User Needs Report

Final • April, 2014

The Role of Climate and Water Resources Data in Societal Decisions within the Klamath Basin of Oregon and California

A User Requirements Framework for the Western United States

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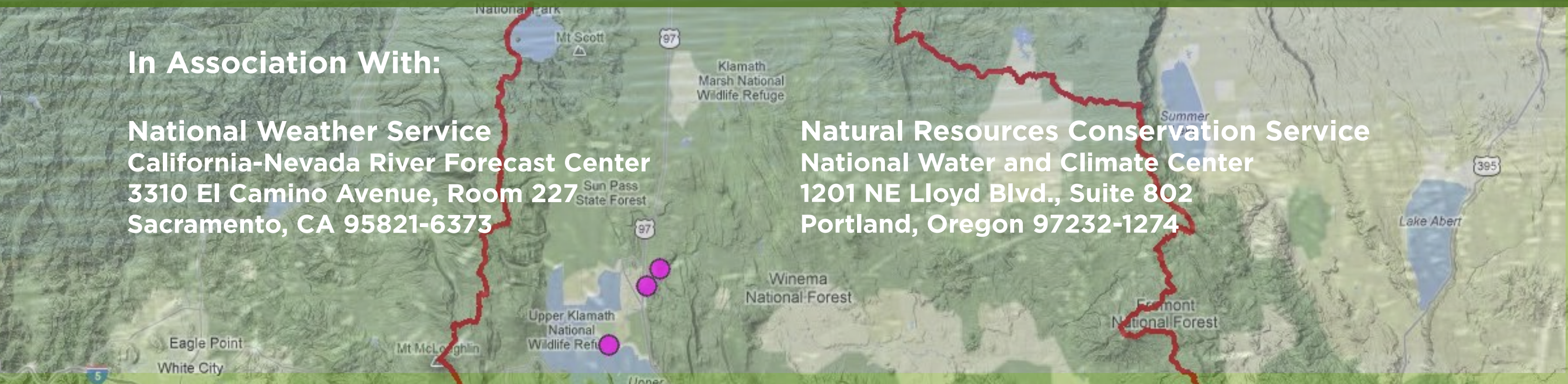

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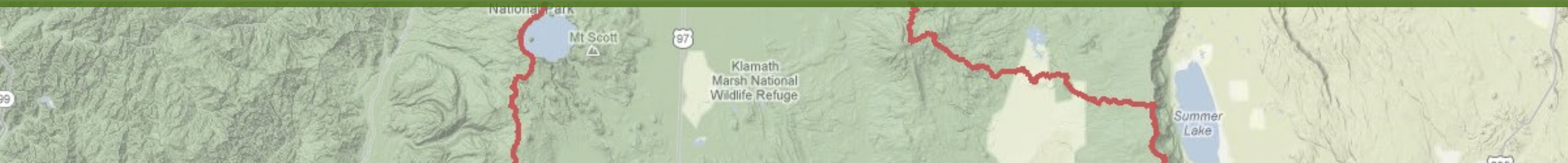

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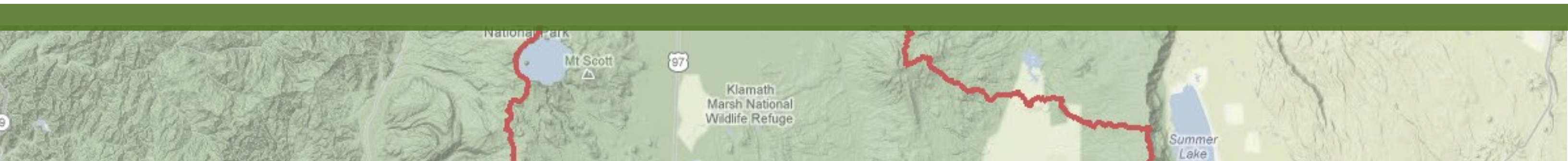

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EXECUTIVE SUMMARY

An important component of the National Oceanic Atmospheric Administration's (NOAA) Sectoral Applications Research Program (SARP) is advancing the understanding about the use of climate, drought and water data (hereafter referred to generally as "data" inclusive of products like charts, graphs and maps derived from the data) in making daily decisions affecting society. Decisions made daily by differing socio-economic sectors rely on the use of data, but information about the relationship between specific decisions and the data used to support those decisions is lacking. The amount of data available with continuing technology advances is staggering and at times overwhelming, but the means and methods of presenting the data in an understandable framework to a range of socio-economic sectors is lagging behind the technology advances. The SARP supports interdisciplinary research working with a broad spectrum of socio-economic sectors to improve our understanding of the relationship between resource decisions and the data used to support those decisions.

A public sector – private sector partnership (i.e., the partnership), funded through a NOAA SARP grant awarded in September 2012, began evaluating the relationship between resource decisions which rely on data using the Klamath Basin, Oregon and California, as a "test bed" for the western United States. The partnership consisted of Klamath County staff, the Natural Resources Conservation Service National Climate and Water Center (NRCS-NWCC), the National Weather Service (NWS) California – Nevada River Forecast Center (CNRFC) and Houston Engineering, Inc. (www.houstonengineeringinc.com). Agricultural production, recreation, tribal trust interests, endangered species management, the generation of power and domestic uses all depend upon the water resources of the Klamath Basin, not unlike to many areas within the western U.S. The research purpose is to provide data which are directly related to the specific decisions faced by Stakeholders, and to effectively communicate decision risk tailored to specific resource decisions.

This report provides information about the relationship between societal decisions made on a frequent basis within the Klamath Basin, the temporal and spatial scales of these decisions and the data relied upon for decision-making. The report describes the "user requirements" for Stakeholders representative of specific socio-economic sectors referred to as "Focus Groups" within the Klamath Basin. Through the use of Focus Groups this research identified the need to improve the context in which data are presented to users. Context can be improved by:

- Displaying information for a specific period of time with which the user has first-hand knowledge or experience in addition to the current time period;
- Comparing the current time period to some baseline condition which represents a known point in time and resource condition;
- Showing the data in comparison to one or more values where the value(s) informed a decision, implemented through the performance of specific actions;
- Integrating measured and forecast information into a single graph;
- Providing the opportunity to compare data for inferential purposes; and

- Focus Group participants noted that improved methods are needed for communicating data certainty and decision risk. The data users differ in their ability to use and interpret the information presented. This results in challenges when presenting data.

A concept coined “data vertical integration” presented to Focus Group participates seemed to address this issue. Streamlining the presentation of data and products to the user is important to avoid “information overload” for many users across socio-economic sectors. One method for streamlining the presentation of data and products is to authenticate the user within the web environment, allow the data to be customized and to save the final data from a client session. The saved settings are presented to the user upon initiation of the next session. Context for the data and products can be established by comparing the current time period to some baseline condition which represents a known point in time and resource quality.

One of the methods used to relate the data provided and the specific decisions of users is through the use of “decision timelines.” A decision timeline graphically presents the relationship between the data and information needed by a user, the user decisions and the timing of those decisions. Decision timelines are useful for describing the decisions made by each Focus Group and vetting the relationship between the data needed and the decisions made. Decision timelines were developed for six different Focus Groups, and used to guide development of a functional applications interface for presenting data to users.

Describing the current climate, water supply and resource condition in the Klamath Basin, and whether a change in the condition has or is occurring requires a baseline condition. Stakeholders involved in focus group meetings identified the need to download baseline datasets that describe current climate, water supply and resource conditions in order to assess change. In addition, the Stakeholders prioritized a need to access and understand changes. Criteria were developed and used to identify stations with a sufficient period of record to establish baseline conditions for many data types including climate, hydrology, groundwater and agricultural production data.

Robust tools for user access and user data aquisition requires a suite of interacting and complimentary technologies. These technologies can be categorized as: 1) external data source retrieval (i.e., web services); 2) server side applications for loading the retrieved data into databases (i.e., data loaders), data storage for subsequent processing (data center) and geoprocessing; and 3) front-end applications including an applications interface and tools and applications to provide the data to the users. Recommended technologies are described within the report as well as an estimate for implementing these technologies to share data.

Wireframes were developed to describe and communicate the functionality of the front end applications for presenting the data. Wireframes present a visual and functional guide or “framework” for an application. Wire framing for this research effort is the method used to show the interconnectedness among the resource issues being addressed by the Focus Groups, the data they need to address the issues, the means and methods for using the data and the specific critera used to reach decisions.

Many of the data needs are unique to the Klamath Basin primarily because of the presence of the Klamath Project and existence of the Klamath Basin Restoration Agreement. Although the NRCS-NWSS and CNRFC are capable of providing the basic data necessary to meet the user's needs, providing data in a format necessary to meet the unique needs of the Basin is an unrealistic expectation. However, providing some of the basic data (e.g., streamflow discharge) in a different manner (as change in discharge between gages) would likely increases the data value to users.

The ultimate vision for this applied research is the development of a robust set of technologies which can be used to harvest a range of data types from disparate sources, process and store the data in a uniform database, and development of an application which allows the user to interact with the information in a meaningful way to assist decision making.

