which can be printed or saved as PDF

files include a map of the AOI, a summary of NPD locations and grid features within the AOI, and a tabular output with all feature attributes for NPDs and grid features in the AOI.

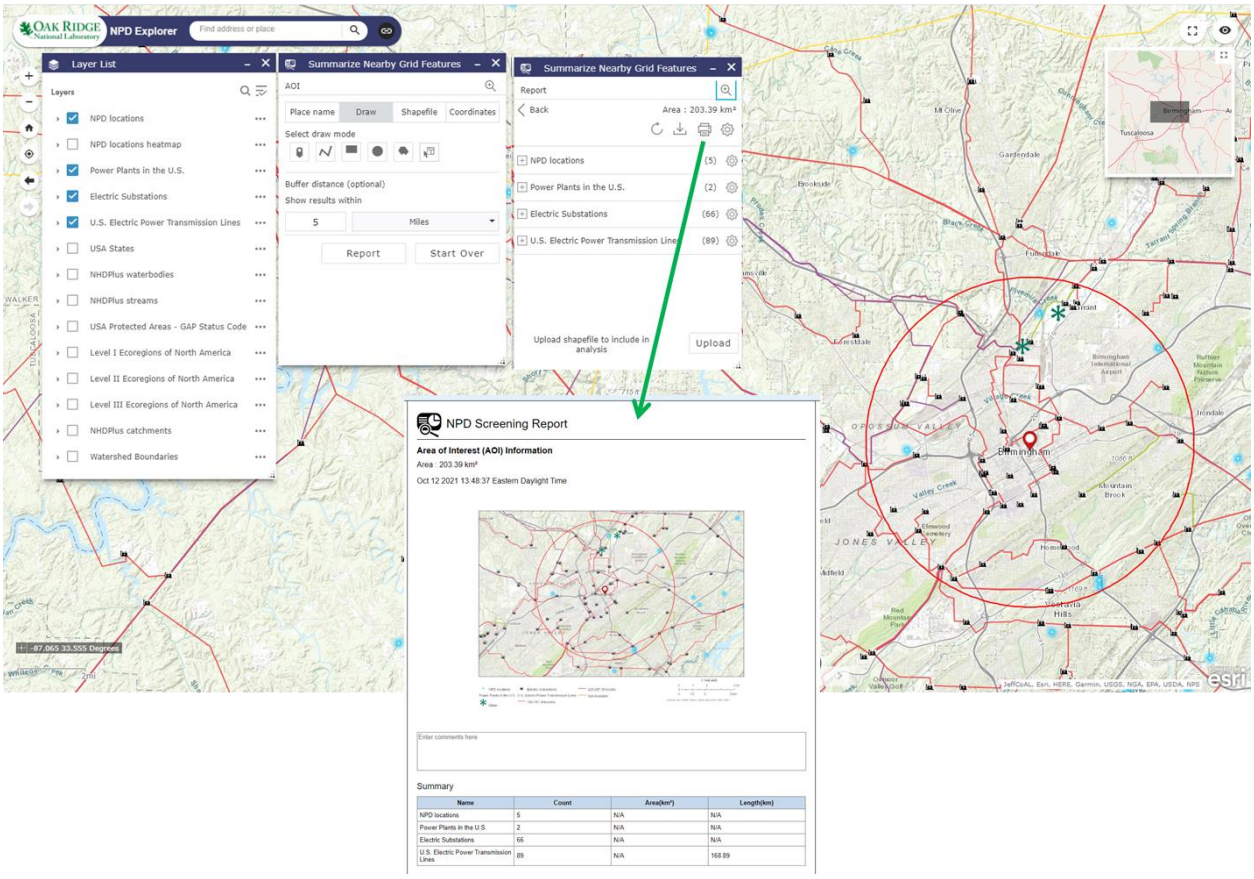


Figure 13. Summarizing nearby grid features. (In this example, the user chose a point near the center of Birmingham, applied a 5 mi buffer to the point, and generated a summary and report of grid features within the AOI buffer).

Because generation potential, hydraulic head, and stream flow are important metrics for questions related to NPD development, NPD Explorer also includes the **Power Potential, Head, and Flow** infographic widget (Figure 14). When this infographic is active, the user can dynamically pan around the map and see generation potential, head, and flow values for the streams within the map view. When the user hovers over bars on the infographic, the relevant NPD will be dynamically highlighted on the map. This infographic also responds to NPD selections made with the **Select** widget.

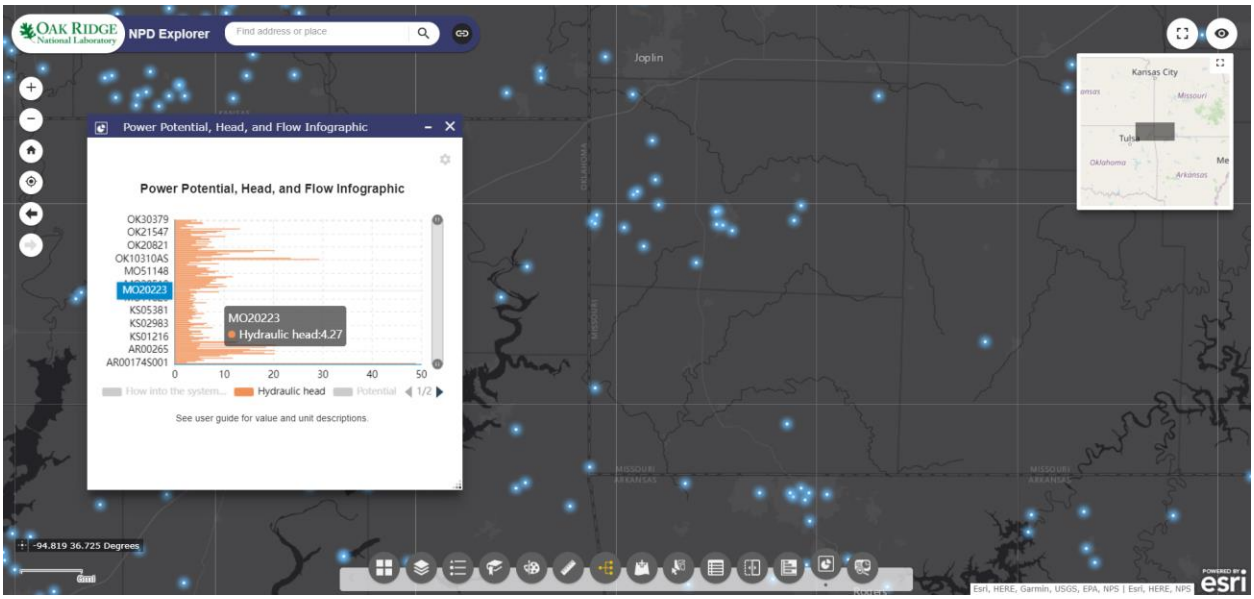
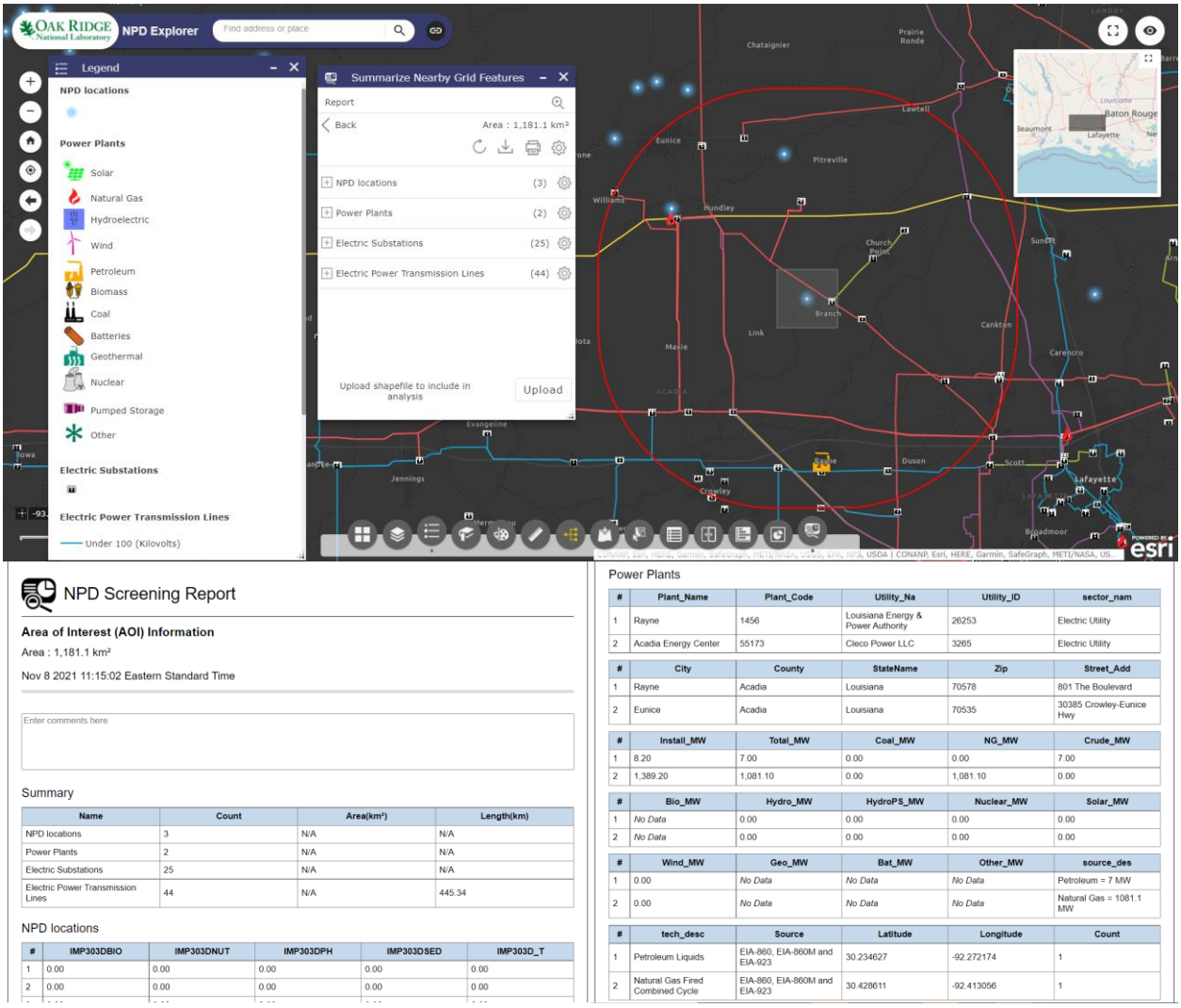


Figure 14. Dynamic panning to view generation potential, hydraulic head, and flow information in the Power Potential, Head, and Flow Infographic widget.

2.4 SUMMARIZING NEARBY GRID FEATURES

A major application area for the NPD Explorer is hydropower development at NPDs. To support development-related analysis, a user may wish to summarize existing grid-related infrastructure features within a specified distance of a dam or subset of dams. First, a user turns on layers of interest related to the energy grid (**Power Plants**, **Electric Substations**, **Electric Power Transmission Lines**).Then, with the **Summarize Nearby Grid Features** widget activated, the user creates an area of interest or AOI around a dam, set of dams, or other features. Alternatively, an AOI can be specified by uploading a shapefile. Then, a buffer around the AOI is created according to a user-specified distance. Finally, a report is generated that summarizes the counts and attributes for grid-related features within the AOI buffer distance. This summary information can also be downloaded as a comma separated value file or output in a printer-friendly format (Figure 15).



NPD Screening Report

Area of Interest (AOI) Information

Area : 1,181.1 km²

Nov 8 2021 11:15:02 Eastern Standard Time

Enter comments here

Summary

Name	Count	Area(km²)	Length(km)
NPD locations	3	N/A	N/A
Power Plants	2	N/A	N/A
Electric Substations	25	N/A	N/A
Electric Power Transmission Lines	44	N/A	445.34

NPD locations

#	IMP303DBIO	IMP303DNUT	IMP303DPH	IMP303DSED	IMP303D_T
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00

Power Plants

#	Plant_Name	Plant_Code	Utility_Na	Utility_ID	sector_nam
1	Rayne	1456	Louisiana Energy & Power Authority	26253	Electric Utility
2	Acadia Energy Center	55173	Cleco Power LLC	3265	Electric Utility

#	City	County	StateName	Zip	Street_Add
1	Rayne	Acadia	Louisiana	70578	801 The Boulevard
2	Eunice	Acadia	Louisiana	70535	30385 Crowley-Eunice Hwy

#	Install_MW	Total_MW	Coal_MW	NG_MW	Crude_MW
1	8.20	7.00	0.00	0.00	7.00
2	1,389.20	1,081.10	0.00	1,081.10	0.00

#	Bio_MW	Hydro_MW	HydroPS_MW	Nuclear_MW	Solar_MW
1	*No Data*	0.00	0.00	0.00	0.00
2	*No Data*	0.00	0.00	0.00	0.00

#	Wind_MW	Geo_MW	Bat_MW	Other_MW	source_des
1	0.00	*No Data*	*No Data*	*No Data*	Petroleum = 7 MW
2	0.00	*No Data*	*No Data*	*No Data*	Natural Gas = 1081.1 MW

#	tech_desc	Source	Latitude	Longitude	Count
1	Petroleum Liquids	EIA-860, EIA-860M and EIA-923	30.234627	-92.272174	1
2	Natural Gas Fired Combined Cycle	EIA-860, EIA-860M and EIA-923	30.428611	-92.413056	1

Figure 15. Using the Summarizing Nearby Grid Features widget to evaluate grid-related features by proximity to an AOI. (In this example, a user has drawn a rectangular AOI around a dam and created a buffer of 10 miles (red circle). The widget popup shows the counts of other NPD locations, Power Plants, Electrical Substations, and Electric Power Transmission Lines that fall within the buffer distance. A print summary of the report lists attributes for the features in these layers that are within the buffer distance).

2.5 NPD EXPLORER TUTORIAL

The NPD Explorer provides an open-ended platform that allows a relatively unconstrained experience for NPD data interaction. To further illustrate possible interactions and features, the following tutorial demonstrates how the tool can be used to accomplish a specific objective.

Many users are interested in exploring hydropower development potential within certain constraints. For example, a user may be interested in exploring potential hydropower capacity at federal dams of a certain age, with a certain hazard potential, but not located on protected land. In this case, the user would follow the steps below.

Step 1. Customize the map interface.

By default, the map displays the Imagery basemap and all NPD locations. Launch the **Basemap Gallery** widget on the bottom of the app interface and change the basemap to **Dark Gray Canvas**. Add the protected lands data to the map by launching the **Layer List** widget and select **Protected Areas Database**. If this layer not visible, then zoom in on the map until it appears. The map now displays the NPD locations and areas of the US listed in the Protected Areas Database.

Step 2. Use the filter option in the attribute table (Figure 16) to display federal dams less than 50 years old with a low downstream hazard potential that are not on protected land.

Launch the **Filter and View Attributes** widget from the bottom of the app interface. Make sure "NPD locations" is active (highlighted from the layer options listed across the top of the attribute table), and then select Options > Filter > Add expression. In the first drop-down menu, select the **Simplified type of owner** field, select **is any of**. In the third drop-down menu, select **Federal** and **Multiple owners, including federal**.

Add another expression by selecting **Add Expression** again. In the first drop-down menus, select: **Construction Age**. In the second drop-down menu, select **is less than**. In the third field, enter "50."

Similarly, add two more expressions: **Hazard potential downstream of dam** > **is** > **Low**, and **Protected land status** > **is** > **Dam is not on protected land**. If the specific value for an attribute is unknown, then expressions can also be constructed using the **is any of** option in the second drop-down menu. This selection will turn the third field into a drop-down menu, and possible values will be shown.

