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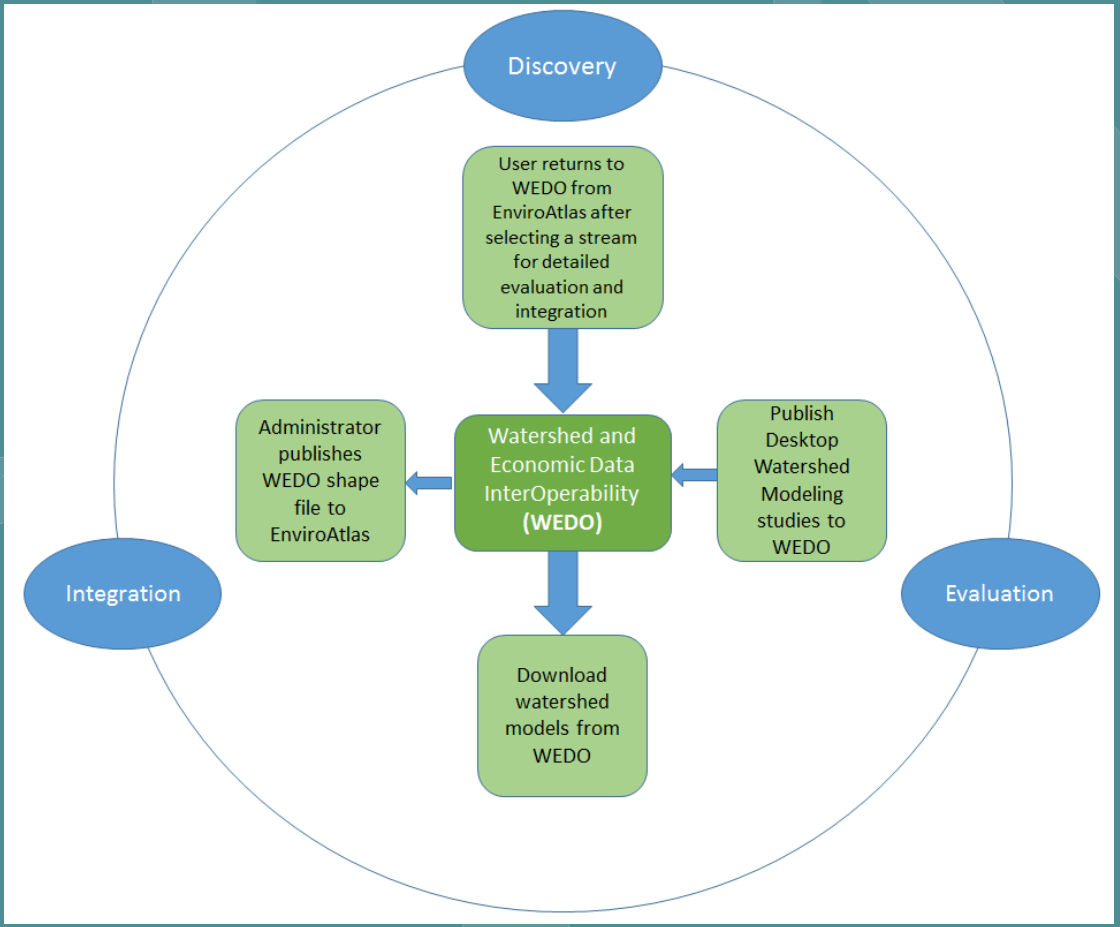
Watershed and Economic Data InterOperability (WEDO)

FACILITATING DISCOVERY, EVALUATION, AND INTEGRATION THROUGH THE SHARING OF WATERSHED MODELING DATA



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Watershed and Economic Data InterOperability (WEDO)

Facilitating Discovery, Evaluation and Integration through the Sharing of Watershed Modeling Data

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Notice

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Foreword

The U.S. Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Exposure Research Laboratory (NERL) within the Computational Exposure Division is the Agency's leading laboratory in environmental exposure science. NERL supports EPA's mission to protect human health and the environment by developing and applying innovations in exposure science. Exposure science sets the context for understanding and solving real world problems, and is used to help understand risks that exist and was to mitigate or prevent that risk.

Watershed **E**conomic **D**ata Inter**O**perability (**WEDO**) helps to support the mission of the NERL by offering a new way to support discovery and integration of watershed modeling data. Through the use of WEDO and its Web-based database, modelers can publish their detailed modeling studies to a centralized place, which can be downloaded by other modelers for use in their various studies and research. This is an important step forward to environmental exposure science because it allows for further discover, evaluation and integration of watershed modeling data to help improve watershed integrity across the United States.

EPA's Safe and Sustainable Water Resources (SSWR) research program is an overarching Agency-wide program that provides the science and innovative technologies that the Agency and the nation need to maintain drinking water resources and systems, as well as to protect the chemical, physical and biological integrity of the nation's waters. It uses an integrated, systems approach to support the availability of the clean, adequate, and equitable water supplies necessary for human well-being and resilient aquatic ecosystems. Towards these goals, SSWR provided funding to develop WEDO as contribution 1.3A.2 within Topic 1 "Interoperability of data and models."

Gerald Brunson, Acting Director
Computational Exposure Division, USEPA/Office of Research and Development

Table of Contents

Table of Figures

Tables

Acronyms and Abbreviations

CSV	Comma-Separated Values
EPA	U.S. Environmental Protection Agency
FAQ	Frequently Asked Questions
HSPF	Hydrological Simulation Program-Fortran
HUC	Hydrologic Unit Code
NERL	National Exposure Research Laboratory
NHD	National Hydrography Dataset
NWIS	National Water Information System
ORD	Office of Research and Development
STORET	STOrage and RETrieval
SWAT	Soil and Water Assessment Tool
UCI	Unified Configuration Interface
WEDO	Watershed and Economic Data InterOperability

Acknowledgments

We would like to acknowledge the support of the Safe and Sustainable Water Resources research program, especially Suzanne van Drunick, Michael McDonald and Blake Schaeffer (of the Immediate Office of the National Exposure Research Laboratory). Without their support, WEDO would not have come to fruition. Appreciation is also extended to Topic 1 co-leads Christopher Nietch and Matthew Heberling of the National Risk Management Research Laboratory for guidance on evaluating the economic feasibility of nutrient trading markets, including the interplay of traditional and non-traditional economic models and watershed modeling. WEDO demonstrates the shared vision that new tools should support a wide array of models and platforms and not be limited to a particular study or choice of technology.

Executive Summary

Watershed and **E**conomic **D**ata Inter**O**perability (**WEDO**) is a system of information technologies designed to publish watershed modeling studies for reuse. WEDO facilitates three aspects of interoperability: discovery, evaluation and integration of data. This increased level of interoperability goes beyond the current practice of publishing modeling studies as reports or journal articles. Rather than summarized results, modeling studies can be published with their full complement of input data, calibration parameters and output with associated metadata for easy duplication by others. Simulation calibration parameters for a model study are a boon for modelers as these parameters are often costly in terms of time and computational resources to determine. Reproducible science is possible only if researchers can find, evaluate and use complete modeling studies performed by other modelers. WEDO greatly increases transparency by making detailed data available to the scientific community.

WEDO is a next generation technology, a Web Service linked to the EPA's EnviroAtlas for discovery of modeling studies nationwide. Streams and rivers are identified using the National Hydrography Dataset network and stream IDs. Streams with modeling studies available are color coded in the EnviroAtlas. One can select streams within a watershed of interest to readily find data available via WEDO. The WEDO website is linked from the EnviroAtlas to provide a thorough review of each modeling study. WEDO currently provides modeled flow and water quality time series, designed for a broad range of watershed and economic models for nutrient trading market analysis. Modeling studies are packaged for download and easy integration into work flows and to reproduce results.

EPA developed WEDO for anyone interested in publishing watershed modeling studies for wide dissemination and reuse. EPA's STOrage and RETrieval (STORET)[1] and the U.S. Geological Survey (USGS) National Water Information System (NWIS)[2] are examples of nationwide repositories for sharing monitoring data on water resources. However, no such system exists for modeling studies. We provide a number of step-by-step examples of discovery and publishing in this guide. WEDO addresses public-access requirements for storing and publishing modeled data. The vision for WEDO is a flexible repository for those interested in locating modeling studies and economic data necessary to evaluate the feasibility for nutrient trading in a watershed or river basin of interest—without having to know where to locate the information from various reports and academic literature.

[1] http://www3.epa.gov/storet/
[2] http://waterdata.usgs.gov/nwis

1.0 Using WEDO

1.1 Overview of Using WEDO

A typical watershed modeling study involves a modeler running a model or models on their computer and publishing the model results as a paper or report. This paradigm of peer review and publishing often in a peer-reviewed journal limits reuse of the study. Without direct access to model inputs, including initial conditions and parameters, as well as study metadata for all input data utilized and expert knowledge used in calibration, others experience barriers to reproducing the science. These barriers are also experienced beyond watershed modeling. For example, an analyst who wants to assess market feasibility for nutrient trading in a watershed of interest will likely have to repeat flow and water quality modeling because the analyst may not even know that a study for the area of interest exists. However, even if the analyst is aware of the report, access to the detailed data beyond the published summaries may be unavailable. Another example is that of calibration studies, a vast majority of which are published in state and federal government reports. These and other grey literature may not be searchable on the Internet. In addition, many journals now require as a best practice that research data for the study be made available online. **WEDO** (**W**atershed and **E**conomic **D**atabase for inter**O**perability) is a solution that enables publishing of modeling studies for evaluation, download, and leveraging by others.

Many government agencies have repositories for monitored stream flow and water quality data. EPA's STOrage and RETrieval (STORET) and the U.S. Geological Survey (USGS) National Water Information System (NWIS) are well known examples. Although monitoring data are commonly made publicly available via repositories, currently there are no watershed modeling study data repositories. WEDO provides a flexible, centralized, and interoperable database for multiple models, as well as Web services for storing, retrieving, evaluating and publishing modeling output as time series. Model inputs and study metadata are also stored in the database. While the functionality of the system will be outlined in subsequent chapters, this chapter provides general tips for using the system. Further information about the schematics of WEDO can be found in Appendix B.

The steps for a modeler to publish a study to WEDO are briefly described hereafter. First, the modeler uses a publishing utility provided by WEDO that is downloaded to the modeler's desktop. More information about the publishing utility can be found in Section 1.3. Once it is opened, the publishing utility presents a series of dialogs to collect information to more fully describe the study. The modeler selects river(s) and stream networks that correspond to the study. The modeler is then instructed to standardize the stream numbers by mapping the stream identifiers to the National Hydrography Dataset (NHD) reach codes. Finally, all inputs along with the self-selected model outputs (water flow, dissolved, and suspended constituents for example) and metadata are uploaded to WEDO. A study on WEDO is labeled "Pending" status at the time of upload. An administrator periodically may decide to publish the studies with "Pending" status on WEDO to EPA EnviroAtlas.[3]

To publish studies to EnviroAtlas, the administrator generates a Comma Separated-Values (CSV) file and sends the file to EnviroAtlas team by email. The CSV file contains study information: reach code, web link to the study stored in WEDO and a list of simulation constituents. The EnviroAtlas team loads the CSV file to its NHD map layer. The status of studies included in the CSV file changes to

[3] http://www.epa.gov/enviroatlas

"Publishing" as soon as the file is generated. After confirming that the file has been published on EnviroAtlas, the administrator changes the status of studies with "Publishing" status to "Published" status. A study in "Publishing" or "Published" status cannot be withdrawn. Only a study with "Pending" status can be withdrawn, and this can be completed only by an administrator. A modeler can send an email to one of the contacts listed on the contact page requesting a "Pending" study to be withdrawn, or to request that a published study be changed to "Pending" and then withdrawn. More information about withdrawing a study can be found in Section 2.2.2.

Within WEDO, there are a number of tasks that can be undertaken by modelers, investigators and administrators. These tasks are outlined in Table 1 below.

Table 1. WEDO Tasks

	Tasks
Modelers	Download Publishing utility, run publishing utility and publish model data on WEDO, send email to WEDO administrator to withdraw a study
Investigators	Discover streams of interest on EnviroAtlas, visit WEDO Web pages to view dashboard, study summaries, study details, download study data
Administrators	Log in, add administrator(s), withdraw a study, generate CSV file to publish studies on EnviroAtlas, email CSV file to EnviroAtlas team, for publishing, change status of "Publishing" studies to "Published," respond to issues reported by researchers and modelers

Information discovery is a major aspect of interoperability. EnviroAtlas[4] is EPA's main interface to communicate with communities (Figure 1). Publishing WEDO data on EnviroAtlas enhances discoverability (Figure 2). The other two major aspects of interoperability are Evaluation and Integration. WEDO facilitates evaluation by providing graphical interfaces to search and query summarized and detailed data. WEDO facilitates integration by providing data download and upload services.

[4] EnviroAtlas (https://www.epa.gov/enviroatlas) provides interactive tools and resources for exploring the benefits people receive from nature or "ecosystem goods and services". Ecosystem goods and services are critically important to human health and well-being, but they are often overlooked due to lack of information. Using EnviroAtlas, many types of users can access, view, and analyze diverse information to better understand the potential impacts of various decisions.

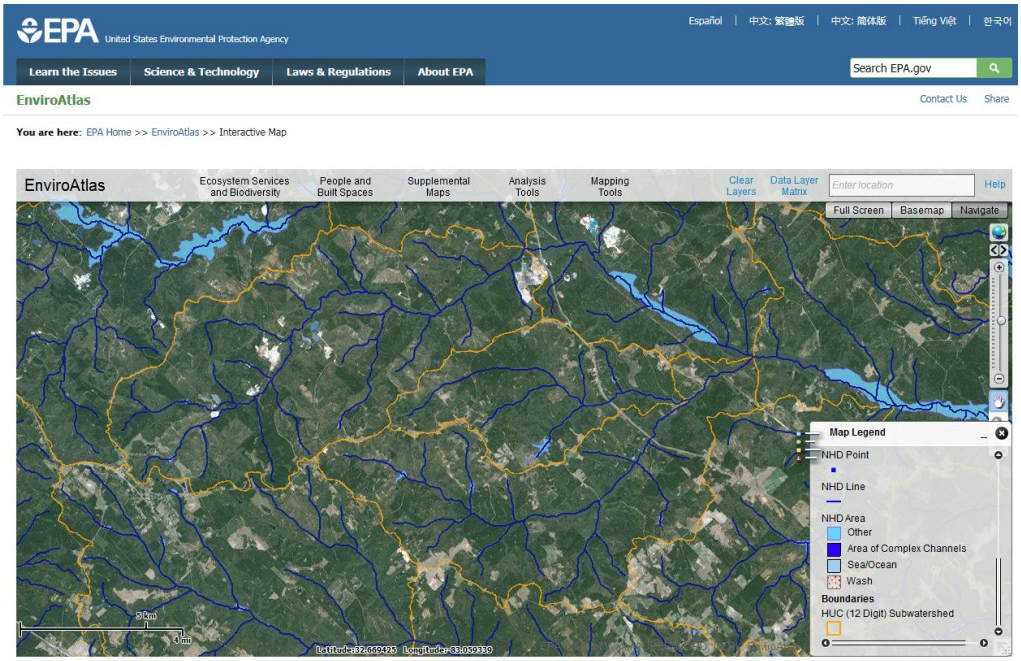

Figure 1. EPA EnviroAtlas showing stream network in blue and yellow

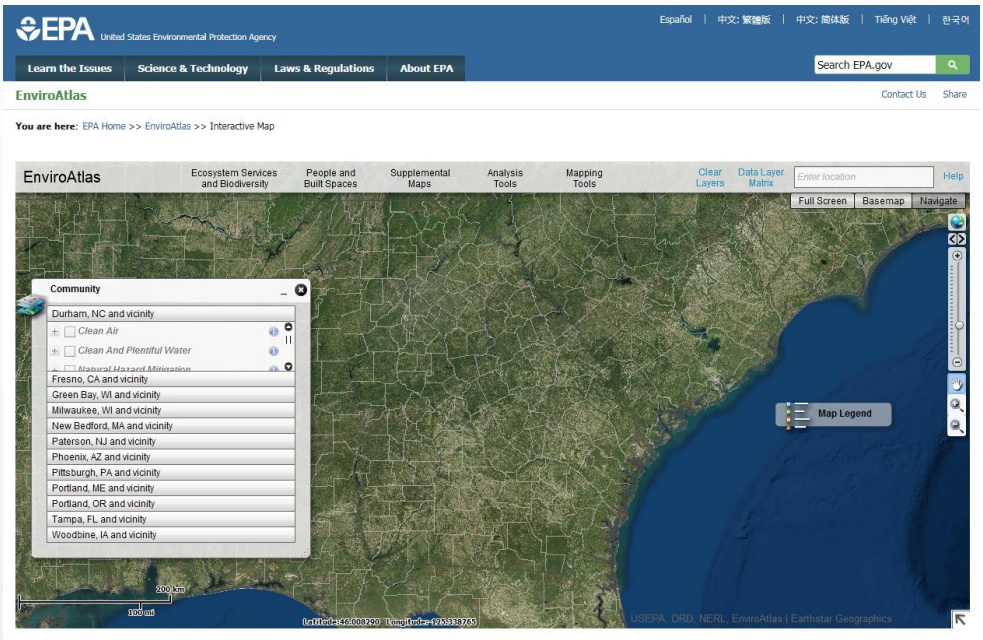

Figure 2. *EnviroAtlas Interactive Map—Discovering published modeling studies*

1.1.1 General User Tips for WEDO

The WEDO Home page (Figure 3) provides a navigation bar on the left-hand side, a brief system description, a dashboard, login button and links to features and references.