INTRODUCTION

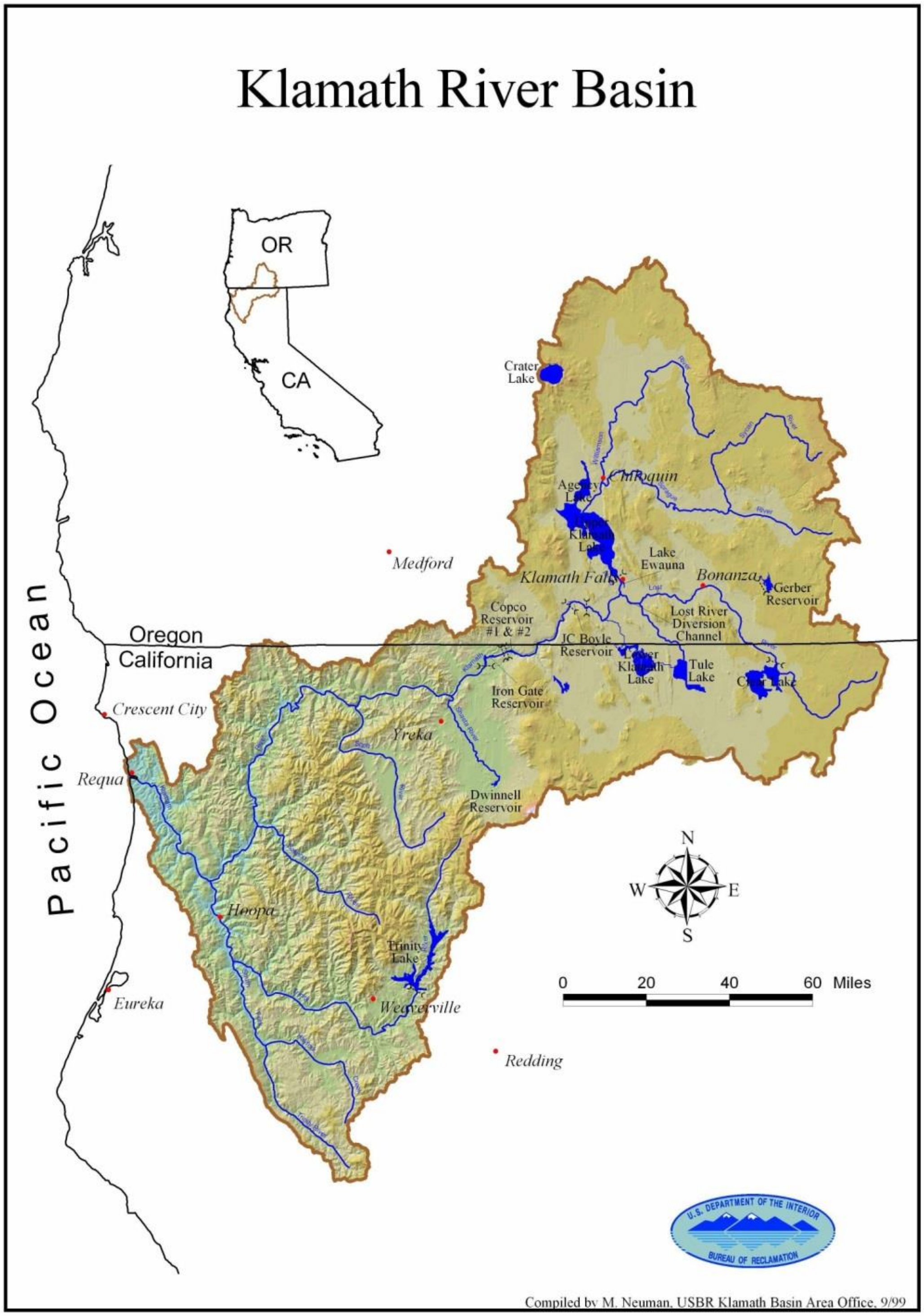
<u>Background</u>

An important component of the National Oceanic Atmospheric Administration's (NOAA) Sectoral Applications Research Program (SARP) is advancing the understanding about the use of climate, drought and water data (hereafter referred to generally as "data" inclusive of products like charts, graphs and maps derived from the data) in making daily decision affecting society. Decisions made daily by differing socio-economic sectors rely on the use of data, but information about the relationship between specific decisions and the data used to support those decisions is lacking. The amount of data available with continuing technology advances is staggering and at times overwhelming, but the means and methods of presenting the data in an understandable framework to a range of socio-economic sectors is lagging behind the technology advances. The SARP supports interdisciplinary research working with a broad spectrum of socio-economic sectors to improve our understanding of the relationship between resource decisions and the data used to support those decisions.

A public sector – private sector partnership (i.e., the partnership) funded through a NOAA SARP grant awarded in September 2012 began evaluating the relationship between resource decisions which rely on data using the Klamath Basin, Oregon and California, as at "test bed" for the western United States. The partnership consisting of Principal Investigators from the private engineering and sciences consulting firm Houston Engineering, Inc., the Natural Resources Conservation Service National Water and Climate Center (NRCS-NWCC), the California – Nevada River Forecast Center (CNRFC) of the National Weather Service (NWS) and Klamath County, Oregon, received funding for the proposal titled *From Fisheries Manager to Family Farmer: Improved Products for Communicating Water Supply, Drought and Climate Change Risk for Daily Decision Making within the Klamath Basin, California and Oregon, US.* The proposal described an approach for using the issues faced by the socio-economic sectors (i.e., Stakeholder community) within the Klamath Basin as a test-bed for the conceptual development of improved data for communicating climate, water supply and drought conditions.

The grant application described providing data which are directly related to the specific decisions faced by Stakeholders, to effectively communicate decision risk tailored to specific resource decisions. By using the Klamath Basin (see **Figure 1**) as a test-bed, a basin with a very broad range of Stakehodlers and resource issues, the project results are expected to be applicable to other western basins within the U.S. facing similar challenges. The applied research is consistent with NOAA's long-term climate adaptation and mitigation goal of an informed society anticipating and responding to climate and its impacts. Specifically, the proposed work is expected to result in products able to inform mitigation and adaptation choices supported by sustained, reliable and timely data as well as understanding vulnerabilities to climate.

Figure 1. Location of the Klamath Basin, Oregon and California, US.



The magnitude of fiscal resources expended, number of scientific studies completed, variety and amount of data collected, public interest and social conflict within the Klamath Basin is a consequence of the complex set of issues resulting from the need and demand for water. During the last decade and certainly since 2001 when the U.S. Bureau of Reclamation (Reclamation) temporarily ceased water delivery to agricultural producers within the Klamath Project, because of the presence of and potential adverse impact to federally endangered species, the people and agencies managing resources within the Klamath Basin have experienced reoccurring complex resource management challenges. These challenges result from the multiple and sometimes conflicting uses of water and the need for a reliable water supply. In many ways the issues are not unique to the Klamath Basin. The Klamath Basin is simply representative of many basins in the western U.S.

Agricultural production, recreation, tribal trust interests, endangered species management, the generation of power and domestic uses all depend upon the water resources of the Klamath Basin. The amount of water available within the basin is directly correlated to climate (e.g., the amount of precipitation and evaporation). Daily decisions related to the management of the Basin's resources rely upon the seasonal water supply forecasts, which through 2009, have benn issued jointly by the NRCS-NWCC and the CNRFC. As of 2010, the NRCS-NWCC and CNRFC are issuing independent though collaborative forecasts.

Although daily decisions rely upon and use the forecasts issued by the NRCS-NWCC and the CNRFC, there is a general lack of understanding within these agencies about how their information is used by the broader Stakeholder community for decision making and how the uncertainty associated with the forecasts is related to associated decision risk. A lack of understanding also exists relative to how Stakeholders use and rely on data. This research identifies ways to develop the information necessary to address the lack of knowledge about the use of climate and drought data and the water supply forecasts used in decision making, and demonstrates ways to develop data that fills the knowledge gap. The information gained through this research is intended to serve as a guide for providing data in similar areas within the western U.S. with complex resource issues, which rely on surface runoff as a source of water supply.

Report Purpose

This report provides information about the relationship between societal decisions made on a frequent basis within the Klamath Basin, the temporal and spatial scales of these decisions and the data relied upon for decision-making. The report describes the "user requirements" for Stakeholders representative of specific socio-economic sectors referred to as "Focus Groups" within the Klamath Basin. Some of the user requirements identified by this research are unique to the Klamath Basin, while other requirements can be generalized to other locations within the western United States. Specific decisions relying on the use of data, when during the water year the decisions are made and the temporal and spatial scale of the decisions are described by this report. The report includes recommendations about specific technologies to provide data to users within a web environment, describes new web design concepts and data formats, and provides implementation recommendations. The report is intended to sufficiently describe the user requirements prior to programming and testing beta applications for deployment to the web. Implementation guidance is provided to NOAA, the NWS and the NRCS.

PARTICIPATING AGENCY OVERVIEW

Representative from the NRCS-NWCC, the CNRFC and Klamath County are Principal Investigators (PIs) under the NOAA grant agreement. The roles of the NRCS-NWCC and CNRFC are important within not only the Klamath Basin, but the entire western U.S. Both the NRCS-NWCC and the CNRFC generate and provide data for the Klamath Basin, routinely used as the basis for resource decision making. Many services provided by Klamath County to their residents, also rely on data. A summary of the mission and roles of these agencies specific to generating and providing data is useful and helps define potential data gaps relative to user needs.

Natural Resources Conservation Service

The NRCS-NWCC is a primary source of data including climate and water products for the western U.S., including the Klamath Basin. The mission of the NRCS-NWCC is *to lead the development and transfer of water and climate information and technology which support natural resource conservation.* The vision for the NRCS-NWCC is to be *a globally recognized source for a top quality spatial snow, water, climate, and hydrologic network of information and technology.* The NRCS-NWCC functions are generally categorized as:

- Natural resource planning support;
- Data acquisition and management;
- Technology innovation;
- Partnerships and joint ventures; and
- Technology transfer.

From a basin perspective, the natural resource planning support, and data acquisition and management functions are relied upon most. Natural resource planning support includes providing seasonal water supply forecasts, which are heavily used for decision-making within the Basin. The data acquisition and management function includes operating the Snowpack Telemetry (SNOWTEL) and the Soil Climate Analysis Network (SCAN) data collection systems. The NRCS-NWCC designs and manages these datasets to support resource planning at the farm, watershed and river basin scales. Developing and adapting new technologies to transfer knowledge and information to customers is consistent with these functions.

National Weather Service

The NWS is also a primary source of data including climate and water products within the Klamath Basin. The mission of the NWS is to *provide weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community.* The NWS is guided by a strategic plan which identifies the six goals focused on critical weather issues:

- Improve weather decision services;

- Deliver improved weather forecasting services to support management of the Nation's water supply;
- Support enhanced climate services;
- Improve sector-relevant information in support of economic productivity;
- Integrate environmental forecasting services to support healthy communities and ecosystems; and
- Sustain a highly-skilled, professional workforce equipped with the training, tools, and infrastructure to meet our mission.

The NWS operations at the regional level are typically divided into two general areas to provide data and forecast ; i.e., river forecasts issued by the River Forecast Center (RFC) and weather operations issued by the Weather Forecast Office (WFO). From a basin perspective, the CNRFC office provides streamflow forecasts, which are used for communicating flood risk. More recently, the CNRFC began providing streamflow forecasts for low flow conditions. Forecasts issued by the CNRFC are coordinated with the NWCC. The NWS WFO provides numerous weather and climate related products for the Basin, many of which come from the Climate Prediction Center. Some of these products include measured and forecast precipitation, current weather condition, weather watches and warnings, and climate summaries.

SOCIETAL DECISIONS WITHIN THE KLAMATH BASIN RELYING ON DATA

Challenges Associated with the Societal Use of Data

One of the most substantive challenges faced by data providers is ensuring the data are provided and presented in a meaningful manner to the audience. The NWS has expended considerable effort objectively evaluating the level of satisfaction with their products (CFI Group, 2005; 2009; 2013). The NWCC also places considerable resources into updating and revising data. There are several reasons the challenges are substantive. These reasons include:

- User diversity – the societal sectors using the information are diverse. Users include a range of skill levels; e.g., a citizen seeking recent weather information, an organization responsible for the delivery of water to a farmer or community, a scientist or engineer striving to interpret resource information and an academician using climate data as forcing functions within climate or water resources planning models.
- User technical expertise – user diversity is often associated with a range in ability to interpret, understand and use data. For example, a citizen seeking weather data is generally less familiar with using and interpreting scientific data described by graphs and charts than an academician.
- User decision domain – user diversity means there are a large number of questions posed creating a large decision domain, thus increasing the number of products needed.
- Multi-disciplinary resource decisions – the data are used to address multi-disciplinary resource issues related to fisheries management, ecosystem function and services, agricultural production, municipal water supply demand and use and the suitability of daily outdoor activities. The many disciplines involved differ in their approaches to using data to make decisions.
- Communicating uncertainty – no characteristic can be measured perfectly. Uncertainty is associated with all data, whether measured or modeled. Understanding how to communicate the amount of uncertainly and how it becomes used in the decision process especially relative to the user's acceptable risk level is challenging.
- Integrating data – the need to integrate related data (e.g., measured and forecast streamflows) from different sources into a single product. Data integration is often a challenge because data delivery systems lack standaridization as do the means of providing the data to users.
- Decision linkage – the specific decisions made which rely on the data are often inadequately defined in terms of the exact type of information needed, the precise criteria causing a decision or action, and the temporal and spatial scales of the decision. Understanding what specific decisions are made, when these decisions are made and the data needed to make the decisions creates a real challenge. Users often poorly convey their specific data needs and sometimes inappropriately use data for reaching decisions because of a lack of understanding about the meaning. The types and amount of data available for reaching a decision may not be obvious. The range of actions for addressing uncertainty in the decision making process are often limited and the data are rarely presented in a manner which allows decision makers to understand the tradeoffs between strategies relative to the amount of uncertainty.