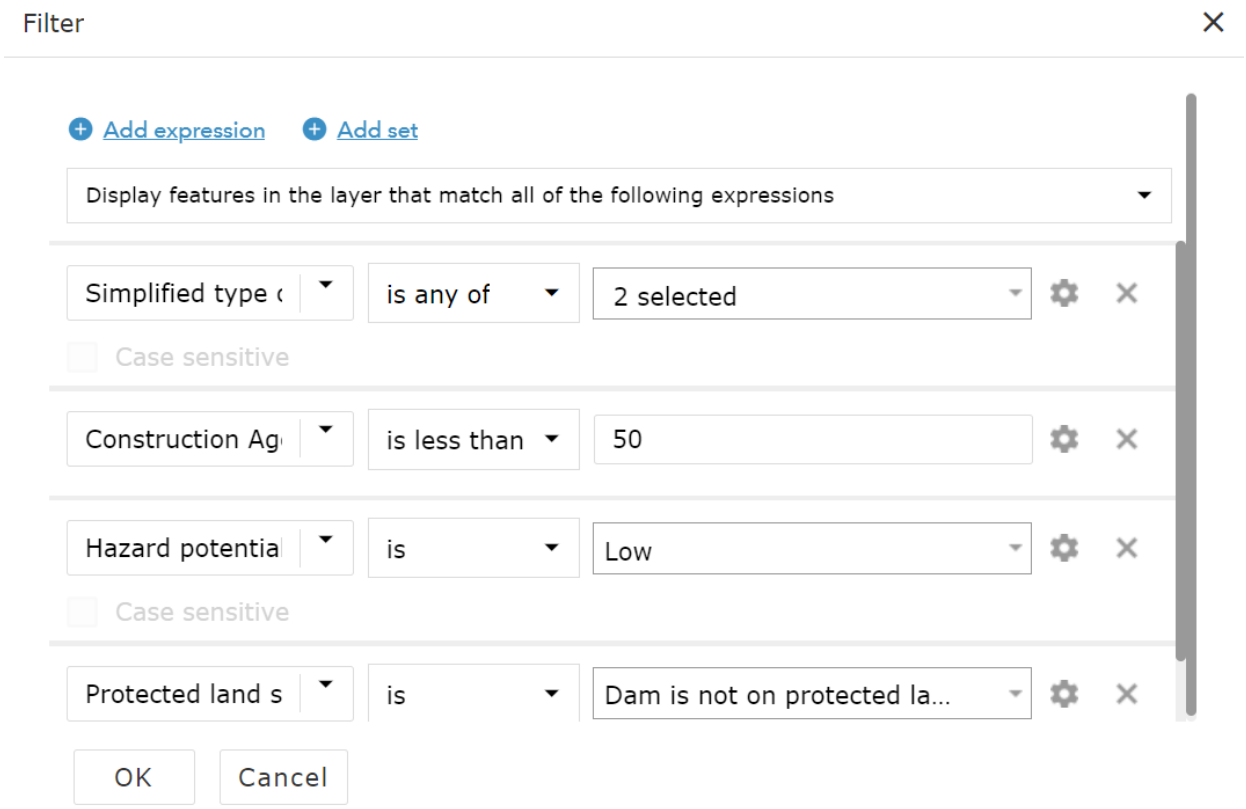


Figure 16. Filtering by building a multi-attribute query expression in the attribute table.

Once all applicable expressions have been added, select **OK**. The map now displays only those dams that (1) have at least one federal owner, (2) are less than 50 years old, (3) have low hazard levels, and (4) are not on protected land. This subset includes 342 dams (Figure 17).

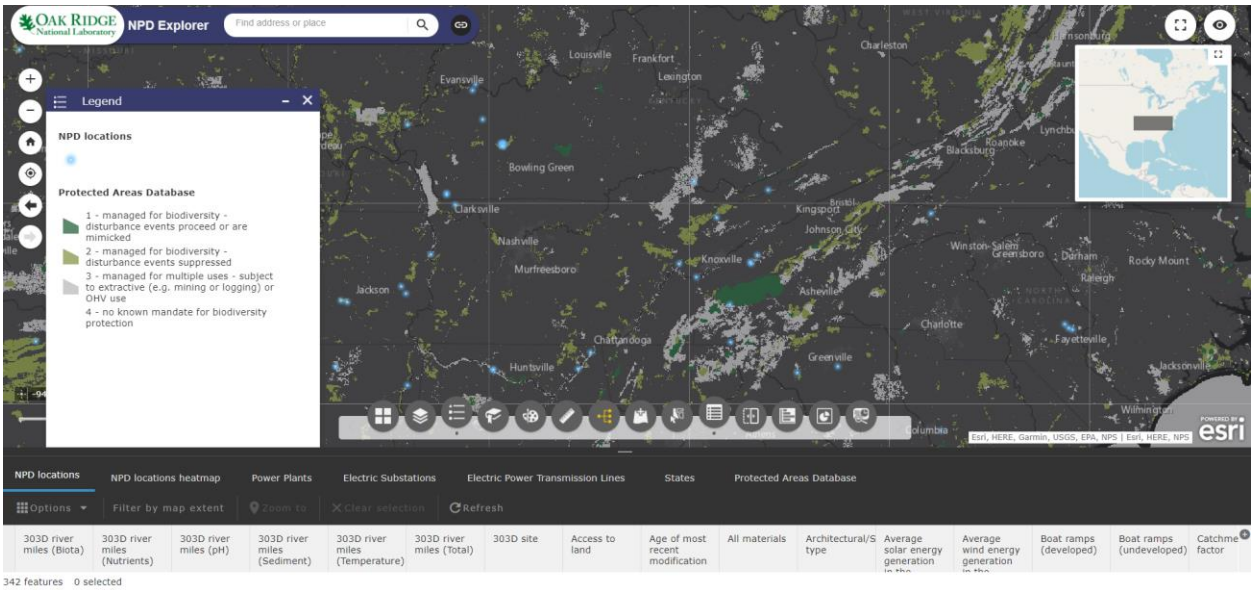


Figure 17. Map displaying only the filtered subset of dams and protected areas.

Step 3. Use the infographics features to explore hydropower potential.

Launch the **Generation Potential, Head, and Flow Infographic** widget  from the bottom of the app interface. Toggle on/off labels in the legend to display only one of the attributes on the chart (choose from **Flow into the system**, **Potential nominal capacity**, or **Hydraulic head**). Results are shown for individual dams, which are ordered alphabetically by their NID IDs. The slider on the right-hand side can be used to narrow in on a few dams or to expand the dams displayed.

Finally, pan around the map and select any of the displayed points to view all attributes for that one dam in a pop-up window.

2.6 GROUPING DAMS THROUGH THE NPDAMCAT APP

2.6.1 APP OVERVIEW

The NPDamCAT app allows the user to build a custom taxonomy of NPDs based on user-specified characteristics and classes by navigating through a series of steps, as described in the following sections. While filtering or subsetting features is possible in NPD Explorer, there is limited functionality in the NPD Explorer interface for performing more complex analysis of dam types. For example, a user may wish to evaluate the makeup of dams in a certain region or to compare the size of dam populations across different groups. The taxonomy created in the NPDamCAT app organizes dams into groups, which allows convenient analysis of characteristics within and between different groups of dams. The groups of dams (and their attributes) can then be exported and viewed in the NPD Explorer or an external GIS program.

2.6.2 USING THE NPDAMCAT APP

NPDamCAT is included as a widget within NPD Explorer. The user selects the widget and then accesses the app by clicking on the link in the popup window (Figure 18). The app opens in a new window in the user's internet browser.

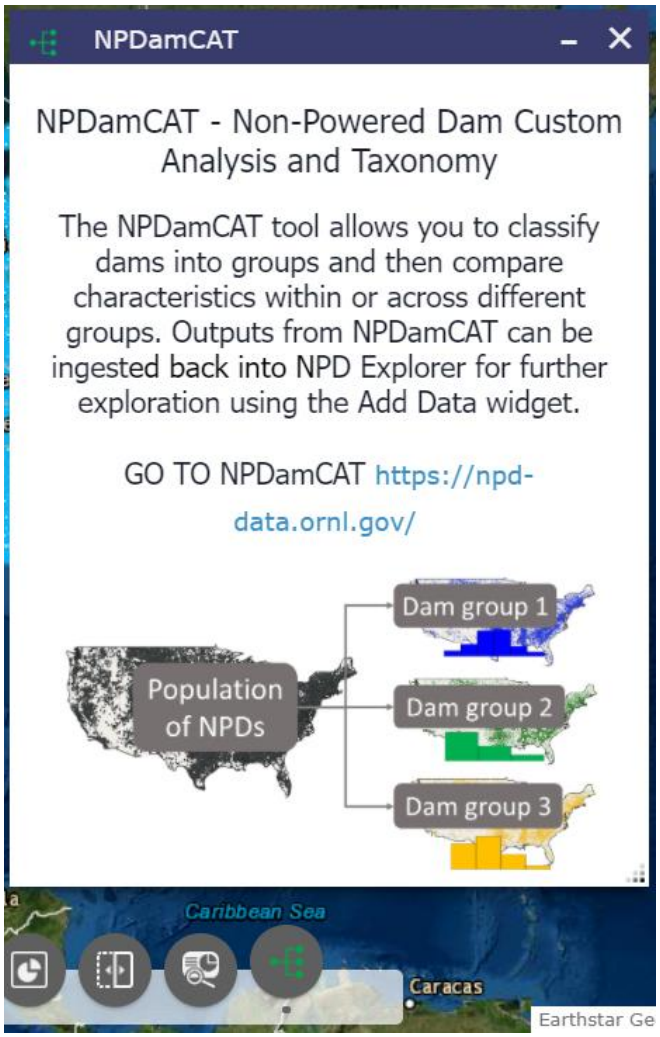


Figure 18. Popup window for the NPDamCAT widget.

The user begins on the landing page (Figure 19), which provides basic information about the app and links to the organizations involved in its development. A diagram shows the five main steps to build a custom taxonomy of NPDs. These steps mirror the five steps outlined in the *Non-Powered Dam Custom Analysis and Taxonomy Framework* report [3].

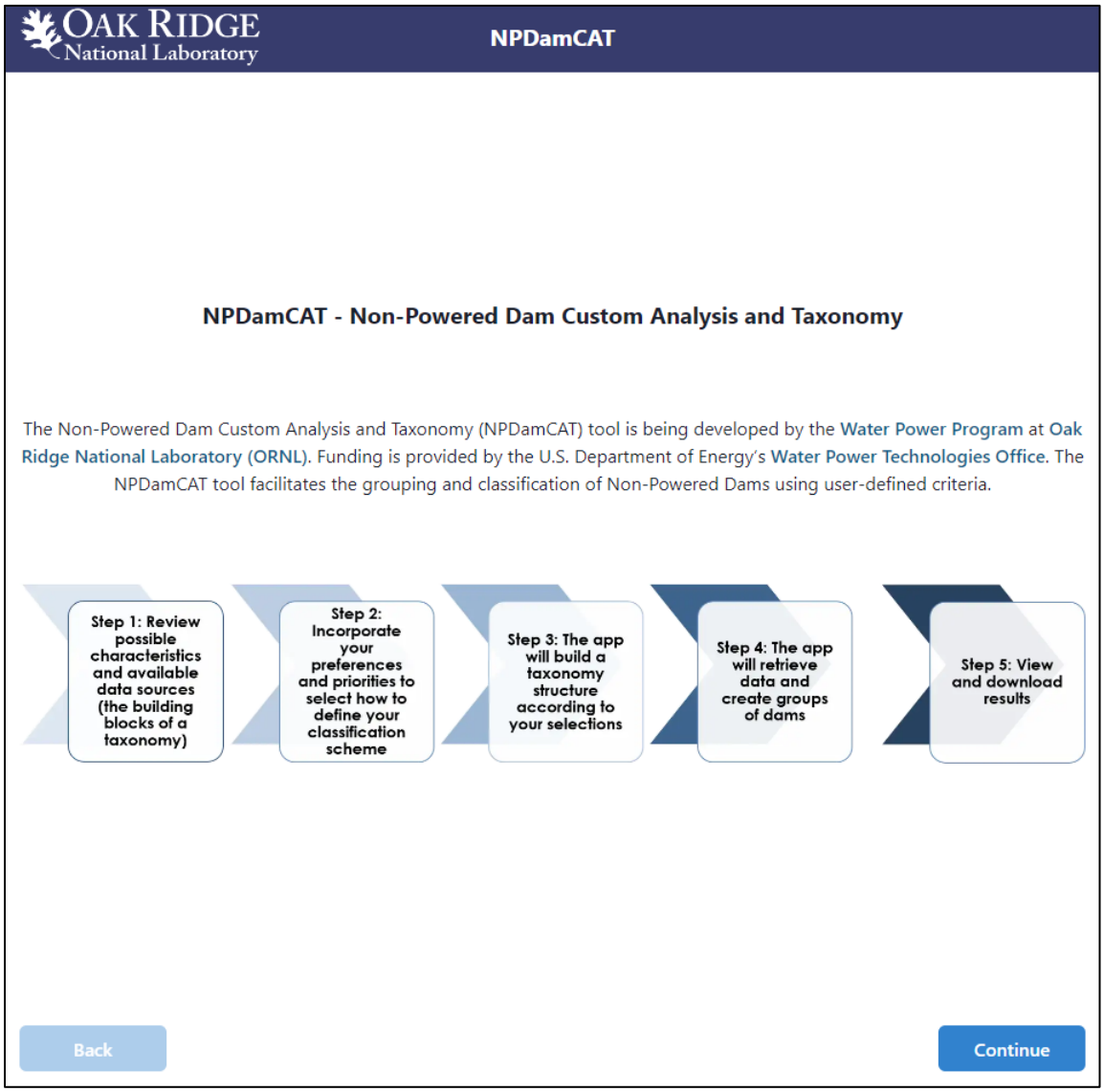


Figure 19. Landing page for the NPDamCAT app.

2.6.2.1 Selecting Characteristics for Creating a Taxonomy

The user selects the **Continue** button to proceed to the characteristics page (Figure 20), where the user can select the NPD characteristics of interest. The alphabetical list of available characteristics appears in the **Unselected** column. The user must drag and drop at least one characteristic into the **Selected** column to proceed. The order of the characteristic in the **Selected** column is important because it determines the order of subgroups in the later creation of the taxonomy. For example, if *Hydraulic Height* is ordered above *Construction Age* (as shown in Figure 20), then groups will first be created based on height classes, and then they will be further divided into subgroups based on age.

The info buttons show metadata (unit information, a brief description, and source of data) for each characteristic. The delete buttons remove characteristics from the **Selected** column. The user can go to the filter icons and specify which NPDs should be included in the classification process. If a filter is based on a numerical characteristic, then it can be defined using an upper and lower threshold; categorical characteristics can be filtered by selecting one or more checkboxes. The filter icon will turn green if a characteristic has a filter enabled.

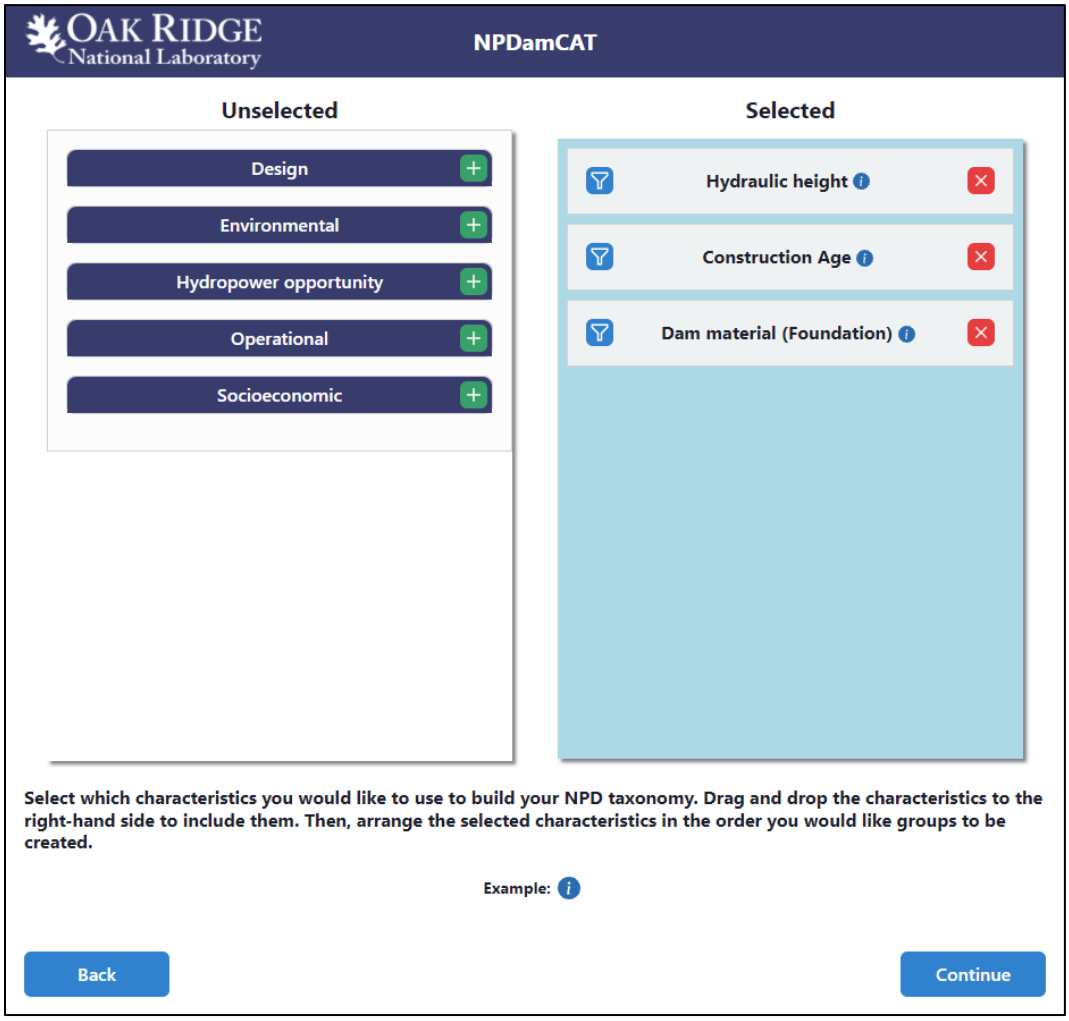


Figure 20. Characteristics selection and ordering page.

