WaDE 5-Year Work Plan: 2022-2026 (DRAFT)

The Western States Water Council (WSWC)

Water Data Exchange (WaDE) Program

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The WaDE Program is committed to assisting WSWC member states in sharing water allocation, supply, and use data through a common streamlined and standardized web service that enables regional analyses to better inform water resources planning and policies in the West.

States allocate and administer rights to the use of water in the West and are therefore in the best position to provide water rights and water use data, but rights and uses and their data are managed separately and distinctly by each state.

This document first provides a brief background on the WaDE Program, followed by a 5-year Work Plan for the years 2022-2026. Section 3 summarizes the six areas mentioned in the Work Plan tasks that we could hire interns to work on. The Work Plan consists of 7 main tasks that are defined into 45 sub-tasks. We welcome any feedback or suggestions to improve this Work Plan and better align it with the interests of our member states, federal partners, and philanthropic organizations.

Sec A: Background

The Water Data Exchange (WaDE) Program began in 2011 under a subcontract with the Western Governors Association (WGA), as a cooperative effort between WSWC and the Sandia National Labs, with funding from the Department of Energy made available under the American Recovery and Reinvestment Act (ARRA) of 2008. It was subsequently sustained with WSWC funds and in-kind support through participation from our member States that committed staff and resources, as well as sharing data, without which WaDE would not be possible. Other early funding came from the Environmental Protection Agency's Exchange Network (EN), as well as funding from the Cynthia and George Mitchell Foundation, the Water Funders coalition, and the Gordon and Betty Moore Foundation, through the Internet of Water and Duke University.

The focus of the WaDE program is to provide a framework for states to share important water data with each other, with federal agencies, and with the public with an emphasis on enabling regional analysis. States make their water data available to the WaDE platform, which streamlines the data into standardized and machine-readable formats. Making the water data accessible enables users to answer regional and national questions about water availability, scarcity, and resilience in a cost-effective, sustainable, and consistent way. With the continuous support of the Western States' Governors, natural resource agency directors, state engineers, and their staff, the WaDE Program is approaching its 10th anniversary and entering an exciting third phase (Figure 1).

In this third phase, we will develop a user-friendly dashboard called the Western States Water Data Access and Analysis Tool (WestDAAT), an operational decision support and planning tool that will streamline the sharing of water data for western states. The WaDE Program has progressed from its initial concept and creation phase (2011-2018), which established working relationships with states agencies and created data sharing protocols while building and populating a collaborative data management system in response to interest and funding from the WSWC States, federal agencies (DOE, EPA), and philanthropic groups. In its second phase (2019-2021), WaDE created a template for transforming disparate state water-related data systems into a functional regional and cloud-based data system with standards and metadata. These data services help streamline access to water rights and water use data.

WaDE is one of the major data hubs within the Internet of Water project https://internetofwater.org/resources/hubs/. In addition, a WaDE metadata dictionary that includes controlled vocabularies is considered as the standard method for sharing state agency water use data between WaDE and the U.S. Geological Survey (USGS) Water Use Data Research (WUDR) Program (https://water.usgs.gov/wausp/wudr/files/WUDR-USGS-data-transfer-guidance.pdf).

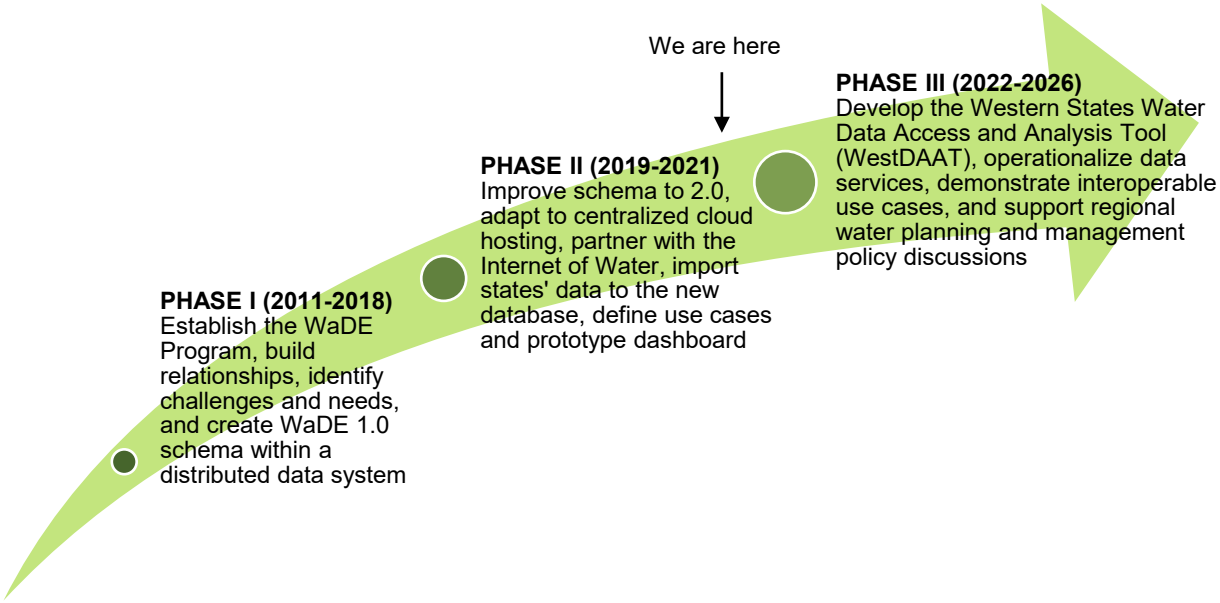

Figure 1: The Water Data Exchange (WaDE) Program's past, current, and next phases, and their key activities. This Work Plan will establish the third WaDE phase that operationalizes WestDAAT.

The current WaDE 2.0 Data System focuses on sharing the following four major types divided into nine subtypes of water data: 1) Water Rights data: Points of Diversions (POD) and Places of Use (POU), 2) Regulatory data, 3) Site-Specific time series data: reservoirs and gages & water use, and 4) Aggregated Use: Consumptive use, Delivered Water Use, Demand, Supply, and Withdrawal (Figure 2). The goal is to share nine of these datasets for as many of the states as possible as some states do not produce one or many of these data types or they do not have such data publicly available yet.

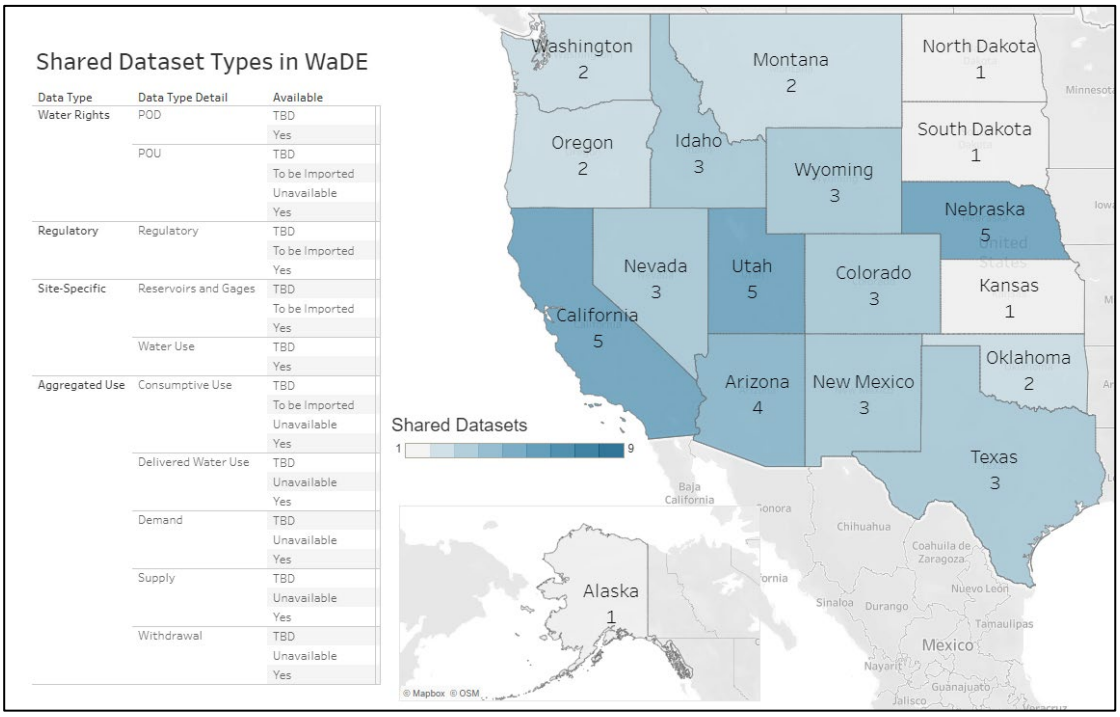

Figure 2: Number of shared datasets through the WaDE Data System across the western eighteen states. An interactive Tableau dashboard is available here https://public.tableau.com/app/profile/wswc/viz/WaDE2_0_Shared_Datasets/ShraedDatasets_dash?publish=yes