Focus groups were established according to the perceived resource issue categories within the Klamath Basin as means of better understanding the challenges associated with the societal use of data. Focus group workshops were used to identify specific issues within the Basin where decisions rely on the use of data provided by the NRCS and the NWS.

Use of Focus Group Workshops

Workshops attended by representatives of data users within the upper portion of the Klamath Basin were held in Klamath Falls, OR in December 2012 and April 2013. The individuals within each Focus Group were intended to represent the diversity of data users in the Klamath Basin. A list of individuals participating in the Focus Groups is provided in **Appendix A**. The initial "summit workshop" consisted of formal presentations by the NRCS-NWCC and CNRFC as data providers and a discussion about the use of data when making resource decisions by seven different Focus Groups. The April meeting focused explicitly on discussing, understanding and documenting the resource decisions made by each Focus Group. A list of the questions and discussion topics are provided in **Appendix B**. Preliminary ideas and general concepts about designs for providing and presenting data to meet the needs of each Focus Group were also described and discussed.

Access to data has become "socialized". Providing data through internet access is now common. No longer is the audience for data largely confined to the scientific community. Through the socialization of data and because of the broad audience using these data, the technical expertise of the users varies considerably and there is a need to clearly define data dependent decisions. Initially, nine Focus Groups were formed based upon the belief that the decisions made and actions taken by each group were unique and non-overlapping (see Deutschman et. al. 2013). The Focus Groups as initially organized are shown in **Table 1**.

Table 1. Initial Focus Group names and characteristics used to assess Klamath Basin data needs.

Focus Group Name	Description	Data Use Skill Level	Primary Information Need(s)	Type of Organization
General Public	Casual user seeking climate and water supply data. May or may not be Basin resident.	Novice	General information about climate and resource condition in the Basin.	Layperson
Federal Water Supply Project Operator	Staff from the federal agencies directly responsible for daily operation of federally constructed projects, like the Klamath Project.	Expert	Near real time information about water supply and natural resources condition.	Bureau of Reclamation

Focus Group Name	Description	Data Use Skill Level	Primary Information Need(s)	Type of Organization
Local Water Supply Project Operator	Staff from local Irrigation District responsible for the delivery of water to agricultural producers.	Novice	The amount of water currently available and forecast to become available for irrigating agricultural crops.	Irrigation Districts
Local Water Supply Administrative Organization	Staff from local water management agency responsible for policy matters related to water supply.	Novice	The amount of water currently available and forecast to become available for irrigating agricultural crops.	Klamath Water and Power Agency; Klamath Water Users Association
Agricultural Producer	Layperson who is an agricultural producer in the Basin	Novice	Recent precipitation amounts and basin condition with regard to drought and water supply.	Individual farmer; Oregon Agricultural Extension Service
Fisheries Manager	Staff from the federal agencies directly responsible management of the fisheries resource.	Moderate	Current and future water levels within reservoirs and lakes and current and future instream flows.	Fish and Wildlife Service; National Marine Fisheries Service
Federal Natural Resource Management Agency and Land Steward	Staff from the federal agencies responsible for management of refuges and federal lands.	Moderate	Volume and timing of water available to a refuge.	U.S. Fish and Wildlife Service
Local government	Staff from County Government responsible for public works, drainage districts and local water management.	Moderate	Condition relative to drought status, recent precipitation	Klamath County

Focus Group Name	Description	Data Use Skill Level	Primary Information Need(s)	Type of Organization
			amounts.	
Native American Nation	Staff from tribal government.	High	All aspects of water and natural resources management.	Klamath Tribes

Data and products available to the Focus Groups were described and summarized and desired refinements captured as a result of the Klamath Basin Summit (Deutschman et. al. 2013). Common themes emerged from the Klamath Basin Summit (**Table 2**), but specific details about the decisions made, and the data and products relied upon remained challenging to define. Most of the themes emerging from the Summit were applicable to resource issues within the western U.S. rather than specific to the Klamath Basin.

In retrospect, the Focus Groups miss a potentially important user; i.e., state agencies responsible for water management, although many of their needs are likely congruent with one or several of the Focus Groups. A Focus Group specific to water rights was purposely avoided because of the unique information needs.

The Focus Groups were convened for a second workshop in April 2013 to gain a more specific understanding of and better describe the most common questions and issues addressed using data. The reasons for and the decisions made based on the data were also described, reviewed and confirmed with members of the focus groups during the workshop. A summary and description of the alert categories and their associated data types and criteria are provided in **Appendix C**. Because many of the questions and issues are common across Focus Groups, the number of groups was reduced subsequent to the initial workshop. For example, all Focus Groups described the need for information about current and forecast seasonal water supply volume relative to operational criteria for the Klamath Project. The decisions and actions for each Focus Group were documented through the development of “decision timelines.” Developing decision timelines serves as an initial step to ensure the user requirements for each Focus Group are known and the data customized to those decisions.

Summary of Lessons Learned From the Focus Group Workshops

Establishing Context

Information about various methods for presenting data emerged from the Focus Group workshops. Measured data (e.g., the amount of precipitation, streamflow discharge) are often used to describe resource conditions, understand trends, and evaluate correlations. Focus group members suggested the traditional means of presenting these data and in particular univariate time series plots can be

Table 2. **Common themes expressed during the Klamath Basin Summit held in December 2012.**

Theme	Description	Applicable to Western U.S. Water Issues or Klamath Basin Specific?
Water Supply Forecast Accuracy	The seasonal water supply forecast issued by the NRCS-NWCC is reasonably accurate from a statistical sense (e.g., on a percentage basis or expressed by the standard error). However, in terms of water use and management, resource issues and decision-making the volume of water (c.a. 50,000 acre-feet) and forecast uncertainty is still quite large. The general perception is that "improved forecast accuracy" is desirable. The desire for improved forecast accuracy, however, fails to consider technical limitations including the ability to forecast future climate, the personnel resources needed to issue the forecasts, and the incremental improvement in forecast accuracy that is possible. The net Upper Klamath Lake UKL inflow is presently used for estimating the amount of water available to agricultural producers and for instream flow needs. The "known" net UKL inflow is in fact estimated by Reclamation based on a water budget for Upper Klamath Lake (i.e., it is not physically measured), which includes potentially important water budget terms (e.g., evapotranspiration). The error in the net UKL inflow estimate is not quantified by Reclamation. To improve accuracy, additional streamflow gaging and monitoring is needed. When asked about the "desired accuracy" for the seasonal water supply forecast, providing a specific numeric value proved challenging. Reclamation communicated the need for a seasonal water supply forecast accuracy with a maximum error of 5% in forecast volume.	Western U.S. Water Issue and Klamath Basin Specific
Water Supply Forecast "Uncertainty"	There is a general understanding of representing the seasonal water supply forecast uncertainty (issued by the NRCS-NWCC) as a series of percent exceendance values. A more challenging issue is aligning the percent exceedance values with specific decisions.	Western U.S. Water Issue

Theme	Description	Applicable to Western U.S. Water Issues or Klamath Basin Specific?
Temporal and Spatial Scales of Water Supply Forecast Products	Additional water supply forecast locations, particularly along the Klamath River, are desirable. These locations include Keno Dam, below Klamath Straights Drain, and Iron Gate Dam. There is need for water supply forecast products including the volume of water on a daily, weekly, and monthly basis. Shorter time periods typically correspond better to resource decisions being made (e.g., shorter-term ecological processes).	Western U.S. Water Issue
Timing of Decision Making	Stakeholders literally rely on climate and water supply forecast products on a daily basis for decision-making within the Klamath Basin beginning in September and October, prior to the next year's irrigation season.	Western U.S. Water Issue
User Expertise	User expertise, relative to the need for climate and water supply forecast products, varies widely among the Stakeholders and largely depends on the specific decisions. In many cases, a Stakeholder relies only on a small subset of the available climate and water supply forecast products.	Western U.S. Water Issue
Climate and Forcing Data	Climate products (e.g., precipitation depths, the amount of snow water equivalent) are relied upon in the decision-making process and used to supplement water supply forecasts. Additional data would be helpful. Ideas for providing additional data include: 1) adding SNOTEL locations; 2) improving the precipitation monitoring network; 3) adding streamflow gaging stations, especially on the Wood River system, Crooked Creek, and Fork Creek. One of the primary reason for additional data would be to improve spatial resolution. A critical evaluation of the current data to identify information gaps and limitations should guide the need for additional data.	Western U.S. Water Issue

Theme	Description	Applicable to Western U.S. Water Issues or Klamath Basin Specific?
Climate Products	There is value in climate products which can be used either independently or in conjunction with the water supply forecasts. Climate products need to be presented in a form which can be easily interpreted across varying levels of user expertise. Specific products of interest include simple departures from normal (e.g., precipitation, temperature, snow water equivalent, streamflow, reservoir water levels). Specific drought indices (e.g., Palmer Drought Severity Index), as well as actual measurements or indices of soil moisture are of value.	Western U.S. Water Issue

substantially enhanced by including specific information to establish context. Examples of how context can be established include:

1) display information for a specific period of time with which the user has first-hand knowledge or experience in addition to the current time period;
2) compare the current time period to some baseline condition which represents a known point in time and resource condition;
3) show the data in comparison to one or more values where the value(s) result in a decision, implemented through the performance of specific actions;
4) display information along with historical ranges and percentiles for the period of record;
5) Integrate measured and forecast information into a single graph; and
6) Provide the opportunity to compare data for inferential purposes.

Data users, especially those residing within or having first-hand experience in the Klamath Basin, have an inherent perception about how the current resource condition relates to some historic condition. Context can be established simply based on anecdotal information (i.e., the memory of the individual). Context can be established by comparison of the current condition to some historical time period. For example, the amount of precipitation during the last several weeks can be compared to a time period with a differing amount of precipitation the user remembers as unusually wet or dry (**Figure 2 and 3**). Context is established by comparison of the current period of time, retrospective to known conditions. Portions of the historic data record can be extracted for comparison to the current condition (e.g., a particular period of time) or categorized using statistical methods as representing the condition of a resource based on period of record information (e.g., as a dry, normal or wet).

Data are often used to affect and inform decisions. Context is established by comparison to specific threshold values (i.e., criteria), which when approached and exceeded, elicits or results in a decision to perform one or more actions. An example criterion is a desired streamflow discharge necessary to maintain fish habitat with an action to release more or less flow from an upstream reservoir to maintain favorable flow conditions (**Figure 4**). Another example, specific to the Klamath Basin, is the magnitude of the April-September seasonal water supply forecast, which determines the probable amount of water available for irrigation within the Klamath Project. The ability to compare data to one or more user specified criteria increases data value and establishes context.