2.6.2.2 Specify Classes for Chosen Characteristics

The user selects the **Continue** button to proceed to the classes page, where the user can customize class definitions to form a taxonomy (Figure 21). Each characteristic chosen in the selection step is displayed with one or more choice of attribute and data source.

If the attribute is numerical, then predefined classes are displayed. The default values for these classes are as follows:

- min–33rd percentile,
- 33rd–67th percentile, and

- 67th percentile–max.

The user can also go to the green plus button and define custom bins to use as ranges. After these custom ranges are specified, they will appear as a class choice.

If the attribute is categorical, then a list of possible values is displayed. The user must select or clear the checkboxes next to each value to determine which values will be included in the taxonomy. The **Select All** and **Clear All** buttons allow the user to select or clear all items at once.

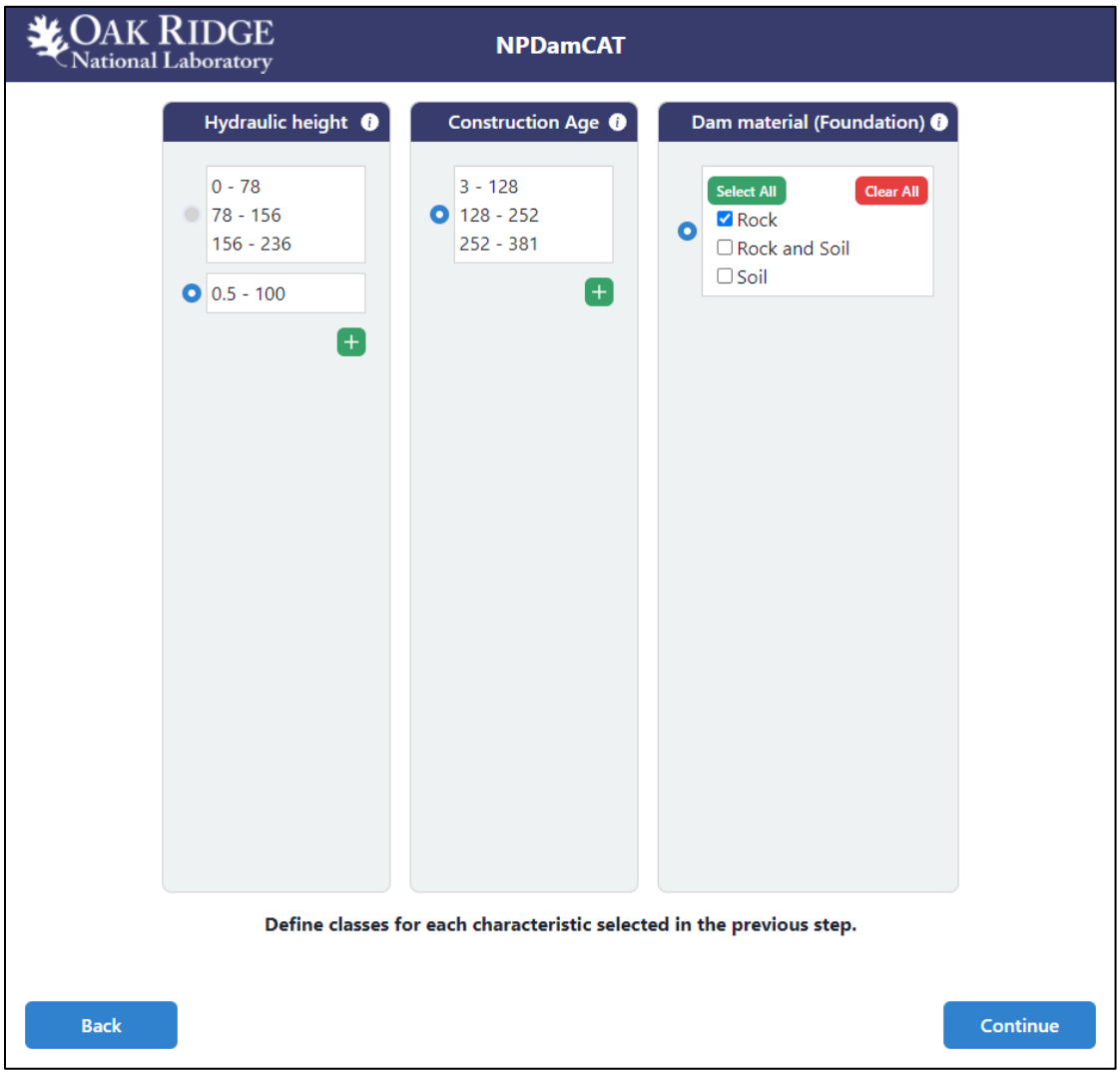


Figure 21. Classes page, where classes are defined for each selected characteristic.

2.6.2.3 View Results in a Taxonomy Diagram

The user selects the **Continue** button to proceed to the results page, which displays a taxonomy diagram (Figure 22). This diagram shows how the population of dams is divided into the specified classes for each characteristic, with the number of NPDs corresponding to each characteristic shown at the bottom of each box, or node. **No Data** results are displayed along the top of the diagram. Each node is linked to subsequent classes by a gray line. Nodes can be rearranged by dragging and dropping. Nodes can also be selected, and then the elements can be downloaded in a variety of formats using the **Download** button. Selected elements can also be viewed on a map or on a bar chart using the **Map** and **Group Characteristics** tabs.

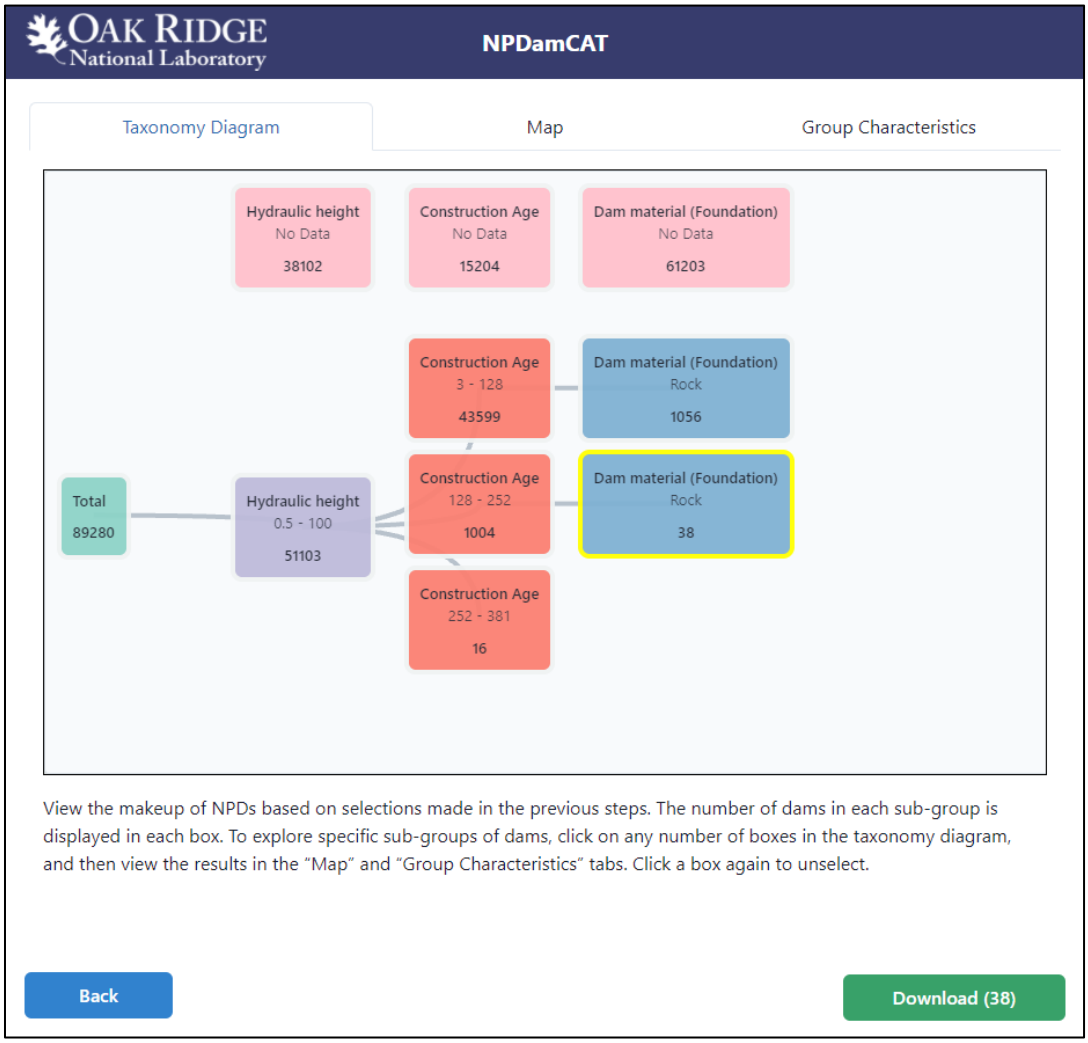


Figure 22. Taxonomy Diagram tab of the results page.

2.6.2.4 View Selected Groups of Dams on a Map

The **Map** tab displays the selected NPDs on a simple interactive map (Figure 23). Basemaps can be changed via the selection circle in the lower left corner of the map. The user can select an NPD point to show its attributes in a table.

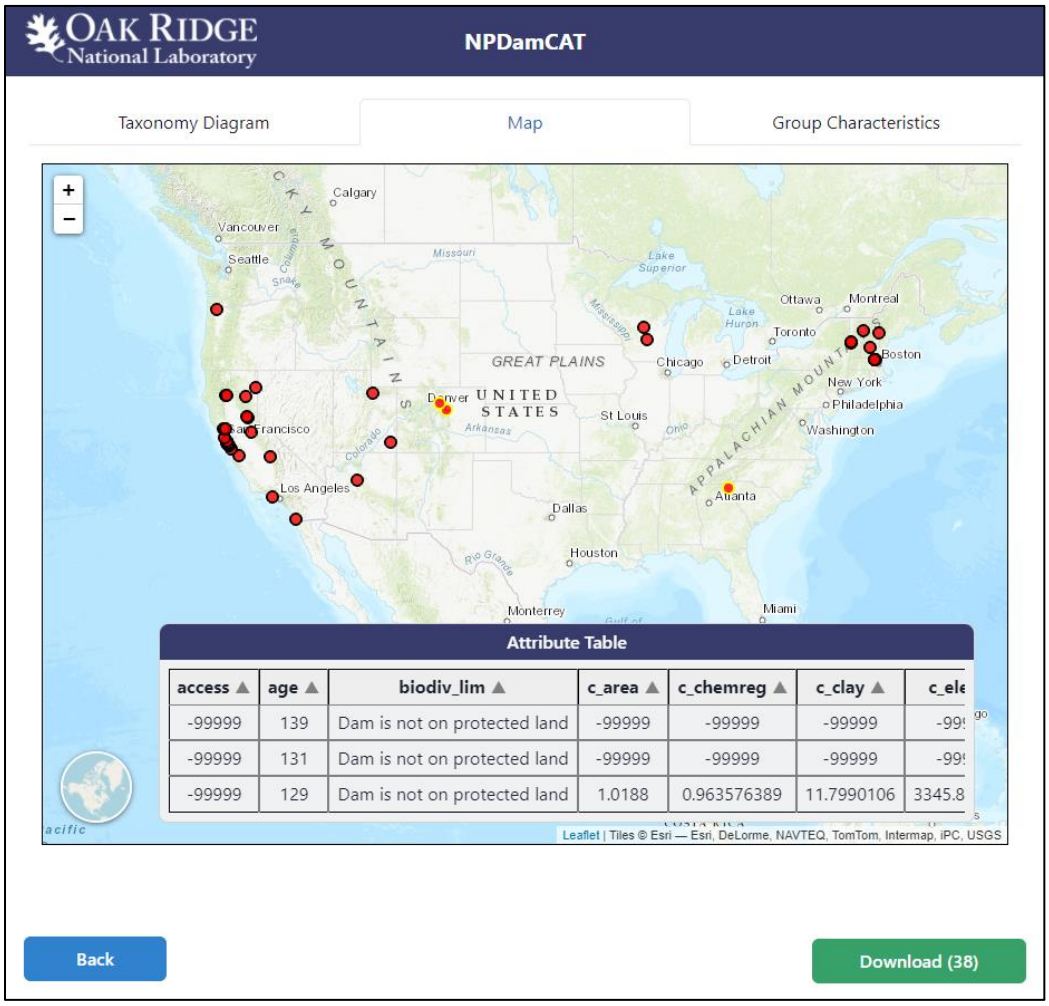


Figure 23. Map tab of the results page.

2.6.2.5 View Characteristics for Selected Groups of Dams

The **Group Characteristics** tab of the results page displays attributes for the selected NPDs on a bar chart (Figure 24). The attribute displayed can be changed using the drop-down menu in the lower right corner. The sum and average are shown if the field is numerical. Specific values can be seen by hovering over each bar in the chart.

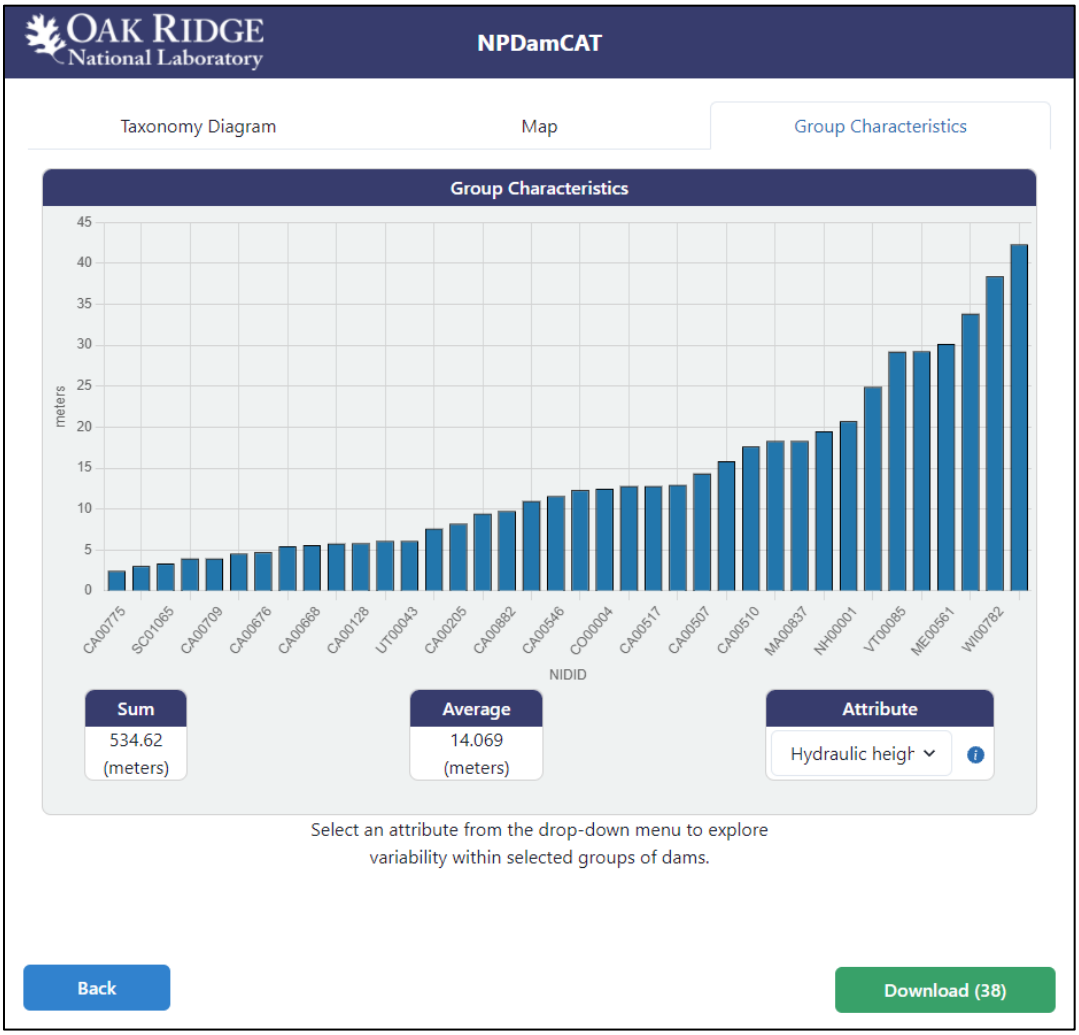


Figure 24. Group Characteristics tab of the results page.