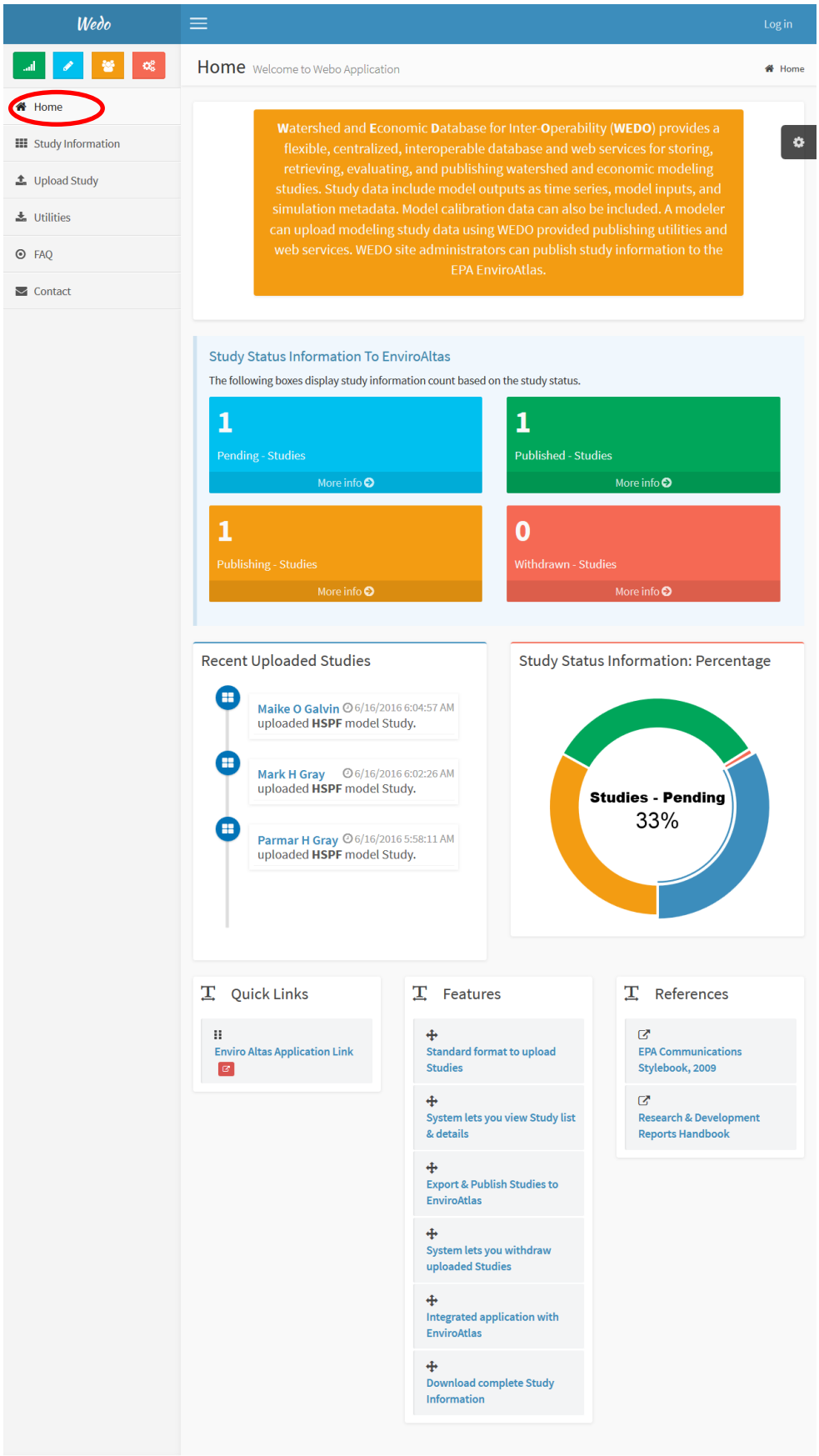

Figure 3. *WEDO Home Page*

A more detailed description of the functionality of the home screen and how it supports discovery within WEDO can be found in Section 1.1.2.

The Frequently Asked Questions (FAQ) page (Figure 4) contains commonly asked questions and serves as an evolving source of information for modelers and researchers within WEDO. This page includes sample output file formats, as well as a sample metadata file formats.

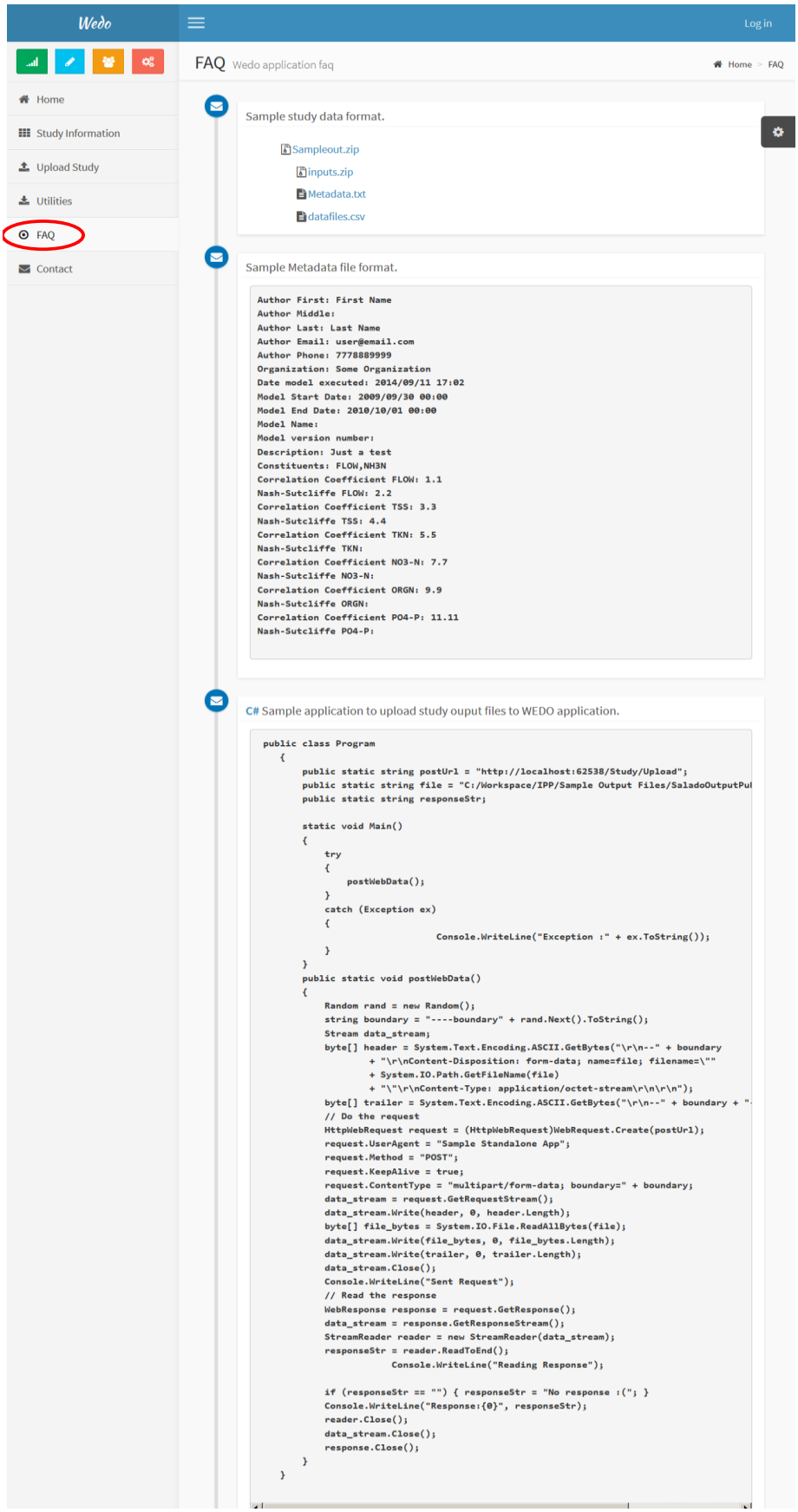

Figure 4. *WEDO FAQ Page*

The FAQ page will be updated periodically to reflect new frequently asked questions to help support modelers and researchers within WEDO.

The "Contact Us" page (Figure 5) includes the relevant contacts for any questions in relation to using WEDO. This is the key page for modelers and researchers if they experience an issue and would like to report it, or if they have a question about using the system. A researcher or modeler can use the contact information to withdraw a study that is waiting to be published to the EnviroAtlas.

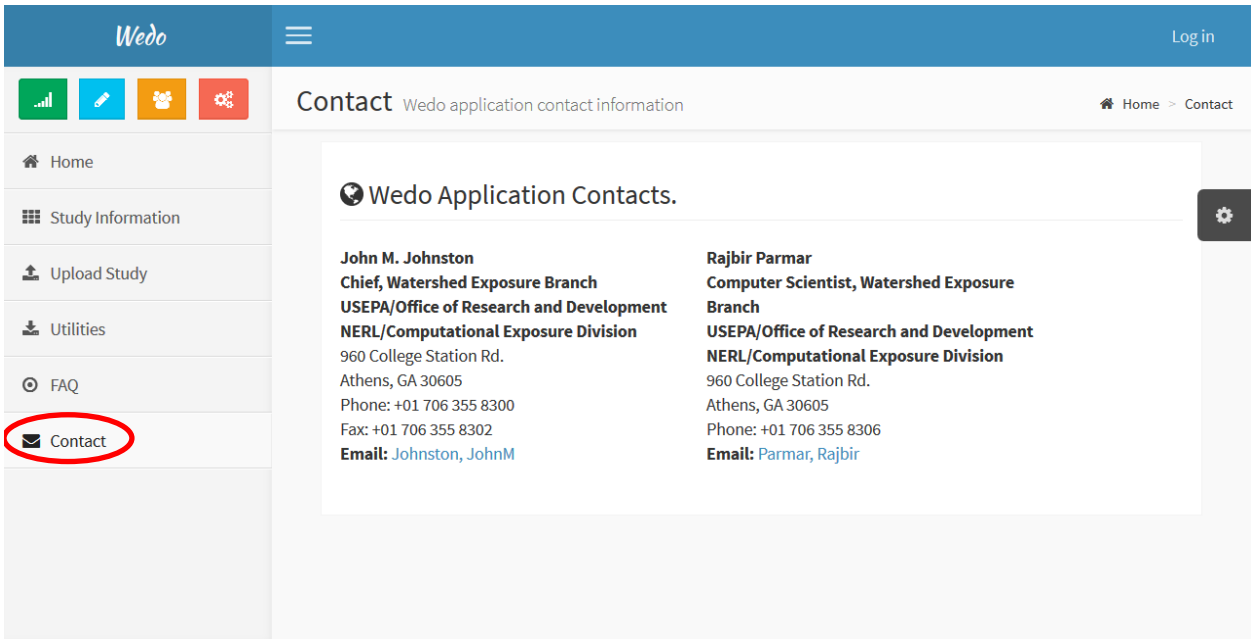

Figure 5. WEDO Contact Page

If someone would like to withdraw a study from WEDO, a request needs to be submitted to the WEDO administrator. This can be done by sending an email to one of the addresses on the "Contact Us" page. Note that only studies marked as "Pending" can be withdrawn. A request to withdraw a study already published on EnviroAtlas would be treated as an exception that requires manual tasks. More information about withdrawing a study can be found in Section 2.2.2.

The Utilities page (Figure 6) has links to download publishing utilities. Currently, there is only one publishing utility that can publish modeling studies from Hydrological Simulation Program–Fortran (HSPF) and Soil and Water Assessment Tool (SWAT) models. This will be an evolving page as new utilities become available.

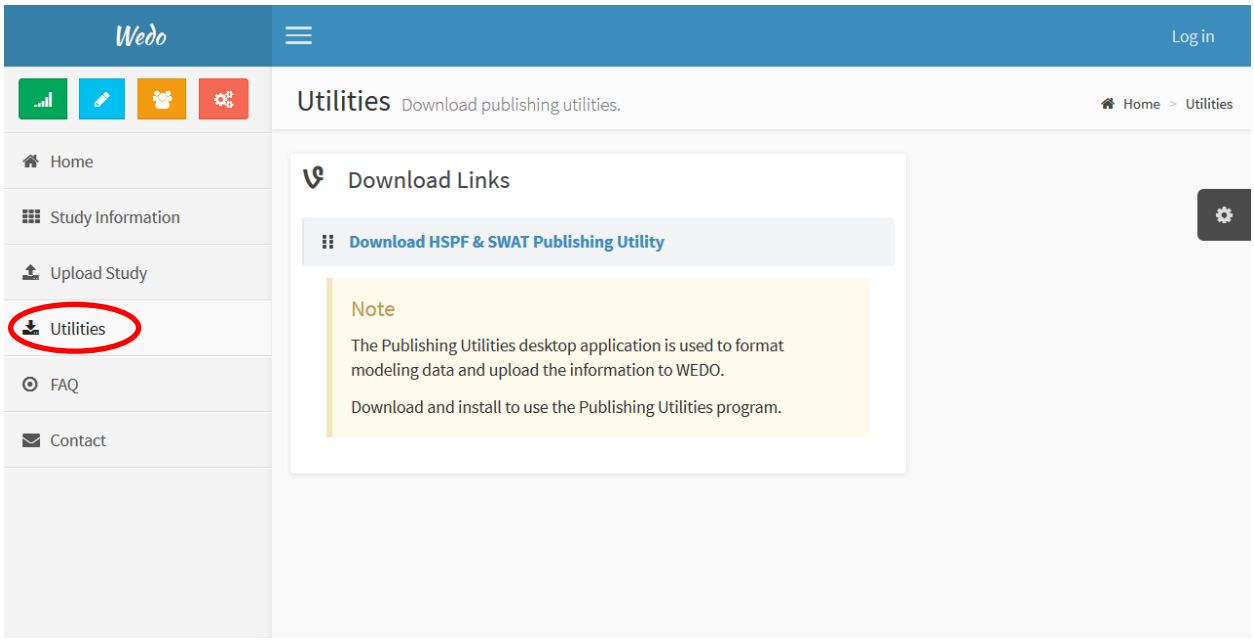

Figure 6. WEDO Utilities Page

The Study Information page (Figure 7) allows investigators to search for and explore studies in the WEDO database. Studies can be searched for by author email, constituent or parameter, publication status or watershed hydrologic unit.