Current and historical conditions are typically described using measured data. The ability to integrate measured and forecast data into a single graph or product establishes context, by providing information about the probable future direction (**Figure 5**). For example, a time series graph of measured reservoir

levels captures the historical trend, but lacks information about the probable future trend. Integrating forecast information establishes additional context upon which decisions can be made (**Figure 6**).

Expert users described the need for data for inferential and data exploration purposes. Their need is primarily the ability to create graphs, plots and charts to explore the interdependency of data (e.g., the relationship between precipitation depth and streamflow discharge). These users also expressed the need to download historical datasets of known quality not only for the purposes of data analysis, but as input to various hydrologic and resource models. Historical data should be date and time stamped and include a means of tracking modifications to the data using a versioning system.

Data Certainty and Decision Risk

Improved methods are needed for communicating data certainty and decision risk. A challenging aspect associated with presenting data is communicating data certainty and understanding the relationship between certainty, a user's decision's and the user's decision risk. Considerable Focus Group discussion helped clarify the issues associated with data certainty and decision risk, especially surrounding the seasonal water supply forecasts issued by the NRCS-NWCC. **Table 3** shows forecast accuracy for two locations within the Klamath Basin.

Many within the Klamath Basin rely upon the seasonal water supply forecasts issued by the NRCS-NWCC for making various decisions. An improved understanding with regard to how the information is being used is valuable to the NRCS-NWCC. Although forecast skill is communicated by providing a numerical expression of accuracy in the form of probability of occurrence by the NRCS-NWCC, data users frequently struggle interpreting these forecasts. From a practical perspective the expression of certainty is largely ignored in the decision-making process. From the water user's perspective, even a relatively small percent error in the forecast has considerable practical implications. An error of 10% in an April – September seasonal water supply forecast of 450,000 acre-feet has large implications about the amount of water available for irrigation, even though the forecast skill level is good. Focus Group participants repeatedly indicated the need for "more accurate" forecasts, even though even small improvements in the forecast statistical methods are unlikely to result in the desired accuracy. Users of the forecasts indicated of a need for an accuracy with a maximum error of 5% of forecast volume. The key therefore, is to define the decisions which rely on the use of the data and how these decisions change based on forecast skill.

Ideally, forecast uncertainty would be managed by a specific user of data through a robust decision making process, where the consequences of one or more decisions and the tradeoffs among the decisions is clear.

Figure 2. Daily average streamflow below iron gate dam. Context is established by adding comparison years and specific action criteria related to a resource decision.

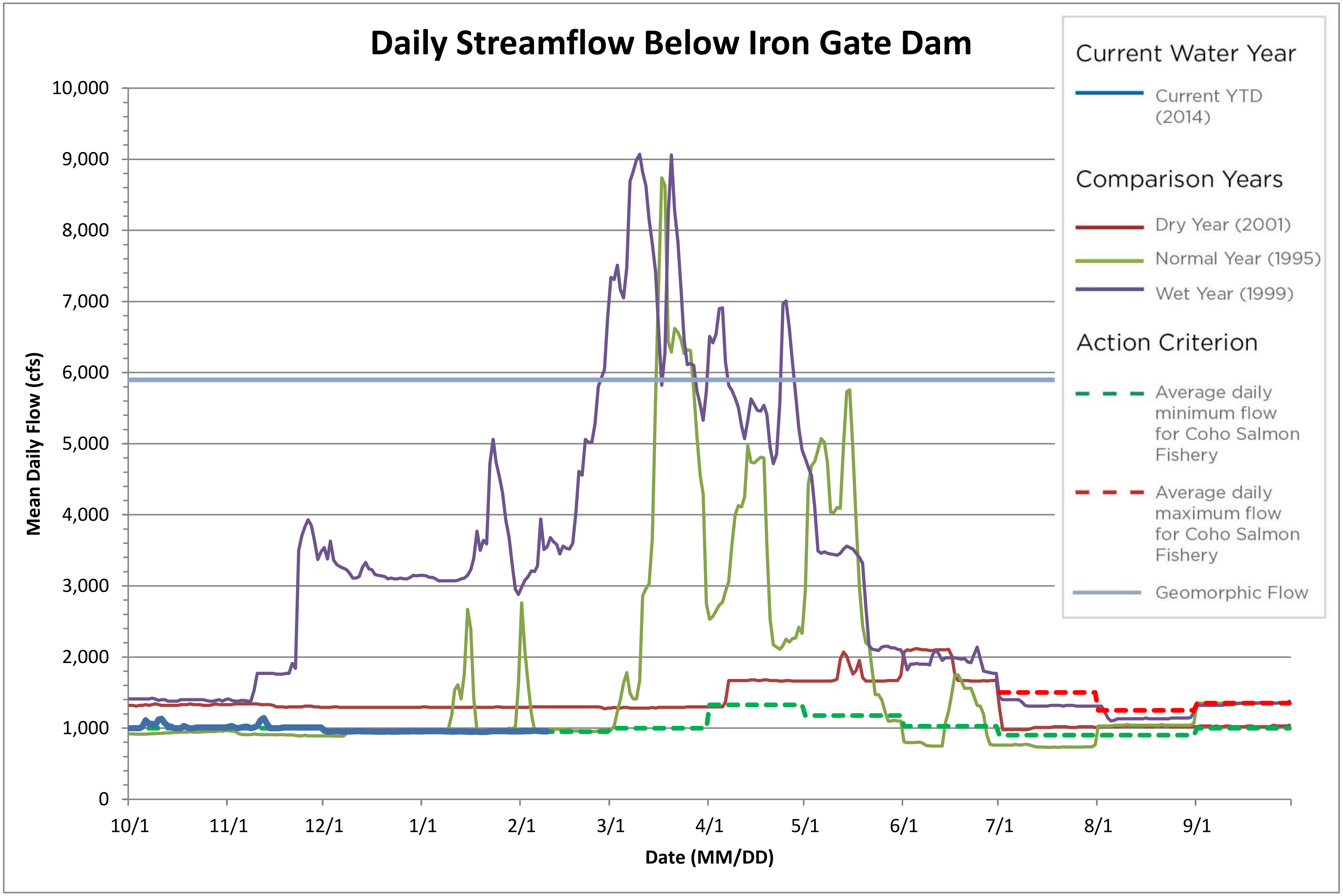


Figure 3. Daily average elevation of Upper Klamath Lake. Context is established by adding comparison years and specific action criteria related to a resource decision.

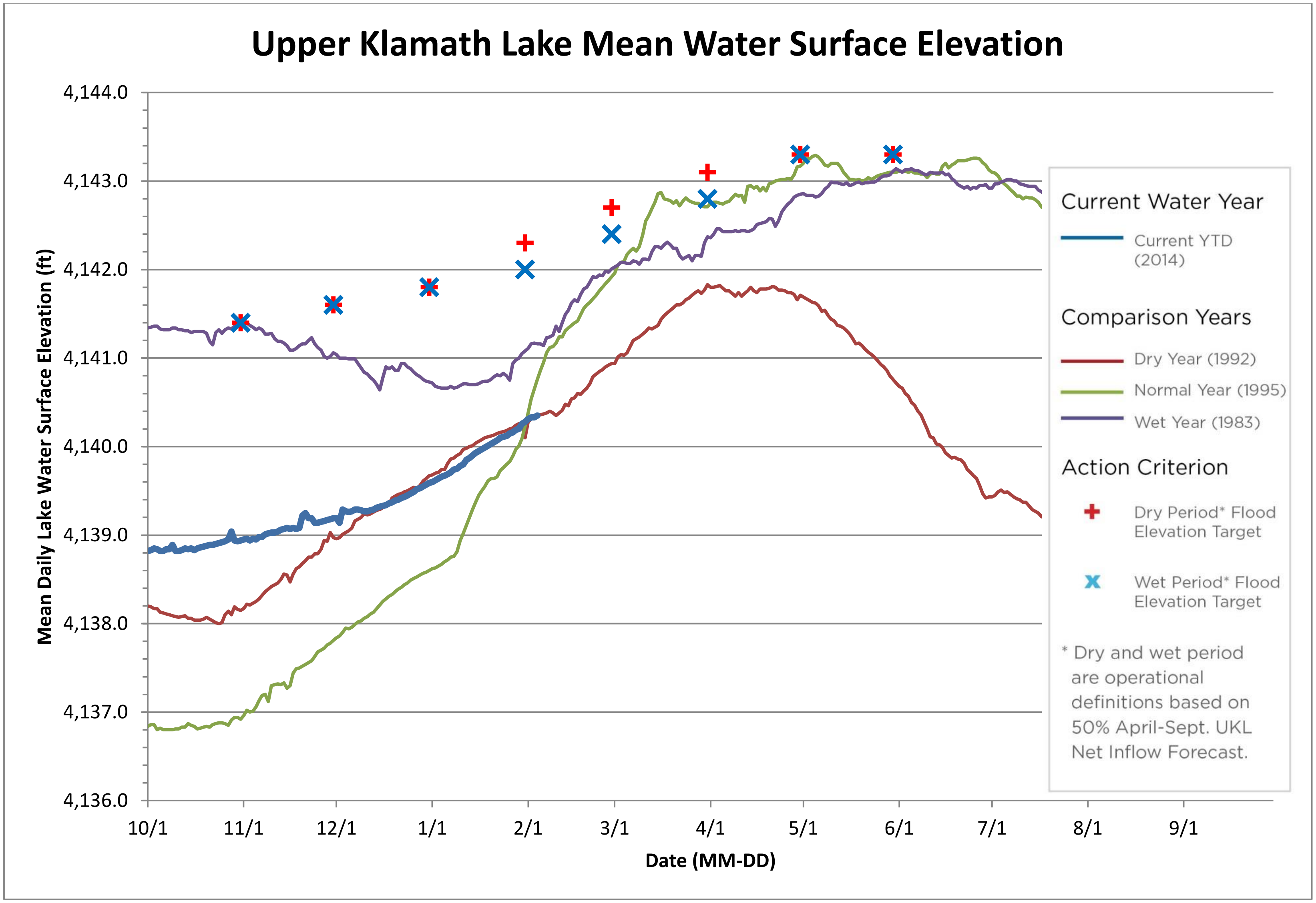


Figure 4. Daily streamflow below iron gate dam. The example graph shows the use of minimum flow needs for fish to increase data value.