2.6.3 Downloading Data and Viewing in the NPD Explorer

By selecting the **Download** button in any of the tabs of the results page, the user can choose from various file formats: shapefile, CSV file, JSON, or GML2.

In the NPD Explorer app, select the **Add Data** widget and upload the file of downloaded data. Note that there is currently a limit to the size of user-uploaded data (a maximum of 1000 features can be added in any individual layer to the NPD Explorer).

2.6.4 NPDAMCAT TUTORIALS

Tutorial exercises for NPDamCAT illustrate several use-case examples in which the user navigates through the NPDamCAT app to accomplish specific objectives.

2.6.4.1 Hydropower Developer Use-Case Example

A hydropower developer may be interested in NPDs with a high potential for energy generation and a relatively low environmental impact. Specifically, the developer may be seeking NPDs that are not located within protected lands or rivers. This example is similar to the tutorial described for the NPD Explorer app; however, it demonstrates the unique capability provided by the NPDamCAT app which enables evaluation of different groups of dams and how the potential capacity varies within these groups or between the different groups.

Step 1. On the characteristics page, the developer selects three characteristics of interest (Figure 25).

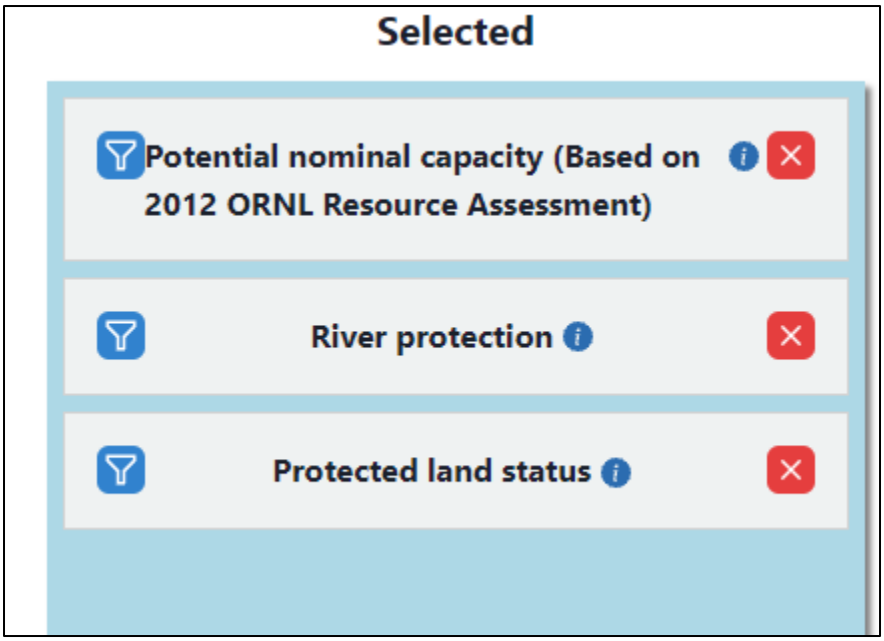


Figure 25. Selected characteristics for a hypothetical hydropower developer.

Step 2. On the classes page, the developer specifies classes for all three characteristics (Figure 26). In this case, the user may accept the default classes. Classes for generation capacity are based on numeric thresholds, whereas classes for protected land status and river protections are categorical.

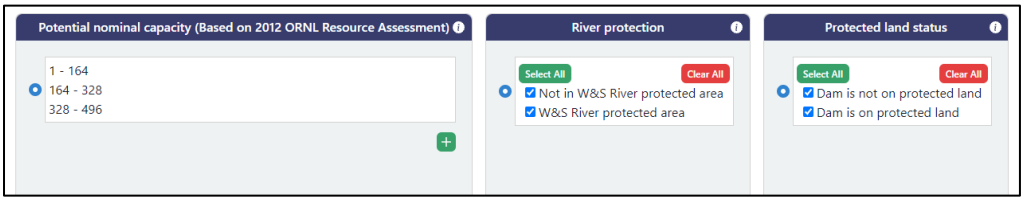


Figure 26. Classes for the characteristics selected by a hypothetical hydropower developer.

Step 3. On the results page, the developer can explore the makeup of the NPD population with respect to the selected characteristics (Figure 27). The taxonomy diagram shows how the subgroups of dams are related to the others. For example, relatively few dams have the highest potential generation capacity (n = 491 for the lowest class of potential capacity, n = 5 for the medium potential capacity class, and n = 2 for the highest potential capacity class). Furthermore, across all classes of potential capacity, most dams are not located on land or rivers with protected status. The developer may wish to investigate the four NPDs with medium potential capacity that are not on protected lands or rivers. This investigation would be accomplished by selecting the node of the subgroup for those dams.

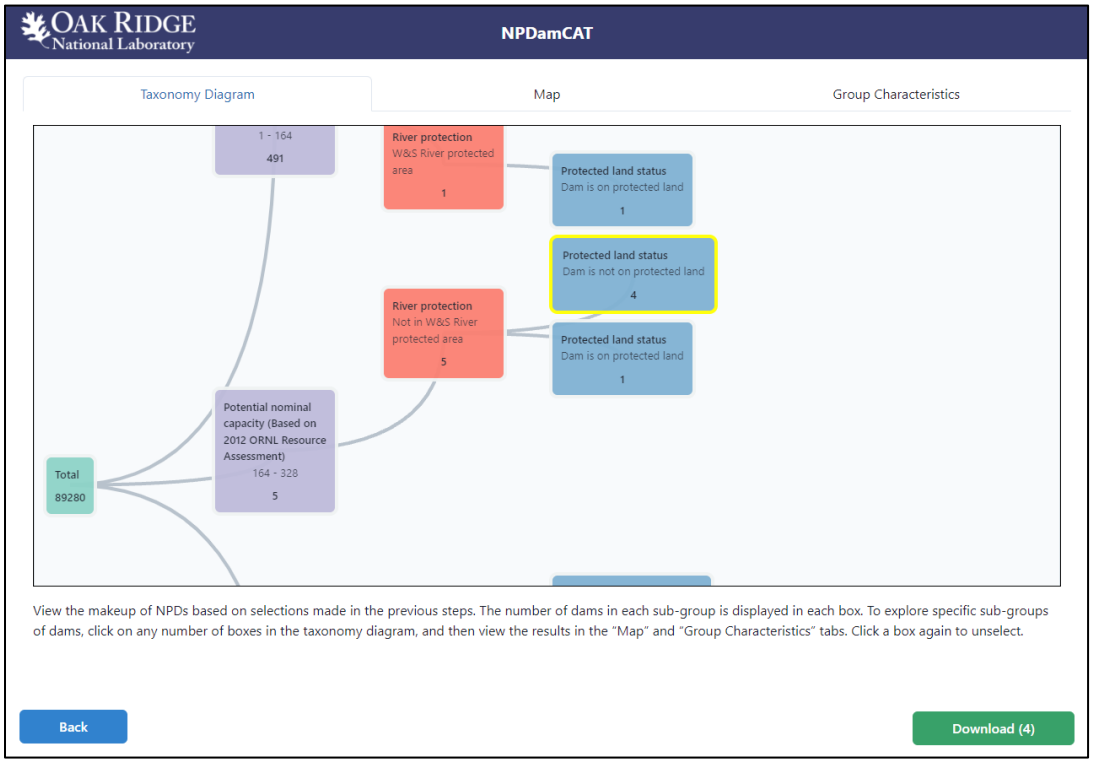


Figure 27. Example taxonomy diagram for potential generation capacity, protected land status, and river protection status.

Step 4. The developer uses the **Map** tab (Figure 28) to see the attributes of the four selected NPDs.

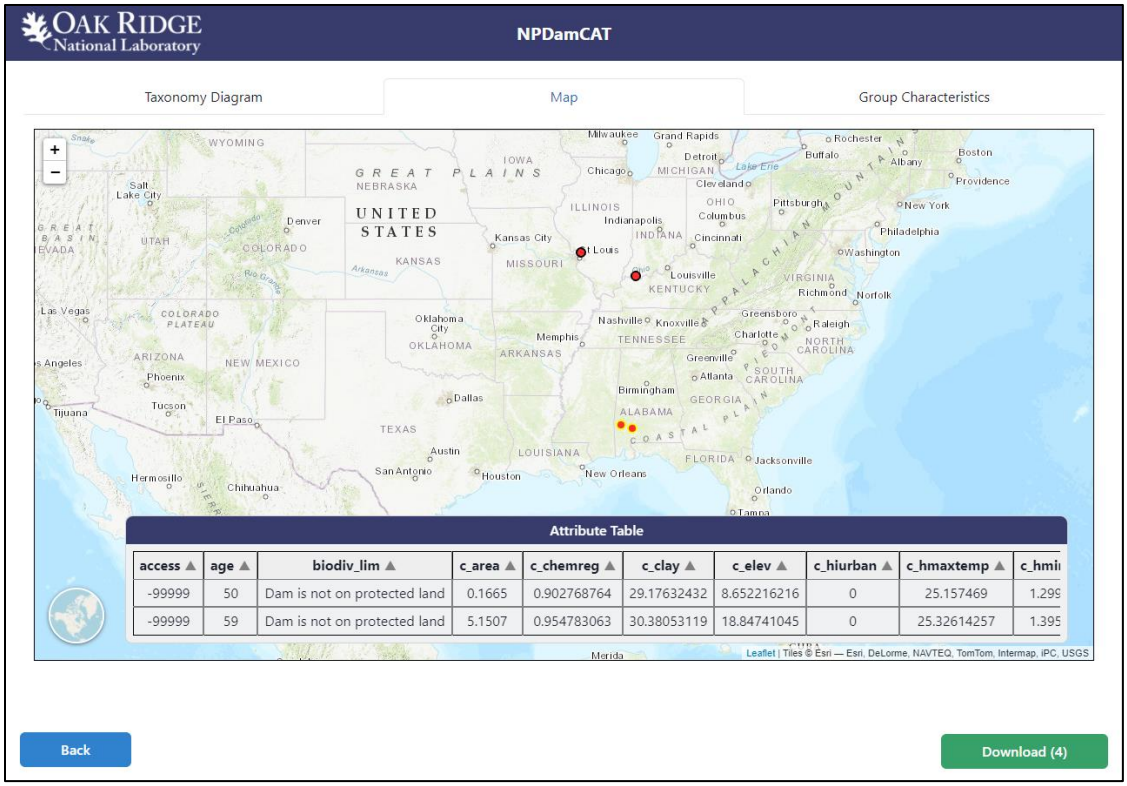


Figure 28. View of selected dams meeting criteria defined by a hypothetical hydropower developer.

Step 5. Finally, the developer selects the **Download** button and obtains a shapefile of the four selected NPDs for further analysis.

2.6.4.2 Dam Safety Researcher Use-Case Example

A dam safety researcher may be interested in knowing how many dams are regulated under federal authority and are similar to a particular dam that the researcher has studied in detail, such as an older dam with a rock foundation.

Step 1. On the characteristics page, the researcher selects three characteristics of interest, as shown in Figure 29.

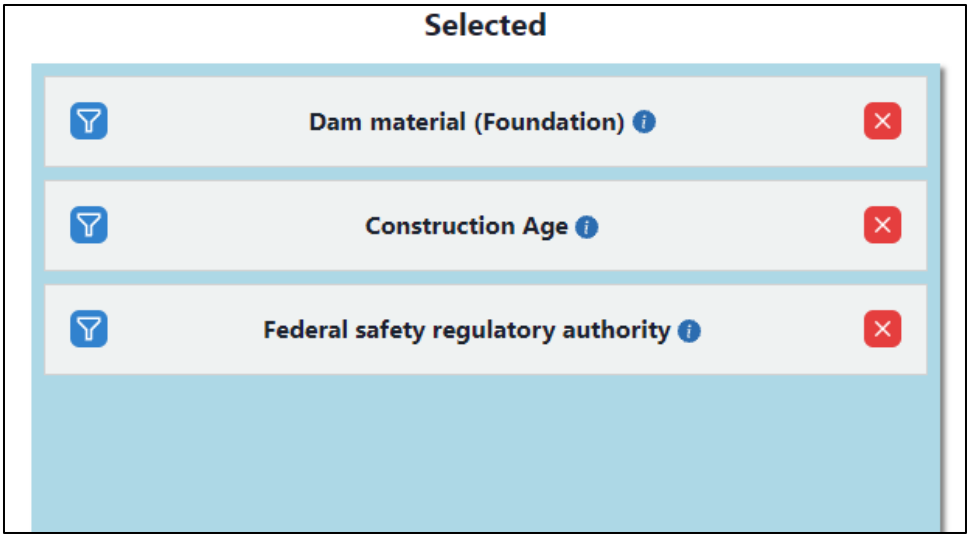


Figure 29. Selected characteristics for a hypothetical dam safety researcher.

Step 2. On the classes page, the researcher creates a new class for the **Construction Age** characteristic: dams between 100 and 200 years old and dams between 200 and 381 years old. The other two characteristics remained with their default classes selected (Figure 30).

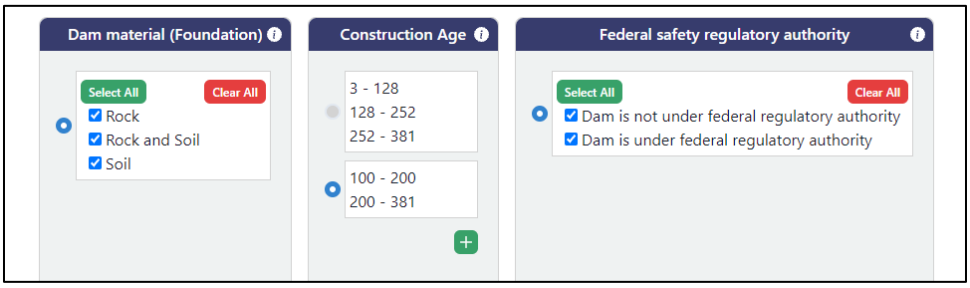


Figure 30. Classes for the characteristics selected by a hypothetical dam safety researcher.

Step 3. The results page shows that eight older (>200 years) NPDs have a soil foundation and are not under federal regulatory authority. The researcher selects these NPDs for further investigation, as illustrated by the highlighted node in Figure 31.

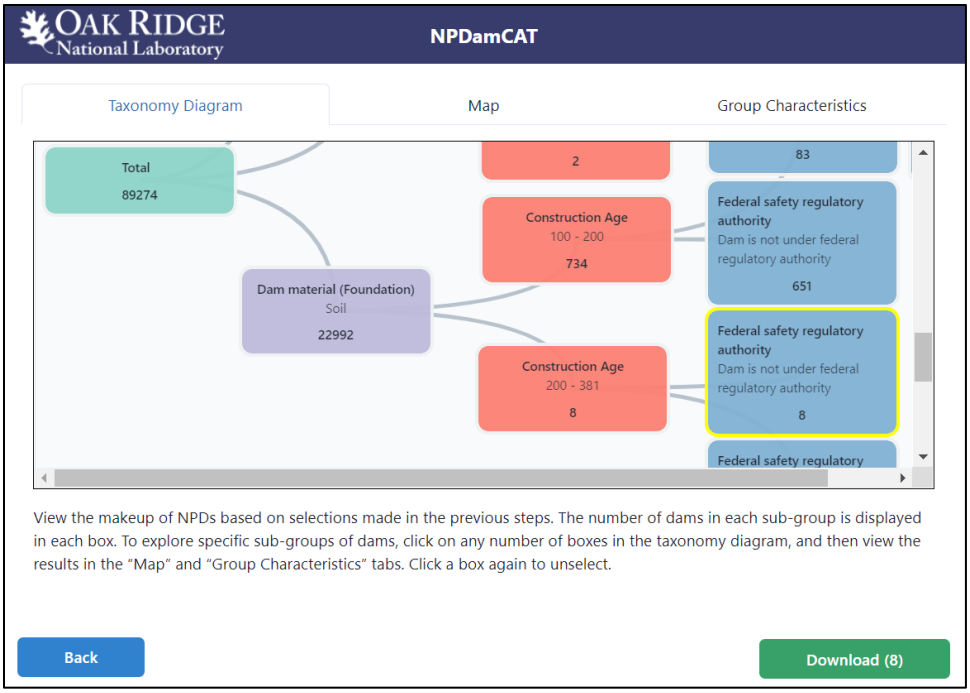


Figure 31. Example taxonomy diagram for dam foundation type, age, and regulatory authority.

Step 4. The researcher uses the **Map** view to investigate the locations and attributes of the eight selected NPDs (Figure 32).