Earlier this year, with support from the Moore Foundation through the Internet of Water, we developed a WestDAAT prototype to be used as a proof-of-concept and basic features application that connects the WaDE database to an online visualization environment (Mapbox). This past spring, we worked to specify the features and desired full functionality of the planned application. The prototype is not connected to any data but simulates the user experience. We have identified different categories of WestDAAT potential users as illustrative personas with different roles in managing or understanding water resources, and with different water data needs. The WestDAAT user personas and related outreach will provide the WaDE Team with meaningful use cases for the further design and development of software that meets the goals and expectations of end-users.

The personas include (1) Gary the Governor; (2) Stan the State Engineer; (3) Maggie the River Basin Manager; (4) Laila the Land Use Manager; (5) Frank the Farmer (or an Irrigation Canal Company Manager); and (6) Ratib the Researcher. Other personas may be created, or existing personas modified as this effort evolves. Obviously, some persona features and needs may overlap. We plan to use the WestDAAT prototype we developed to facilitate feedback from participants in our persona focus groups, which will then be used as a blueprint to improve the final WestDAAT product that our contractor will build later this year or next depending on the availability of funding. The WaDE system, with WestDAAT as a front-end application, is expected to drive innovation and improve water management in the West through its simple user interface and ability to provide access to often disparate regional water data. Our goal at the WSWC is to make water rights and water use information more findable, accessible, interoperable, and reusable (FAIR), leading to more innovative and drought-resilient applications. We anticipate it will facilitate other water management and protection activities:

1. Prolong the use of scarce water supplies to ensure future water source reliability.
2. Improve drought and environmental risk management, building climate resiliency.
3. Highlight conjunctive groundwater and surface water use opportunities.
4. Facilitate state water rights administration and better define federal agency water rights.
5. Promote water conservation and efficiency.
6. Focus initiatives for fish and wildlife habitat management and species protection.
7. Promote water marketing, transfers, leasing and banking.

WaDE data services will complement and help integrate with other national water data services such as U.S. Geological Survey (USGS) stream gages/streamflow information, Bureau of Reclamation Information Sharing Environment (RISE) data on reservoirs and canals, and the Environmental Protection Agency's (EPA) water quality data services. As part of this integration effort, the WaDE team is currently working with the Internet of Water and USGS groups on connecting WaDE to the Geoconnex project. This includes indexing the state data in WaDE with the Network-Linked-Data-Index (NLDI) tool. Geoconnex will provide permanent identifiers to all sites that have data in WaDE and generalized landing pages with common metadata to facilitate the searchability of the data. NLDI will provide data query capabilities for locations upstream or downstream of water sites referenced in WaDE, USGS, Reclamation, and EPA data services based on the National Hydrography Dataset (NHDPlus). Users can further query WaDE sites and view their landing pages while federal data will point to their external landing pages as maintained by each federal data provider.

The WaDE team is also coordinating with another regional project, OpenET, to integrate aggregate consumptive water use summaries and allow comparisons between permitted water rights and estimated consumptive use in a watershed. The OpenET project (https://openetdata.org/) has developed an operational system for mapping evapotranspiration (ET) and consumptive use for the 17 states in the Western U.S. OpenET provides daily, monthly, and annual ET data at a spatial resolution of 30 m x 30 m (0.22 acres). It uses an ensemble of well-established satellite-driven ET models implemented on the Google Earth Engine cloud computing platform. This allows interoperability across different datasets, massive parallel processing, storage, and scalability in time and space, and automated operational updates with new observations that would otherwise be very costly and burdensome for State and federal agencies to develop, operate and maintain.

Sec B: WaDE Work Plan

The following Work Plan consists of seven main tasks that are further defined altogether to 45 sub-tasks (Table 1). See below for further descriptions of each task.

Table 1: WaDE Work Plan through 7 main tasks and their time frame execution (to be specified further).

#	Main Task	Time Frame				
		1 Year	2 Year	3 Year	4 Year	5 Year
1	Provide access to water rights data including point of diversion (POD), place of use (POU), and regulatory overlays					
2	Provide access to aggregate water use data					
3	Develop an operational WaDE dashboard (WestDAAT)					
4	Incorporate federal water rights ownership interests recognized by states or court decrees, or settlements, and map water rights on federal lands					
5	Streamline the sharing of western states' site-specific time series water use data with USGS as part of the national water assessment and use reporting					
6	Provide access to site-specific time series reservoir and gage stations water data					
7	Conduct outreach and pilot projects to develop “personas” and use cases and sustain the WaDE Program and its dashboard					

1. Provide Access to Water Rights Data including Point of Diversion (POD), Place of Use (POU), and Regulatory Overlays

This task aims at fully publishing administrative water data which includes the first WaDE data type of water allocations (i.e., rights, permits) and the second type of regulatory overlays such as compacts, special management areas that define local and regional water use guidelines, and restrictions within each state in the West. Regulatory data in WaDE are supported through metadata and spatial boundaries that are related to all water diversion and use sites in the database. Examples of regulatory overlays include the Active Management Areas (AMA) in Arizona and the Sustainable Groundwater Management Act (SGMA) basins in California. Both administrative data are commonly available in our member states. Figure 3 shows a preliminary map of all the points of diversions (POD) we have imported into the WaDE 2.0 database and available place of use (POU) data to be imported next. We note that these datasets are still incomplete for the states of Texas and New Mexico. The following subtasks define what will be specifically accomplished under this task.

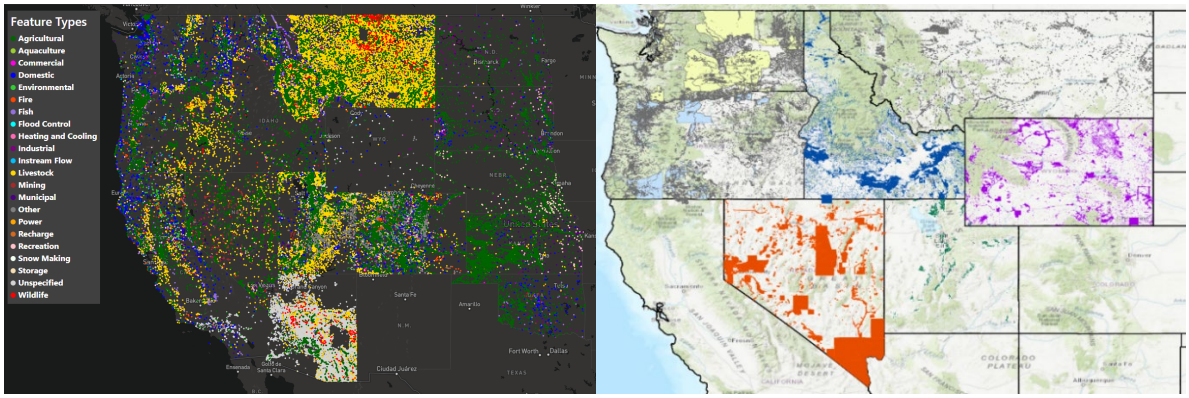

Figure 3: (**Left**) Point of Diversions for Water Rights Data Already Imported to WaDE. Colors on the map represent beneficial use categories as classified by the WaDE team. (**Right**) Available Place of Use Geospatial Data we recently imported to the WaDE database.

1.1 Finish importing POD data for Texas, New Mexico, and Alaska

We have imported POD data for 15 states while datasets for the states of Alaska, New Mexico, and Texas and are incomplete and pending a public release of their data. We will continue to work with these states to review and approve the imported data to the WaDE database.