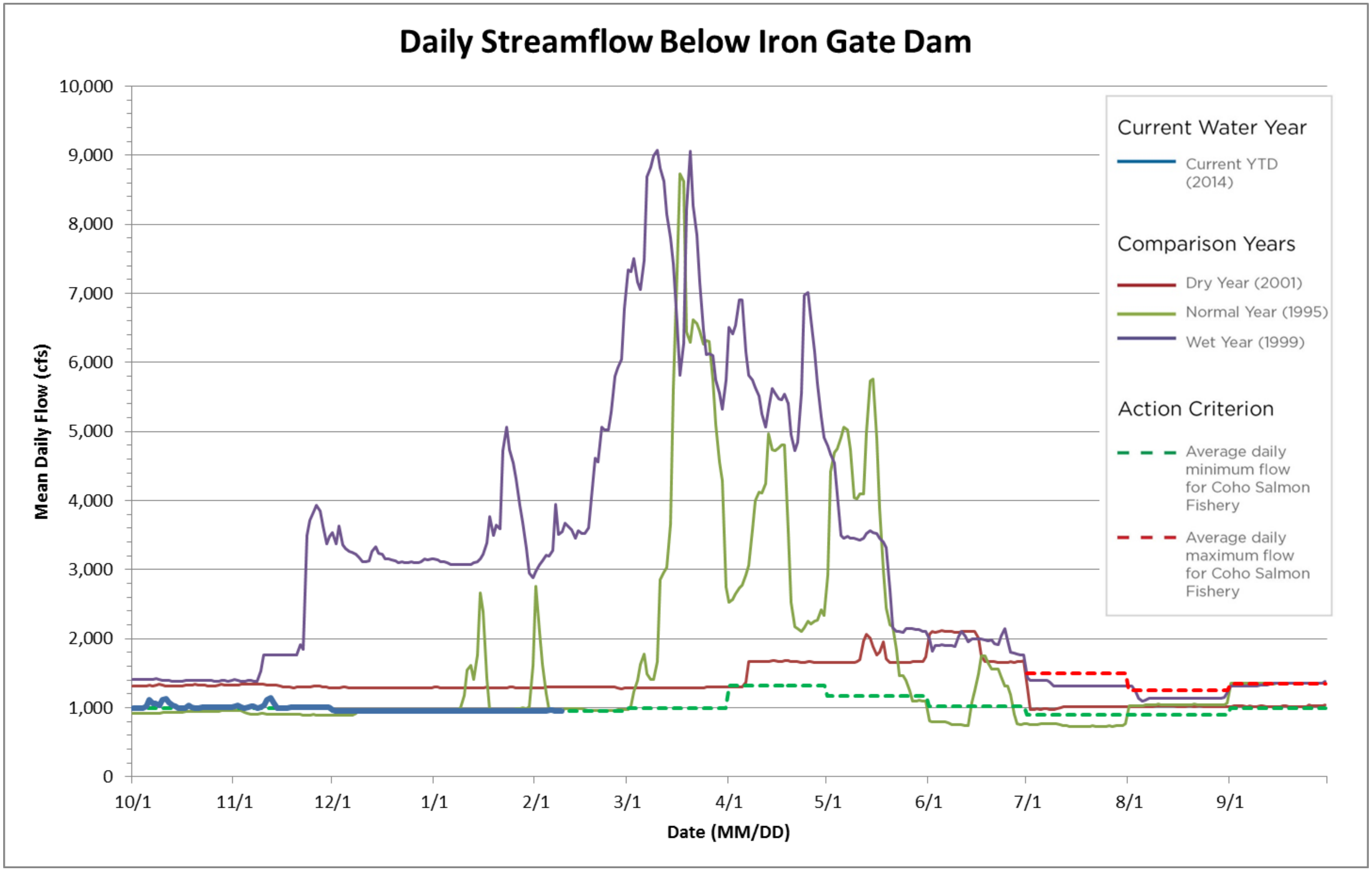


Figure 5. Measured and forecast daily streamflow for the Williamson River near Chiloquin, OR. Integrating measured and forecast streamflow and historical data reflects increased data value.

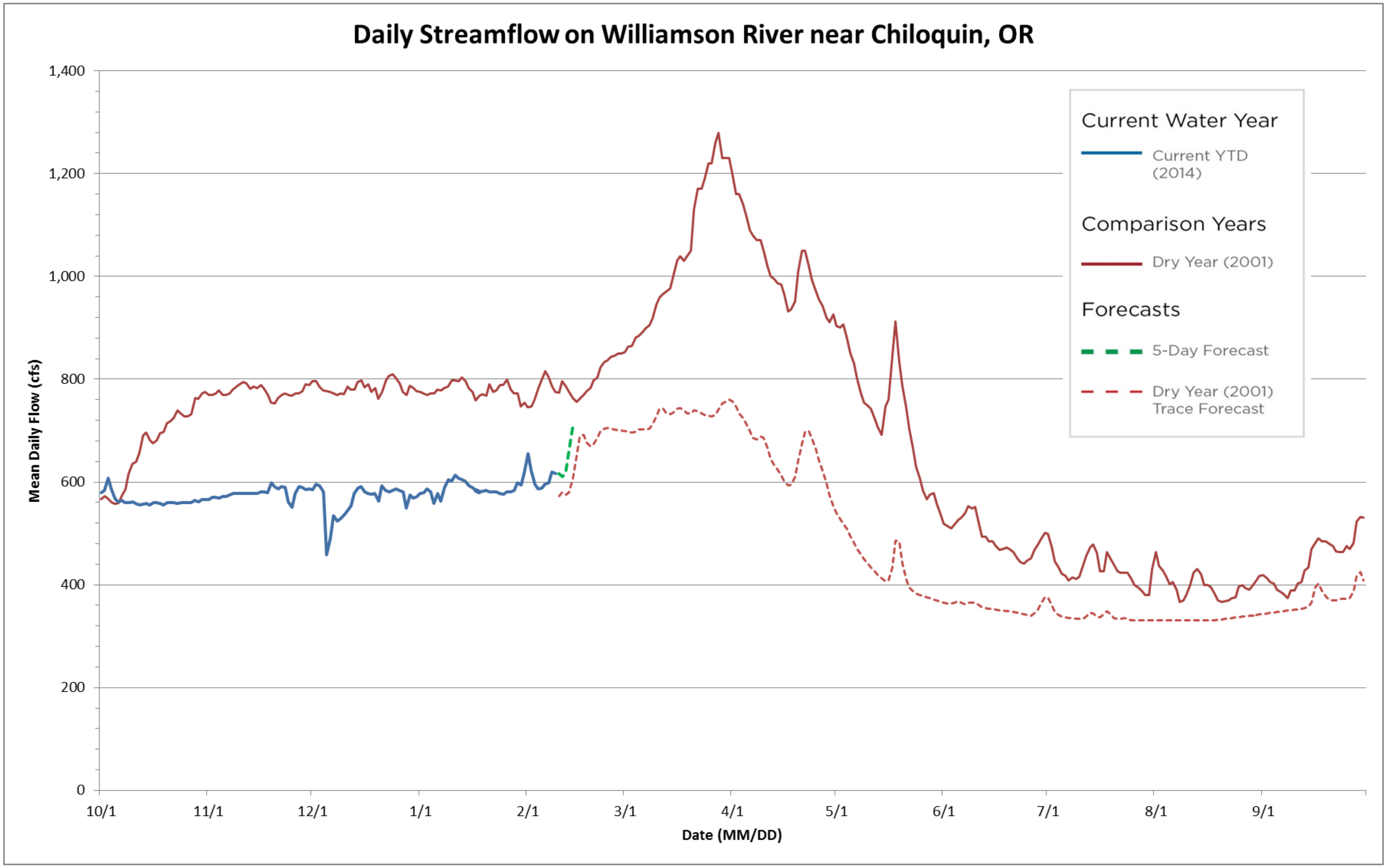
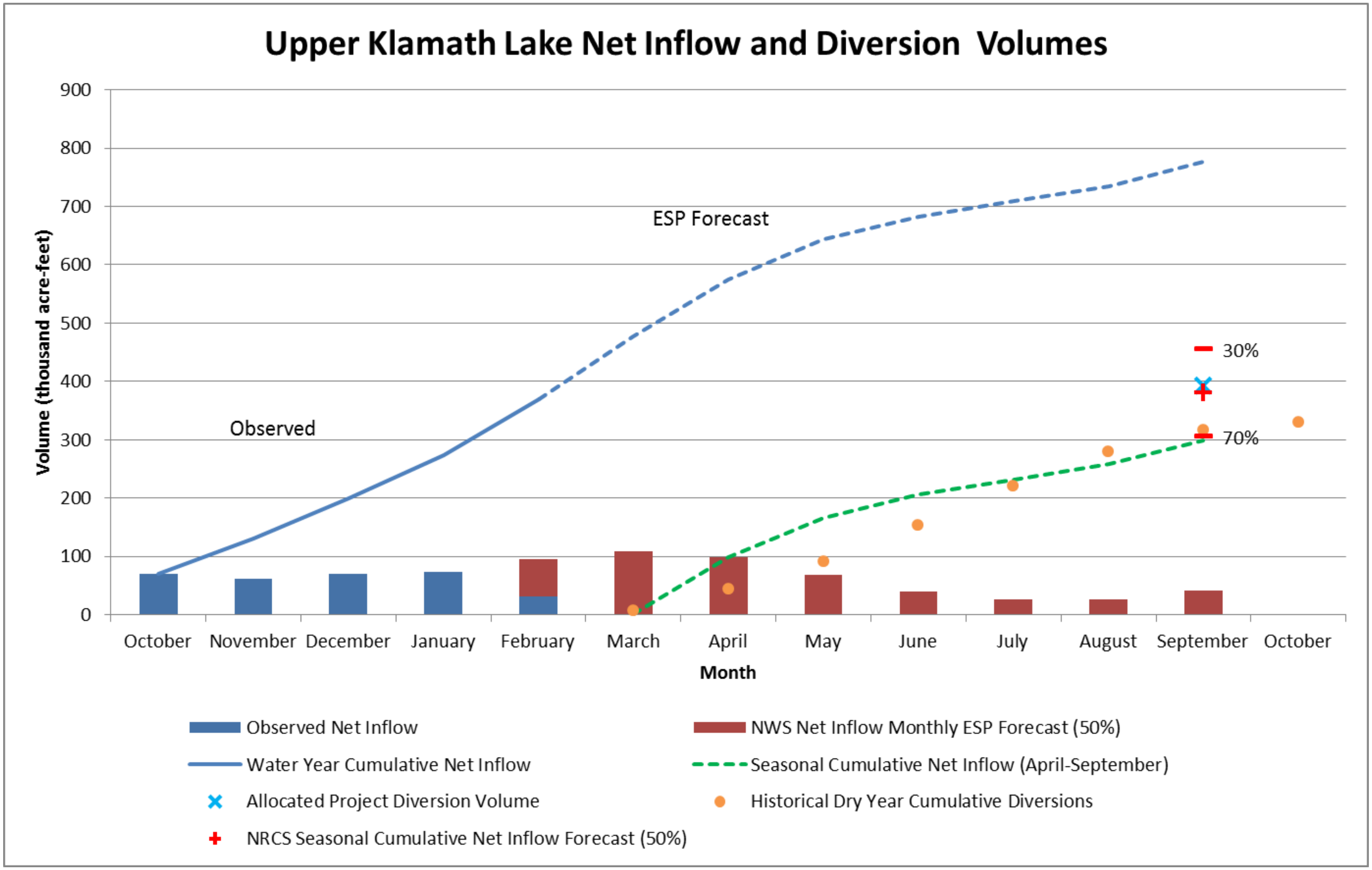


Figure 6. Upper Klamath Lake net inflow graph integrating estimated runoff volume, the NWS and NRCW-NWCC forecasts relative to the amount of water available for agricultural diversion.



The goal of rhobust decision making is for decision makers to identy and create new decision options that would not have otherwise been considred. Data are used to support the decision making process. Sometimes the new decision option is an adaptive strategy that changes through time.

Table 3. Accuracy of the median and 70% nonexceedance seasonal water supply forecast issued by the NRCS-NWCC related to forecast date.