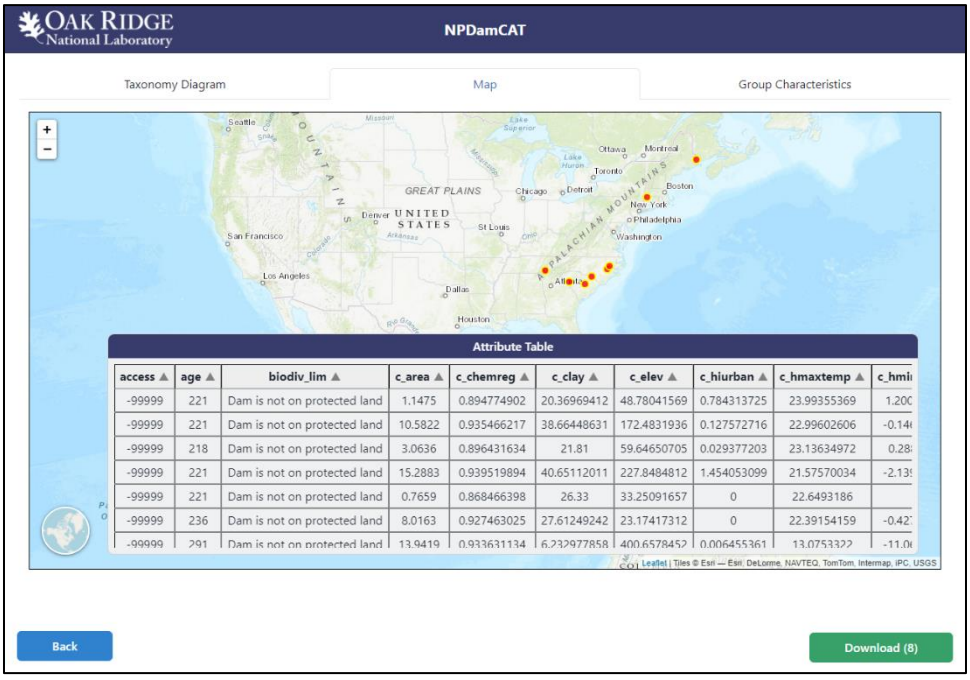


Figure 32. View of selected dams meeting criteria defined by a hypothetical dam safety researcher.

Step 5. The researcher selects the **Group Characteristics** tab to see the relationship of the eight dams based on various attributes (Figure 33).

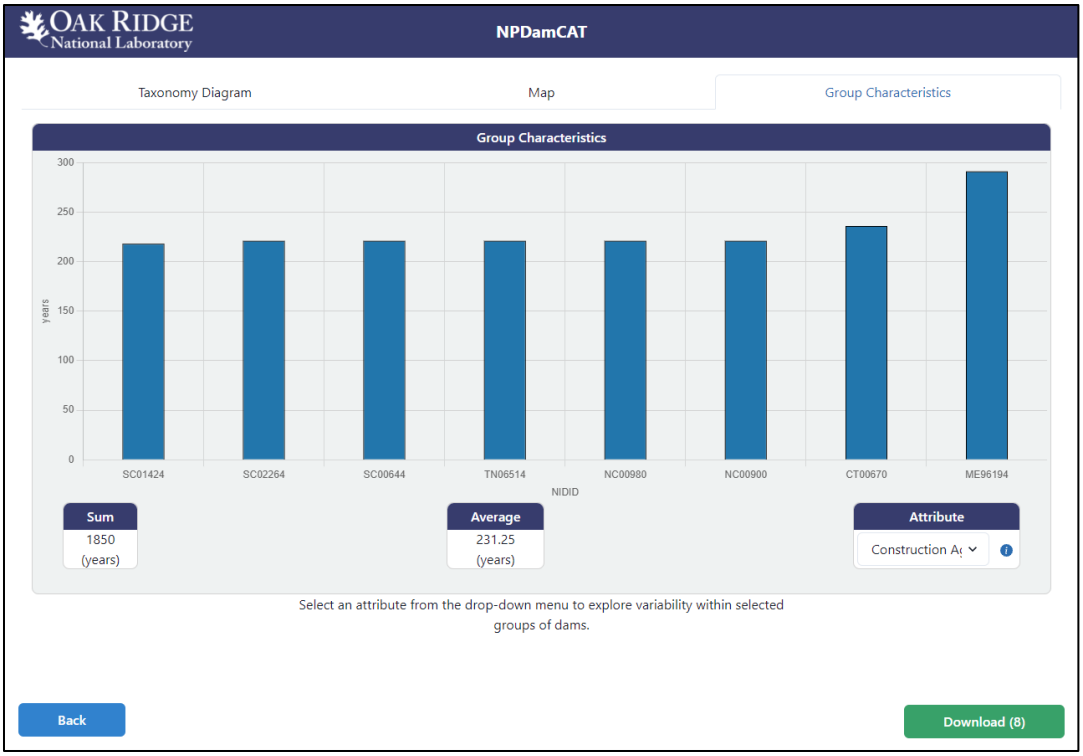


Figure 33. Variability of selected attribute (age) within the selected NPDs.

Step 6. The researcher downloads a CSV file of the attributes of the eight selected NPDs (Figure 34).

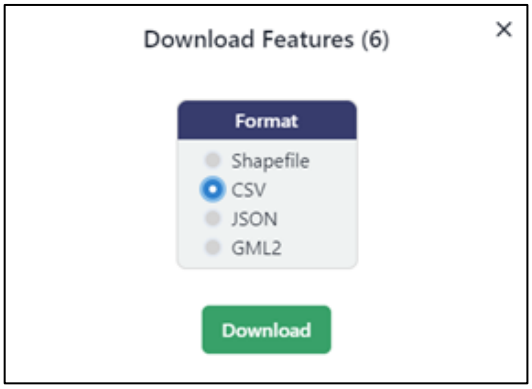


Figure 34. Output file formats include CSV files.

2.6.4.3 Energy Modeler Use-Case Example

An energy modeler may be interested in identifying recently constructed dams and determining whether they have the capacity to produce enough power to be economically viable. These potential capacity additions could factor into models of future energy systems. A researcher may be interested in a particular region, so exploration of dams would need to reflect this focus.

Step 1. The energy modeler selects two characteristics, as shown in Figure 35.

Figure 35. Selected characteristics for a hypothetical energy modeler.

Step 2. The researcher is only interested in a limited region of the United States, so a filter is applied on **Hydrologic Unit - Region**. Hydrologic Unit - Region does not need to be added to the list of selected characteristics. Rather, this filter is applied by going to the filter icon next to **Hydrologic Unit - Region**, clearing all regions except 15, and selecting the **OK** button, as shown in Figure 36.

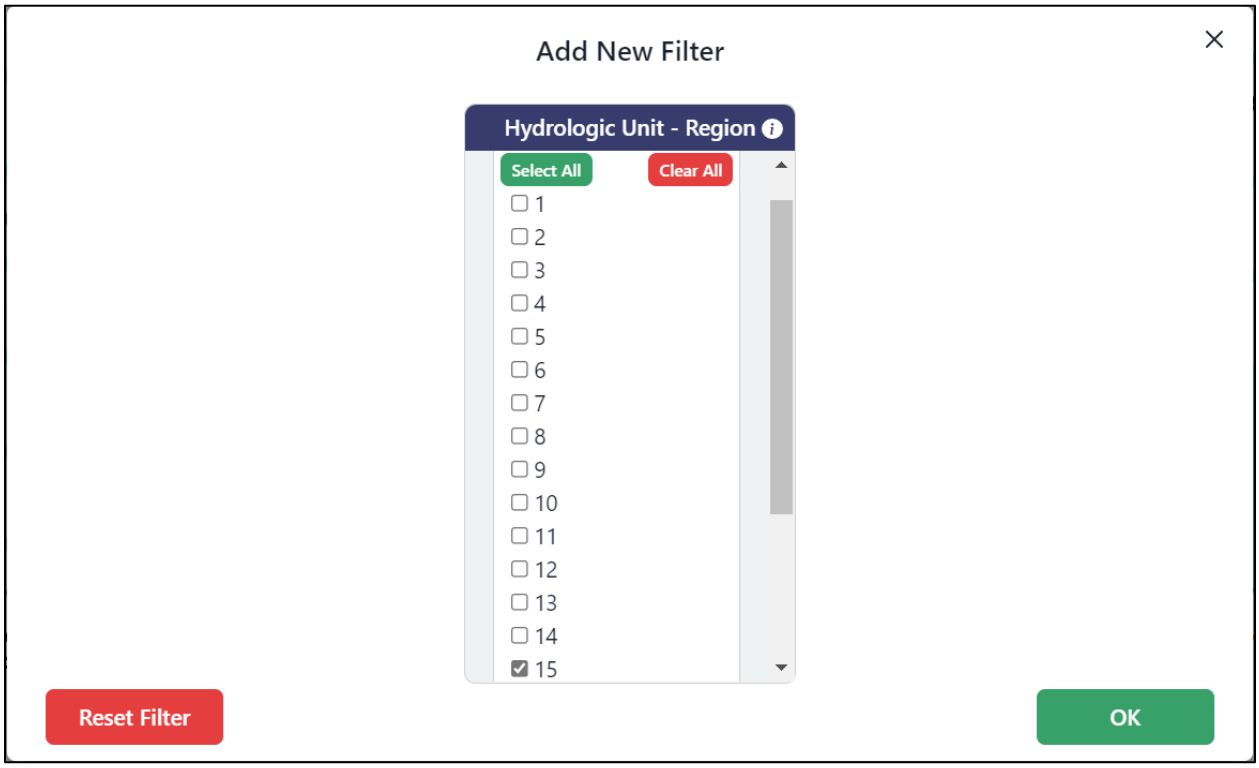


Figure 36. Filter for Hydrologic Region.
The population of NPDs that will be classified is restricted to the selected region.

Step 3. On the classes page, a custom age class is specified to divide dams into the categories of *new* (3–50 years), *aging* (50–100 years), and *older* (100–381 years). A custom class is also applied to potential capacity to divide dams into the categories *small* (1–5 MW), *medium* (5–10 MW), and *large* (10–496 MW), as shown in Figure 37.

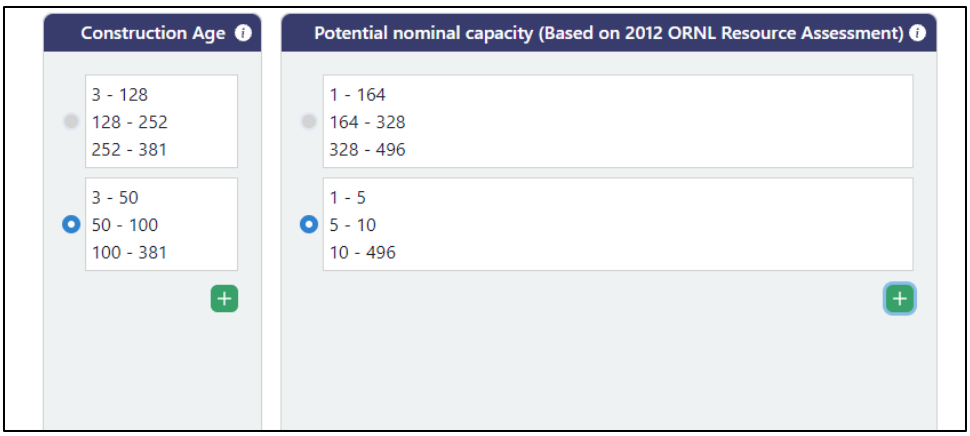


Figure 37. Classes for the characteristics selected by a hypothetical energy modeler.

Step 4. The results page highlights four aging NPDs with large potential capacity (i.e., 50–100 years old with 10–496 MW capacity). Those NPDs are selected for further analysis, as illustrated by the highlighted node in Figure 38.

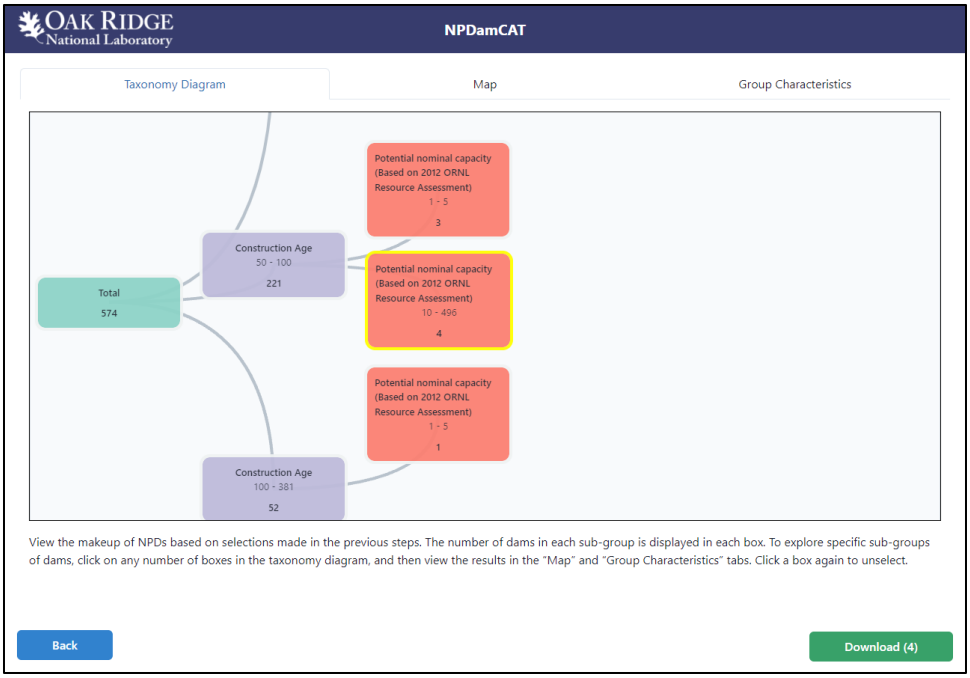


Figure 38. Example taxonomy diagram for age and potential generation capacity.

Step 5. The locations of the four NPDs and their attributes can be viewed in the **Map** tab (Figure 39).

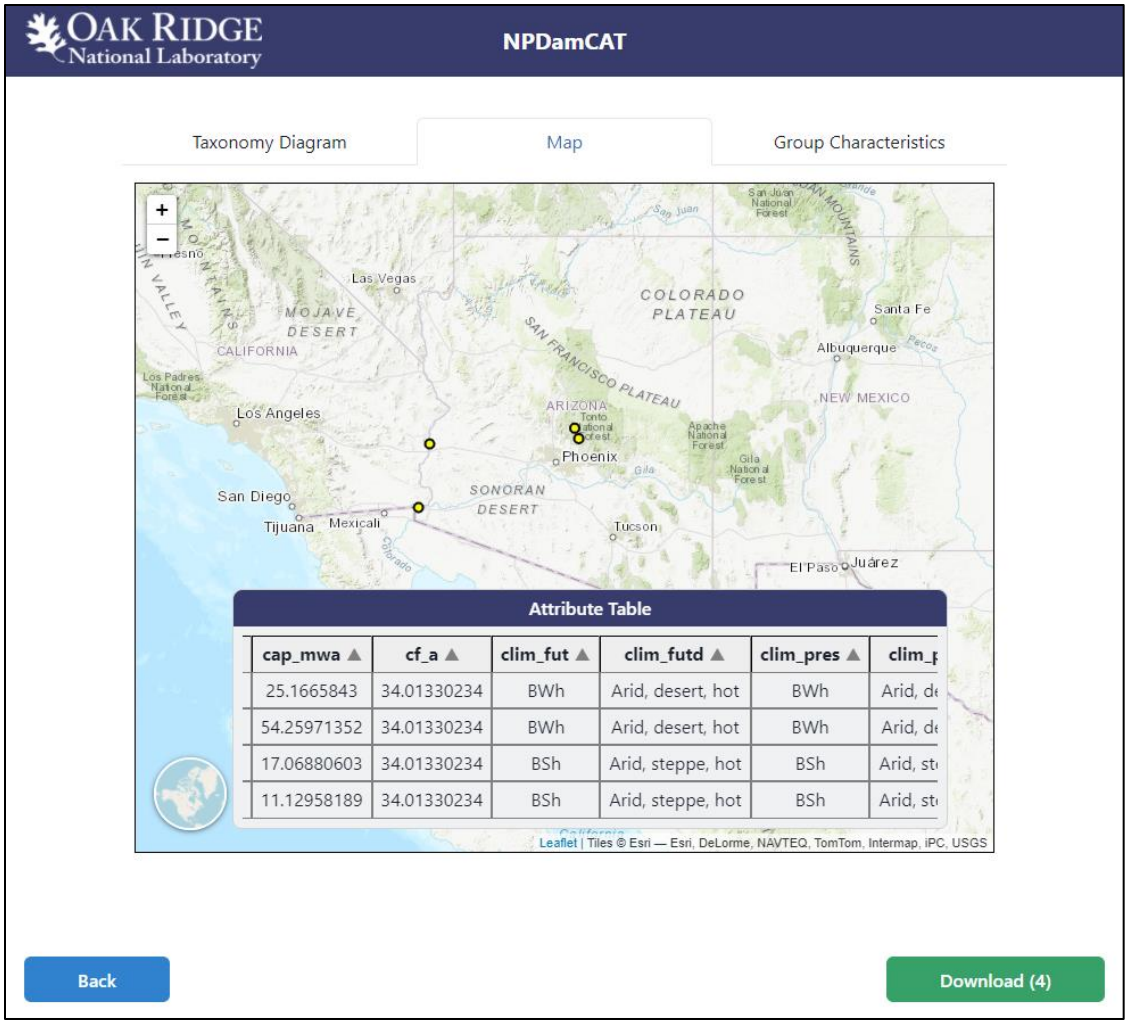


Figure 39. View of selected dams meeting criteria defined by a hypothetical energy modeler.