1.2 Import POU data for Arizona, Nebraska, North Dakota, and Oklahoma

We have imported POU data for the states of Idaho, Montana, Oregon, Nevada, Oklahoma, and Utah, Washington, and Wyoming. The data and its mapping to WaDE's database need to be reviewed by the state agency's staff. Next, we will work with the states of Arizona, Nebraska, North Dakota, and Oklahoma to import their POU data. The states of California, New Mexico, Texas, Colorado South Dakota, and Alaska either do not have such POU data in a digitized form or it is not publicly available yet. We will import the POU data to any of these states once they make their data publicly available.

1.3 Import water rights data for the Canadian part of the Colombia River

We plan on importing the publicly available water rights data in British Colombia province in Canada if there is a common interest from our northwest member states and the Canadian partners. This data would be useful in informing water management discussions in the Colombia basin. Here is a GitHub issue that provides more details on the Canadian data sources:
https://github.com/WSWCWaterDataExchange/MappingStatesDataToWaDE2.0/issues/66

1.4 Automate water rights data retrieval from states' datasets to WaDE starting once every six months up to a year for as many states as possible + Ask states for a final review of WaDE data and vocabulary mapping and approve their sharing in WaDE

To import water rights datasets to WaDE, we have thus far manually downloaded those water rights datasets to a local machine, followed by running a custom Python script to map and fit the state's data to WaDE generalized data template, then manually running the WaDE data loader script to upload the data into WaDE database in Microsoft Azure (Figure 4). In this sub-task, we aim at automating these processes with an automatic download, process, and upload of data to the WaDE database regularly. This will help reduce the effort it takes to share the data with WaDE and to keep WaDE up to date with any changes published to the states' datasets. This automation is possible through the Azure Workflow Automation service.

We are continuously coordaining with the point of contact for our member states to review the mapping of their data into WaDE. We plan to have them review our documentation and ask if they approve of how their data appears in the WaDE API and the WestDAAT dashboard (this is done before we officially release a state's data). The current documentation for each state is available on GitHub here https://github.com/WSWCWaterDataExchange/MappingStatesDataToWaDE2.0.

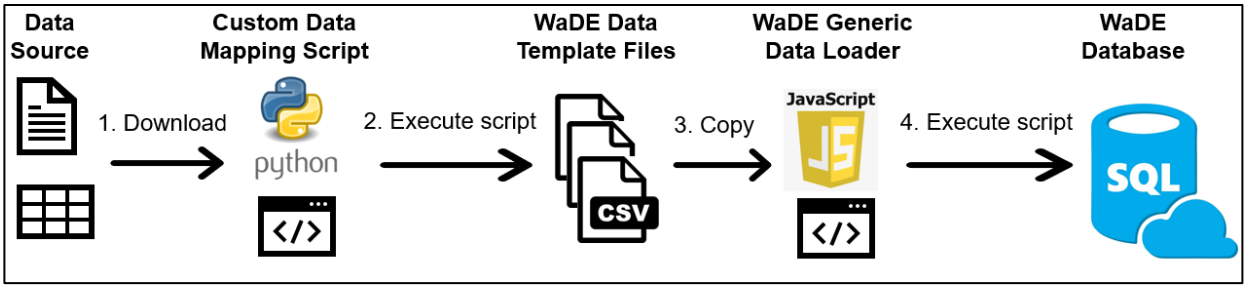

Figure 4: Four steps to be automated for extracting, transforming, and loading data from our states to the WaDE database

1.5 Hire an Intern for 3-4 months to coordinate with states on creating a hierarchical order of beneficial uses for each state to determine which use is considered the primary beneficial use when many are provided

Many states allow multiple beneficial uses for a single water right such as allowing domestic, and livestock secondary water use within a primary irrigated farm. The WaDE database supports this case and tracks the primary beneficial use if clearly defined. However, none of the states clearly define the primary beneficial use which is a need in data query, filtering, visualization, and analysis. As a starter, when many beneficial uses are listed for a single water right, we assumed that "irrigation" is the primary beneficial use. However, we need to work closely with each state water rights permitting agency to define the primary beneficial use for this case and others to more accurately filter water rights based on the most important beneficial use that drives water use. We plan to hire an intern to help us define and write an algorithm for each state to choose the primary beneficial use based on a list of if-clauses that define the hierarchical order of importance of beneficial use combinations.

1.6 Work with the WSWC Legal Committee to define controlled terms for the Legal Status and Water Right Type of water rights in WaDE

Our member states use distinct terminology and descriptions on similar terms to describe important metadata items that define a water right's legal status of whether it is adjudicated, active, or abandoned, among others. We have asked the WSWC Legal Committee to help us define common terminology that can relate to the legal status values across our states. Such common terms will help enable consistent data analysis and comparisons across states. The agreed-upon WaDE terms will be posted online along with the corresponding native terms that the state use: http://vocabulary.westernstateswater.org/.

1.7 *Hire an intern for 3-4 months to work on a clearinghouse project for Nebraska Natural Resource Districts (NRDs) certified parcels*

Nebraska has 23 NRD local regulatory government units that each have programs to conserve and protect the state's natural resources (such as groundwater). Each NRD has its own data collection and reporting methods to the Nebraska Department of Natural Resources (NeDNR). Each year NeDNR staff spend significant time in compiling land-use datasets known as “certified parcels” that are provided from the 23 NRDs into a common layer that can be used for their groundwater model. The NeDNR Assistant Director highlighted a need to assist them in creating a clearinghouse process that would automate the NRD’s certified parcels into a common GIS layer. If funding is available, a WSWC intern would first review the data structures provided by a subset of 7 pilot NRDs and identify common attributes among them that constitute a general layer. The intern will then create ArcGIS workflows that would automate merging the different layers into the common GIS layer. WaDE will in turn share a more accurate POU layer for Nebraska and update water use datasets as provided by NeDNR groundwater model results. More details to come as NeDNR consults with the NRDs over the next few weeks.

1.8 Hire an intern to survey/ask states about how they track the changes in water rights in their databases

Over time, statutes and use of a water right might change either through new permits, abandoned or forfeited permits, and transfers from one beneficial use to another. Many states only share the current active status of water rights, while others report the type and status of rights over time as they keep old rights in the same database. The WaDE database is designed to share the most recent snapshot of shared data on water rights (i.e., a mirror from state’s public datasets) and cannot directly track changes over time (if any are available). We plan to hire an intern to survey how states track and publish these types of changes to their water rights and whether if they would be comfortable in WaDE sharing old data to track changes over time. The goal of this subtask is the ability to track changes in water rights over time. The WaDE database could be updated in repose to this posed question based on survey results and recommendations, which would likely require a change in our database schema. This GitHub issue describes relevant technical details: https://github.com/WSWCWaterDataExchange/MappingStatesDataToWaDE2.0/issues/88

1.9 Import regulatory overlays data for at least 10 states and create a GIS shapefile layer that merges all the regulatory overlays across states and relate them with all POD and POU sites

Importing regulatory data has been a lower priority in our long to-do list of activities. We will work on importing regulatory overlay data for at least 10 states. Available regulatory data to be imported to WaDE are listed on GitHub here https://github.com/WSWCWaterDataExchange/MappingStatesDataToWaDE2.0/issues?q=is%3Aopen+is%3Aissue+label%3A%22Regulatory+data%22

The WaDE dashboard requires a shapefile for the regulatory boundaries with unique universal identifiers that connect each polygon with the WaDE database for full access to its metadata. WaDE allows users to query water rights or diversion or use sites within a selected regulatory overlay polygon. Also, for each water right, users can get a list of all the regulatory overlays that apply to it. Importing regulatory overlays to WaDE is not expected to be difficult but connecting them with sites requires geospatial data joins that might take more time.

2. Provide Access to Aggregate Water Use Data

Most states have their water budget models or aggregate water supply or use to different spatial scales such as a county, custom watershed, or planning area. This task aims to provide this data through WaDE in a variety of spatial scales as shared by the states. Figure 5 shows the progress of connecting agencies' aggregate water data into the WaDE database as reflected in the number of shared datasets.