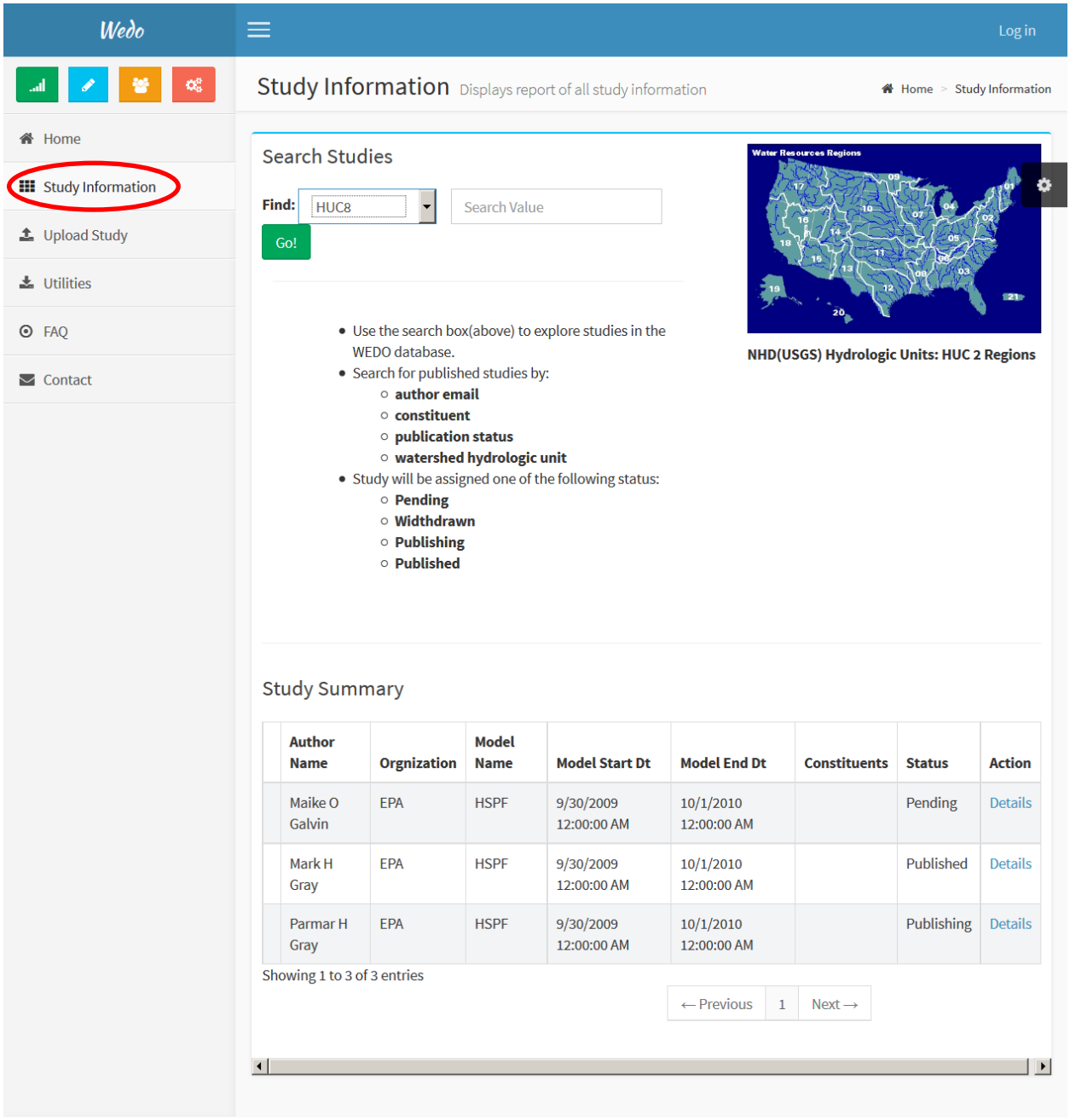

Figure 7. *WEDO Study Information Page*

The map on the Study Information page orients the researcher to understanding the geographic location of the stream, using the two-digit Hydrologic Unit Code (HUC) number on the map above. The Study Information page is useful for modelers and researchers because it helps them discover numerous studies in their area of interest that can be further evaluated and downloaded for use.

1.1.2 Home Page For Navigation to All Functionality

The home screen (Figure 8) is the starting point for using WEDO to search, evaluate and upload studies.

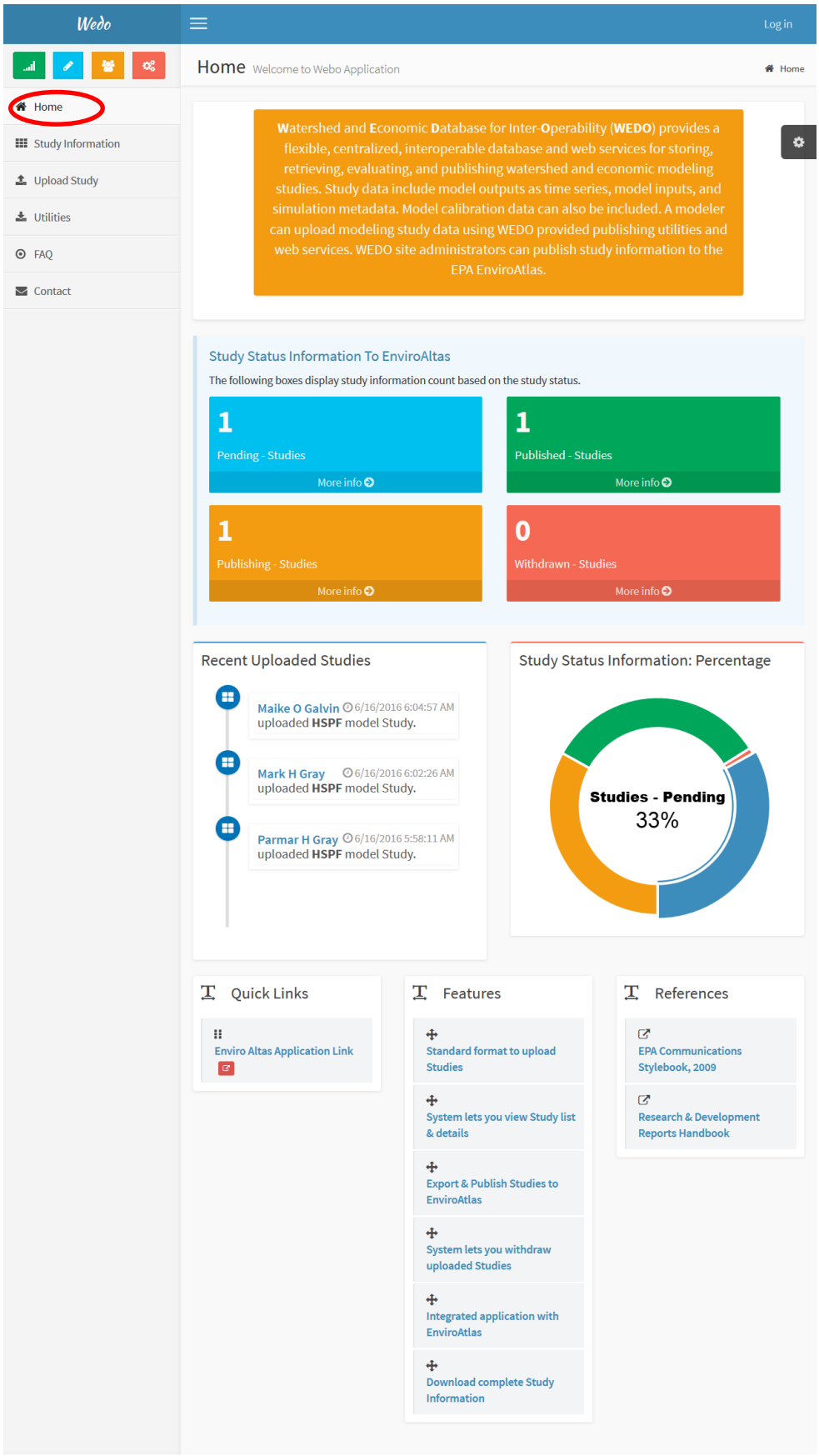

Figure 8. *WEDO Home Page*

The left-side navigation bar provides navigation to the system functionality. Links are provided for Home, Study Information, Upload Study, Utilities, FAQ and Contact Us pages. On the bottom of the home screen, there are sections that provide further information about the status of studies being uploaded to EnviroAtlas. These sections help support discovery, integration and evaluation by providing information about the number of studies in the process of being uploaded to WEDO and EnviroAtlas.

The home page serves as both a starting place for navigation within WEDO as well as dashboard that allows the modelers and investigators to see how many studies have been published or are pending within WEDO. The "Study Status Information to EnviroAtlas" section provides the investigator with information regarding how many studies are in the four stages of publishing, which are "Pending," "Publishing," "Published," and "Withdrawn." These boxes outline all studies within these stages in WEDO, not only the individual modeler's studies. To find out more information about each of these categories, the researcher can click on "More info" at the bottom of each box.

The "Recent Uploaded Studies" box on the lower left-hand part of the home page allows the user to see studies that have been uploaded to WEDO recently, which helps with discovery by allowing users to look at new studies and keep track of their own studies that have been uploaded.

The "Study Status Information" graphic on the lower right-hand corner of the home page provides a visual representation of the percentage of studies that have been published to WEDO. For example, in Figure 8 above, there is 1 study published and 1 study pending, so the Home page says that 50% of the studies are published.

The "Quick Links" section provides relevant links to the EnviroAtlas Application. EnviroAtlas provides visual links (color-coded stream reaches) to studies that can be used to download study data from WEDO. More information about downloading modeling studies from WEDO can be found in Section 1.2. The "Features" section provides an overview of the key features of WEDO, which includes the ability to view study list and details as well as export and publish studies to EnviroAtlas. The "References" section provides links to key resources that may help guide people to additional information. This list will evolve over time to include further resources to support the use of WEDO by modelers and researchers.

The publishing utility can be downloaded by navigating to the Utilities page. These publishing utilities are used to publish data to WEDO. The process of publishing data to WEDO can be found in Section 1.3.

In the upper right hand corner of the home screen, the administrator can log in to the system, which allows them to perform administrative tasks. If someone would like to become an administrator, the user will have to email one of the contacts on the "Contact Us" page.

1.2 Downloading Modeling Studies from WEDO

In general, when a modeling study is published in a paper or other publication, modelers and researchers can access only a summary of the study itself, while the detailed input and output data remain with the modeler. This scenario is useful to provide an understanding of modeling studies that exist, but it does not support discovery or integration of data in their own work or workflow. This limitation is often due to lack of access, non-standard data formats, non-standard units, and differences in terminology, among other issues.

Increasingly, users of modeling studies as well as peer-reviewed journals are asking for more transparency in relation to data. WEDO alleviates this problem by making modeling studies accessible to modelers and researchers through the download function. By doing so, WEDO directly supports evaluation by allowing modelers and researchers to query and view detailed modeling study data and metadata.

Within WEDO, there are a number of parameters that are included within the data that can be downloaded from each study. The parameters within WEDO are outlined in Table 1 below.

Table 2. WEDO Parameters

Parameter	**Definition**
Flow	Stream flow
TSS	Total suspended solids
TKN	Total Kjeldahl Nitrogen
NH3-N	Ammonia-Nitrogen
NO3-N	Nitrate Nitrogen
NO2-N	Nitrite Nitrogen
ORGN	Organic Nitrogen
P	Total Phosphorus

Parameter	Definition
PO4-P	Soluble Reactive Phosphorus
PPO4	Particulate Phosphorus

These parameters are important because they allow for flexibility of use. For example, someone may be running a modeling study on water quality on a specific stream. The user can go into WEDO and find studies relating to this stream and download the data that relates specifically to water quality. Within WEDO, the user is not required to download the entire study if only a portion of it is needed.

There are two ways to search for data within WEDO. Firstly, the user can search directly on the WEDO site searching by reach code or metadata information. Secondly, the user can browse EnviroAtlas for streams that have modeling data published on WEDO. When the user clicks on a published stream on EnviroAtlas, a pop-up comes up showing the reach code, a list of modeled water quantity, quality, and economic parameters, and a hyperlink pointing to the corresponding stream web site on WEDO. The user can click on the hyperlink to navigate to the WEDO Web page showing a list of studies corresponding to the stream. The user can also note down the reach code from EnviroAtlas and can then enter the reach code for the stream into WEDO to view corresponding studies.

To search for a modeling study within WEDO, the user should click on "Study Information" on the left-hand navigation bar. This will bring the user to the Study Information page (Figure 9) that shows all the studies available in the system.

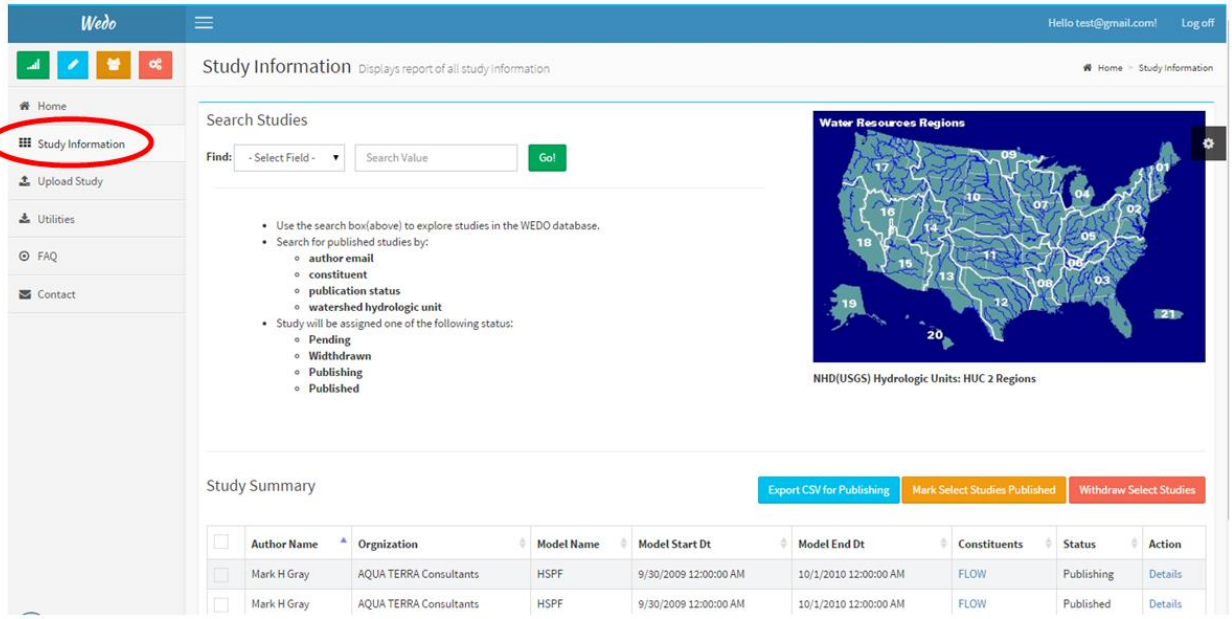

Figure 9. WEDO Study Information Page

The user can search for studies using the search bar at the top and search for studies by metadata, NHD reach code, HUC 12, and HUC 8. Once the user searches using a parameter, the studies that match this parameter will be listed under "Study Summary" at the bottom of the screen. To learn more about these studies, the user can click on "Details" under the "Action" column, which will expand to show the Study Details page (Figure 10).

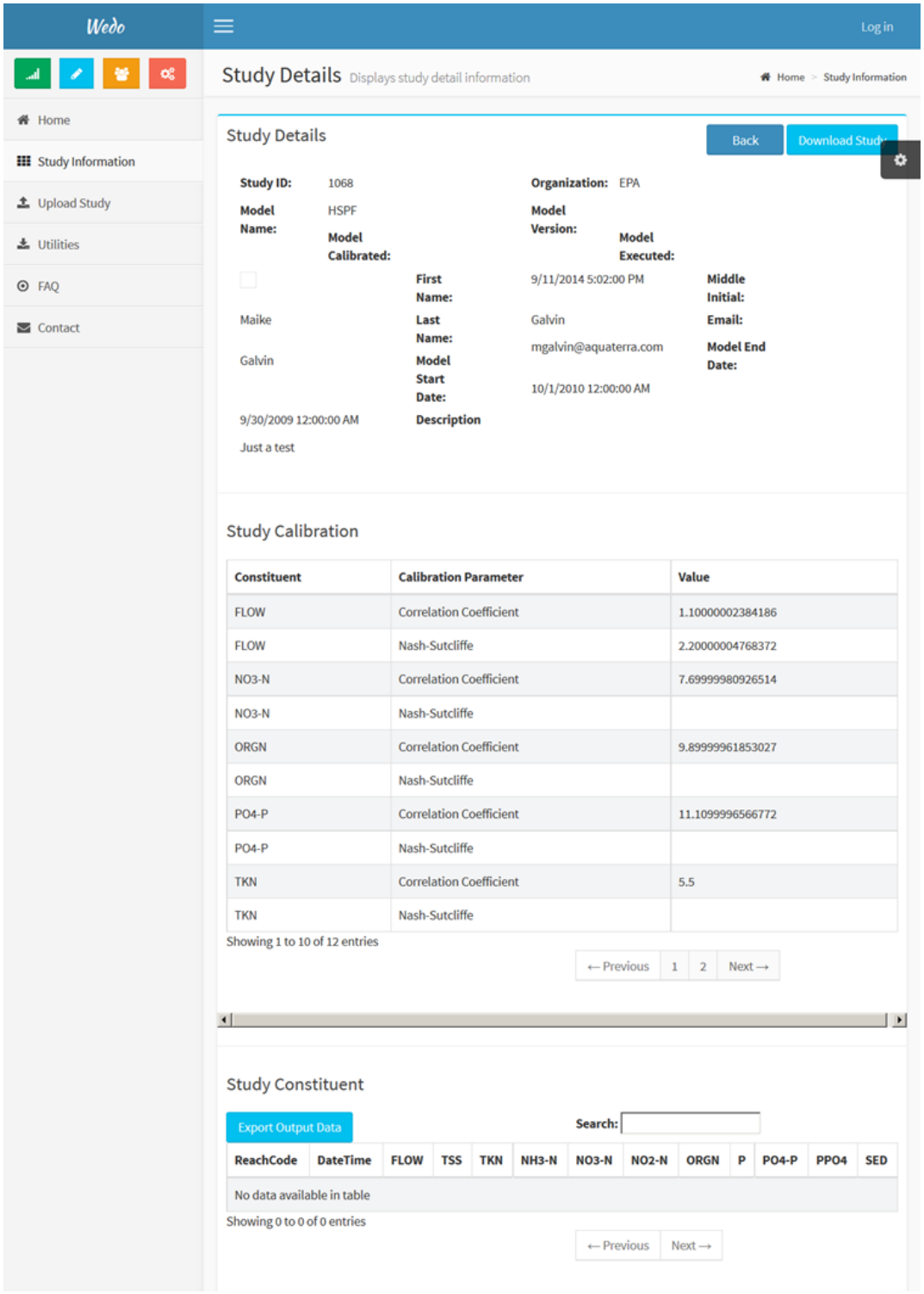

Figure 10. Study Details

The study details page has a number of sections outlining the Study Details, Study Calibration and Study Constituent. On this page, the user can look through study metadata, calibration statistics and time series data for each modeling parameter or constituent.