Step 6. Characteristics can be compared in the **Group Characteristics** tab. Figure 40 shows the potential capacities of the four selected NPDs.

Figure 40. Variability of selected attribute (potential generation capacity) among the selected NPDs.

Step 7. Finally, the energy modeler downloads a shapefile of the four NPDs for further analysis (Figure 41). The shapefile format is particularly helpful for connecting the NPD data to other spatial information.

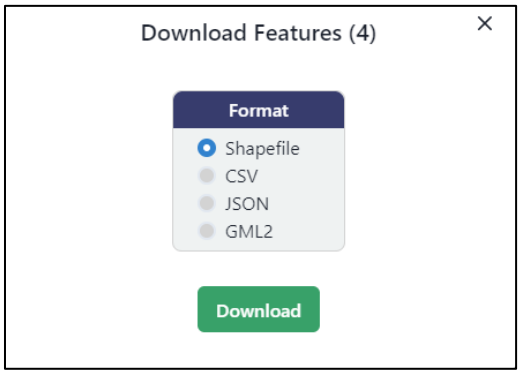


Figure 41. Output file formats include shapefiles.

Step 8. The shapefile of selected dams can be loaded into the NPD Explorer app via the **Add Data** widget in NPD Explorer (Figure 42).

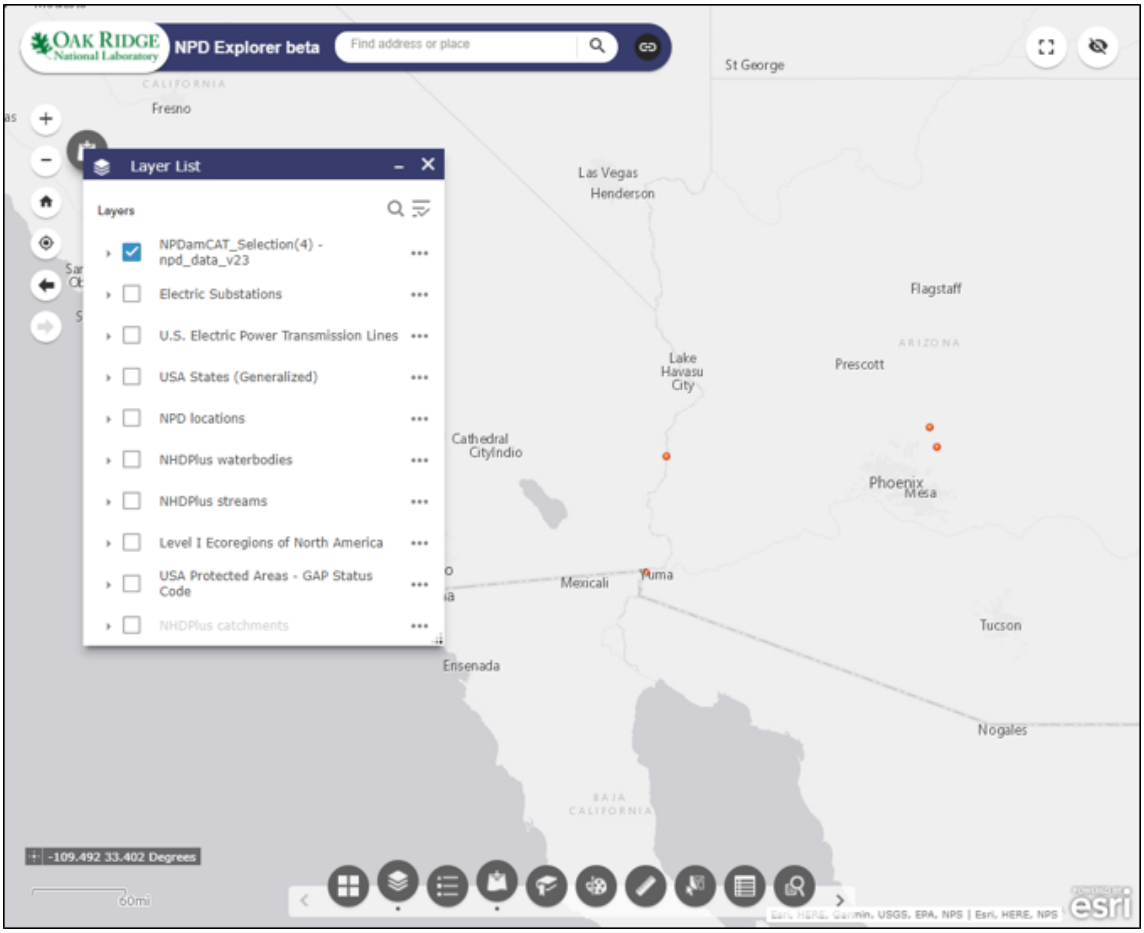


Figure 42. Outputs from the NPDamCAT app can be imported and viewed within the NPD Explorer app.

3. CONCLUSION

The tools described in this user guide provide a variety of features that enable exploration of diverse characteristics related to NPDs, including their geospatial relationships to other infrastructure and physical features. Through this exploration, various users will better understand the population of non-powered dams from perspectives that reflect their unique objectives or geographic interests. While these tools provide a variety of opportunities for exploration of NPDs and NPD-related information, it is important to note the limitations accuracy and completeness; therefore, the information presented within these tools is preliminary and cannot take the place of detailed site-specific analysis that is required for final decision making. Rather, the apps are intended to provide a foundation of understanding and offer support for diverse areas of dam-related research such as identification of dams that meet certain or requirements for various development, retrofit, or removal opportunities or defining the range and distribution of characteristics among the population of NPDs (or smaller groups of dams). Improvements may be made as new data become available and as large-scale analysis provides additional insight into other characteristics that are not yet included.

4. REFERENCES

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APPENDIX A. NPD DATA

The underlying non-powered dam (NPD) characteristics inventory uses the US Army Corps of Engineers (USACE) National Inventory of Dams (NID) ID as the fundamental identifier for the dam. Other NPDs may be documented outside of this data set; however, the NPD Explorer and NPDamCAT apps use the NID because it is the most comprehensive, publicly available catalog of dams in the United States at time of writing.

Data supporting the NPD Explorer and NPDamCAT apps consist of values related to characteristics of US NPDs and their surroundings, including characteristics or attributes related to the physical nature or design of a dam, environmental conditions, safety conditions, socioeconomic aspects, and hydropower development potential. Data may be continuous or discrete/categorical. Data were obtained for each dam listed as an NPD (based on USACE NID).

Data are sourced using the following methods:

a) Data may be collected from existing sources that are readily referencing either a dam or its associated hydrography feature using unique dam ID or hydrography ID (e.g., NHD Common Identifier [COMID] or hydrologic unit code).

b) Data may be extracted from spatial data sets using standard geographic information system (GIS) processing (e.g., spatial intersect or spatial joins).

c) Data may be calculated from model outputs.

Attributes for the various characteristic themes (operational, design [age, materials and architectural/structural, size/dimensions, water conveyance], hydropower opportunity, socioeconomic, and environmental [hydrology, climate, landscape, water quality, geology]) were obtained from a variety of sources. Each attribute is documented in the following tables, including:

- associated field name (limited to 10 characters to comply with the standard ESRI shapefile format),
- a brief description,
- units,
- suggested classes (may be the available values of categorical data or suggested thresholds for continuous data that are based on existing design, safety, or other guidelines),
    - **User-defined** indicates that no suggested class exists; classes may be defined entirely based on the user's objectives and preferences.
    - **Not applicable** indicates that classes may not be appropriate to assign. The characteristic may be more appropriately viewed as an identifier (such as the ID of the NHDPlus stream reach) or for filtering (such as the state or county in which the dam is located).
- source of the data, and
- type of data (text or numeric).

Table A-1. Operational Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Primary purpose	PRPS_PRMRY	The primary purpose of a dam, as reported by dam inventories. Because of differences in reporting standards, this purpose may reflect the original purpose of dam construction, or it may reflect the reservoir services that primarily govern the operations of the reservoir. The first purpose listed is assumed to have the highest importance or priority; however, multiple purposes may have equal weight or importance.	—	• Irrigation • Flood control and storm water management • Navigation • Water supply • Recreation • Fire protection, stock, or small farm pond • Fish and wildlife pond • Debris control • Tailings • Grade stabilization • Other	NID 2019 [1] (Purpose)	text
Multipurpose	MULTI_PRPS	Dams may serve one or more purposes, which may evolve over time. This characteristic describes whether a dam has multiple purposes reported by the data source.	—	• Single purpose • Multipurpose	NID 2019 [1] (Purpose)	text
Simplified purpose	PRPS_GEN	Dam purpose, simplified into storage for hydrologic purposes, namely water storage, debris storage, or navigation/passage.	—	• Storage • Storage - debris/waste • Navigation	NID 2019 [1] (Purpose)	text

Table A-1. Operational Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Hydraulic head	HYD_HD_A	The generation capacity of an individual facility is a function of its available head. Head can vary at a site depending on the level of the reservoir.	m	Common distinctions between high- and low-head dams [4]: • High/Low head (~30 ft or 10 m) Thresholds based on general head ranges corresponding with turbines [5]: • Low: 2–25 m • Medium: 25–70 m • High: > 70 m	NID 2019 [1] (Hydraulic height, Structural height, NID height)	numeric
Operating entity	FED_OP	Describes whether a federal agency is involved in the operation of the dam.	—	Federal agency involved in operation (Y/N)	NID 2019 [1] (Federal Agency Involvement in Operation)	text
Operating entity	FED_OP_OWN	In some cases, multiple federal agencies may be involved in ownership and operation. For those dams under federal ownership or operation, this characteristic describes whether the owner is the same as the operating entity.	—	• No federal agency involved in operation • Federal agency owner is same as federal operating entity • Federal agency owner is not the same as same as federal operating entity	NID 2019 [1] (Federal Agency Involvement in Operation)	text
Maximum storage	MAX_STRG	The total storage space in a reservoir below the maximum attainable water surface elevation, including any surcharge storage.	m^3	ASCE/FEMA size classes: • Small: < 1.23×10^6 m^3 (< 1 kaf), • Intermediate: 1.23×10^6–6.17×10^7 m^3 (1–50 kaf), • Large: > 6.17×10^7 m^3 (> 50 kaf)	NID 2019 [1] (Maximum Storage)	numeric
Normal storage	NORM_STRG	The total storage space in a reservoir below the normal retention level, including dead and inactive storage and excluding any flood	m^3	ASCE/FEMA size classes: • Small: < 1.23×10^6 m^3 (< 1 kaf), • Intermediate: 1.23×10^6–6.17×10^7 m^3 (1–50 kaf), • Large: > 6.17×10^7 m^3 (> 50 kaf)	NID 2019 [1] (Normal Storage)	numeric

Table A-1. Operational Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
		control or surcharge storage.				
Max discharge rate	MAX_DISCHA	Maximum flowrate the spillway is capable of discharging when reservoir is at its maximum designed water surface elevation.	m^3/s	User-defined	NID 2019 [1] (Maximum Discharge)	numeric
Upstream mainstem dams	UM_DAM_CT	Count of dams upstream (main stem) of stream reach. Note this only includes dams in the National Anthropogenic Barrier Dataset (not updated since 2012).	dams	User-defined	Dam Metrics Representing Stream Fragmentation and Flow Alteration [6]	numeric
Upstream mainstem dam density	UMDAMCTLEN	Upstream network dam density per unit stream network length. Note this only includes dams in the National Anthropogenic Barrier Dataset (not updated since 2012).	dams/km	User-defined	Dam Metrics Representing Stream Fragmentation and Flow Alteration [6]	numeric
Total upstream dams	TOTUDAM_CT	Total count of dams upstream of stream reach. Note this only includes dams in the National Anthropogenic Barrier Dataset (not updated since 2012).	dams	User-defined	Dam Metrics Representing Stream Fragmentation and Flow Alteration [6]	numeric
Downstream mainstem dams	DM_DAM_CT	Count of dams downstream (main stem) of stream reach. Note this only includes dams in the National	dams	User-defined	Dam Metrics Representing Stream Fragmentation and Flow Alteration [6]	numeric

Table A-1. Operational Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
		Anthropogenic Barrier Dataset (not updated since 2012).				
Total mainstem dams	TOTMSDAMCT	Total count of dams on the mainstem (up or downstream) of the stream reach. Note this only includes dams in the National Anthropogenic Barrier Dataset (not updated since 2012).	dams	User-defined	Dam Metrics Representing Stream Fragmentation and Flow Alteration [6]	numeric
Distance to upstream dam	DISTTOUDAM	Distance to the nearest upstream dam. Note this only includes dams in the National Anthropogenic Barrier Dataset (not updated since 2012).	km	User-defined	Dam Metrics Representing Stream Fragmentation and Flow Alteration [6]	numeric
Distance to downstream dam	DISTTODDAM	Distance to the nearest downstream dam. Note this only includes dams in the National Anthropogenic Barrier Dataset (not updated since 2012).	km	User-defined	Dam Metrics Representing Stream Fragmentation and Flow Alteration [6]	numeric
Upstream storage	PERCDISUS	Percent of the annual discharge stored in reservoirs upstream. Note this only includes dams in the National Anthropogenic Barrier Dataset (not updated since 2012).	%	User-defined	Dam Metrics Representing Stream Fragmentation and Flow Alteration [6]	numeric

Table A-1. Operational Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Downstream mainstem dam density	DMDAMCTLEN	Downstream mainstem dam density per unit downstream mainstem length. Note this only includes dams in the National Anthropogenic Barrier Dataset (not updated since 2012).	dams/km	User-defined	Dam Metrics Representing Stream Fragmentation and Flow Alteration [6]	numeric

Table A-2. Design - Age Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Construction Age	AGE	Reflects the original construction age of the dam. Does not account for any modifications, upgrades, or retrofits that have taken place after the dam was completed.	yr	User-defined	NID 2019 [1] (Year completed)	integer
Age of most recent modification	MOD_AGE	Reflects the age of the dam according to the most recent reported year of modification.	yr	User-defined	NID 2019 [1] (Year modified)	integer

Table A-3. Design - Materials and Architectural/Structural Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Material (Primary construction material)	PRMRY_MTRL	Primary construction material. Note that a dam may consist of multiple materials.	—	• Earth • Rockfill • Roller-compacted concrete • Concrete • Masonry • Stone • Timber crib	NID 2019 [1] (Dam Type)	text
All materials	MTRL	All construction materials.	—	Any combination of: • Earth • Rockfill • Roller-compacted concrete • Concrete • Masonry • Stone • Timber crib	NID 2019 [1] (Dam Type)	text
Dam material (Core)	CORE_MTRL	The material of the dam core (i.e., zone of material with low permeability), which may be different from the primary construction material.	—	• Bituminous concrete • Concrete • Earth • Metal • Plastic	NID 2019 [1] (Core)	text
Dam material (Foundation)	FND_MTRL	The material upon which a dam is founded.	—	• Rock • Rock and soil • Soil	NID 2019 [1] (Foundation)	text

Table A-3. Design - Materials and Architectural/Structural Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Architectural/Structural type	CNST_TYPE	General description of structural type of dam	—	• Gravity • Buttress • Arch • Gravity–arch • Multi-arch • Buttress–arch • Buttress–gravity • Buttress–multi-arch • Gravity–multi-arch	NID 2019 [1] (Dam Type)	text