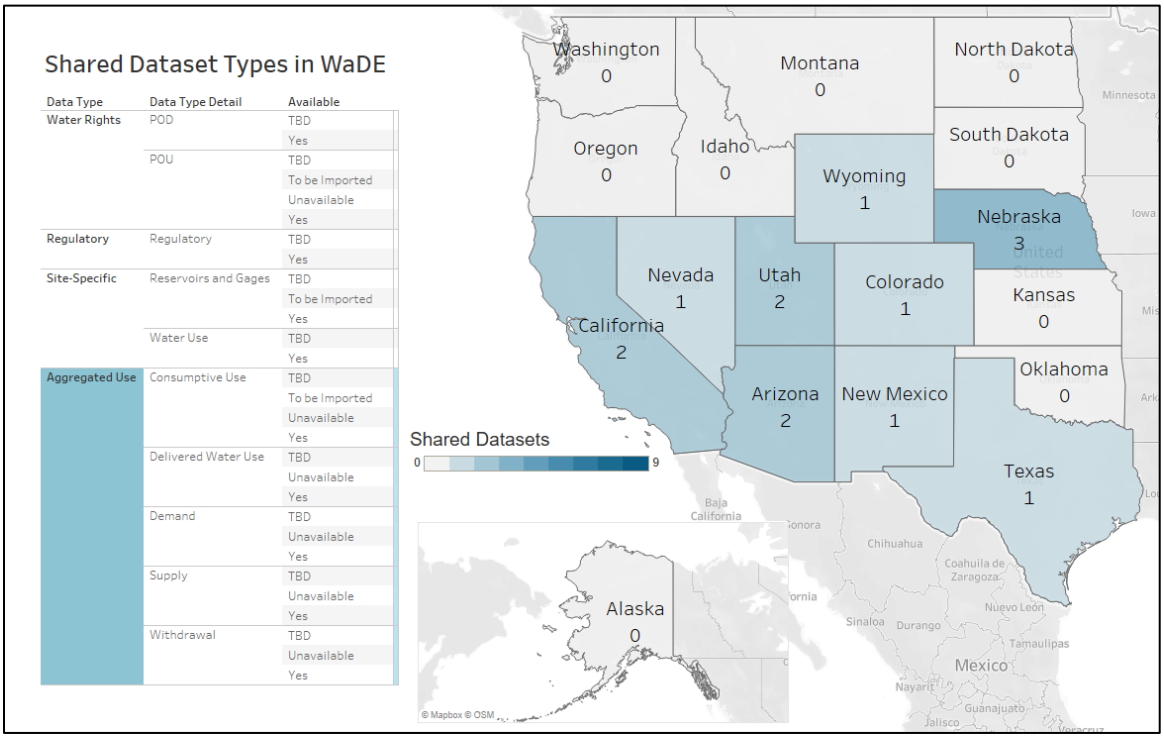

Figure 5: Progress of importing aggregate water use data to the WaDE database

2.1 Provide programmatic access to aggregate water use data by various spatial scales such as state, county, river basin, water district, special for at least 10 states

We already have a mix of aggregate water supply and use data loaded into the WaDE database for nine states and we will continue to import data for four more states (Figure 5). The states of Washington, Montana, Oregon, and Idaho do not produce or publish aggregate water budget estimates at this time.

2.2 Provide access to consumptive water use data as estimated by the OpenET Platform

On May 20, 2021, the OpenET team submitted a collaborative joint first-stage proposal with the WSWC to the NASA Research Opportunities in Space and Earth Science (ROSES) grants. The proposed project seeks to accomplish the following: (1) aggregate OpenET consumptive water use estimates from field boundaries to different spatial hydrologic or administrative spatial data layers as needed by our member states for their water budget models; (2) allow comparisons between permitted water rights and estimated consumptive use in a watershed through the WestDAAT dashboard; and (3) allow states to share consumptive use estimates with the USGS Water Use Research Program through WaDE. The OpenET project (https://openetdata.org/) has developed an operational system for mapping evapotranspiration (ET) and consumptive use for the 17 western states. OpenET provides daily, monthly, and annual ET data at a spatial resolution of 30 m x 30 m (0.22 acres) using an ensemble of well-established satellite-driven ET models implemented on the Google Earth Engine cloud computing platform (https://earthengine.google.com/) which allows for interoperability across different datasets, massively parallel processing, storage, and scalability in time and space, and automated operational updates with new observations that would otherwise be very costly and burdensome for state and federal agencies to develop, operate and maintain. On July 12, the NASA ROSES program sent a notification encouraging us to apply to the second-stage proposal which is due in late September 2021.

2.3 Automate aggregate water use data retrieval from states datasets to WaDE + Ask states for a final review of WaDE aggregate data and vocabulary mapping and approve their sharing in WaDE

Once every six months up to a year for as many states as possible. We will work on using Azure data services to automate data scraping of aggregate water supply and use data once every six months (Figure 4).

We will continue to work diligently with our state agencies and ask them to review the documentation of how their aggregate data was mapping in WaDE and how it shows up in our data system through the dashboard and API. We will ask for their approval before we publicly release WaDE data services.

2.4 Identify gaps and comparative insights about estimating and reporting aggregate water use in our member states

Currently it is a difficult question to answer of how much water was used in a river basin that spans multiple states. States have different methods in estimating and reporting water use at different spatial scales and components of use. In this sub-task, we will identify data gaps that need to be filled to answer regional water use questions. We will perform comparisons that generate insights that can be used by states to learn from each other to fill those data gaps. The data availability comparison will span sources provided by the states, OpenET estimates, USGS Water Use Program, and the Beaurea of Reclamation for the Upper Colorado River Basin. We will summarize the gaps and provide comparative insights into a report we share publicly.

3. Streamline the Sharing of Western States' Site-Specific Time Series Water Use Data with USGS as part of the National Water Assessment and Use Reporting

This task aims at facilitating how our member states share their site-specific time series water use data with the USGS "Water Availability and Use Science Program: National Water Census" (https://www.usgs.gov/mission-areas/water-resources/science/national-water-census-water-use) through the Water-Use Data and Research Program (WUDR) grants (https://water.usgs.gov/wausp/wudr/). USGS has published compilations of national water use trends at the county level for the major water use categories once every five years since 1950. Recognizing the limitations of current water-use data, the SECURE Water Act authorized a program that supports activities related to data collection and methods research and development at the State level.

The USGS team is interested in historical monthly water use data from points of diversions including the water source type and where the water is being used. The WaDE team has collaborated with the WUDR team to facilitate this data sharing between our member states and USGS. The WaDE Data system has been adapted two times to represent the complexity of this type of data to support USGS reporting requirements at different spatial scales especially hydrologic unit codes (HUCs) (Figure 6).

The WaDE metadata dictionary includes controlled vocabularies that are being considered for use as the standard method for sharing state agency water use data between WaDE and the U.S. Geological Survey (USGS) Water Use Data Research (WUDR) Program, see here: https://water.usgs.gov/wausp/wudr/files/WUDR-USGS-data-transfer-guidance.pdf. The following subtasks define the specific objectives to be achieved within this task.