The user can download the study by clicking on “Download Study” button on the upper right of the Study Details page. When a user clicks the “Download Study” button, there is the option to download the whole study or download one or more constituent. When downloading the whole study, this includes the input zip file, the metadata file and all the output data. Investigators have the option of saving the file as either CSV or XML. The user can also click on the “Export Output Data” section under “Study Constituent” to download only the Export Data for the particular study.

As mentioned above, investigators can also view where WEDO-published watershed modeling was completed using a map layer on EPA’s geo-spatial website EnviroAtlas. The user can search for a specific location in EnviroAtlas to find the streams of interest. Within EnviroAtlas, streams that have modeling studies within WEDO are marked as red on the map, as shown in Figure 11.

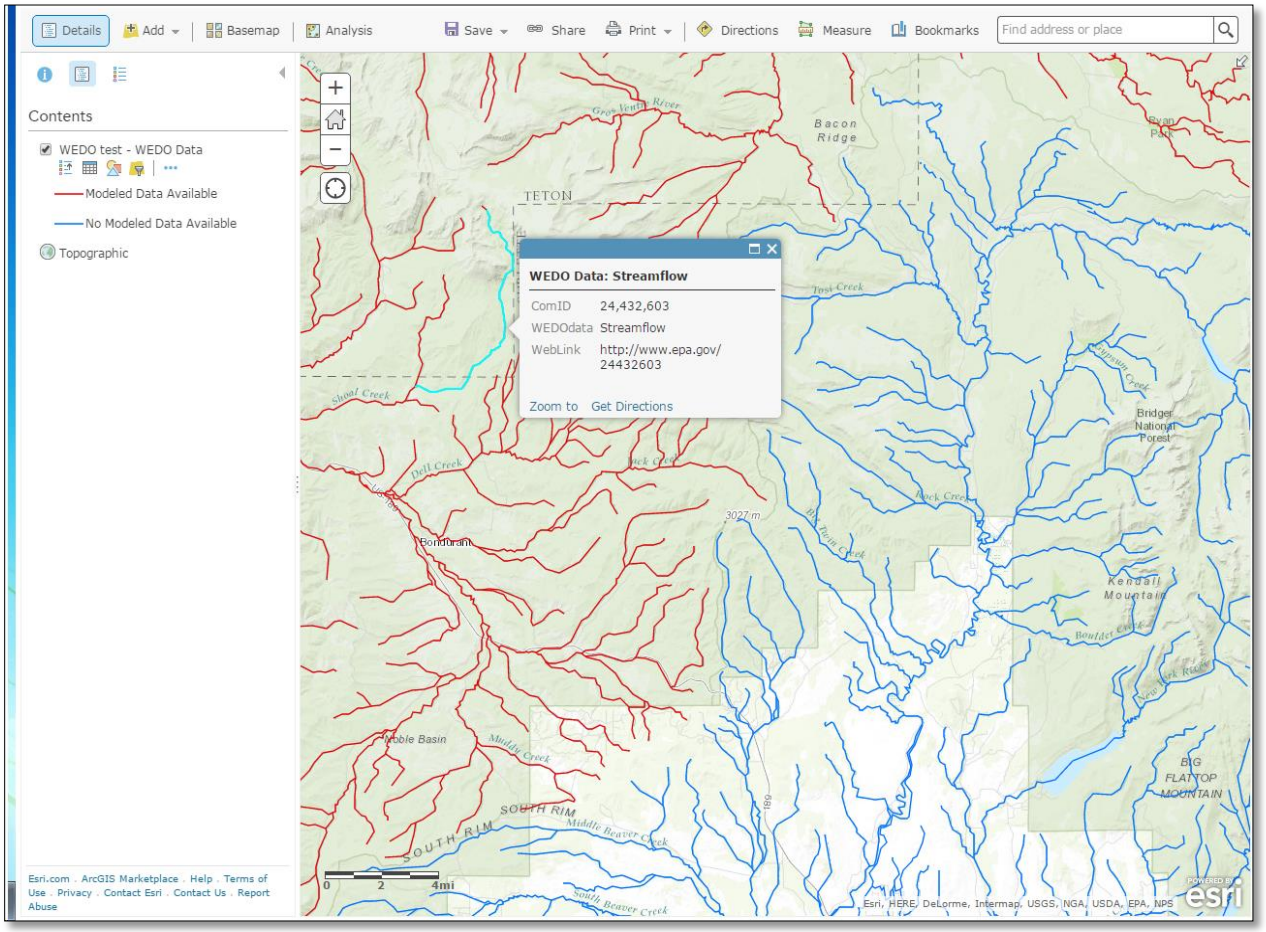

Figure 11. EnviroAtlas Showing Streams with WEDO Modeling Studies in Red

Once the person finds the stream of interest in red, the user can click on the stream itself to see the parameters where modeling data is available. The user can click on the hyperlink provided in the pop-up to navigate to the WEDO study information page. As described above, the user can then click “Details”

under the “Action” column to interrogate the data further and download it for use.

1.3 Publishing Modeling Studies to WEDO

WEDO is a unique tool because it has a standardized Web-based database that allows modelers to publish their detailed modeling studies, including input data, calibration data and model outputs, to a centralized place. Publishing modeling studies to WEDO is the key component that supports interoperability among those who use WEDO because it allows other modelers and researchers to download this data, evaluate it, and use the data to support their own studies. The studies that modelers publish to WEDO are a useful source of information, and knowledge-transfer may support further development of watershed models by other researchers.

The quality of data is important when publishing data to WEDO. While the integrity of the data is ensured by the WEDO administrator, quality control is not a component of the WEDO process. Therefore, it is important that the user ensure the quality of the data before publishing it to WEDO. To ensure that the data being uploaded is of the highest quality, quality control could be included in the workflow of the user prior to uploading data to WEDO. By making sure sufficient quality control is performed before publishing, the user makes certain that the studies will be useful for modelers and researchers who wish to download these studies to integrate into their work.

To publish data to WEDO, a publishing utility is needed. This is a program that runs on the modeler’s desktop and allows the user to create a zip file of the user’s study that will later be uploaded to WEDO using a Web service provided by WEDO. To download the publishing utility, click on “Utilities” on the left-hand navigation bar on the home screen (Figure 12).

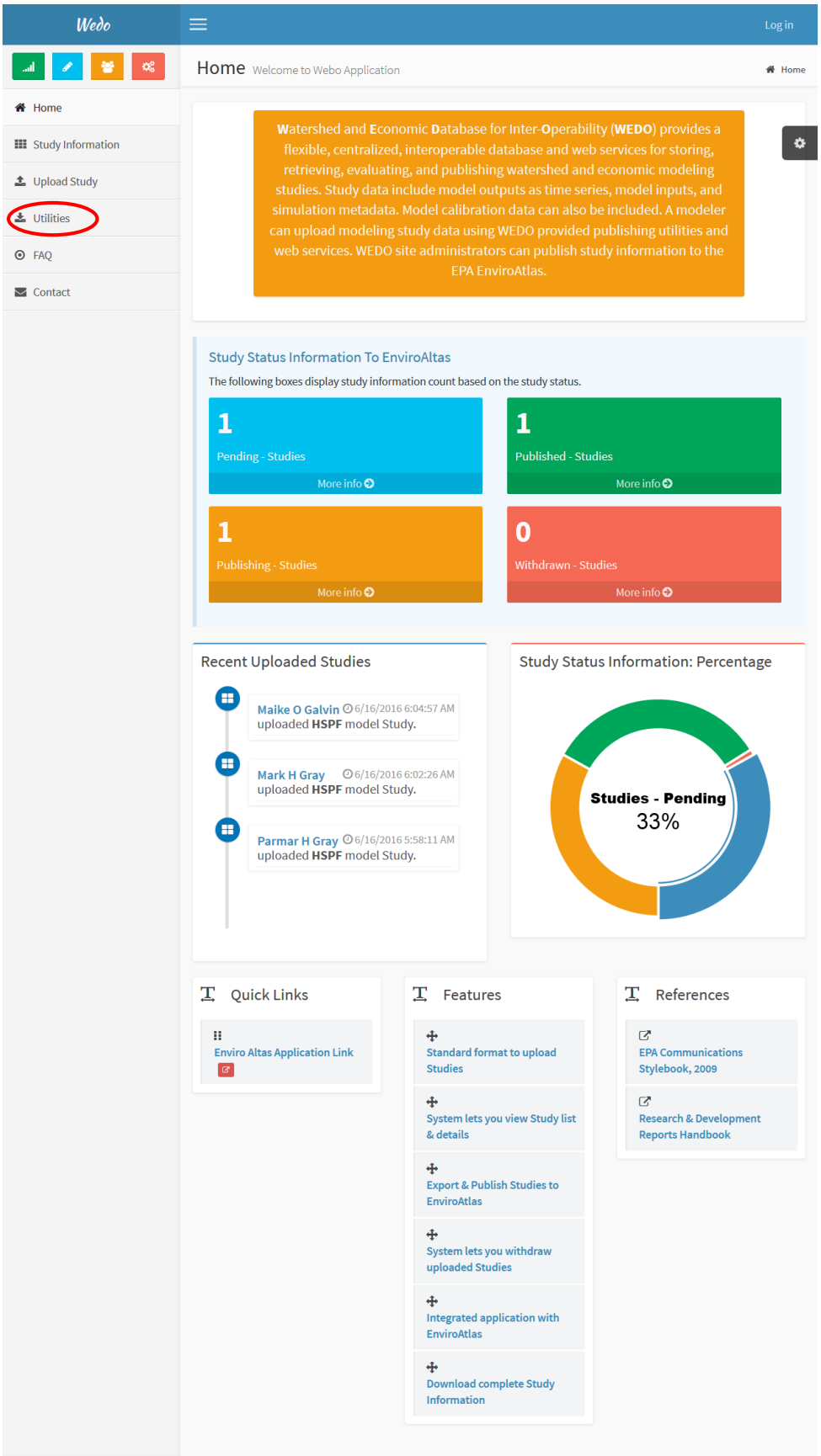

Figure 12. Finding the Utilities Page within WEDO

This will take you to the "Utilities" page (Figure 13) where you can download the publishing utility needed to publish your modeling study. Currently, only one utility for publishing data to WEDO is available. This utility can be used to publish HSPF and SWAT model data to WEDO. When the user clicks the "HSPF and SWAT data publishing utility" hyperlink on the "Utilities" page, the utility executable called WEDO.Publish.exe is available for download, and can be saved on the user's computer to publish the user's modeling study at any point.

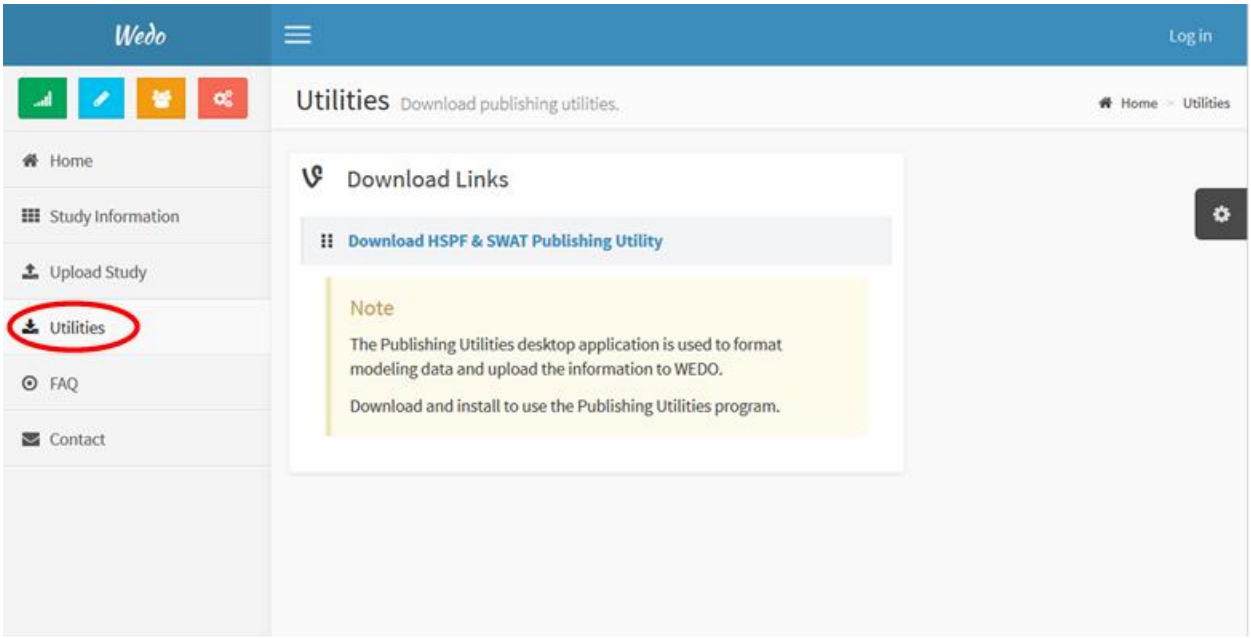

Figure 13. WEDO Utilities Page

Note that the "Utilities" page will be an evolving page, and utilities for more models will be added to the list as they become available.

When the user runs the publishing utility, the wizard will pop up on the screen. The user is prompted to click which type of model to publish, either HSPF or SWAT (Figure 14).

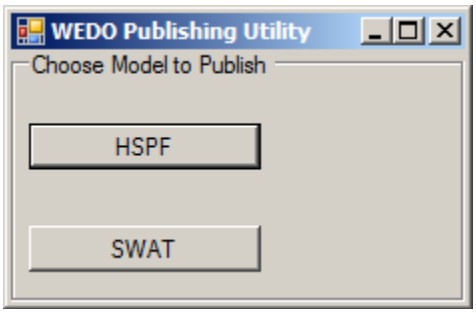

Figure 14. Choosing a Model within the Publishing Utility

If the user chooses HSPF, then the wizard prompts the user to select the appropriate UCI (Unified Configuration Interface) file (Figure 15). The UCI file is used to determine the list of input files, units and output files. To select a UCI file within the publishing utility, search for the file on your computer. Once you have identified the file, click "Open."