Table A-4. Design - Size/Dimension Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Hydraulic height	HYD_HT	Difference between the maximum design water level and lowest point in the original streambed	m	USFWS Dam Safety Program Definitions [7]: • Small: < 12.2 m (< 40 ft) • Intermediate: 12.2–30.5 m (40–100 ft) • Large: > 30.5 m (> 100 ft)	NID 2019 [1] (Hydraulic height)	numeric
Dam height	DAM_HT	Difference from lowest point of the crest of the dam and the lowest point in the original streambed	m	USFWS Dam Safety Program Definitions [7]: • Small: < 12.2 m (< 40 ft) • Intermediate: 12.2–30.5 m (40–100 ft) • Large: > 30.5 m (> 100 ft)	NID 2019 [1] (Dam height)	numeric
Structural height	STR_HT	Difference from lowest point of excavated foundation to the top of the dam (parapet wall, not crest)	m	USFWS Dam Safety Program Definitions [7]: • Small: < 12.2 m (< 40 ft) • Intermediate: 12.2–30.5 m (40–100 ft) • Large: > 30.5 m (> 100 ft)	NID 2019 [1] (Structural Height)	numeric
Maximum height	MAX_HT	Max value of Hydraulic, Dam, and Structural Height	m	USFWS Dam Safety Program Definitions [7]: • Small: < 12.2 m (< 40 ft) • Intermediate: 12.2–30.5 m (40–100 ft) • Large: > 30.5 m (> 100 ft)	NID 2019 [1] (NID Height)	numeric
Dam length	DAM_LEN	Length along the top of the dam	m	User-defined	NID 2019 [1] (Dam Length)	numeric
Dam volume	DAM_VOL	Cubic yards of occupied by the materials used in the dam structure.	m^3	User-defined	NID 2019 [1] (Volume of Dam)	numeric

Table A-5. Design - Water Conveyance and Electrical Infrastructure Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Gate	GATE	Describes presence of any barrier that regulates water released from a reservoir. Gates may be located on the crest or connected with other types of outlets.	—	• No gates reported • Some type of gate/control structure reported • Number of gates unknown	NID 2019 [1] (Outlet Gates)	text
Presence of locks	LOCKS	Navigation locks enable transportation of commercial and/or recreational craft upstream and downstream of dam structures through inland waterways.	—	• No locks • Dam includes at least one lock	NID 2019 [1] (Number of locks)	text
Number of locks	NUM_LOCKS	Navigation locks enable transportation of commercial and/or recreational craft upstream and downstream of dam structures through inland waterways.	—	User-defined	NID 2019 [1] (Number of locks)	integer
Spillway control type	SPLLWYCONT	Describes whether the spillway is controlled or uncontrolled (or does not exist)	—	• Controlled, uncontrolled • No spillway • Invalid spillway type reported	NID 2019 [1] (Spillway Type, Outlet Gates)	text
Distance to substation	DISTTOSUB	Distance from the power plant to the existing substation.	km	User-defined	HIFLD Electrical Substations [8]	numeric

Table A-6. Hydropower Opportunity Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Potential nominal capacity (Based on 2012 ORNL Resource Assessment)	CAP_MWA	Estimated nominal power capacity.	MW	User-defined	2012 NPD Resource Assessment [9]	numeric
Potential annual energy (Based on 2012 ORNL Resource Assessment)	GEN_MWHA	Estimated energy generation on an annual basis.	MWh	User-defined	2012 NPD Resource Assessment [9]	numeric
Subject to FERC regulatory authority	REG_FERC	Indicates whether the Federal Energy Regulatory Commission (FERC) would likely regulate future hydropower project. Some projects may be exempt from FERC's licensure because of size or because of arrangements with a federal owner (e.g., lease of power privilege through the USBR).	—	• Dam likely would fall under FERC regulatory authority • Dam may not fall under FERC regulatory authority • Owner is a federal agency	NID 2019 [1] (Owner Type, Federal Agency Owner, Source Owner)	text
Regional capacity factor (Based on 2001–2008 data)	CF_A	The fraction of actual energy output to the maximum possible energy output during a given time period.	—	User-defined	HUC2-based historical (2001-2008) regional capacity factor from 2012 NPD Resource Assessment [9]	numeric
Average solar energy generation in the HUC12	DLYSOLGEN	Average annual daily potential solar energy (kWh/m2/day)	kWh/m2/day	User-defined	EnviroAtlas [10]	numeric
Average wind energy generation in the HUC12	DLYWINDGEN	Average annual daily potential wind	kWh/m2/day	User-defined	EnviroAtlas [10]	numeric

		energy (kWh/m2/day)				

Table A-7. Socioeconomic Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Type of owner	OWNER_TYPE	NPDs may be owned by a variety of different entities. In cases where a dam is owned by more than one entity, all types of owners are included.	—	• Private • Local government • Public utility • Utility • State • Federal • None reported • Federal/public utility • Private/state • Local government/private • Local government/state • Federal/private • Federal/local government • Local government/private/state • Private/public utility	NID 2019 [1]	text
Simplified type of owner	OWNER_GEN	A simplified case description of the "Type of owner" that reflects whether a single owner is involved (and if so, that owner type is described) or if multiple owners are involved.	—	• Private • Other • Public utility • Federal • None reported • Multiple owners, including federal • Multiple owners, nonfederal	NID 2019 [1]	text

Table A-7. Socioeconomic Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Federal owner	FEDOWNNAME	Which federal agency owns the dam (if applicable).	—	• Federal prisons • TVA (Tennessee Valley Authority) • US DoD (US Department of Defense) • US DOE (US Department of Energy) • US DOI (US Department of the Interior) • USACE (US Army Corps of Engineers) • USAF (US Air Force) • USBIA (US Bureau of Indian Affairs) • USBLM (US Bureau of Land Management) • USBR (US Bureau of Reclamation) • USDA (US Department of Agriculture) • USFS (US Forest Service) • USFWS (US Fish and Wildlife Service) • USNPS (US National Park Service) • Other	NID 2019 [1]	text
Population	HUC12_POP	Population estimated in the HUC12. The current and projected population densities within watersheds surrounding NPDs serve as indicators for the size and types of communities that may be affected by or have interest in NPD development.	people	User-defined	StreamCat [11]	numeric

Table A-7. Socioeconomic Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Landmark Status	CULTURE	Historical status is a measure of the social or cultural importance of the NPD. Describes whether the dam is located within the bounds listed by The National Register for Historic Places officially as worthy of preservation based on cultural value. This register includes several hundred dams and lists their level of significance (local, state, national, international).	—	Dam is located on a historical or cultural site or within the bounds of a national monument (Y/N)	National Register of Historic Places [12]	text
Hazard potential downstream of dam	FEMA_HZRD	Potential hazard is meant to quantify the hazard (expected loss of human life and economic/environmental losses) posed to "the downstream area resulting from failure or mis-operation of the dam or facilities" [1].	—	• Low • Significant • High	NID 2019 [1]	text

Table A-7. Socioeconomic Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
High hazard dams	HH_DAM_CT	Number of high hazard potential dams in the HUC12	# of dams	User-defined	EnviroAtlas [10]	numeric
Federal safety regulatory authority	FED_REG	Indicates whether a dam falls under the authority of the Federal Energy Regulatory Commission for dam safety coordination.	—	• Dam is under federal regulatory authority • Dam is not under federal regulatory authority	NID 2019 [1] (Fed Regulatory)	text
Support for renewable energy funding	RESPPRT	Percent of the county population in support of funding renewable energy research.	%	User-defined	Yale Climate Opinion Maps [13]	numeric
Risk perception of global warming	GWRISK	Percent of the county population that is worried about global warming.	%	User-defined	Yale Climate Opinion Maps [13]	numeric
Belief in global warming	GWBLF	Percent of the county population that believes global warming is happening.	%	User-defined	Yale Climate Opinion Maps [13]	numeric
Current political party	PLTCLPRTY	Political party associated with the representative in the congressional district where the dam is located at the time of the most current NID version.	—	• R (Republican) • D (Democrat) • O (Other)	NID 2019 [1](Party)	text

Table A-7. Socioeconomic Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Domestic water use by HUC12	DOM_WD	Domestic water use by HUC12	million gallons	User-defined	EnviroAtlas [10]	numeric
State	STATE	Abbreviation for state where dam is located.	—	Not applicable	NID 2019 [1] coordinates	text
County	COUNTY	Name of county location of dam.	—	Not applicable	NID 2019 [1] coordinates	text
NERC Region	NERCREG	Name of region according to the North American Electric Reliability Corporation	—	Not applicable	HIFLD NERC Regions [14]	text
NERC Subregion	NERCSUBREG	Name of sub-region according to the North American Electric Reliability Corporation	—	Not applicable	HIFLD NERC Regions [14]	text

A-8. Socioeconomic – Recreation Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Demand for Freshwater Fishing	FFSHDLYTRP	Freshwater fishing recreation demand (day trips per year)	# trips/day	User-defined	EnviroAtlas [10]	numeric
Boat ramps (developed)	CTDVBTRMP	Number of developed boat ramps in the HUC12	Number of sites	User-defined	Recreational data obtained from DeLorme digital data (no longer available on the web) see [15]	numeric
Boat ramps (undeveloped)	CTUDVBTRMP	Number of undeveloped boat ramps in the HUC12	Number of sites	User-defined	Recreational data obtained from DeLorme digital data (no longer available on the web) see [15]	numeric
Coldwater fishing sites	CTFISHCOLD	Number of sites for coldwater fishing in the HUC12	Number of sites	User-defined	Recreational data obtained from DeLorme digital data (no longer available on the web) see [15]	numeric
Saltwater fishing sites	CTFISHSALT	Number of sites for saltwater fishing in the HUC12	Number of sites	User-defined	Recreational data obtained from DeLorme digital data (no longer available on the web) see [15]	numeric
Whitewater paddling sites	CTWWPAD	Number of sites for put-in or take-out for whitewater paddling in the HUC12	Number of sites	User-defined	American Whitewater National Whitewater Inventory [16]	numeric

Table A-9. Environmental – Hydrology Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
River segment	COMID	Unique identifier of river segment in NHDPlusV2 Med Res data set.	—	Not applicable	NHDPlusV2 Medium Resolution [17]	numeric
Type of river segment	FTYPE	Description of the type of flowline/river segment to which a dam is matched.	—	• Artificial path • Canal/ditch • Coastline • Connector • Pipeline • Stream/river	NHDPlusV2 Medium Resolution [17]	text
Strahler Stream Order	STRM_ORDR	Modified Strahler Stream Order of the NHDPlusV2 stream reach associated with the dam	—	Not applicable	NHDPlusV2 Medium Resolution [17]	numeric
Flow into the system, max daily flow rate	MAXDLYQ	Maximum daily flow, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, min daily flow rate	MINDLYQ	Minimum daily flow, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, mean annual average flow rate (Dayflow)	MNANNAVGQ	Mean annual average flow rate, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, 10% exceedance flow	PERC10Q	Flow rate that is exceeded by 10% of flows, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, 20% exceedance flow	PERC20Q	Flow rate that is exceeded by 20% of flows, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric

Table A-8. Environmental – Hydrology Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Flow into the system, 30% exceedance flow	PERC30Q	Flow rate that is exceeded by 30% of flows, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, 40% exceedance flow	PERC40Q	Flow rate that is exceeded by 40% of flows, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, 50% exceedance flow	PERC50Q	Flow rate that is exceeded by 50% of flows, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, 60% exceedance flow	PERC60Q	Flow rate that is exceeded by 60% of flows, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, 70% exceedance flow	PERC70Q	Flow rate that is exceeded by 70% of flows, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, 80% exceedance flow	PERC80Q	Flow rate that is exceeded by 80% of flows, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, 90% exceedance flow	PERC90Q	Flow rate that is exceeded by 90% of flows, modeled during 1981–2015.	m^3/s	User-defined	Modeled streamflow [18]	numeric
Flow into the system, mean annual average flow rate (EROM)	Q_EROM	Mean annual average flow rate, modeled using the Enhanced Runoff Method	m^3/s	User-defined	EROM Streamflow from National Hydrography Dataset Plus V2 [17]	numeric
Hydrologic Unit - Region	HUC_2	Hydrologic unit at the region level	—	Not applicable	NHD WBD [17]	numeric

Table A-8. Environmental – Hydrology Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Hydrologic Unit - SubWatershed	HUC_12	Hydrologic region at the sub-watershed level	—	Not applicable	NHD WBD [17]	numeric
River Name	RIVER	Name of river associated with the dam in the NID	—	Not applicable	National Hydrography Dataset Plus V2 [17]	text
River GNIS Name	GNIS_NAME	Name of river associated with the NHD stream reach, according to the Geographic Names Information System	—	Not applicable	National Hydrography Dataset Plus V2 [17]	text
Drainage area	DRNG_AREA	Drainage area of the stream reach where the dam resides	km^2	User-defined	NID 2019 [1]	numeric
Watershed area	W_AREA	Watershed area at the NHDPlus stream segment outlet (including upstream catchments)	km^2	User-defined	StreamCat [11]	numeric
Catchment area	C_AREA	Area of local NHDPlus catchment (area that drains directly to the stream segment, not including any upstream catchments)	km^2	User-defined	StreamCat [11]	numeric
Watershed elevation	W_ELEV	Mean watershed elevation	m	User-defined	StreamCat [11]	numeric
Catchment elevation	C_ELEV	Mean catchment elevation	m	User-defined	StreamCat [11]	numeric
Reservoir surface area	SRFC_AREA	Surface are of the impounded water behind the dam	km^2	Based on size classes used in the US Environmental Protection Agency (EPA) National Lakes Assessment • < 2.47 km^2 (< 1 ha)	NID 2019 [1]	numeric

Table A-8. Environmental – Hydrology Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
				• 2.47–9.88 km^2 (1–4 ha) • 9.88–24.71 km^2 (4–10 ha) • 24.71–49.42 km^2 (10–20 ha) • 49.42–123.55 km^2 (20–50 ha) • 123.55–247.11 km^2 (50–100 ha) • 247.11–1235.53 km^2 (100–500 ha) • >1235.53 km^2 (> 500 ha)		
Mean annual runoff in the watershed	W_RUNOFF	Mean annual runoff during 1971–2000, calculated by McCabe and Wolock [19]	mm/yr	User-defined	StreamCat [11]	numeric
Mean annual runoff in the catchment	C_RUNOFF	Mean annual runoff during 1971–2000, calculated by McCabe and Wolock [19]	mm/yr	User-defined	StreamCat [11]	numeric
Hydrologic regulation index for watershed	W_HYDREG	Hydrologic regulation component score for watershed [20]	—	User-defined	StreamCat [11]	numeric
Hydrologic regulation index for catchment	C_HYDREG	Hydrologic regulation component score for catchment [20]	—	User-defined	StreamCat [11]	numeric
Hydrologic connectivity component score for watershed	W_HYDCON	Hydrologic connectivity component score for watershed [20]	—	User-defined	StreamCat [11]	numeric
Hydrologic connectivity component score for catchment	C_HYDCON	Hydrologic connectivity	—	User-defined	StreamCat [11]	numeric

Table A-8. Environmental – Hydrology Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
		component score for catchment [20]				
Storage in NID dams in the HUC12	DAM_STRG	Water supply from NID reservoirs in the HUC12	million gallons	User-defined	EnviroAtlas [10]	

Table A-10. Environmental - Climate Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Historical precipitation in the watershed	W_HPRECIP	30-year normal mean annual precipitation, derived from PRISM data for 1981–2010 [21]	mm/yr	User-defined	StreamCat [11]	numeric
Historical precipitation in the catchment	C_HPRECIP	30-year normal mean annual precipitation, derived from PRISM data for 1981–2010 [21]	mm/yr	User-defined	StreamCat [11]	numeric
Historical mean temperature in the watershed	W_HMNTEMP	30-year normal mean air temperature, derived from PRISM data for 1981–2010 [21]	°C	User-defined	StreamCat [11]	numeric
Historical mean temperature in the catchment	C_HMNTEMP	30-year normal mean air temperature, derived from PRISM data for 1981–2010 [21]	°C	User-defined	StreamCat [11]	numeric
Historical max temperature in the watershed	W_HMAXTEMP	30-year normal maximum air temperature, derived from PRISM data for 1981–2010 [21]	°C	User-defined	StreamCat [11]	numeric
Historical max temperature in the catchment	C_HMAXTEMP	30-year normal maximum air temperature, derived from PRISM data for 1981–2010 [21]	°C	User-defined	StreamCat [11]	numeric
Historical min temperature in the watershed	W_HMINTEMP	30-year normal minimum air temperature, derived from PRISM data for 1981–2010 [21]	°C	User-defined	StreamCat [11]	numeric

Table A-9. Environmental - Climate Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Historical min temperature in the catchment	C_HMINTEMP	30-year normal minimum air temperature, derived from PRISM data for 1981–2010 [21]	°C	User-defined	StreamCat [11]	numeric
Present climate (Code)	CLIM_PRES	Summary (class) of long-term weather and meteorological conditions. (1980–2016)	—	See [22] for classes	World map of Köppen-Geiger climates [22]	text
Present climate (Name)	CLIM_PRESD	Summary (description) of long-term weather and meteorological conditions. (1980–2016)	—	See [22] for classes	World map of Köppen-Geiger climates [22]	text
Projected future climate (Code)	CLIM_FUT	Climate refers to long-term weather and meteorological conditions. (2071–2100)	—	See [22] for classes	World map of Köppen-Geiger climates [22]	text
Projected future climate (Name)	CLIM_FUTD	Summary (description) of long-term weather and meteorological conditions. (2071–2100)	—	See [22] for classes	World map of Köppen-Geiger climates [22]	text