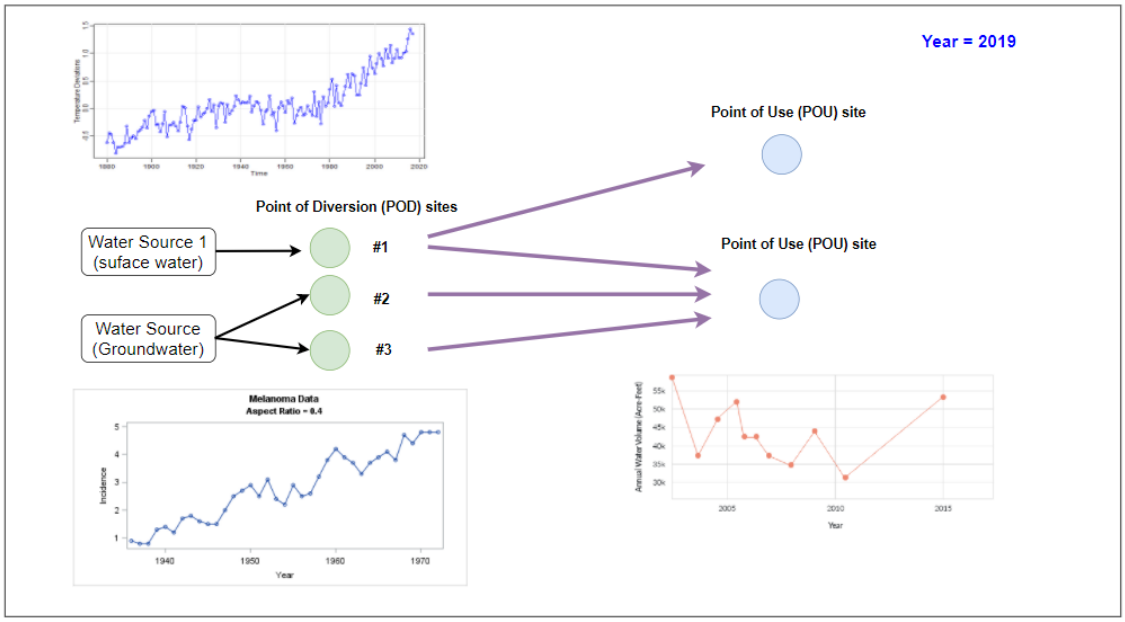

Figure 6: Conceptual diagram showing how points of diversions with different water source types may supply water to different places of use. This mapping between PODs and POUs may change from one year to another.

3.1 Complete a pilot project of municipal and industrial (M&I) water use data sharing with USGS for Texas, Utah, and California and then share data for the rest of the states

We recently implemented a database schema change to the Site-Specific time series data type in WaDE to accommodate a USGS data need as identified in our data sharing pilot for Utah with them. The change allowed tracking the different water sources and points of diversions that supply a place of use (e.g., city) with water. We are in the process of updating both Utah and Texas drinking water use data to fit the new changes. We are also working on importing California's Drinking Water data into the database. We are also evaluating how the API reflects these changes and fulfills how the USGS team wants to process its data. The Texas Commission on Environmental Quality (TCEQ) staff indicated that they want to keep the locations of their water supply sites to be private. We already asked our IT contractor to activate a SwaggerHub API security access feature to keep this data sharing privately with USGS. We will explore options with USGS and TCEQ staff to potentially mask the locations and share the data publicly.

States have different ways of tracking and reporting water use data. We will evaluate how the pilot data sharing works for two more states to make sure the design still accommodates any differences that are likely to exist in other states' data. Accordingly, we may plan another minor round of schema and API changes to the site-specific water use data type in the WaDE database.

We will then expand the data sharing with USGS to the rest of our member states. The goal here is to facilitate how USGS collects water use data from our members' states through WaDE which would reduce the time and effort that each of our member states spends to share data frequently with USGS. As part of this subtask, we will coordinate with the USGS

team around co-organizing a Water Information Management Systems (WIMS) Workshop that follows up on the 2019 workshop. https://westernstateswater.org/events/2019-wims/

3.2 Hire interns to help member states with WUDR related tasks: CA, CO, AZ, AK, WY

Many of our member states such as CA, CO, AZ, WY, and AK have indicated they do not have sufficient staffing time to apply for and manage the WUDR grants. The USGS team is evaluating if the WSWC could apply on behalf of one or many of our member states and manage the grant for them. We will work with each state agency and USGS on identifying specific tasks that can improve state data management and sharing that align with the USGS priorities. We are likely to hire, train, and supervise interns to execute one or many tasks such as data quality assurance, data quality control, automating workflows to share data from a state-local database to an online platform such as ArcGIS Open Data tools, Socrata, or CKAN.

3.3 Ask states for a final review of WaDE site-specific data and vocabulary mapping and approve their sharing in WaDE.

We will work diligently with states and tribes to map their site-specific data to WaDE and document the process in GitHub. We will ask them to review and approve the data and documentation before we make it publicly available through WaDE.

4. Provide Access to Site-Specific Tim Series Reservoir and Gage Stations Water Data

This is the same WaDE data type as the above task #3 Site-Specific time series data, but it covers instrumental data that is not necessarily related to water use and it is outside the scope of the USGS Water Use Program. Instead, it is part of a commitment to the Internet of Water group to share this type of data through the WaDE Data System as part of their grant to the WSWC. This type of data is not available at regional scales and the sharing as WaDE data service will complement other national networks like the USGS stream gauge network (https://dashboard.waterdata.usgs.gov/).

4.1 *Import site-specific streamflow, groundwater, reservoirs, and withdrawals data into WaDE*

Our member states have their systems that either measure or collect water levels in state-owned or managed reservoirs, gage stations, or meters. This data is often measured every 15 minutes or hourly but then aggregated to daily or monthly values. We have imported this data into the WaDE database for Idaho, Nebraska, and Colorado. We will continue to import this data for other states.

4.2 Import tribal stream gage data (e.g., CSKT, Navajo)

We will work with tribal data services to catalog their sites into WaDE. Our first step would be to work with the Hydrology data portal of the CSKT tribes: *https://www.csktwaterdata.org/AQWebPortal*

4.3 Ask states for a final review of WaDE site-specific data and vocabulary mapping and approve their sharing in WaDE and automate data retrieval

We will work diligently with states and tribes to map their site-specific data to WaDE and document the process in GitHub. We will ask them to review and approve the data and documentation before we make it publicly available through WaDE. We will work on using Azure data services to automate site-specific reservoir and gage stations data scraping on time series data monthly (Figure 4).

5. Develop an Operational WaDE Dashboard (WestDAAT)

As introduced earlier, the proposed dashboard (WestDAAT) will provide access and support analysis to the four data types in WaDE. WestDAAT will be integrated with other national data efforts such as the Hydro-Network Linked Data Index (NLDI) and Geoconnex. The WaDE Program is part of a collaborative effort among many other data providers that aim to be interoperable and allow data queries across their data services. The USGS, WaDE, Internet of Water, Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI), U.S. Environmental Protection Agency (EPA), and Reclamation Information Sharing Environment (RISE) and others have begun experimenting with implementing a linked data architecture for the water data community, organized around the Geoconnex project (Figure 7; https://geoconnex.internetofwater.dev). Geoconnex is establishing a common metadata framework based on landing pages with persistent identifiers for real-world environmental features that will link disparate water datasets and enable users to search data across data systems. This architecture would allow water data providers to publish metadata about common environmental features using standardized approaches amenable to automated aggregation and inference of relationships between the underlying datasets without the need for centralized data governance and storage. We are working with the Geoconnex team to index all the WaDE data including POU and POD water allocation sites and aggregate watersheds into the Geoconnex system. A unique web browser landing page will be created for each WaDE site (with embedded site metadata), which will allow data crawlers (such as Google) to search it and create better public access to the site metadata information.

In addition, we will also index the WaDE water allocation sites with the NHDPlus network as part of the NLDI framework (https://labs.waterdata.usgs.gov/about-nldi/index.html). The NLDI is a system that can index spatial information and river network-linked data together with site metadata, which allows users to navigate the river network (upstream and downstream) for the discovery of related indexed site information. Users can use this approach to better understand the relationship between a single monitoring location and the broader world of available water metadata. This feature will be part of the planned WaDE dashboard, WestDAAT.