Forecast Accuracy
Based On 1981 - 2011 Reconstructed Forecast
April - September Seasonal Volumes

	Median (50%) Forecast							
	Williamson River				UKL Net Inflow*			
Forecast Date	Median Forecast Value (KAF)	Jacknife Standard Error (KAF)	Mean Absolute Error (KAF)	Mean Percent Difference	Median Forecast Value (KAF)	Jacknife Standard Error (KAF)	Mean Absolute Error (KAF)	Mean Percent Difference
1 January Forecast	319.3	96.0	71.3	22.7%	426.7	136.2	106.9	27.1%
1 February Forecast	358.2	76.8	52.6	16.1%	482.7	103.8	75.6	18.4%
1 March Forecast	365.9	66.8	48.9	16.0%	493.8	88.8	69.4	17.9%
1 April Forecast	307.5	43.3	32.4	9.6%	511.8	63.2	46.5	10.1%
	70% Exceedance Forecast							
	Williamson River				**UKL Net Inflow***			
Forecast Date	**Median Forecast Value (KAF)**	**Jacknife Standard Error (KAF)**	**Mean Absolute Error (KAF)**	**Mean Percent Difference**	**Median Forecast Value (KAF)**	**Jacknife Standard Error (KAF)**	**Mean Absolute Error (KAF)**	**Mean Percent Difference**
1 January Forecast	268.8	---	80.5	22.0%	354.5	---	114.7	24.2%
1 February Forecast	317.5	---	61.6	17.3%	427.7	---	85.7	18.4%
1 March Forecast	330.4	---	34.5	16.1%	446.7	---	77.8	17.7%
1 April Forecast	284.5	---	35.8	11.2%	478.3	---	52.5	11.6%

**** "Known" UKL Net Inflow is an estimated value from BOR MODSUM (water balance) model (not measured).***

Mean percent difference computed from absolute values of (forecast volume - measured volume) divided by measured volume.

Observed April through Steptember volumes were 344.8 and 473.03 kaf for the Williamson River and Upper Klamath Lake (UKL) Net Inflow respectively.

Based upon information gained through the Focus Group meetings, the decision options for many are somewhat limited when water supply becomes scarce. **Table 4** shows example decision options for select focus groups.

The range of decision options seems somewhat limited especially within select Focus Groups. For example, based upon information gained through the Focus Groups, agricultural producers have an expectation to plant all arable land assuming full water supply. The reason being, reducing the acreage planted in advance of the irrigation season, based on the forecast water supply, has greater financial consequences should water be available. Instead, agricultural producers often seek a means of supplementing surface water supply rather than reducing the acreage planted.

Table 4. Example decision options for select focus groups for addressing water supply uncertainty.

Focus Group	Decision Actions	Range of Options
Agricultural Producer	Acreage Planted	• All arable land • Some portion of arable land • Fallow arable land
	Source of Water	• Use of surface water supply only • Use of surface water supply and supplemental supply (e.g., ground water) • Use of supplemental supply only • Fallow
	Crop Types	• High water demand crops (e.g., orchards) • Mix of high water demand and low water demand • Low water demand crop (pasture)
	Amount of Water	• Use technology to better estimate the amount of water needed to improve irrigation scheduling
Federal Water Supply Project Operator	Delivery of Water Supply	• Decrease Rate • Maintain current rate • Increase rate • Stop Delivery
Local Water Supply Administrative Organization	Need for Water User Mitigation Program	• Volume of supplemental water supply needed • Amount of acreage fallowed
Irrigation District	Delivery of Water Supply	• Proportion of lands served • Range of water supply provided (up to full)
Fisheries Manager	Fish Harvest	• Alter harvest limits in response to anticipated impacts of instream flow allocations
	Challenge Flow Allocations	• Petition Reclemation • Legal action

User Expertise

The data users differ relative to their expertise and ability to use and interpret the information presented. This results in challenges when presenting data. A concept coined "data vertical integration" presented to Focus Group participates seemed to address this issue. Much of the data and many products are presented to the user in a single format regardless of user expertise. The data vertical integration concept is one where the data and products presented to the user become more detailed and technical with each user interaction experience (i.e. click of the mouse). Initial presentation of data and products are for a general user (novice user), but a expert user can quickly find, analyze and interpret detailed technical information, with no more than three user interaction experiences. Fully customizable methods for presenting, analyzing and interpreting data are available to the expert user. This satisfies the expert user's expressed need for the ability to fully modify the temporal and spatial scale of the data and products presented.

Customizable Interface

Streamlining the presentation of data and products to the user is important to avoid "information overload" for many users regardless of expertise. One method for streamlining the presentation of data and products is to authenticate the user within the web environment, allow the data to be customized and to save the final data from a client session. The saved settings are presented to the user upon initiation of the next session.

Collaboration and Social Media Use

Once a user customizes data or products, the ability to share the information with colleagues for the purposes of scientific collaboration is needed. Potential methods for sharing the information include generating high quality graphics in multiple formats and the use of social media.

Baseline Datasets and Versioning

Context for the data and products can be established by comparing the current time period to some baseline condition which represents a known point in time and resource quality. Data are also routinely used as inputs to and as forcing data within climate and hydrologic models. Many of the models are legacy models and are used and maintained over many years for making resource management decisions. The Bureau of Reclamation for example, uses a water budget model for making Klamath Project operational decisions and managing water supply within portions of the Klamath Basin. The model uses long-term measured daily discharge data collected by the U.S. Geological Survey (USGS) as input. The model also relies on historic crop demand information to estimate water supply availability. Reclamation is literally forced to rely on "provisional data" because of the need for near-real time information. Resource decisions are made before data are fully quality assured. Provisional data periodically changes as a normal part of the quality assurance review process, prior to finalization. There is need to identify and make available "standardized" baseline datasets for use in comparing the current and historic condition. A versioning system which automates the labor intensive process of manually comparing two datasets, identifying and reporting dataset changes is needed.

Describing Current Condition

Resource condition is generally described by presenting a single value for the present state (e.g., precipitation depth within the last day). Presenting data in this manner fails to convey information about the direction of change and the rate of change. Using symbology capable of describing the present state, the direction of change in the state (static, increasing, decreasing) and the rate of change (e.g., slow, moderate, fast) relative to a specific decision criteria improves data context (see **Appendix F)**.

Using Decision Timelines To Correlate Data Needs and Decisions

One of the methods used to relate the data provided and the specific decisions of users is through the use of "decision timelines." A decision timeline graphically presents the relationship between the data and information needed by a user, the user decisions and the timing of those decisions. Decision timelines are useful for describing the decisions made by each Focus Group and vetting the relationship between the data needed and the decisions made.

A list of questions was developed for each Focus Group (see **Appendix B**) and used to guide the creation of the decision timelines. The questions were presented in a manner to elicit the type, as well as the spatial and temporal scales of the data needed. An explanation of the reasons the data are needed and the actions taken based on the data were included in questions.

Criteria were identified that resulted in actions, subsequent to the completion of the Focus Group meetings (**Appendix D**). Specific criteria corresponding to an action were identified through review of the literature, reports, and based upon experience working in the Klamath Basin. By identifying specific criteria, data can be used to notify a data user of the approach or exceedance of a criterion. Most criteria are applicable to climate and water issues throughout the west, although the criteria values are specific to the Klamath Basin. For example, areas throughout the Western U.S. often have instream flow requirements for endangered species. However, the Klamath Basin has an instream flow policy for Coho Salmon that is specific to the area (see Figure 4).

Because of a realization that a single decision timeline was capable of serving the needs of more than one Focus Group, the number of decision timelines was reduced to five (**Appendix E)**. The decision timelines share some common features. Each decision timeline is identified by Focus Group, describes a general purpose for the decision timeline and presents the user skill level. A graphic shows the months of the most recent water year and the current date is represented by a red arrow along the line. The data shown are for the date indicated by the red arrow in "pods." Each pod represents a single type of data. The type and number of pods is specific to the needs of the Focus Group. By using the water year calendar the type of data available at a given time period can be related to the specific information needs and decisions corresponding to the same time period. Each Pod shows the current value, location and temporal scale for a single data type. The data types are generally climate or water parameters measured in real time, although the data type can include indices derived from the measured data. Example data types are precipitation, snow, water level, climate and streamflow discharge. The characteristics for the current value of a data type presented within each pod can be altered. For example for the precipitation data type, the current value can be displayed for depth, maximum intensity, percent of normal and departure from normal.

Each decision timeline utilizes the concept of "vertical integration" meaning that more detailed information is accessible with successive and subsequent user interaction. Information is initially presented using the pods, but with charts, graphs and customized reports used to present information with subsequent user interaction. The decision timelines contemplate the need to compare current and historic information to establish context; i.e., view the current information by comparison to some historic time period. The decision timelines rely upon data presentation methods consistent with those currently used by federal agencies. For example streamflow discharge is presented as percentiles using the same number of bins, bin sizes and color coding.

The decision timelines were used to identify the specific data types needed to meet the requirements of each Focus Group. The decision timelines were also used as a beginning point for the development of a more refined framework for presenting data and products to users.

Datasets for Describing the Current Climate, Water Supply and Resource Condition and Assessing Change in the Klamath Basin

Describing the current climate, water supply and resource condition in the Klamath Basin and whether a change in the condition has or is occurring requires a baseline condition. During the Focus Group Meetings, Stakeholders from within the Klamath Basin identified as a priority the need to access, understand changes within and download for their use baseline datasets. The baseline datasets are used to describe the current climate, water supply and resource condition, and for use in assessing change.

Many decisions made on a daily basis require an accurate description of the current climate, water supply and resource condition in the Klamath Basin. Just a few of these decisions include whether to irrigate crops, understanding the adequacy of the water supply for fish species, and whether drought conditions are occurring and the need to declare a drought disaster. Describing the current condition requires data with preferably a long-term period of record. A long period of record allows the current condition to be placed within a historical context.

Measured data including climate, streamflow, lake and reservoir elevation data are especially useful when describing the current climate, water supply and resource condition. The precipitation or snow water equivalent departure from normal is just one example of how measured climate data can be used to describe basin condition.

Indices derived from measured data are also important for describing Basin condition. Climate and streamflow data are often used to develop various indices describing the severity, duration and intensity of drought and the adequacy of the water supply. For example the Standardized Precipitation Index (SPI) is calculated from precipitation and used to describe the extent of wet and dry conditions at a variety of time scales ranging from 1 to 72 months. The SPI assigns a single numeric value to the measures precipitation which can be compared across different geographic regions with different climate.

A number of indices are derived from multiple and sometimes different sources of data and used to describe Basin condition. The different sources of data include spectral imagery, remotely sensed data and measured data. For example, the NRCS's Surface Water Supply Index (SWSI) combines several types of climate and hydrologic data into a single index value expressing the status of surface water availability for spring and summer use. The SWSI unfortunately is specific to a region, preventing comparison across large geographic regions.

Within many western states, the volume of available of water depends upon the amount of and water content within the snowpack. The products generated by the National Operational Hydrologic Remote Sensing Center (NOHRSC) are valuable datasets specific to snowpack. Unfortuately these 1 km gridded data derived from a a combination of modeled, measured and remotely sensed data every 24 hours are only sometimes processed into value added products, such as the amount of water within snowpack .

Although subject to some bias in mountainous terrain because of width effects (see Clow et. al, 2012), this limitation can be overcome. **Figure 7** shows how the snow water equivalent data can be processed to estimate the amount of water within the snowpack within a subwatershed. These data are useful as a means of placing forecast data into context.