Table A-11. Environmental - Landscape Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Ecological region	ECOREGION	Broad description of regional ecology	—	Not applicable	EPA EcoRegions [23]	text
Protected land status	PROTSTATUS	Dams on protected lands may face additional restrictions in development. Describes whether the dam is located on protected lands.	—	• Dam is not on protected land • Dam is on protected land	United States Protected Area Database [24]	text
Entity responsible for land protection	PROT_MGMT	Describes which agency is responsible for managing protected lands (if the dam is located on protected lands).	—	• Federal • Joint • Local government • Regional agency Special district • State • Unknown	United States Protected Area Database [24]	text
Type of land protection	PROT_TYPE	Describes the type of protected land a dam is located on (if the dam is located on protected lands).	—	See [24] for classes	United States Protected Area Database [24]	text
Access to land	ACCESS	Describes the level of land access (if the dam is located on protected lands).	—	• Closed • Open access • Restricted access • Unknown	United States Protected Area Database [24]	text
River protection	WSR	Dams within the 0.25 mi buffer of a protected wild and scenic river may have additional flow restrictions.	—	• Wild and scenic river protected area • Not in Wild and scenic river protected area	Wild and Scenic Rivers [25]	text

Table A-10. Environmental - Landscape Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Limits to land use/activity due to biodiversity protections	BIODIV_LIM	Describes the types of biodiversity protections that may exist.	—	• Dam is not on protected land • Disturbance events may occur • Disturbance events suppressed • Managed for multiple uses—subject to extractive or off-highway vehicle use • No biodiversity protection	United States Protected Area Database [24]	text
Density of CERA sites	CERADENS	The number of Candidate Ecological Restoration Areas (CERAs) per square kilometer.	sites/km2	User-defined	EnviroAtlas [10]	numeric
Density of roads in watershed	W_RDDENS	Mean of road density values (length of roads per area) in watershed.	km/km^2	User-defined	StreamCat [11]	numeric
Density of roads in catchment	C_RDDENS	Mean of road density values (length of roads per area) in catchment.	km/km^2	User-defined	StreamCat [11]	numeric
Urbanization in the watershed	W_HIURBAN	Percent of watershed classified as developed, high-intensity land use.	%	User-defined	StreamCat [11]	numeric
Urbanization the catchment	C_HIURBAN	Percent of catchment classified as developed, high-intensity land use.	%	User-defined	StreamCat [11]	numeric
Cropland in the watershed	W_CROP	Percent of watershed classified as crop land use.	%	User-defined	StreamCat [11]	numeric

Table A-10. Environmental - Landscape Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Cropland in the catchment	C_CROP	Percent of catchment classified as crop land use.	%	User-defined	StreamCat [11]	numeric
Wetlands in the watershed	W_WETLD	Percent of watershed classified as wetland (herbacious and woody).	%	User-defined	StreamCat [11]	numeric
Wetlands in the catchment	C_WETLD	Percent of catchment classified as wetland (herbacious and woody).	%	User-defined	StreamCat [11]	numeric
Forest in the watershed	W_FOREST	Percent of watershed classified as forest (deciduous, coniferous, or mixed)	%	User-defined	StreamCat [11]	numeric
Forest in the catchment	C_FOREST	Percent of catchment classified as forest (deciduous, coniferous, or mixed)	%	User-defined	StreamCat [11]	numeric
Imperviousness in watershed	W_IMPERV	Percent of the watershed composed of impervious anthropogenic materials (e.g., parking surfaces, roads, building roofs).	%	User-defined	StreamCat [11]	numeric
Imperviousness in catchment	C_IMPERV	Percent of the catchment composed of impervious anthropogenic materials (e.g., parking surfaces, roads, building roofs).	%	User-defined	StreamCat [11]	numeric

Table A-10. Environmental - Landscape Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Ocean Sturgeon species count in HUC8	CTOCNSTRG	Number of species of oceanic sturgeon documented in the HUC8	# of species	User-defined	NatureServe Digital Distribution of Native U.S. Fishes by Watershed [26]	numeric
Inland sturgeon/paddlefish species count in HUC8	CTINLDSTRG	Number of species of inland sturgeon/paddlefish documented in the HUC8	# of species	User-defined	NatureServe Digital Distribution of Native U.S. Fishes by Watershed [26]	numeric
Ocean clupeid species count in HUC8	CTOCNCLPD	Number of species of oceanic sturgeon documented in the HUC8	# of species	User-defined	NatureServe Digital Distribution of Native U.S. Fishes by Watershed [26]	numeric
Ocean eel/lamprey species count in HUC8	CTOCNEEL	Number of species of oceanic sturgeon documented in the HUC8	# of species	User-defined	NatureServe Digital Distribution of Native U.S. Fishes by Watershed [26]	numeric
Ocean salmonid species count in HUC8	CTOCNSALM	Number of species of oceanic sturgeon documented in the HUC8	# of species	User-defined	NatureServe Digital Distribution of Native U.S. Fishes by Watershed [26]	numeric
Inland salmonid species count in HUC8	CTINLDSALM	Number of species of oceanic sturgeon documented in the HUC8	# of species	User-defined	NatureServe Digital Distribution of Native U.S. Fishes by Watershed [26]	numeric
Other inland species count in HUC8	CTOTRINLD	Number of species of oceanic sturgeon documented in the HUC8	# of species	User-defined	NatureServe Digital Distribution of Native U.S. Fishes by Watershed [26]	numeric
Fish passage mitigation requirements	FISHPSSREQ	The percent of mitigation sites in the database that had Tier 1 fish passage mitigation required,	%	User-defined	ORNL Environmental Mitigation Database [27]	numeric

Table A-10. Environmental - Landscape Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
		which provides an indirect measure of the need for fish passage mitigation at an NPD.				

Table A-12. Environmental - Water Quality Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
National Pollutant Discharge Elimination System (NPDES) permits in watershed	NPDESDENSW	Density of NPDES permits in the contributing watershed	sites/km^2	User-defined	StreamCat [11]	numeric
NPDES permits in catchment	NPDESDENSC	Density of NPDES permits in the contributing catchment	sites/km^2	User-defined	StreamCat [11]	numeric
Superfund sites in watershed	SF_DENSW	Density of Superfund sites in the contributing watershed	sites/km^2	User-defined	StreamCat [11]	numeric
Superfund sites in catchment	SF_DENSC	Density of Superfund sites in the contributing catchment	sites/km^2	User-defined	StreamCat [11]	numeric
Toxic Release Inventory sites in watershed	TRI_DENSW	Density of Toxic Release Inventory sites in the contributing watershed	sites/km^2	User-defined	StreamCat [11]	numeric
Toxic Release Inventory sites in catchment	TRI_DENSC	Density of Toxic Release Inventory sites in the contributing catchment	sites/km^2	User-defined	StreamCat [11]	numeric
303D river miles (total)	IMP303DTOT	Total length of stream or river flowlines in the HUC12 that have impairments submitted to the EPA by states under section 303(d) of the Clean Water Act	km	User-defined	EnviroAtlas [10]	numeric
303D river miles (biota)	IMP303DBIO	Total length of stream or river flowlines in the HUC12 that have impairments submitted to the EPA by states under section 303(d) of the Clean Water Act for biota	km	User-defined	EnviroAtlas [10]	numeric

303D river miles (Nutrients)	IMP303DNUT	Total length of stream or river flowlines in the HUC12 that have impairments submitted to the EPA by states under section 303(d) of the Clean Water Act for nutrients	km	User-defined	EnviroAtlas [10]	numeric
303D river miles (pH)	IMP303DPH	Total length of stream or river flowlines in the HUC12 that have impairments submitted to the EPA by states under section 303(d) of the Clean Water Act for pH	km	User-defined	EnviroAtlas [10]	numeric
303D river miles (Sediment)	IMP303DSED	Total length of stream or river flowlines in the HUC12 that have impairments submitted to the EPA by states under section 303(d) of the Clean Water Act for sediment	km	User-defined	EnviroAtlas [10]	numeric
303D river miles (Temperature)	IMP303D_T	Total length of stream or river flowlines in the HUC12 that have impairments submitted to the EPA by states under section 303(d) of the Clean Water Act for temperature	km	User-defined	EnviroAtlas [10]	numeric
303D Site	IMP303D	Indicates if the water body is in violation of the Clean Water Act (Section 303D) and currently listed as an impaired water body. Reasons for impairment	—	• Dam is located on a reach that is not listed as impaired • Dam is located on a reach that is listed as impaired	EPA Watershed Assessment, Tracking & Environmental Results System [28]	text

		include unacceptable levels of dissolved oxygen, sediment, pH, turbidity, temperature, biological contaminants, and nutrients.				

Table A-11. Environmental - Water Quality Characteristics (continued)

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Watershed regulation of water chemistry component score	W_CHEMREG	Regulation of water chemistry component score for watershed [20]	—	User-defined	StreamCat [11]	numeric
Catchment regulation of water chemistry component score	C_CHEMREG	Regulation of water chemistry component score for catchment [20]	—	User-defined	StreamCat [11]	numeric
Watershed sediment regulation component score	W_SEDREG	Sediment regulation component score for watershed [20]	—	User-defined	StreamCat [11]	numeric
Catchment sediment regulation component score	C_SEDREG	Sediment regulation component score for catchment [20]	—	User-defined	StreamCat [11]	numeric
Nitrogen from agriculture in the HUC12	AGN_RUNOFF	Dissolved nitrogen in surface runoff from agricultural fields in the HUC12	tons/yr	User-defined	EnviroAtlas [10]	numeric
Phosphorus from agriculture in the HUC12	AGP_RUNOFF	Dissolved phosphorus in surface runoff from agricultural fields in the HUC13	tons/yr	User-defined	EnviroAtlas [10]	numeric
Runoff from agriculture in HUC12	AG_RUNOFF	Annual surface runoff from agricultural land	mm/yr	User-defined	EnviroAtlas [10]	numeric
Erosion from agriculture in HUC12	AG_EROSION	Annual surface sediment erosion from agricultural lands	tons/yr	User-defined	EnviroAtlas [10]	numeric

Table A-13. Environmental - Geology Characteristics

CHARACTERISTIC	FIELD NAME	DESCRIPTION	UNITS	SUGGESTED CLASSES	DATA SOURCES	DATA TYPE
Watershed clay content	W_CLAY	Mean percent of clay content in watershed	%	User-defined	StreamCat [11]	numeric
Catchment clay content	C_CLAY	Mean percent of clay content in catchment	%	User-defined	StreamCat [11]	numeric
Watershed sand content	W_SAND	Mean percent of sand content in watershed	%	User-defined	StreamCat [11]	numeric
Catchment sand content	C_SAND	Mean percent of sand content in catchment	%	User-defined	StreamCat [11]	numeric
Watershed organic matter content	W_OM	Mean percent of organic matter content of soils in watershed	%	User-defined	StreamCat [11]	numeric
Catchment organic matter content	C_OM	Mean percent of organic matter content of soils in watershed	%	User-defined	StreamCat [11]	numeric
Watershed permeability	W_PERM	Mean permeability in watershed	cm/h	User-defined	StreamCat [11]	numeric
Catchment permeability	C_PERM	Mean permeability in catchment	cm/h	User-defined	StreamCat [11]	numeric
Watershed bedrock depth	W_RCKDEP	Mean depth to bedrock of soils in watershed	cm	User-defined	StreamCat [11]	numeric
Catchment bedrock depth	C_RCKDEP	Mean depth to bedrock of soils in catchment	cm	User-defined	StreamCat [11]	numeric
Watershed Kf factor	W_KF	Relative index of susceptibility of bare, cultivated soil to particle detachment and transport by rainfall in watershed	—	User-defined	StreamCat [11]	numeric
Catchment Kf factor	C_KF	Relative index of susceptibility of bare, cultivated soil to particle detachment and	—	User-defined	StreamCat [11]	numeric

		transport by rainfall in catchment				
Seismicity (Modified Mercalli Intensity)	MMI_10PCT	10% Exceedence Probability in 50 years for the Modified Mercalli Intensity for a site	—	User-defined	U.S. National Seismic Hazard Model [29]	numeric
Lithology	LITH	Dominant type of rock in the immediate area.	—	See [30] for classes	USGS State Geological Map Compilation (SGMC) geodatabase [30]	numeric

APPENDIX B. CREATION OF THE NPD CHARACTERISTICS INVENTORY

A series of basic quality checks was performed to improve use and understanding of the data. Because the NID (a major source of information for the NPD Explorer and NPDamCAT apps) is a collection of data from many state and federal agencies, problems with different reporting methods and accuracy cause issues with a small segment of the dam population. Several issues and the checks are performed to remedy or identify the potential issue as described below:

1) **Filtered out auxiliary structures.**

   Some dams in the NID are auxiliary, or supporting or secondary structures, but different methods are used to indicate whether a dam is an auxiliary structure. Some agencies report the OTHERSTRUCTUREID as 0, but most agencies leave the field blank if the dam is not an auxiliary structure. All instances where a *0* is used are changed to blanks, and a compound ID, the NIDIDFULL, is created by concatenating the NIDID and OTHERSTRUCTUREID fields. This change allows a somewhat nested structure: a complex or system of dams and associated structures can be found by querying the NIDID field, whereas the NIDIDFULL field will describe each individual structure.

2) **Filtered out dams that are listed multiple times.**

   Some dams are listed twice in the NID. The most obvious instance of this is when the NIDIDFULL values are identical across multiple structures (n = 4). Other cases of possible duplicates were identified by searching for dams with the same name and reported county (n = 1,513). These cases may not be actual duplicates, but instead auxiliary structures that do not have published OTHERSTRUCTUREID values.

3) **Removed dams with incomplete location information.**

   Some dams do not have complete location information. Dams missing latitude and/or longitude values are flagged with the phrase **Invalid location info in NID**. Another check on accuracy of location was performed by spatially joining county information to the NID: for cases in which the spatially joined county and reported county do not match, dams are flagged with the phrase **Location may not be accurate (reported county does not match)**.

4) **Corrected locations.**

   Locations were corrected for some cases in which coordinates had been updated during thorough quality checks that were conducted as part of the 2012 NPD Resource Assessment. Five hundred ninety-seven dams from this assessment were checked, and locations were adjusted to reflect the true location with respect to flowlines. For cases in which these dams could be matched to the most recent NID, the latitude and longitude were updated, and the LOC_FLAG field was tagged with the phrase **Coordinates based on update from 2012 NPD Resource Assessment**.

5) **Filtered out dams that have been removed.**

   Dams that were removed may remain in the NID because outdated information was provided by individual reporting agencies. The American Rivers Dam Removal Database was used to identify dams that are known to have been removed. In many cases, these dams could be identified using

the NID ID; however, some removed dams were found by spatial proximity to dams reported by the NID. One hundred ninety-four dams listed in the NID2019 were found in the American Rivers Dam Removal Database and were flagged with the REM_FLAG field to note that the dam was removed.

6) **Added an indicator for dams that may have hydropower or support hydropower, but they are not indicated as a powered dam in the NID.**

   Powered status is not always accurately reported. Using the HILARRIv1.1 data set [31], which documents dams in the NID and Global Reservoir and Dam Database and indicates which power plants are associated with them, a greater level of confidence in the powered status of dams was achieved. The STATUSFLAG field was created to reflect whether one of the dam inventories indicates that the dam is powered yet does not have an associated inventoried power plant. The STATUSFLAG field also is used to indicate whether a dam was previously powered. Note that NPDs may not have been powered at the time of writing, but they may be in the pipeline for development—the status could change over time and will need to be updated.

Several data-cleaning and standardization processes were applied to present the data in a form that is more convenient for classification and querying.

- **Missing data.** For example, in the NID, some fields are blank, and others contain 0 to signify that there is no value or that the value is missing. However, not all 0 values reflect missing data (e.g., the number of locks may be 0, so they may not be treated the same way as afield in which the number of locks is simply unreported). In this NPD characteristics inventory, missing data are instead coded with a -99999 value.

- **Aggregation.** If categorical data have many values or if they lack vocabulary constraints, then values may be aggregated to facilitate better filtering or grouping. For example, the NID reports dam owner name, but it also allows many unique names for the same agency. One dam may be reported as owned by the *United States Bureau of Reclamation*, while another is reported as owned by the *U.S.B.R.*, and another is owned by the *US Bureau of Reclamation*. Rather than force all users to implement a data cleaning/standardization process, values have been aggregated and are made available through the NPD Explorer and NPDamCAT in ways that are conducive to quick subset creation or analysis (i.e., the user should only be required to select one value to see dams owned by the USBR).

It is important to note that due to the large size of the dataset, manual verification of all locations is not feasible. There may be inaccuracies that propagate in cases where individual dams with incorrect or inaccurate locations are joined to a flowline or watershed boundary that is used to join to other data. For example, the StreamCat dataset references NHDPlusV2 flowlines; any StreamCat characteristics for a dam assume that the flowline the dam is joined to is accurate.