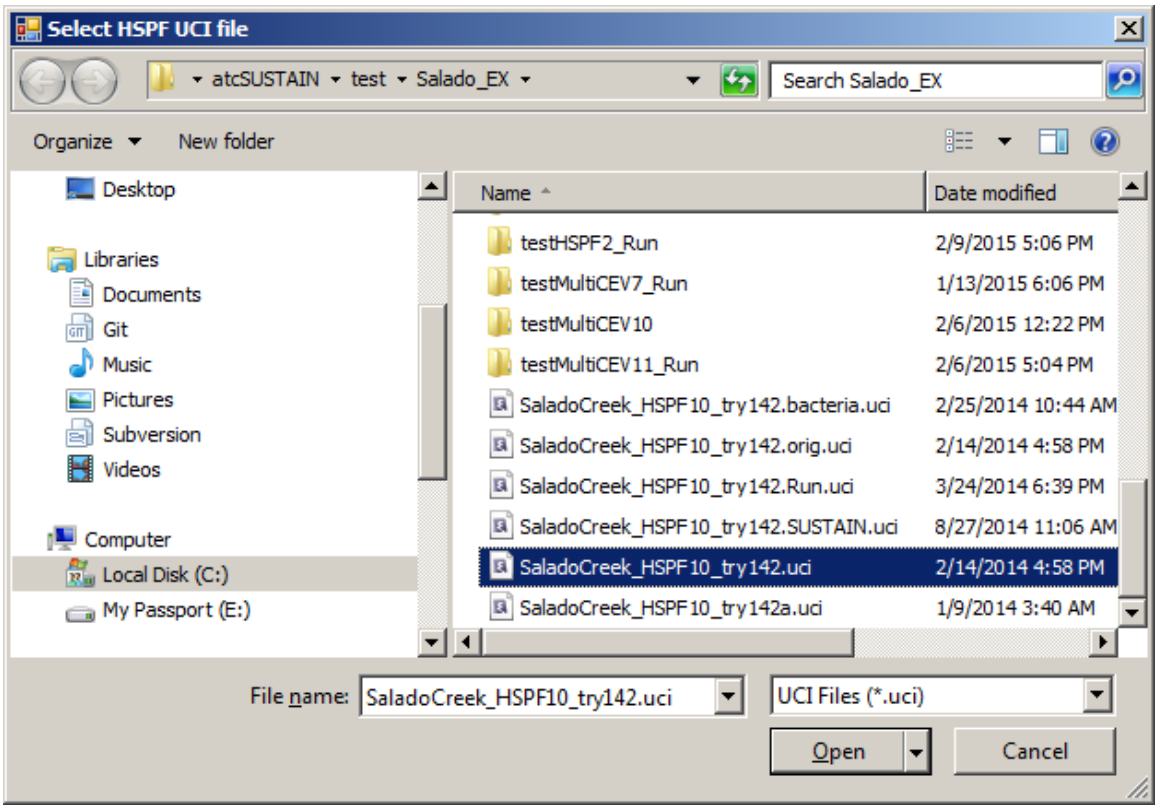

Figure 15. Selecting the UCI File within the Publishing Utility

Once the UCI file is chosen by the user, the publishing utility automatically chooses the input and output files. These files are outlined separately in the sections "Input Files to Publish" and "Output Files to Publish" (Figure 16). All input files are available for WEDO to publish, but a user can choose which streams to publish as an output file. For example if a study contains information for 15 streams but the user wants to include only 2 streams as output data, the user can choose these streams under the "Output Files" section. If there are other components that are not captured in the UCI files, the user can choose to add these by clicking either "Add Input Files" or "Add Output Files." For example, the user may choose to upload the entire model if this is likely to be useful for other modelers and researchers.

Once the input and output files have been chosen, click "Next."

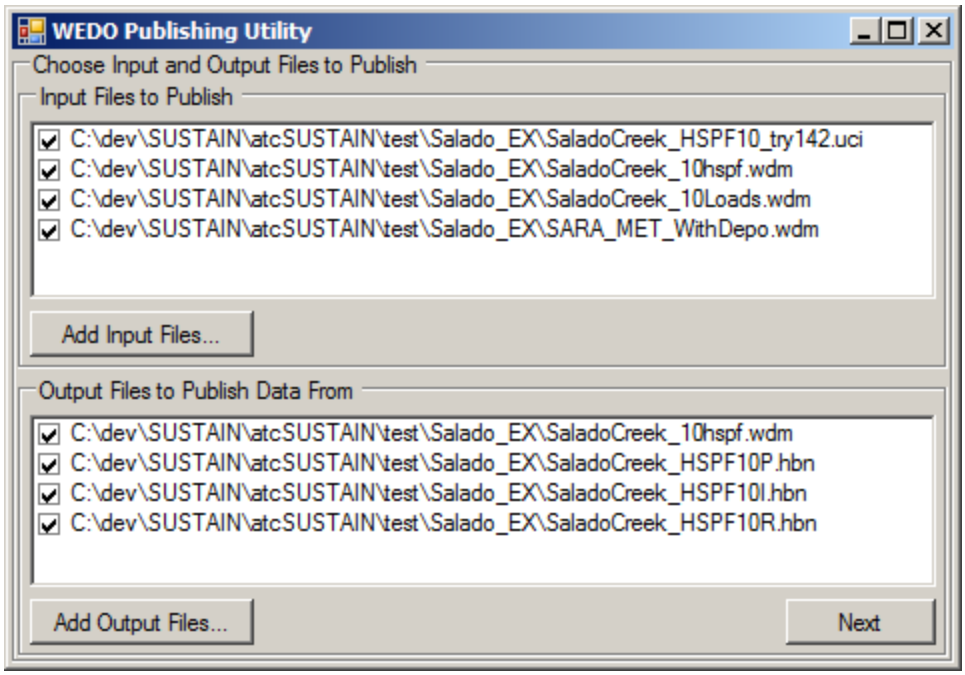

Figure 16. Choosing Input and Output Files to Publish within the Publishing Utility

Within the publishing utility, the user will see that the inputs and outputs are processing (Figure 17).

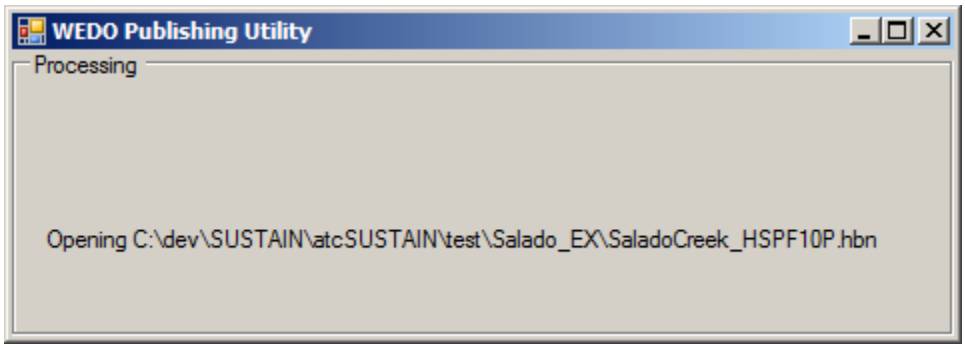

Figure 17. WEDO Publishing Utility Processing Screen

Once the input and output files have been processed, the user is prompted to select the attribute data to publish. On this screen (Figure 18), the user chooses the streams to publish and which parameters to include. By using the drop down menus at the top of the screen, the user can choose the stream first, and then the parameters.

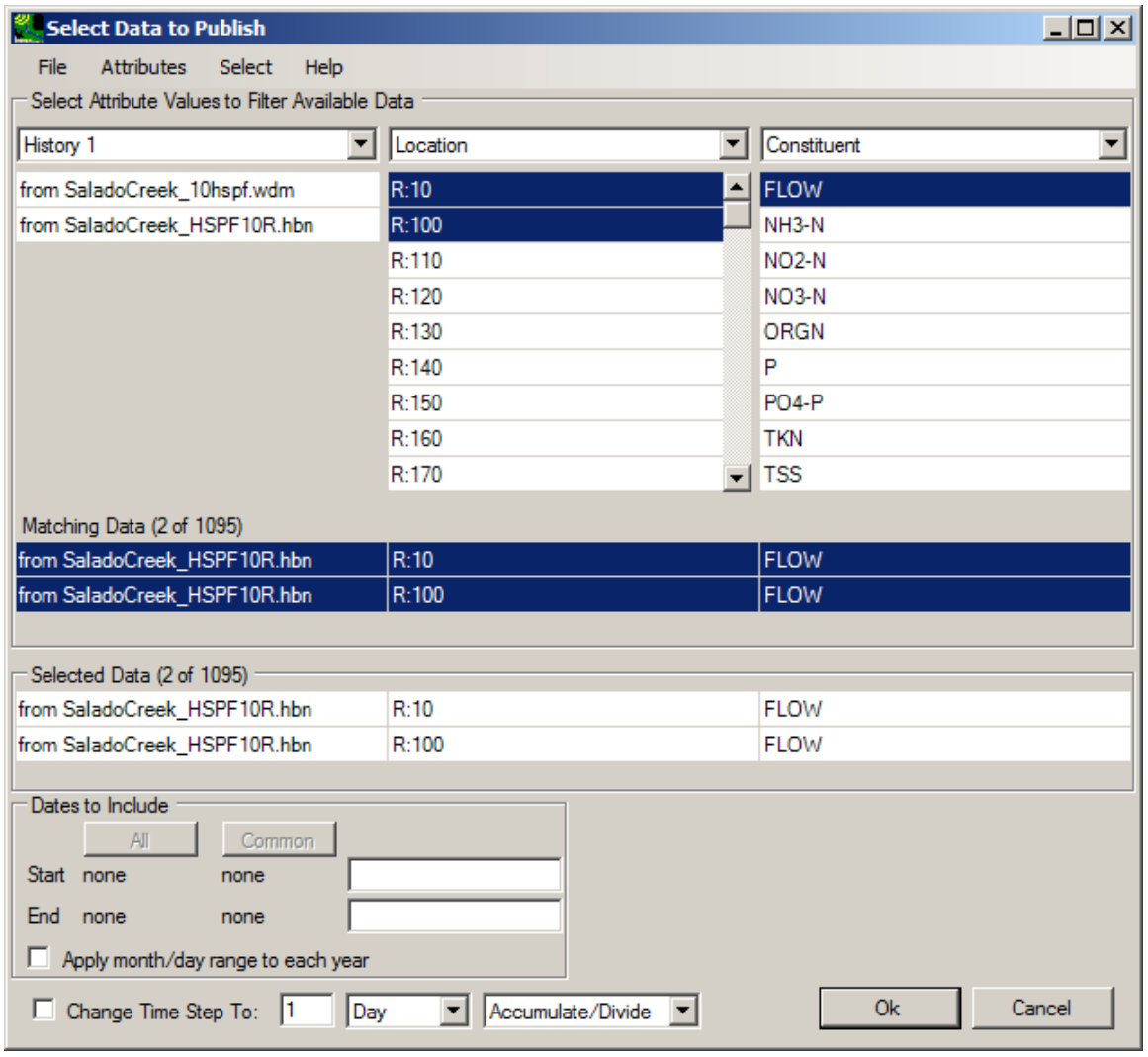

Figure 18. Selecting Data to Publish within the Publishing Utility

Once the data to publish has been chosen, click "Ok" at the bottom of the screen.

Within WEDO, NHD reach codes are used to identify the streams to be published. Using the standardized NHD stream identification numbers is important for maintaining consistency among various models that are being published. The user selects stream segments that include the location of model simulation output. While numerous stream reaches are present within the broader study area watershed, the model output typically represents simulated data at specific locations within the watershed.

While some modelers and researchers may already know the NHD reach codes for their streams, others may know only local identification numbers. If a user knows the NHD reach codes for the user's streams, they can be entered on the screen depicted in Figure 19, next to the relevant model stream ID. The box should be checked under "Publish" for each stream model the user would like to publish to WEDO.

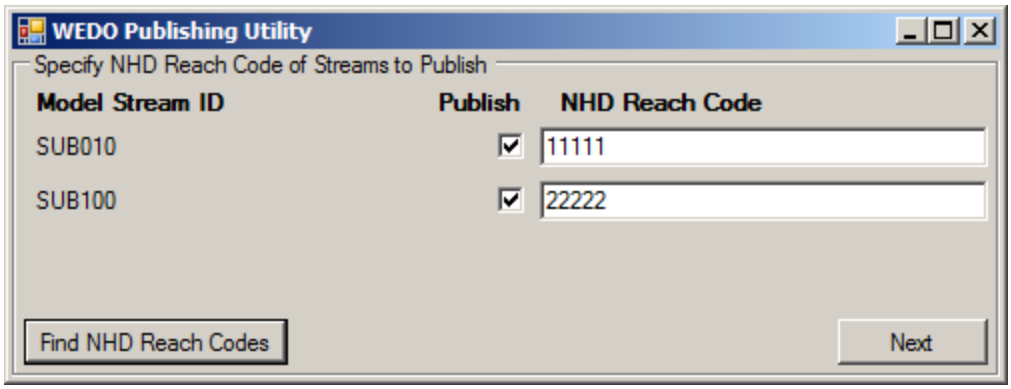

Figure 19. Specifying NHD Reach Codes within the Publishing Utility

If the user does not know the NHD reach codes for the user's streams, clicking "Find NHD Reach Codes" will bring the user to the NHD Flowlines graphical interface for mapping streams to NHD stream reach codes (Figure 20). Note that this interface opens in a separate Internet browser window and is not a part of the WEDO interface.

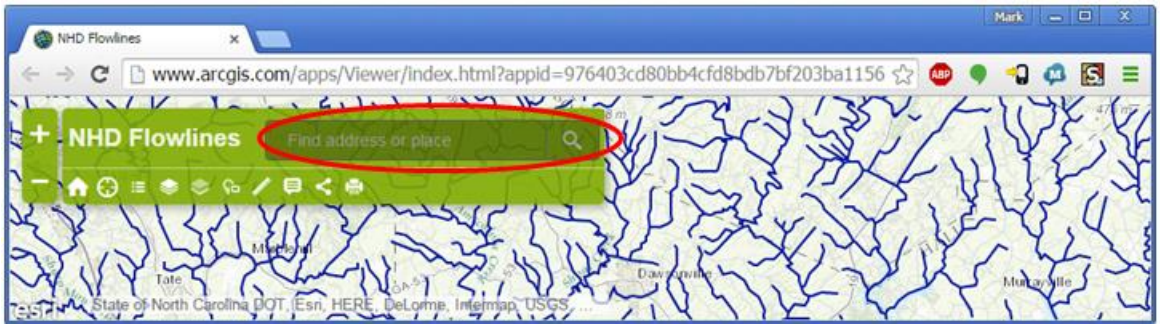

Figure 20. NHD Flowlines Site for Finding Reach Codes

Once the user comes to the NHD Flowlines site, the user can search for the stream of interest by entering the address or places in the search bar at the top of the page. Once the stream is identified on the map, the user can click on the stream to find the NHD reach code. Upon finding the NHD reach codes for all relevant streams[5] to be published within WEDO, the user should return to the publishing utility and enter this information. Once this information has been entered, the user should click "Next."

Once the appropriate reach codes have been entered for the streams, the publishing utility brings the user to the page where the user is asked to enter the relevant metadata for the modeling study (Figure 21). This metadata includes author name and contact details, organization name, and a brief description of the study. This information is required within the WEDO publishing utility.

[5] It is up to the modeler to ascertain which reaches are relevant to a study. Hydrologic model output typically includes streamflow and water quality time series simulations at **specific locations**. Model output often represents a single watershed outflow point but may also include model results for a set of subwatershed pour points (known as "HRUs" or "Reaches" in semi-distributed models SWAT/HSPF).