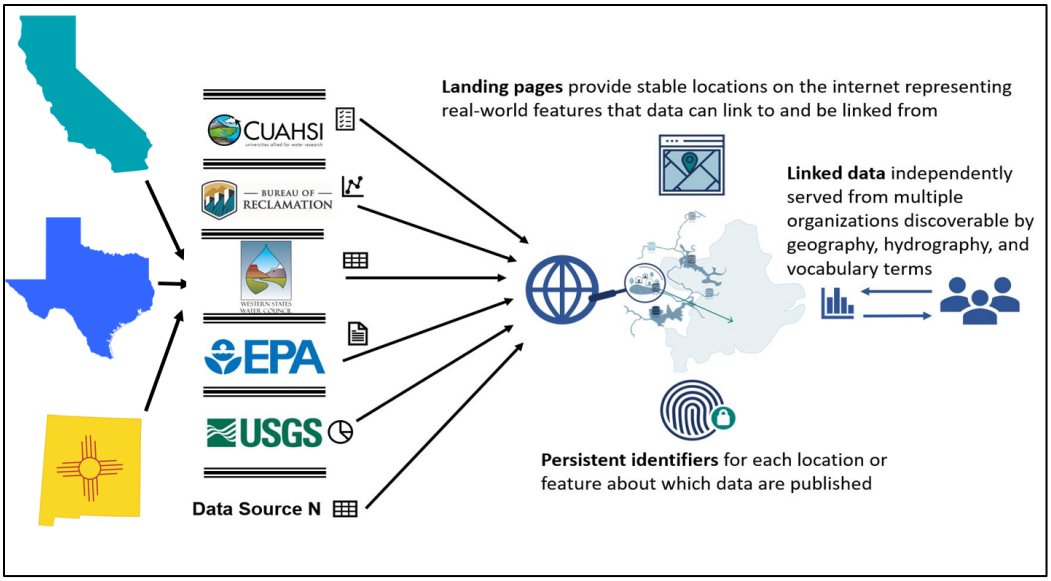

Figure 7: The Internet of Water Geoconnex Project is establishing a common metadata framework based on landing pages with persistent identifiers for real-world environmental features that will link disparate water datasets and enable users to search data across data systems. Credit: Lilli Watson, Internet of Water

As described earlier the WestDAAT prototype is being used as a proof-of-concept and basic features application that connects the WaDE database to an online visualization environment (Mapbox) https://wade-mapbox-prototype.azureedge.net/. The desired full functionality of WestDAAT will be based on the mockup that we developed as well which will be used to facilitate feedback from participants in our focus groups (Figure 8): https://xd.adobe.com/view/b5bc36d8-d490-473b-905a-deefba319a15-e0ef/?fullscreen. We anticipate the development of WestDAAT to begin later this fall depending on the availability of funding.

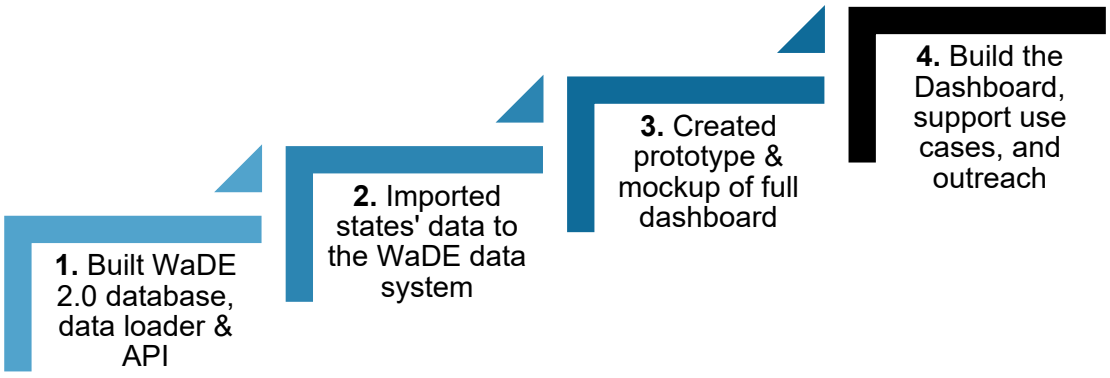

Figure 8: Completed and Proposed WestDAAT Development Stages.

5.1 Hire an intern to help with water rights data + regulatory overlays tab in WestDAAT

Administrative water use data in WaDE include water rights and regulatory overlays that define how water can be used and for what beneficial use mostly under the prior appropriation doctrine. Both types of this data will be available under one tab in WestDAAT. This tab in the dashboard will be the first part that we plan to complete. It will be providing a wide range of data query, filtering, and plotting tools that support regional data analysis to inform policy discussions and planning efforts. More details are available on this task which is described in the WaterSmart proposal we submitted to the Applied Science grants of the Bureau of Reclamation in April 2021.

As part of the dashboard data filters, we identified a need to set the potential range of permitted flow and volume amounts of water rights. After an initial inspection of the range of values for permitted flow and volume amounts across states, we have identified extreme outlier amount entries (e.g., tens of thousands CFS or millions of acre-feet of permitted amounts for single water rights). These could either be the result of errors in the original state-provided data, or the result of poor processing of state data into the WaDE system. This GitHub issue shows the range of amounts for the states we have data for: https://github.com/WSWCWaterDataExchange/WestDAAT/issues/9. We need to further inspect the data for clarity and accuracy to control for these types of errors. In the event of a WaDE side error, we will revisit the initial state processing methodology of data into WaDE. In the event of a data provider error, we will document and track these entries and store them in a special GitHub folder so that we may reach out to our points of contact to review them. This process can be time-consuming so if funding is available, we anticipate hiring an intern to assist us in this work.

5.2 Aggregate Water Use Data Tab

The second tab that we will develop in WestDAAT is for aggregate water use and budget data that our member states share through WaDE. This tab and its functionalities are likely to be developed second after the water rights tab. This subtask will improve how the current WestDAAT prototype displays aggregate water supply and use data across different reporting area types such as counties and basins. Not all states share data using the same reporting area types so we will support displaying a mix of area types to maximize the value of the available data and generate insights across states.

As a part of this subtask, we will plan to support sharing OpenET aggregate ET estimates into WaDE aggregate data. Pending the funding, we will work with the OpenET project developers to design an API call for OpenET that generates monthly consumptive use data to be ingested into WaDE as an aggregated water use data type through the WaDE generalized template and Azure workflow services. We are likely to schedule the automated data injections once every six months up to yearly. We will coordinate with our member states regarding with OpenET consumptive use model to choose, whether we should support the six models or an average value of a subset of them.

Once OpenET data is shared through WaDE, we will work on creating dynamic dashboard plots that display summarize permitted water rights volumes compared to consumptive use estimates for watersheds. We will work with our IT contractor to support a new plotting

feature to summarize “paper” vs “wet” water rights within a selected or provided boundary: (1) query water rights and aggregate their flow or maximum volume permits for irrigated agriculture (or all beneficial uses) – we will coordinate with our member state agency staff about an accepted aggregation method based on their unique flow and volume permits; (2) query the consumptive water use estimate by OpenET for a selected consumptive use estimate model; and (3) share consumptive use estimates with the USGS Water Use Program.

5.3 Site-Specific Time Series Water Data Tab

This tab will offer data visualization and queries for any instrumental and site-specific time series water use or withdrawal data that are measured at a specific site such as gage stations or reservoirs operated by the states. Provided data here will likely be at daily or monthly time steps which will complement other data services provided by federal agencies such as USGS and Reclamation of Reclamation.

5.4 Address additional design features to the database, API, and the dashboard based on feedback we receive from outreach and engagement events

We anticipate and plan to implement additional design improvements based on user experience and feedback. This is the nature of software development especially if we want to continue to support WestDAAT as an operational data support tool for water rights and water use data in the West.

5.5 Support filtering and querying user-provided shapefiles or areas of interest such as a groundwater aquifer

This is a technical feature that we did not plan for in our prototype and mockup discussions, but we plan to support it as it came up many times in conversations with our stakeholders. It will be an additional cost, yet to be estimated, that was not included in the initial estimate by our IT contractor but the benefit and flexibility it brings to the user experience justify supporting it.

5.6 Work with the Geoconnex team to index WaDE PODs and POU for Water Rights, and aggregate polygons unique identifiers in NLDI and Geoconnex

We will work with the IOW group to share a catalog of WaDE data in their system and reference it within the NHDPlus national hydro network. The catalog data will be stored on GitHub here: *https://github.com/internetofwater/geoconnex.us/tree/master/namespaces/wade*

5.7 Implement and test the NLDI call within the WestDAAT dashboard

Our IT contractor (Don't Panic Labs) has experimented with the NLDI call and its efficiency and we have discussed the user experience and designs in WestDAAT. We will coordinate with the NLDI and Internet of Water developers to verify that our use of their API is working as they envisioned it to be.