The results from models can also serve as baseline datasets for describing Basin condition. One advantage of the use of calibrated models to describe basin resource condition is the ability to produce data at locations lacking measurements. Hydrology models like the Sacramento Soil Moisture Accounting Model (SAC-SMA) can be used to estimate the long-term daily streamflow discharge under current land use and historic climatic conditions. The output from these models for specific assumed conditions (e.g., land use / land cover in a specific year) can be used to describe baseline conditions.

Baseline datasets of known origin and quality are also needed for assessing temporal and spatial changes in climate, water supply and resource quality. Temporal and spatial changes occur at multiple scales. Temporal scales of interest are often daily, monthly, seasonal, annual and multi-annual. An individual field, region (e.g., a portion of a County), subwatershed, and basin-wide are common spatial scales of interest. The specific criteria used to characterize and quantify change can differ from person to person. However, criteria used to characterize and quantify change should typically include some threshold value of interest, a comparison of the threshold value to the current magnitude, the direction of change (static, increase, decrease) and the rate of change (e.g., fast or slow). Ideally, the threshold value is directly related to a specific decision or action.

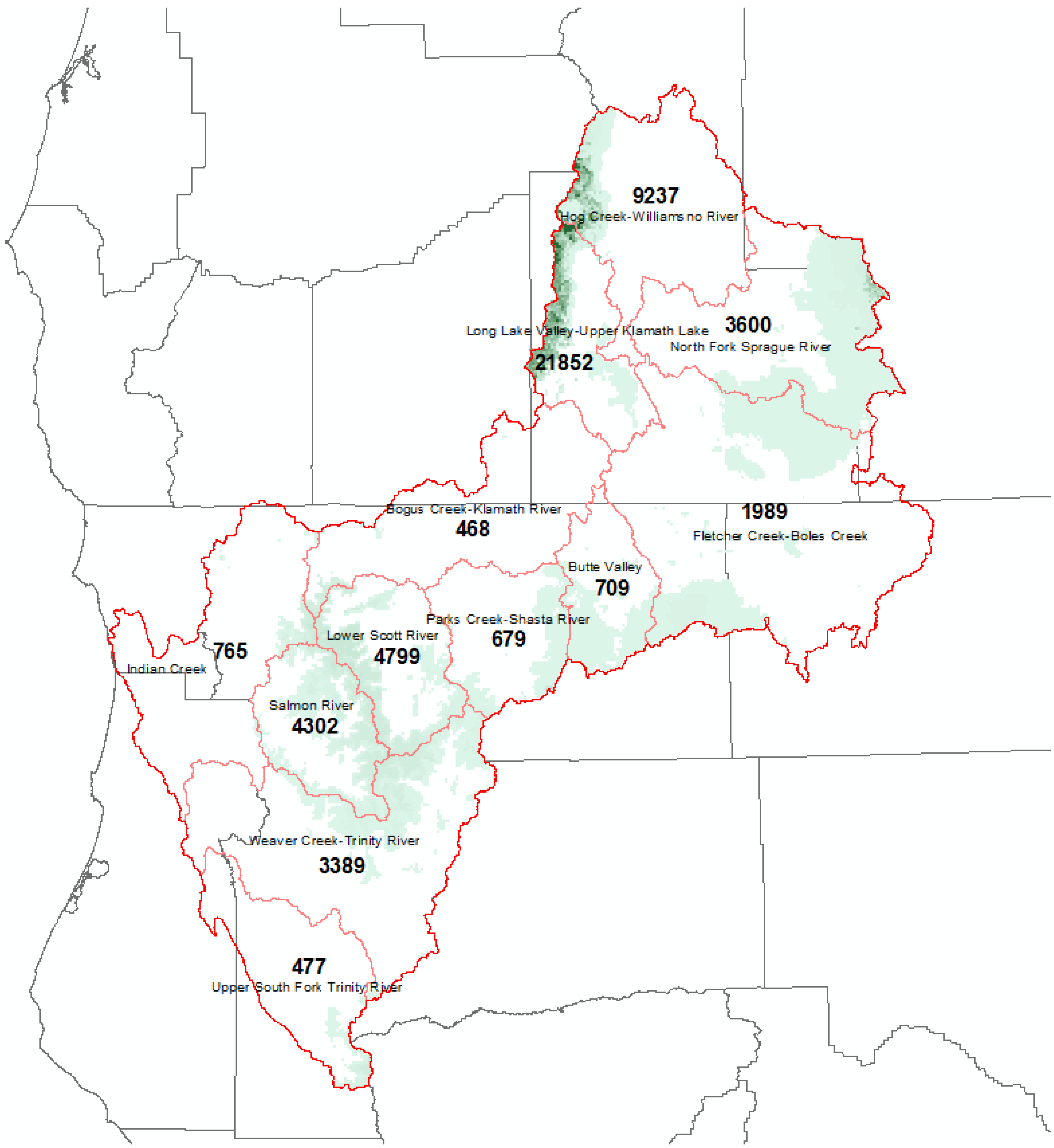
Measured data can be used to describe temporal and spatial changes and are often used as input or forcing data for a variety of models, including hydrology and climate models. The most commonly needed measured data for describing baseline condition and assessing the magnitude of resource change include precipitation, solar radiation, air temperature, percent cloud cover, wind speed, wind direction, snow depth, snow water equivalent, streamflow discharge, soil moisture content and water surface elevation (lakes, reservoirs and wells). Specific years can be used to represent conditions within the Klamath Basin, because of the experience of living within the Basin and the associated consequences of climate and water supply. Frequency analysis of the precipitation record for example, can be used to operationally establish dry, normal or wet precipitation years, which can then be compared to current conditions.

Periodic updates or modifications by the agency responsible for the baseline dataset are sometimes poorly documented because of a lack of time and a formal documentation process. The inability to document updates or modifications to baseline datasets can result in a subsequent, considerable expenditure of time by the recipient of the data and potentially erode the trust relationship among the Stakeholders, essential to constructively managing resource issues in the Klamath Basin.

An example using the MODSUM model illustrates the issue. Reclamation uses the MODSUM model to estimate water volumes on monthly basis throughout portions of the Klamath Basin and relies on the model results to make operational decisions on a daily basis. Because Reclamation makes decisions on a daily basis, they are necessarily forced to rely on the realtime provisional streamflows measured at several locations within the Basin by the USGS. Reclamation computes monthly volumes for input into the MODSUM model thereby creating a new current condition dataset using the provisional USGS

streamflow data. The historical MODSUM model runs are retained by Reclamation for comparison purposes and retrospective evaluation of their water related decisions.

Figure 7. Example showing the estimated amount of water (acre-feet) on January 31, 2014 within the snowpack by subwatershed using the NOHRSC snow data (swe) products (1 km resolution, generated at 24 hour intervals).



Provisional data have not yet been reviewed nor edited by the USGS and therefore are subject to subsequent change. The realtime streamflow measured by the USGS may change after review for logical reasons, including the effect of sediment movement on channel characteristics, ice and debris jams influencing water levels, a change in channel dimensions or equipment malfunction. The final data are generally published by the USGS within 6 months of the end of a water year (i.e., September 30), long after Reclamation relies on the information. This results in constant retrospective analysis of the decisions made by Reclamation, an absence of knowing the streamflow record input into MODSUM was modified without a considerable investment of time and often an absence of understanding about the implications of a changed streamflow record.

Creating the ability to document changes to baseline datasets used to describe resource condition and making the records available is a potential solution to this dilemma. Baseline datasets of known origin, quality, period of record and type can be used to assess the change in resource condition. Climate and water related data are of primary interest within the Klamath Basin. Although the boundaries are sometimes blurred, types of baseline data used for describing basin condition include measured, modeled, and developed indices.

A system of keeping track of changes to measured data (i.e., a revision control system or versioning) can be helpful when these data are used in their native form, subject to subsequent quality assurance review or processed to different temporal or spatial scales. In addition, such a system would aslo be useful in tracking information used as forcing data, boundary conditions and inputs to models. Although techniques vary, a revision control system can be implemented as a software which manages and identifies changes to a measured or derived dataset.

Table 5 shows measured, indices and modeled datasets which can be used to describe the current climate, water supply and resource condition within the Klamath Basin. These datasets are developed and distributed by various federal agencies, with differing temporal and spatial scales for the Klamath Basin. Ideally these datasets would be provided in a format that is readily downloadable and, for provisional or datasets which may change, include information about whether the dataset has multiple versions.

One of the factors diminishing the value of data is an inability to ingest and integrate data from different sources (often different agencies) into a single chart, graph or similar product. Many data purveyors are now providing data through the use of web services, of differing sophistication. The development of scripts (i.e., computer code) to automate the data retrieval process enhances the ability to integrate data from different sources. Several scripts were created as a deliverable under this project, for use by others to retrieve data. These scripts were developed using Python for the web services shown in **Table 6**. Automating the data retrieval process presents an opportunity to provide information requested on the fly relative to historic conditions.

Table 5. Datasets for Assessing and Evaluating a Change in Basin.

	Type of Data	Name of Dataset	Shortest Measured Interval	Source of the Data	Entity Responsible for Data Management	Link
Measured						
Precipitation	Climate	Local Climatological Data Publication	Hourly (from 1945) Daily (from 1930) **Available by state or station	National Climatic Data Center	NOAA (Satellite and Information Service - NESDIS)	http://www.ncdc.noaa.gov/IPS/hpd/hpd.html
Evaporation	Climate	Monthly Average Pan Evaporation	Monthly Average over certain period of years **Only avail. For certain sites	Wester Region Climate Center	NOAA and Others	http://www.wrcc.dri.edu/htmlfiles/westevap.final.html
Solar Radiation	Climate	Solar Hourly Series for day of - / -/ -	Hourly (from 2003) **Only available at certain stations	National Water and Climate Center	USDA – Natural Resources Conservation Service	http://www.wcc.nrcs.usda.gov/nwcc/inventory
Wind Speed	Climate	Local Climatological Data Publication	Every 3 Hours Daily (from 1945) **Available by state or station	National Climatic Data Center	NOAA (NESDIS)	http://www.ncdc.noaa.gov/IPS/lcd/lcd.html
Wind Direction	Climate	Local Climatological Data Publication	Every 3 Hours Daily (from 1945) **Available by state or station	National Climatic Data Center	NOAA (NESDIS)	http://www.ncdc.noaa.gov/IPS/lcd/lcd.html
Sky Cover	Climate	Local Climatological Data Publication	Daily (from 1945) **Available at certain sites	National Climatic Data Center	NOAA (NESDIS)	http://www.ncdc.noaa.gov/IPS/lcd/lcd.html
Snow Depth	Climate	SNOTEL Snow	Daily	National	USDA - Natural	http://www.wcc.nrcs.usda.gov/n