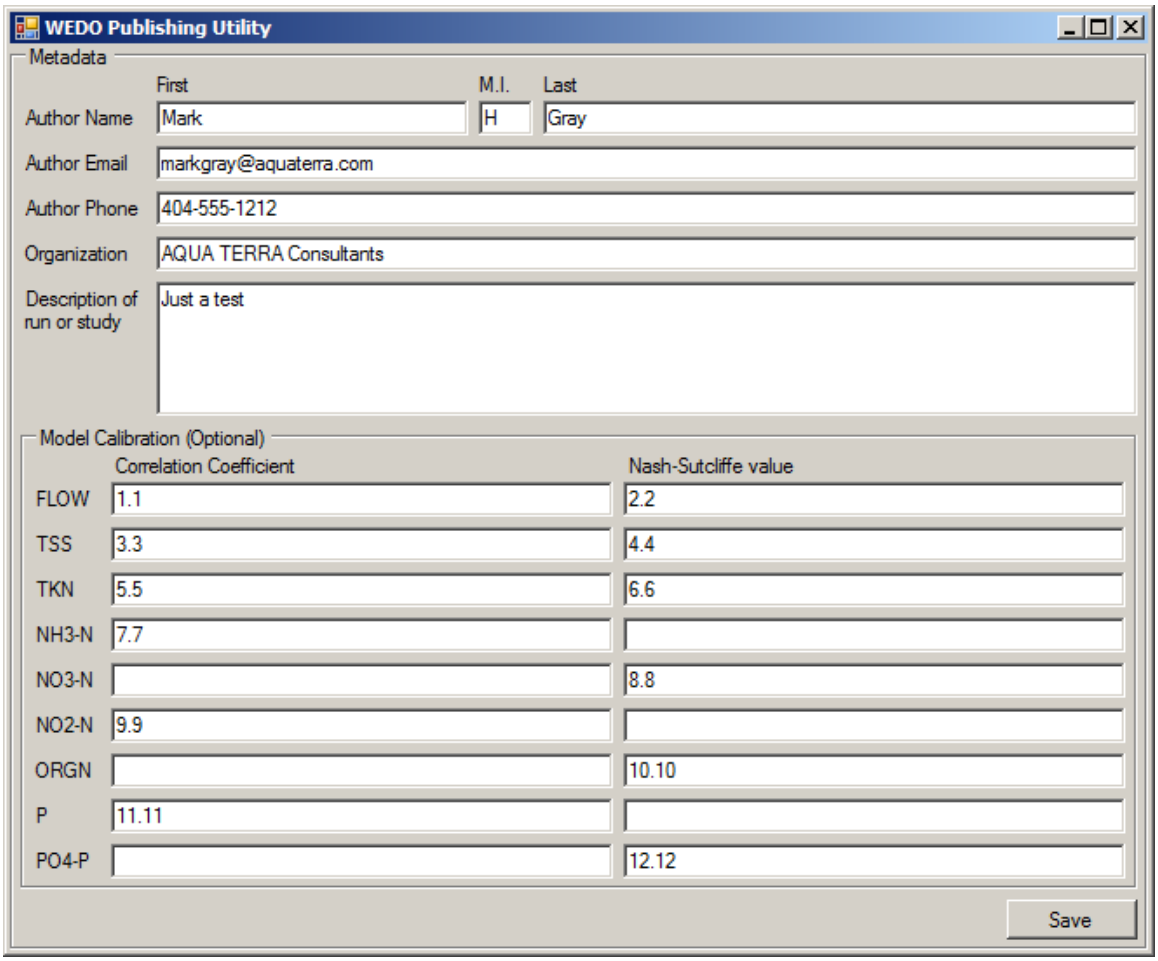

Figure 21. Inserting Metadata in the Publishing Utility

The user is able to enter model calibration information at the bottom of the metadata screen. This is not required within the WEDO publishing utility but can be included if the user thinks it is helpful.

Once the metadata has been entered, click “Save” at the bottom of the screen.

Once all the information for the study to be published has been entered into the publishing utility, individuals are prompted to save the study as a zip file (Figure 22). WEDO takes all the inputs that were entered and saves this as an individual zip file, and then zips that file with the metadata and output file.

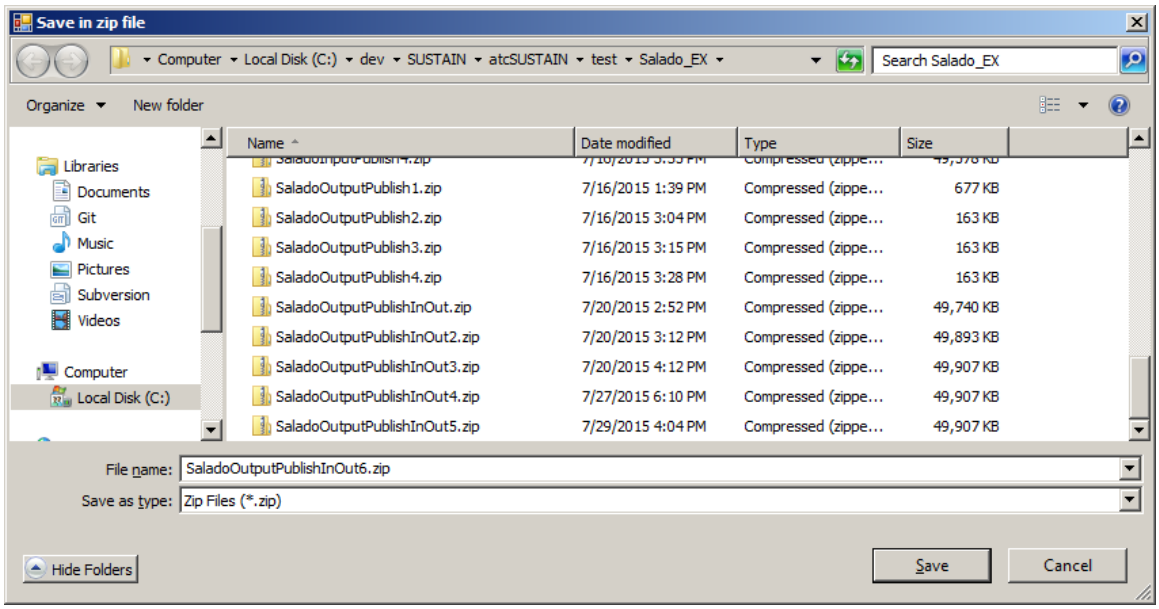

Figure 22. Saving the Study as a Zip File

Once the user clicks "Save," the WEDO publishing utility will process and save the zip file to the user's computer, as shown in Figure 23.

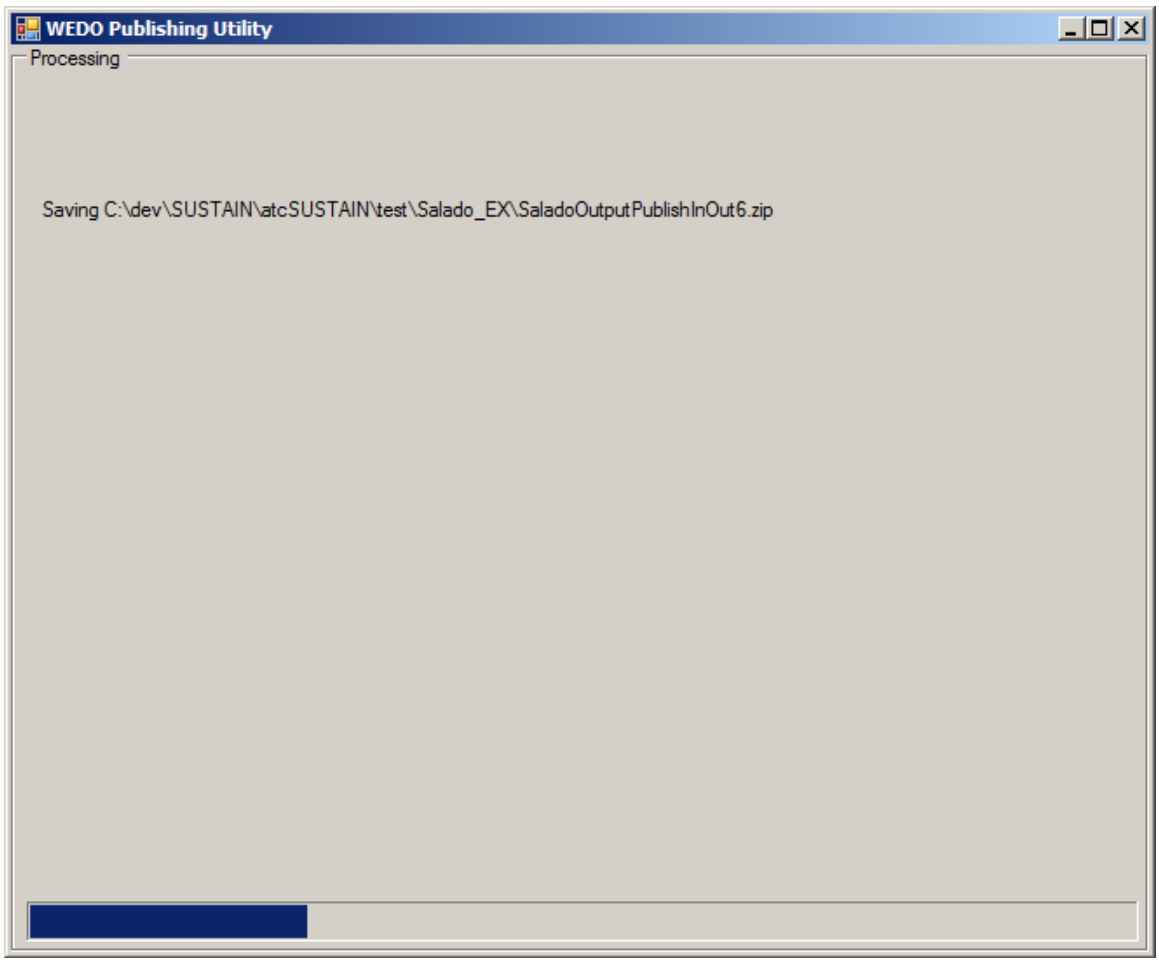

Figure 23. Processing Page within the Publishing Utility

Once the user saves the zip file of the study to the local computer, it is time to upload it to the WEDO site. The user should return to the WEDO site and click "Upload Study" on the left-hand navigation bar, as shown in Figure 24. This will bring the user to the page for uploading the zip file that was created using the publishing utility.

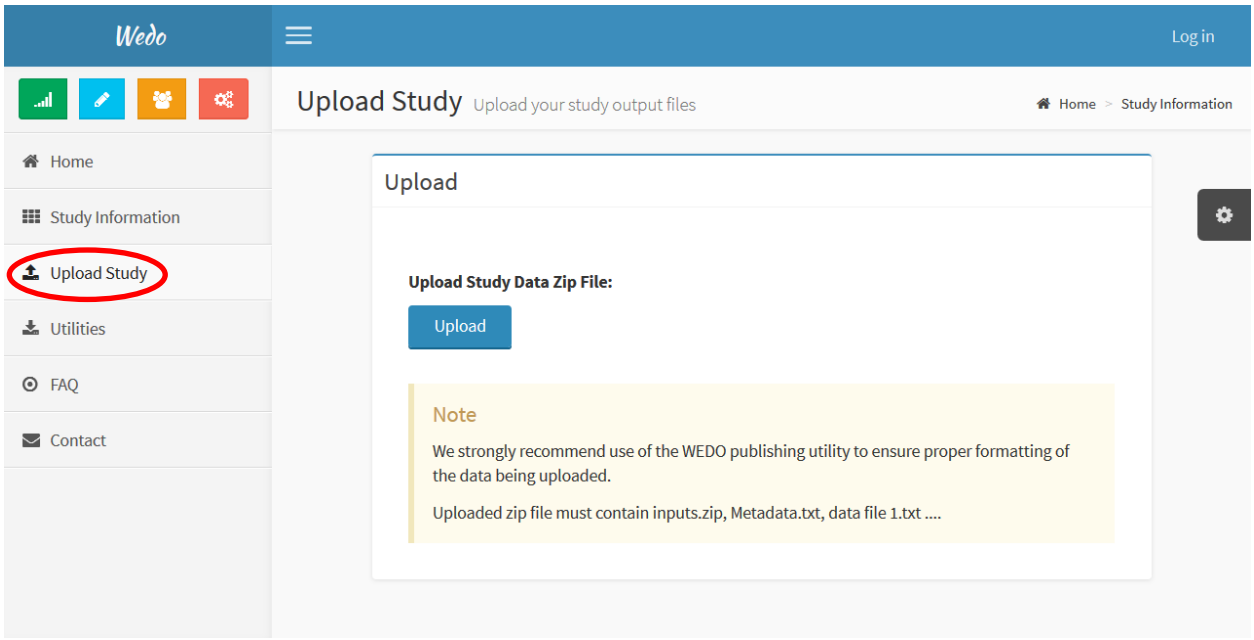

Figure 24. WEDO Upload Study Page

By clicking "Browse" on this page, the user can search for and choose the zip file of the modeling study to be publishing, as shown in Figure 25.

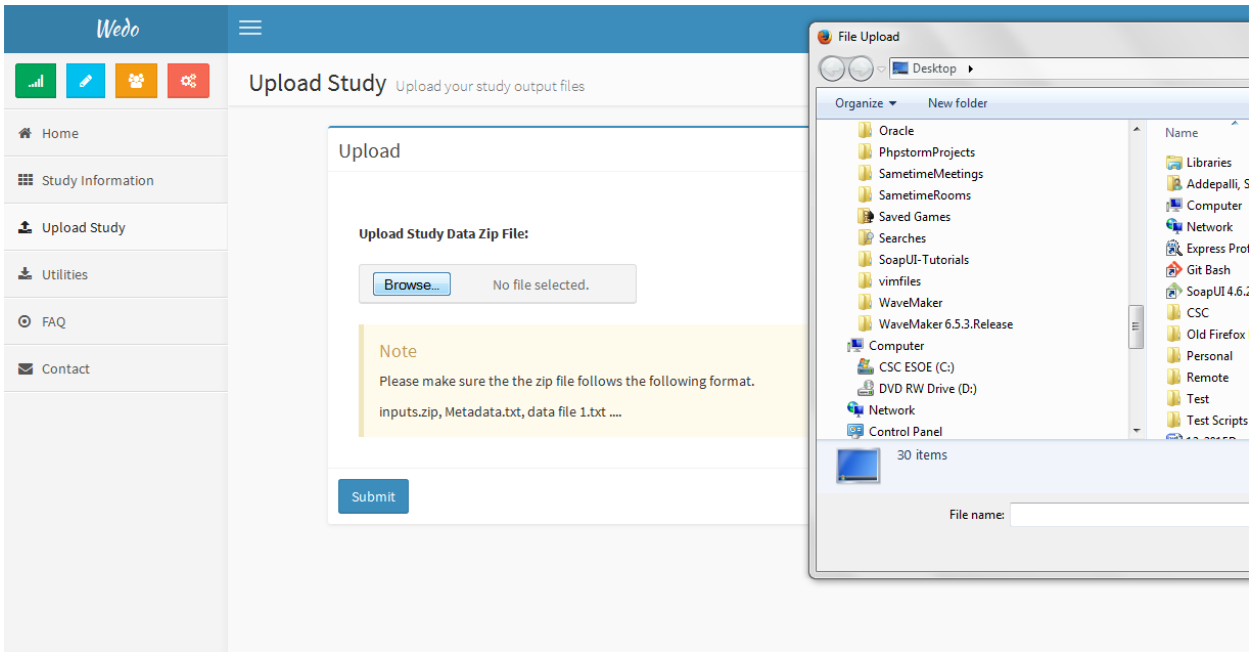

Figure 25. Finding a Study to Upload

Once the zip file is chosen, by clicking submit, the modeler submits the specific study to the WEDO database. The uploaded study automatically assumes “Pending” status in the database. The WEDO administrator periodically publishes all studies in “Pending” status to the EnviroAtlas site. The administrator then confirms that the studies have been successfully published on EnviroAtlas and changes the status of the studies to “Published.” Modelers and researchers will be able to search for this information on the “Study Information” page.

2.0 WEDO for Administrators

The WEDO administrator is a key component to supporting the discovery, evaluation, and integration of watershed modeling data using WEDO. The WEDO administrator function helps to support data integrity within the tool by providing a streamlined process for tracking the status of studies that have been uploaded by WEDO users. Unlike non-administrators who are unknown within the WEDO database, administrators access WEDO using security credentials and are able to undertake a number of actions to maintain system integrity.

There are various tasks within WEDO that can be completed only by a WEDO administrator, and are as follows:

- Publishing a study to EnviroAtlas
- Receiving and processing a request to withdraw a study that is marked as "pending"
- Changing the status of a study from "pending" to "publishing"
- Changing the status of a study from "publishing" to "published" once it has been uploaded to the EnviroAtlas NHD map layer
- Adding new administrators to WEDO

The process and rationale for undertaking these various tasks within the administrator function of WEDO will be explained in the following sections.

2.1 Administrator Home Page Functionality

The WEDO home page for administrators is accessible only for those who hold administrator rights to the site. To obtain administrator rights, a request needs to be submitted to the WEDO administrator by sending an email to one of the addresses on the "Contact Us" page.

An administrator can log in to the system by clicking the "Log in" button on the top right hand corner of the home page (see Figure 26).