5.8 Finalize and test landing pages for all WaDE unique data points

We have already implemented a test design of dynamic landing pages within the prototype of WestDAAT https://wade-mapbox-prototype.azureedge.net/details/COwr_S3022. However, more work is needed to finalize this design per the feedback of the Internet of Water data architect. See this GitHub issue that describes the status of this implementation: https://github.com/internetofwater/geoconnex.us/issues/94

5.9 Improve current WaDE Data System approaches

Below is a list of technical improvements that we plan to work on to improve the WaDE Data System and its approach to data acquisition and sharing.

a. Create a *User Acceptance Testing (UAT) database to use for our demo purposes in addition to the Quality Assurance (QA) database which is used for quick testing after making any database changes*

b. *Start using the finalized Production (Prod) database by uploading all QA approved data*

c. *Optimize the database design by indexing its tables based on full dashboard* performance

d. *Create metrics set up to keep track of visits to WestDAAT and hits to the API calls*

e. *Transfer the WaDE controlled vocabularies into the updated design from the old Amazon Web Services to the new Microsoft Azure Service. The developer team at Utah State University updated the old design due to outdated functions in the previous design)*

f. Add metadata API calls and create *API Software development Kit (SDK) endpoints to facilitate their use like this example http://odm2.github.io/ODM2RESTfulWebServices/* and here https://support.smartbear.com/swaggerhub/docs/apis/generating-code/client-sdk.html

g. *Add user-friendly data loader error messages. Currently, if a state's data has incomplete data, the error messages are very technical and sometimes are hard to discern*

6. Incorporate Federal Water Rights Ownership Interests Recognized by States, Court Decrees, or Settlements, and Map Water Rights on Federal Lands

We are coordinating with the Bureau of Reclamation on their own internal water rights and asset management support tool project. We have shared with them a copy of the WaDE water rights data, including the owner classification categorization, especially for state-recognized federal government water rights. We will continue to collaborate with Reclamation's team, especially on classifying water right ownership, as it relates to water received from Reclamation such as by farmers and water districts (note: Reclamation delivers water to some 140,000 farmers). At this time, we identified around 2,000 water rights in the WaDE database where the states explicitly recognize Reclamation as the water right owner (Figure 9).

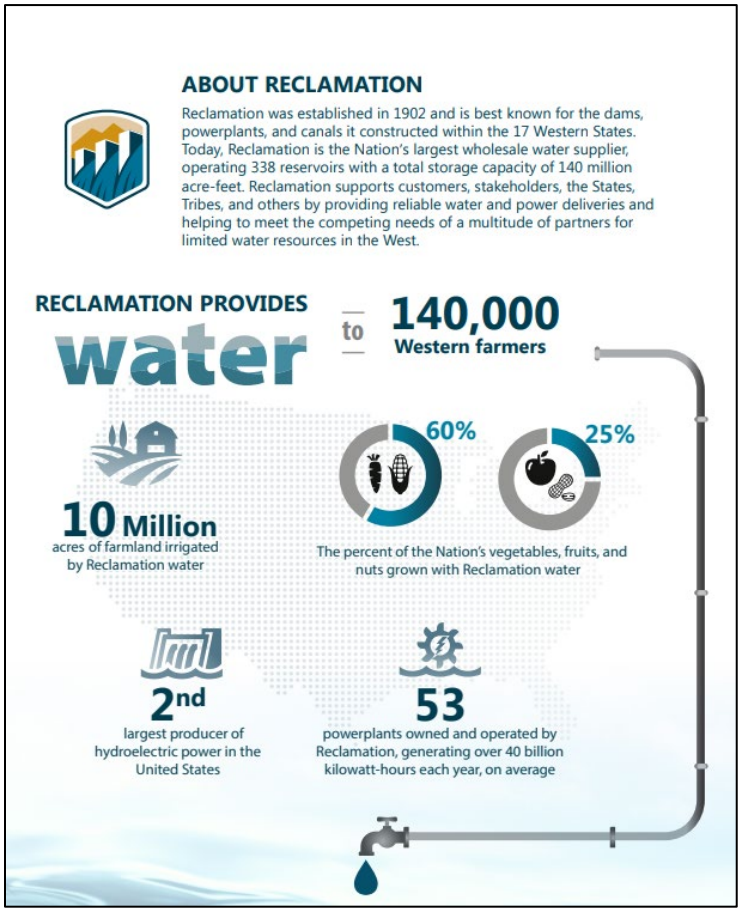

Figure 9: Reclamation Summary Figure (Source: https://www.usbr.gov/climate/secure/2021secure.html)

6.1 Hire an intern for 3-4 months to work with Reclamation on classifying landowners or districts that use Reclamation water

As part of this effort, we have compiled a keyword search algorithm that identifies and classifies owners of water rights into separate groups. Group examples include the following: Privately Owned, Commercial, US Forest Service, US Bureau of Reclamation, US Bureau of Land Management, etc. The algorithm needs to be refined to better capture more variations of owner names, but the major needed work would be related to classifying water rights ownership for farmers that Reclamation provided them with water. This work will require close coordination with the Reclamation team that might require a memorandum of understanding. We will hold regular calls to make sure the work is going as they expect. More details are provided on GitHub here: https://github.com/WSWCWaterDataExchange/MappingStatesDataToWaDE2.0/issues/82

This subtask also extends to generating queries and maps for water rights on critical areas of interest. The intern will help further scrub and analyze areas of critical environmental concern across our member states. The intern will first intersect geospatial areas with water rights in the WaDE data system to identify sites of interest that fit this issue. The intern will also work on correctly classifying the recognized beneficial use for these sites. The intern will generate maps of these sites and create statistical summaries and insights to inform BLM and our member states of the findings.

6.2 Work with the WSWC Legal Committee and WestFAST on classifying other federal water rights ownership.

Reclamation water rights ownership is one example of classification that we will expand to other federal agencies such as the Forest Service. We will invite WestFAST representatives to engage with us on how they would like to classify water rights for each federal agency such as Army-related water rights which could be relevant to the Western Regional Partnership (WRP).

This issue address many, but similar problems, of identifying water rights that conflict with areas of critical environmental concern on environmental and private land. For example, the Bureau of Land Management (BLM) has specific designations of land management such as “Areas of Critical Environmental Concern” such as endangered and threatened species critical habitat, wild and scenic rivers, state trust waters. We will work with BLM representatives to coordinate mapping and intersecting these areas with the data in the WaDE dashboard (See here: https://www.blm.gov/programs/planning-and-nepa/planning-101/special-planning-designations/acec).

In addition, water rights on federal recognized Forest Service lands are scattered across states' boundaries and are described using different terms. We will coordinate with the Forest Service on identifying these sites and consolidating used terminology.

Lastly, we will assist in mapping water rights for grazing purposes across state boundaries (see this GitHub issue https://github.com/WSWCWaterDataExchange/MappingStatesDataToWaDE2.0/issues/94).

7. Conduct Outreach and Pilot Projects to Develop "Personas" and Use Cases and Sustain the WaDE Program

Persona use cases are fictional user characters that help guide the creation of the proposed dashboard and how it would support the needs, goals, and desires of these characters representing WaDE partners and stakeholders. Personas of interest range from a farmer up to a governor level. This task starts with holding focus group calls/meetings comprised of state, federal, water managers, and other parties of interest that best represent these personas to further refine these use cases and add new ones if needed. The following subtasks specify the outreach goals and venues that we will pursue during the development of WestDAAT and then its operation. Many of these outreach tasks align with one or many of the earlier tasks described above.

7.1 Hold pre-development outreach campaign to engage stakeholders with persona use cases and incorporate their input into the design of WestDAAT

We have drafted a "*Document for Focus Groups to Help the WaDE Team Refine, Revise, and Improve the Designs of the Upcoming Western States Water Data Access and Analysis Tool (WestDAAT).*" The campaign has three components: (1) five to seven focus group calls with 25-35 invited participants representing state and federal agencies, non-profit organizations, and other users; (2) an in-person workshop at the Colorado River Users Association (CRWUA) meeting in December 2021 for water user, water district, state, and federal agency representatives; and (3) other outreach presentations to members of the WSWC, federal agencies, state, interstate, non-profit association, and academic meetings and conferences. WSWC will publish a report that summarizes the discussion and input ideas from the pre-development outreach campaign and share it back with the involved stakeholders first and then the public by Spring 2022.