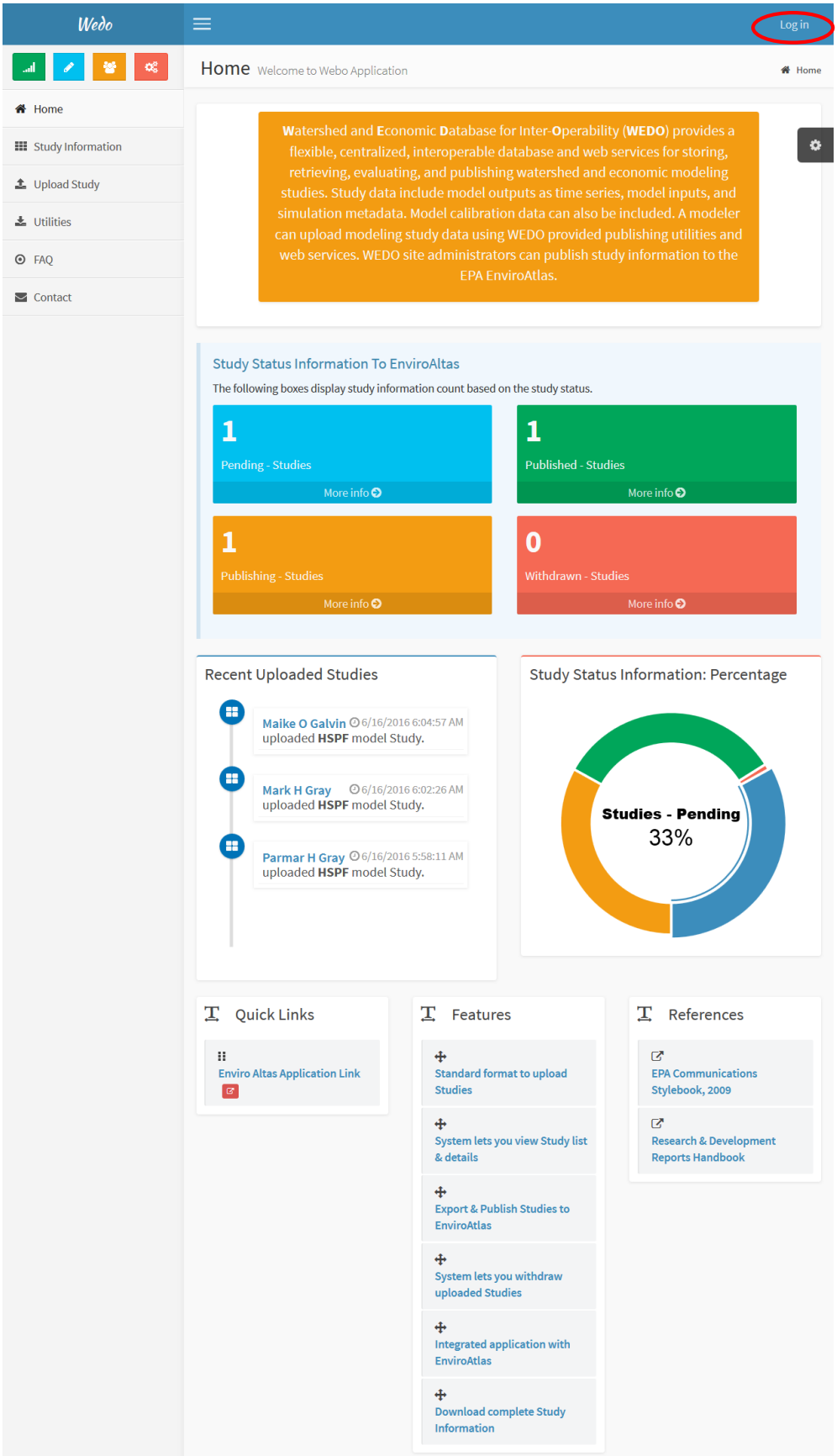

Figure 26. Finding the Log In Page for Administrators

Clicking “Log In” will bring the administrator to the Sign In page (Figure 27) where there will be a prompt to enter the administrator’s email address and password.

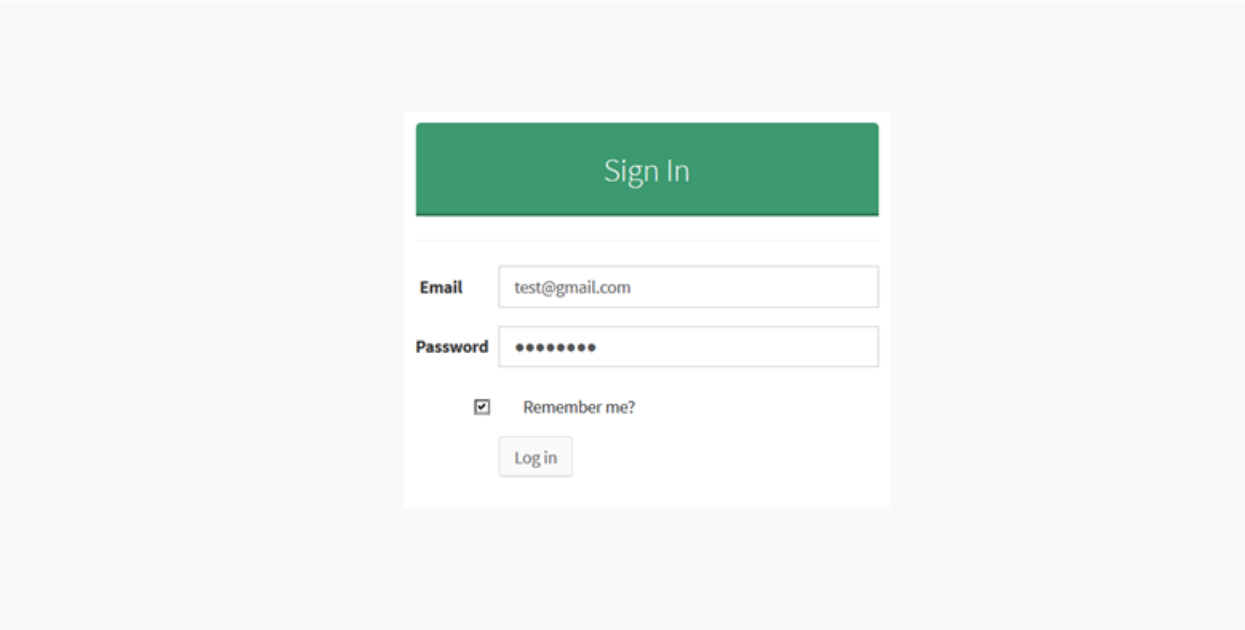

Figure 27. Administrator Log In Page

Once the administrator enters appropriate log in information, the administrator will be directed to the Home Screen for administrators (Figure 28). This page looks nearly identical to the normal home screen, but the administrator’s email address will appear, along with a “Log off” button in the top right corner. Clicking on the “Log off” button logs the administrator out of the system and automatically navigates back to the main WEDO home page for non-administrators.

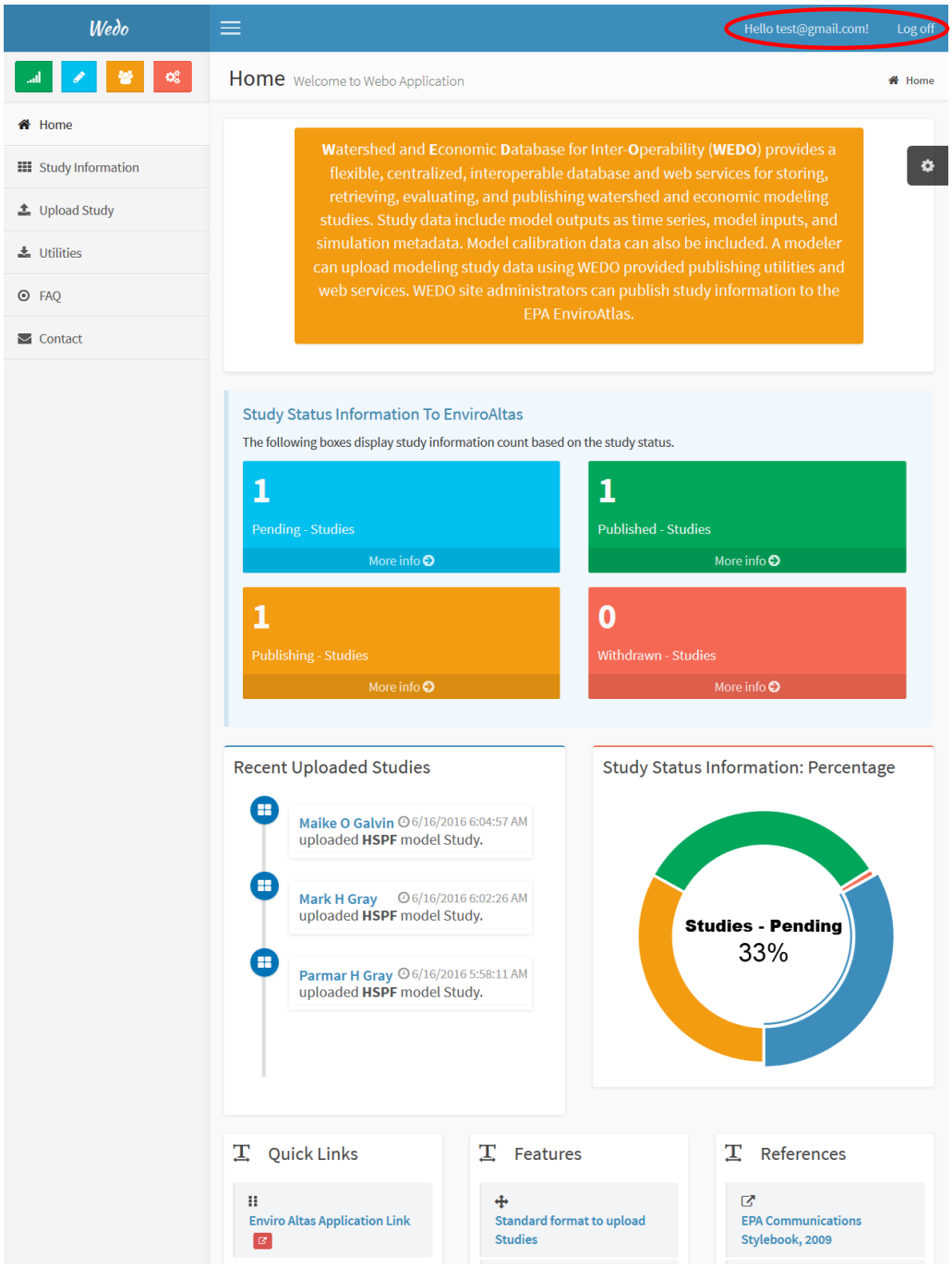

Figure 28. View of the Administrator Home Page

The home page serves as both a starting place for navigation within WEDO as well as dashboard that allows the administrator to see how many studies have been published or are pending within WEDO. The ring on the lower right hand side of the Dashboard displaying pending studies is dynamic. The administrator can move the cursor on a section of the ring corresponding to a status to display number of studies in that status. The page also displays recently published studies on the lower left-hand side. The administrator can click on the author link in a study to navigate to the study information page.

Due to the fact that the administrator accepts the studies to be published to EnviroAtlas and monitors

withdrawal requests, this dashboard provides a useful means for the administrator to keep track of studies in the various stages of publishing.

2.2 Administrative Tasks within WEDO

As mentioned above, there are various administrative tasks that can be performed by the administrator within WEDO, including publishing data to EnviroAtlas as well as withdrawing a study from WEDO. These tasks help to support discovery, evaluation and integration of watershed modeling data by making the information more accessible to modelers and researchers for use in their own studies.

2.2.1 Publishing Data to EnviroAtlas

The key administrative task to be performed by the WEDO administrator is publishing data to EnviroAtlas. This is a key component of the discovery WEDO aims to support for modelers and researchers, and is important for sharing studies.

When a modeler or researcher has submitted a study to be published, it is marked as "Pending" within WEDO, as shown in Figure 29. Once a study is marked as pending, it shows up on the administrator dashboard and is available to be published to EnviroAtlas. If the user is not logged in as an administrator, the "Action" column will not be visible.

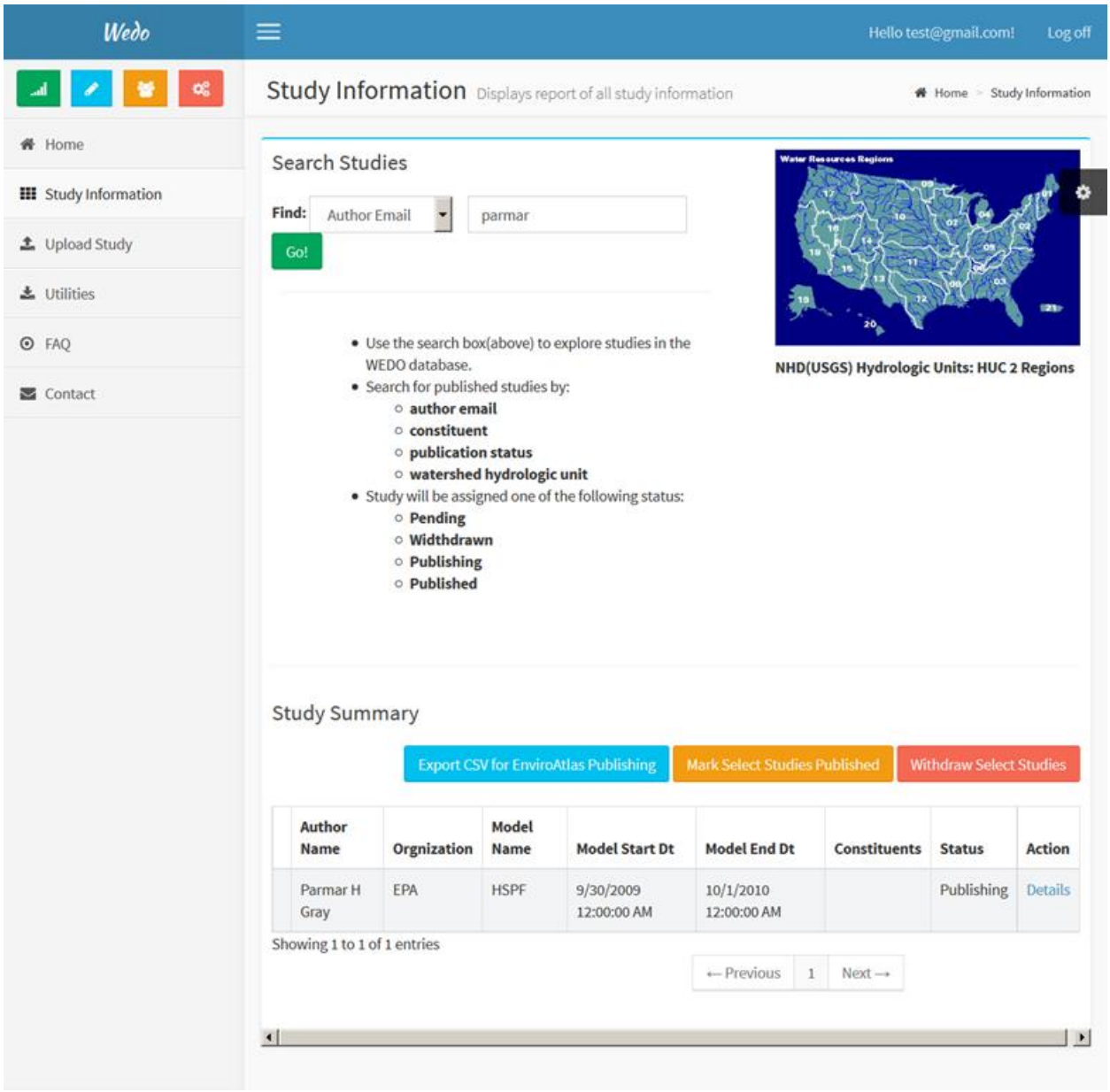

Figure 29. Study Information Page View for Administrator

After the study has been published to WEDO by the modeler and is marked as "Pending," the administrator periodically creates a CSV file of selected "Pending" studies to be published and sends the file to the EnviroAtlas team for publishing. (Criteria used to select the studies for publishing are discussed later in this section.) The Study Information shows the "Export CSV file for EnviroAtlas Publishing" button when the administrator is logged in. The administrator clicks the button to generate a CSV file which is then emailed to the EnviroAtlas team for publishing. Once the file is sent to the EnviroAtlas team, the study moves into the "Publishing" phase, and the study's "Publishing" flag is turned on within WEDO. At this point, the study will show up in the "Publishing" category on the WEDO administrator dashboard.

The CSV file has three fields: REACHCO, WEDOdata, and WebLink. Please note that EnviroAtlas requires field names to be less than or equal to eight characters. REACHCO is the stream Reach Code,

WEDOData is a text string listing available flow , water quality, and economic parameters for the stream segment, and WebLink is a WEDO website hyperlink pointing to the "Study Information" page displaying studies related to the stream segment.

Once the EnviroAtlas team confirms that the study is published to their NHD map layer, the administrator must click a button titled "Mark Selected Studies Published" within WEDO to toggle the "Published" flag, which confirms that the study is officially published. At this point, the study is available on the EnviroAtlas tool to be discovered by EnviroAtlas users.