7.2 Continue organizing three WIDS calls per year

We will continue to hold Spring, Summer, and Fall WIDS virtual meetings that serve as a forum to agencies staff at our member states regarding water data collection, management, and sharing. The WIDS calls will also keep the committee members updated about WaDE developments and make sure we address their feedback. The agenda and minutes of each meeting will be continuously posted online at the WIDS webpage: https://westernstateswater.org/wids

We plan on creating working groups within the WIDS subcommittee to focus the discussions based on topics of shared interest. One of these working groups will focus on the integration of OpenET and WestDAAT and how our member states can operationalize the use of their integration into their water budget models.

7.3 Present about WaDE's data services at two national conferences per year (AWRA, EWRI ASCE), two webinars through the Internet of Water network, and WestFAST groups

The American Water Resources Association (AWRA) is a multidisciplinary association for information exchange, professional development, and education about water resources and related issues (https://www.awra.org/). AWRA conferences attract large federal and state government participation especially on water data and state-federal-and tribal issues. We have participated in AWRA Summer and Annual Conferences in the past and we plan to continue to present about WaDE development at its conferences as part of our outreach plan.

The Environmental & Water Resources Institute (EWRI) is the American Society of Civil Engineers (ASCE) technical source for environmental and water-related issues (https://www.ewricongress.org/). EWRI annual conference attracts worldwide professionals and academics for discussions around the latest methods and applications that advance water resources planning and management. We have participated in EWRI conferences before and plan to continue to participate as part of our outreach efforts especially to this different demographic.

We will also present an update on WaDE development at the WestFAST webinars to reach out to the federal agencies' audience (https://westernstateswater.org/past-westfast-webinars/). We will present to the Internet of Water (Peer-to-Peer Network) which draws an audience from utilities, state agencies staff, and professionals across the US and many countries (https://internetofwater.org/peer-to-peer-network/)

7.4 Coordinate with WestFAST and states on this effort and address feedback on results by interested stakeholders

We will work closely with WestFAST members (especially with BLM) to coordinate the success of this effort and potentially see how it can benefit other federal agencies. We will participate in the upcoming workshop on Wild and Scenic Rivers as part of the WSWC Fall 2021 (197th) Meetings: https://westernstateswater.org/events/wswc-fall-2021-197th-meetings/ (this GitHub issue provides some specifics on how WaDE data can be useful to the discussion: https://github.com/WSWCWaterDataExchange/MappingStatesDataToWaDE2.0/issues/93 We anticipate discussions and feedback on this work, and we plan on addressing them as part of this task.

7.5 Support users who have inquiries on the dashboard and WaDE API calls

Once WestDAAT becomes operational, we anticipate a stream of questions and requests about WaDE data and WestDAAT functionality, report potential errors, and unexpected shortcomings. We expect this operational support may occupy a third of FTE time in the first year of launch.

*7.6 Present at the Colorado River Water Users Association (CRWUA) meeting regarding Colorado River Data (*https://www.crwua.org)

We plan to participate in 2021CRWUA meeting along with the Internet of Water and the OpenET groups to present an update on WaDE development and hold a hands-on workshop to demo WestDAAT and the Geoconnex capabilities. CRWUA draws heavy participation from water resources directors, managers, and professionals of the Colorado River Basin seven states.

7.7 Organize at least two Water Information Management Systems (WIMS) workshops to discuss how WestDAAT and other data initiatives and programs can help in addressing regional water management challenges in the West.

We plan on holding a two-day WIMS workshop in partnership with the USGS Water Use team and potentially another one in partnership with the OpenET team [https://westernstateswater.org/wims]. Such workshops usually draw an audience of water resources and IT managers and their staff at member states. The workshops intend to be a forum for our member states, federal agencies, and groups of water data initiatives such as the Internet of Water and OpenET to collaborate and discuss mutually beneficial needs. We may hold the third half a day workshop that targets participants in one of the WSWC Meetings who are the state engineers and directors of natural agencies in our member states.

7.8 Present updates on WaDE's progress to the WSWC Spring, Summer, and Fall Council Meetings

Since WaDE was established, we have been sharing a progress report to our three Council Meetings and we will continue to do so in the next five years. We also plan on publishing a summary annual report that reflects the key activities and progress made each year.

7.9 Attend and represent WaDE at CA and NM key meetings on their Open Water Data Initiatives

The States of California (https://water.ca.gov/ab1755) and New Mexico (https://newmexicowaterdata.org/) are at the forefront of water data sharing in the west as both have passed laws that require their state agencies to share water data in machine-readable and interoperable formats. We have attended meetings related to the implementation of their data initiatives in the past and we will continue to attend future meetings or closely watch how they progress in this regard.

7.10 Represent WaDE on the ICWP Water Data & Science Committee

The Interstate Council on Water Policy (ICWP) is a sister organization to the WSWC where ICWP includes western states members but also it expands to eastern states. The ICWP Water Data & Science Committee discusses relevant topics around water data collection and sharing among its membership (https://icwp.org/category/minutes/commitee-minutes/water-data-science-committee/), We will continue to serve on this committee and attend its monthly meetings to represent WaDE's perspective and experience on data sharing and learn lessons from other eastern states.

7.11 Set up WaDE email listserv and a public forum discussion channel

In 2020, WSWC staff have re-designed the Council's website which includes WaDE webpages (http://westernstateswater.org/wade). As part of the new design, there is a feature that asks visitors to subscribe to the Council's email list for topics of interest which include WaDE. We will use this list to create a monthly email digest for the WaDE audience. We have created a public forum on Discord (https://discord.com/invite/pNd8zxMTWR) to engage anyone who has questions to the WaDE team and to allow members to chat among themselves. We will explore creating a public Slack channel as well.

7.12 Document WaDE design and use-cases results and publish them

Below is a list of document designs to publish the creation and use of WaDE.

a. Update existing documentation on GitHub about the WaDE data system design and how it works. Then p*ublish a journal article about WaDE data system technical design. This is an important step to engage a broader audience to help solidify the WaDE information model as a standard method for water rights and water use data.*

b. Publish a report or journal article about new insights generated by WaDE use cases. This is a super important product that targets a high-level and non-technical audience to demonstrate the value of WaDE.

c. Write Jupyter Notebooks with instructions and examples on how to use the API to programmatically access data across state boundaries.

d. Integrate and publish WaDE Controlled Vocabularies with the Internet of Water "Coming to Terms" Project

e. Develop story maps that demonstrate the use of WestDAAT for six unique use case personas *for different categories of users ranging from a governor to a farmer level.*

7.13 *WSWC will complete a post-development outreach campaign that engages states and federal agencies in water data and analysis discussions using WestDAAT*
WSWC will publish a report that summarizes the discussion and input ideas out of the post-development campaign and share it back with the involved stakeholders first and then the public by March 2023.

7.14 *Prepare for soft-launch and a press release on WaDE and WestDAAT*

Once the WestDAAT dashboard is fully developed, we plan to release it to our WaDE and Council network as an early launch to acknowledge their contributions and interest in the dashboard. We will address their potential feedback and then launch it publicly with a press release to multiple media outlets.

7.15 *Manage the WaDE Program*

The following are administrative and training activities to sustain the WaDE Program and its staff proficiency.

a. Write proposals for grants to sustain WaDE
b. Hire, train, and supervise interns.
c. Keep track of WaDE financials and grant accounts and their reporting requirements.
d. Adel and Ryan to take courses on user experience design from Interaction Design Foundation https://www.interaction-design.org. Many of the offered courses such as "Information Visualization: Getting Dashboards Right" and "User Experience: The Beginner's Guide" will help us better design WestDAAT with a user experience in mind according to the latest industry standards.
e. Ryan and Adel to take the ScrumMaster training to keep up with WaDE development using industry best practices in software development. More info is here: https://www.scrumalliance.org/get-certified/scrum-master-track/certified-scrummaster

Sec C: Work for Interns

This is a summary of the tasks that are mentioned throughout the Work Plan where we use interns help to complete.

1. Coordinate with states on creating a hierarchical order of beneficial uses for each state to determine which use is considered the primary beneficial use when many are provided
2. Create a clearinghouse for Nebraska Natural Resource Districts (NRDs) certified parcels
3. Survey and ask states about how they track the changes in water rights in their databases
4. Help member states with WUDR related tasks: CA, CO, AZ, AK, WY
5. Help in identifying the potential range of permitted flow and volume amounts of water rights data for WestDAAT filters.
6. Work with Reclamation on classifying landowners or districts that use Reclamation water.