The administrator can choose when to publish the pending studies to EnviroAtlas based on a number of factors. For example, the administrator may want to wait for multiple studies to be completed before sending them to EnviroAtlas so many can be sent at once or may wish to wait until the study has been on the WEDO site for a few months to ensure it is complete. The time frame for uploading studies to EnviroAtlas is flexible based on the administrator's needs, and can be done at any point once a study is marked as "Pending."

By allowing the administrator to publish studies to EnviroAtlas, WEDO helps support discovery and integration by making data and modeling studies readily available to the public. Users can interrogate studies that are published as well as pending. Discovery is a key goal of WEDO, and publishing these studies allows them to be shared and used by other modelers and researchers across the United States.

2.2.2 Withdrawing a Study from WEDO

After a modeler has submitted a study to be published to WEDO, a modeler can request to withdraw the study. A modeler or researcher may wish to withdraw a study from WEDO for a number of reasons; the data may have been incomplete, the data may have been incorrect, or it may have been published before it was ready. Regardless of the reason for submitting a withdrawal request, only those studies that are marked as "Pending" can be withdrawn. A withdraw request for a published study can be handled as an exception to WEDO work flow. The administrator may access the database directly to change the study status to "Pending" and then withdraw the study as described above. There are several possible side effects of withdrawing a published study. EnviroAtlas may have a broken hyperlink pointing to the WEDO Study Information page of the withdrawn study if the withdrawn study were the only study for the corresponding stream. Even if other studies exist for the stream, they may not include all the parameters listed in the pop-up the modeler or researcher sees after clicking on a published stream on EnviroAtlas. Furthermore, if the administrator has to manually change a "Published" study to "Pending" in order to withdraw it, the administrator would be required to republish the studies onto EnviroAtlas to repair broken links from EnviroAtlas to WEDO.

The administrator monitors requests to withdraw a study. Once a modeler or researcher submits a request to the administrator to withdraw a study by contacting the administrator via the "Contact Us" page, the administrator will choose to accept or deny the withdraw request and remove the study, as needed.

2.2.3 Registering a New Administrator

Requests to become a WEDO administrator are monitored and approved by existing WEDO administrators. Once a new administrator has been accepted, the WEDO administrator logs in and adds them as an administrator. Note that only administrators that are logged in can access the Accounts/Register page (Figure 30) to add a new administrator.

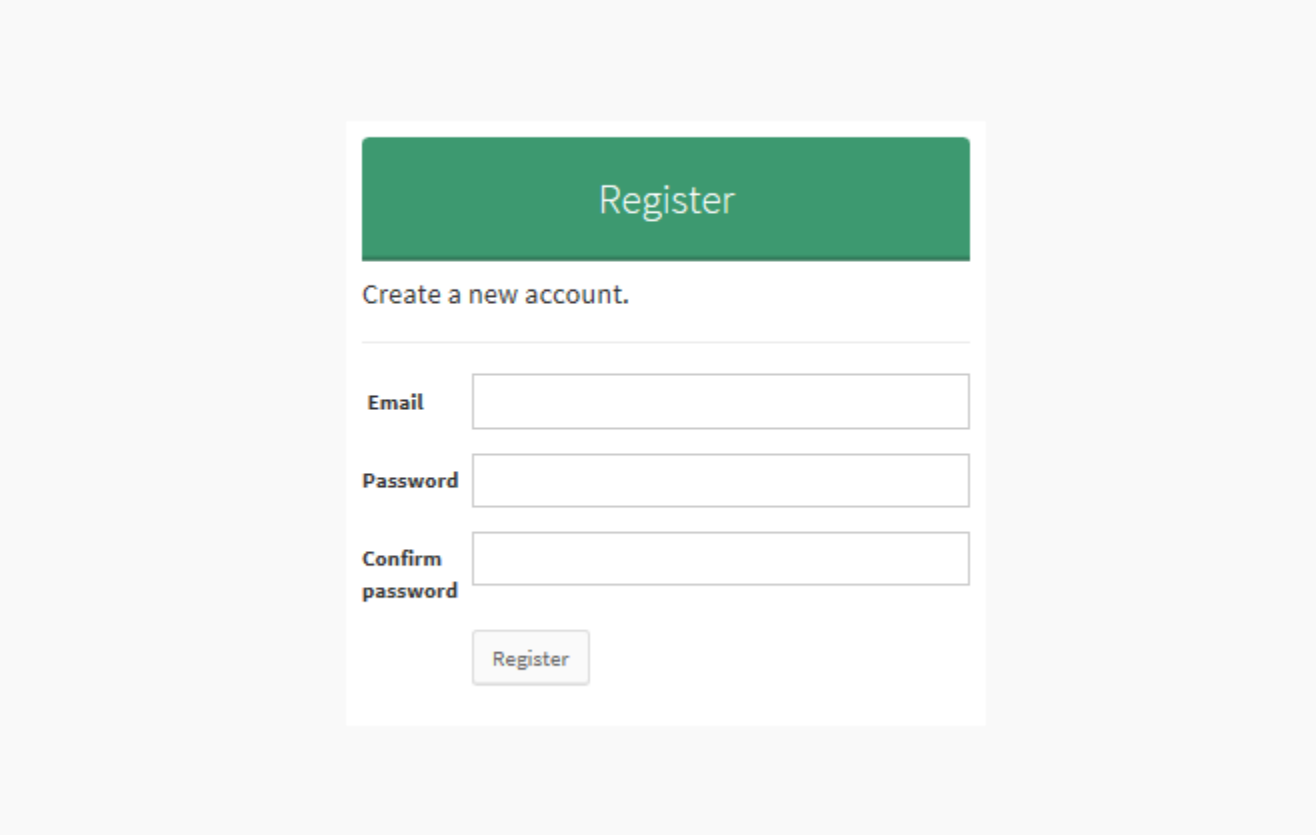

Figure 30. Administrator Screen for Creating a New Account

3.0 References

U.S. Environmental Protection Agency, 2015. “EnviroAtlas.”

U.S. Environmental Protection Agency, 2014. “STORET/WQX.”

U.S. Geological Survey, 2016. “National Water Information System.”

4.0 Appendices

Appendix A. DB Schema

The WEDO database is implemented in Microsoft SQL Server 2008 R2 database management system. The database design has been normalized to minimize data redundancy. Table and field names as well as relationships are shown in the database diagram (Figure 31) below.

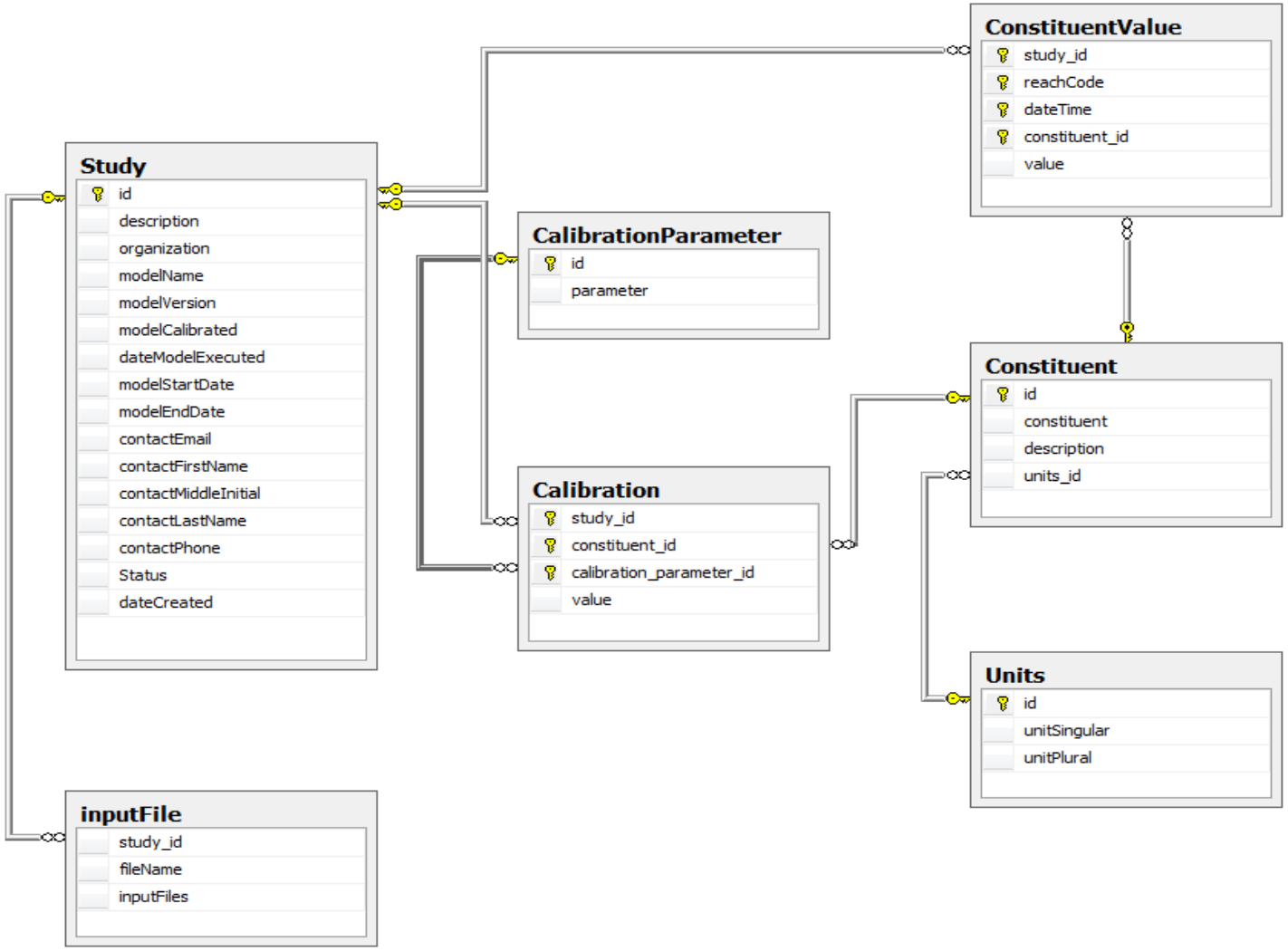

Figure 31. WEDO Database Schema

Table and field names as well as relationships are shown in the database diagram (Figure 31). The following table (Table 3) shows column data types for database tables.

Table 3. WEDO Column Data Types for Database Tables

Table	Column	Data Type
Study	id	int
	description	Varchar(max)
	organization	Varchar(50)
	modelName	Varchar(50)
	modelVersion	Varchar(50)
	modelCalibrated	bit
	dateModelExecuted	datetime
	modelStartDate	datetime
	modelEndDate	datetime
	contactEmail	Varchar(50)
	contactFirstName	Varchar(50)
	contactMiddleIntial	Char(1)
	contactLastName	Varchar(50)

	contactPhone	Varchar(50)
	Status	Varchar(50)
Units	id	int
	unitSingular	Varchar(50)
	unitPlural	Varchar(50)
InputFile	Study_id	int
	fileName	Varchar(50)
	inputFiles	Varbinary(max)
Constituent	id	int
	constituent	Varchar(50)
	description	Varchar(100)
	units_id	int
ConstituentValue	study_id	int
	reachCode	Varchar(20)
	dateTime	Varchar(50)
	constituent_id	int
	value	Decimal(18,4)

CalibrarionParameter	id	int
	parameter	varchar(50)
Calibration	study_id	int
	constituent_id	int
	calibrationParameter_id	int
	value	float

Appendix B. Software Architecture

The architecture of the WEDO software (Figure32) has three logical layers: Desktop models, the WEDO database web site, and the EnviroAtlas web site. Navigation and information flows between the layers has been shown by arrows in the architecture diagram. The desktop models layer contains utilities for publishing modeling studies on the WEDO database web site from desktop computers. All publishing utilities have been developed using Microsoft .NET framework 4.0 and VB.NET programming language. In addition, the WEDO publishing utilities use an ArcGIS.com online interactive map (http://arcg.is/1CLI2YX). This map allows users to discover stream NHD flowline ReachCode identification numbers using the EPA Office of Water watersgeo NHDPlus v2.1 ArcGIS map service. The WEDO web site itself consists of three logical groups of software: database, RESTful web services, and web forms/pages. All software for the WEDO web site has been developed using Microsoft .NET framework 4.0, MVC5, and C# programming language. A combination of SQL/T-SQL has been used to perform database programmatic operations. Microsoft Visual studio 2015 was used as the Integrated Development environment (IDE) for developing WEDO web site. The WEDO web site provides tools to publish summary data to EPA EnviroAtlas which is not part of WEDO but makes the data discoverable by a wider audience. EnvrioAtlas is part of the EPA GeoPlatform developed on the ESRI technology stack.

A prototype implementation can be accessed from within the EPA firewall here:
http://134.67.114.8/wedo

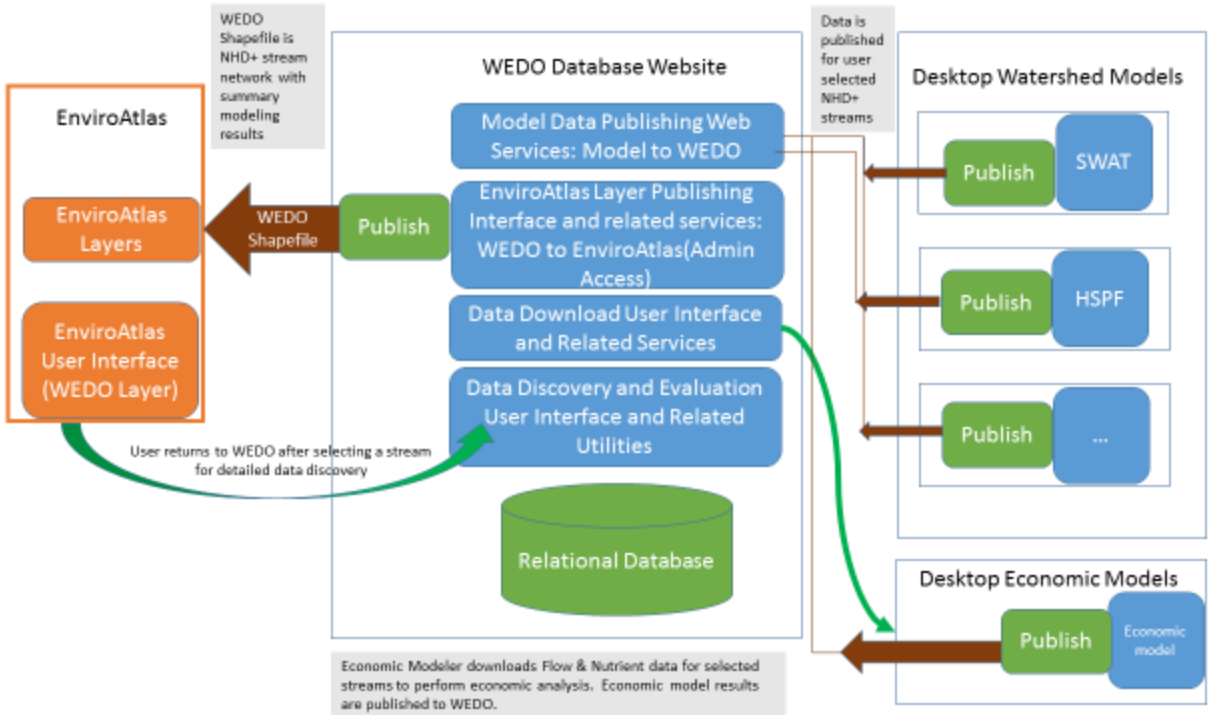

Figure 32. WEDO Software Architecture

Appendix C. Information for Software Developers

(1) Development Environment: Microsoft Visual Studio 2015 was used in the development of WEDO. C# version 4.0 was the development language.

(2) Database Management System: Microsoft SQL Server 2008 R2 is the WEDO DBMS.

(3) Modeling data publishing utility for HSPF and SWAT were developed using Visual Studio 2015 and VB.NET.

(4) Source code repository for WEDO is available at EPA GitHub.
https://github.com/USEPA/WEDO.git

To gain access to the private EPA github repository contact Rajbir Parmar Parmar.Rajbir@epa.gov.

Deploying the web application yourself:

1. In the WEDO application edit the web.config file connection string to match your database server requirements.
2. A backup database image is provided in the database folder. The backup needs to be restored to your SQL Server installation. You may need to grant database access permission to the WEDO application running in IIS (e.g., IIS APPPOOL\DefaultAppPool).

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