	Type of Data	Name of Dataset	Shortest Measured Interval	Source of the Data	Entity Responsible for Data Management	Link
		Depth Products	(From 1999) *Data Available for SNOTEL stations spread throughout the basin	Water and Climate Center	Resources Conservation Service	wcc/inventory
Snow Water Equivalent	Climate	SNOTEL Snow Water Equivalent Data Table	Daily (From 1979)	National Water and Climate Center	USDA - Natural Resources Conservation Service	http://www.wcc.nrcs.usda.gov/snow/snotel-wedata.html
Streamflow	Hydrology	USGS Surface-Water Daily Data	Daily Avg. (from approx. 1930) By site	USGS Water Resources	U.S. Department of the Interior - USGS	http://waterdata.usgs.gov/nwis/dv/?referred_module=sw
Reservoir and Lake Elevations	Hydrology	USGS Surface-Water Daily Data	Daily Avg. (from approx. 1930) By site	USGS Water Resources	U.S. Department of the Interior - USGS	http://waterdata.usgs.gov/nwis/dv/?referred_module=sw
Indices (Derived from Measured or Other Data)						
Standard Precipitation Index	Derived from Climate	Standardized Precipitation Index	Monthly Time Scale (up to 72 months)	NOAA	WRCC	http://www.wrcc.dri.edu/spi/
Precipitation Percent	Derived from Climate	Derived Precipitation Percent	Daily	National Weather Service	River Forecast Centers	http://water.weather.gov/precip/
Soil Moisture Percentiles	Derived from Satellite	Soil Moisture Percentiles	Daily	National Weather Service	River Forecast Center	http://www.cpc.ncep.noaa.gov/products/Drought/Monitoring/smp.shtml
Vegetation (Vegetation	Derived from	Vegetation Drought	Daily	National Drought	National Drought	http://vegdri.unl.edu/

	Type of Data	Name of Dataset	Shortest Measured Interval	Source of the Data	Entity Responsible for Data Management	Link
Drought Response Index)	Satellite	Response Index		Mitigation Center	Migitation Center & Others	
Vegetation (Normalize Difference Vegetation Index)	Derived from Satellite	Greenness (No Noise NDVI)	Daily	NOAA	NOAA	http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_browse.php
Models						
Season Water Supply Forecasts	Hydrology	State Basin Outlook Reports	Monthly (Jan – June) (1990-Present)	Natural Resources Conservation Service - Portland	National Water and Climate Center (USDA)	1) http://www.wcc.nrcs.usda.gov/wsf/wsf.html 2) http://www.wcc.nrcs.usda.gov/cgibin/bor.pl
Daily streamflow (ESP traces)	Hydrology	ESP Forecast Information	Daily Forecast up to one year	National Weather Service California – Nevada Office	NOAA – US Dept. of Commerce	http://www.cnrfc.noaa.gov/index.php?type=ensemble
ModSum Water Balance Model	Hydrology	Historic diversions	Daily	Bureau of Reclamation Klamath Falls Area Office	Bureau of Reclamation Klamath Falls Area Office	Not available
ModSum Water Balance Model	Hydrology	Agricultural demands	Daily	Bureau of Reclamation Klamath Falls Area Office	Bureau of Reclamation Klamath Falls Area Office	Not available

Following development of the web services the data retrieved were evaluated for use in describing baseline condition and for deriving climate, drought and water supply indices within the Klamath Basin. The specific data retrieved through the use of web services included:

- Surface air temperature;
- Precipitation;
- Snowfall (depth);
- Growing degree days;
- Snow water equivalent;
- Streamflow;
- Groundwater elevation;
- Lake / reservoir surface water elevation ;
- Soil Moisture; and
- Evapotranspiration

To ensure the broadest possible use of the data the shortest temporal scale is desired so each parameter can be summarized using the following time periods:

- Instantaneous (near real time, generally 15-minute);
- 1-hour;
- Last 1-day;
- Last 7-days;
- Last 14 days;
- Last 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 18, 24, 30, 36, 48, 60, and 72 months, ending on the last day of the latest month;
- Water Year To Date (WYTD); and
- Calendar Year to Date (CYTD).

Following retrieval the data can be presented in several ways to describe basin condition. For temperature, precipitation, snowfall (depth), growing degree days, snow water equivalent and streamflow (volumes) useful means of describing the current condition include the:

- Amount accumulated;
- Amount accumulated departure from normal;
- Percentage of average;

Table 6. Web services accessed for automated data retrieval by the development of Python scripts.

Network Name	Web Access
Hydromet/ Agrimet	15-minute (instant data) http://www.usbr.gov/pn-bin/webarccsv.pl http://www.usbr.gov/pn-bin/agrimet.pl Daily values http://www.usbr.gov/pn-bin/webdaycsv.pl
National Water and Climate Center	http://www.wcc.nrcs.usda.gov/web_service/awdb_web_service_landing.htm ftp://ftp.wcc.nrcs.usda.gov/data/water/forecast/forecast_bounds_byyear/
CoCoRaHS	http://data.cocorahs.org/cocorahs/export/exportreports.aspx
National Weather Service	Hourly ESP and daily average deterministic http://graphical.weather.gov/xml/ http://www.cnrfc.noaa.gov/send_espTrace.cgi http://water.weather.gov/ahps/forecasts.php HADS http://www.nws.noaa.gov/oh/hads/
PRISM Data	http://www.prism.oregonstate.edu/
USGS Streamflow	http://waterservices.usgs.gov/
Oregon WRD Streamflow	http://apps.wrd.state.or.us/apps/sw/hydro_near_real_time/
Climate (most networks)	http://data.rcc-acis.org/
MesoWest	http://mesowest.utah.edu/html/help/main_index.html
California Data Exchange Center	http://cdec.water.ca.gov/cgi-progs/queryCSV
Oregon WRD Well Graphs	http://filepickup.wrd.state.or.us/files/Publications/obswells/data
Vegetation indices	http://www.star.nesdis.noaa.gov/star/products.php

- Probability of occurrence / percentile (from fitted probability distribution)
- Current value rank (i.e., plus or minus standard deviation based on fitted probability distribution); and
- Compared to historical time periods operationally defined (e.g., as dry, normal or wet).

For streamflow discharge, groundwater elevation, lake and reservoir elevation useful means of describing the current condition include the:

- Current value;
- Current value departure from normal;
- Percentage of average;
- Probability of occurrence / percentile (from fitted probability distribution);
- Current value rank (i.e., plus or minus standard deviation based on fitted probability distribution); and
- Compared to historical time periods operationally defined (e.g., as dry, normal or wet).

Once available the data can be subsequently used and processed to compute a variety of climate and similar indices. These indices include

- Current value rank (i.e., plus or minus standard deviation based on fitted probability distribution) for each parameter described above;
- Standard Precipitation Index;
- Palmer Drought Index;
- Percent soil moisture;
- Short and Long-Term Drought Indicator Blends;
- Streamflow Index;
- Drought Intensity (Severity Classification); and
- Surface Water Supply Index.

Focus Group participants also expressed the need to develop subwatershed scale indices from the point location data. Development of the indices at the 8-digit Hydrologic Unit Code (HUC) level seems most likely.

The most promising stations for describing baseline condition were identified using the data retrieved through the use of web services. The criteria to select the stations to describe baseline condition were based on:

- Period of record. Generally a minimum of 10-years of data is desirable, with at least 30 years prefered;
- Continuity of record. A continuous record is preferred.
- Data quality. Known quality developed using standardized quality assurance procedures of known accuracy and precision.
- Spatially representative. The site does not have localized factors bias results and is representative of a larger geographic portion of the basin.

Figures 8 shows locations meeting these criteria for periods of record with a minimum of 30-years of data respectively (**Appendix F**) for locations with 10 years of record) . **Figure 9** shows water supply forecast locations in the basin. Those locations with a period of record of 30 years or more were selected for use in prototype development.

Figure 8. Potential monitoring locations for use in describing baseline conditions with the Klamath Basin with a minimum of 30-years of data.

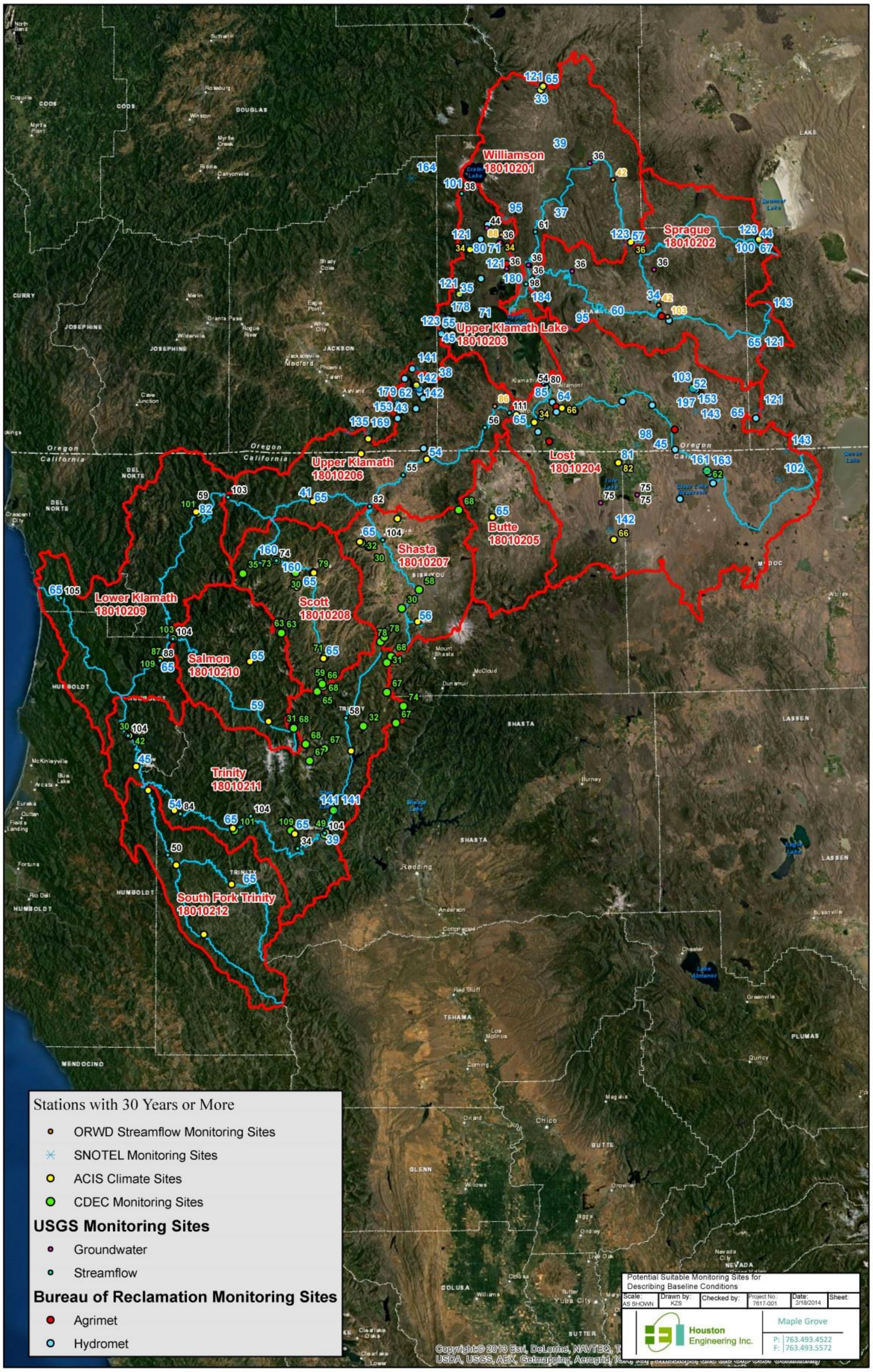
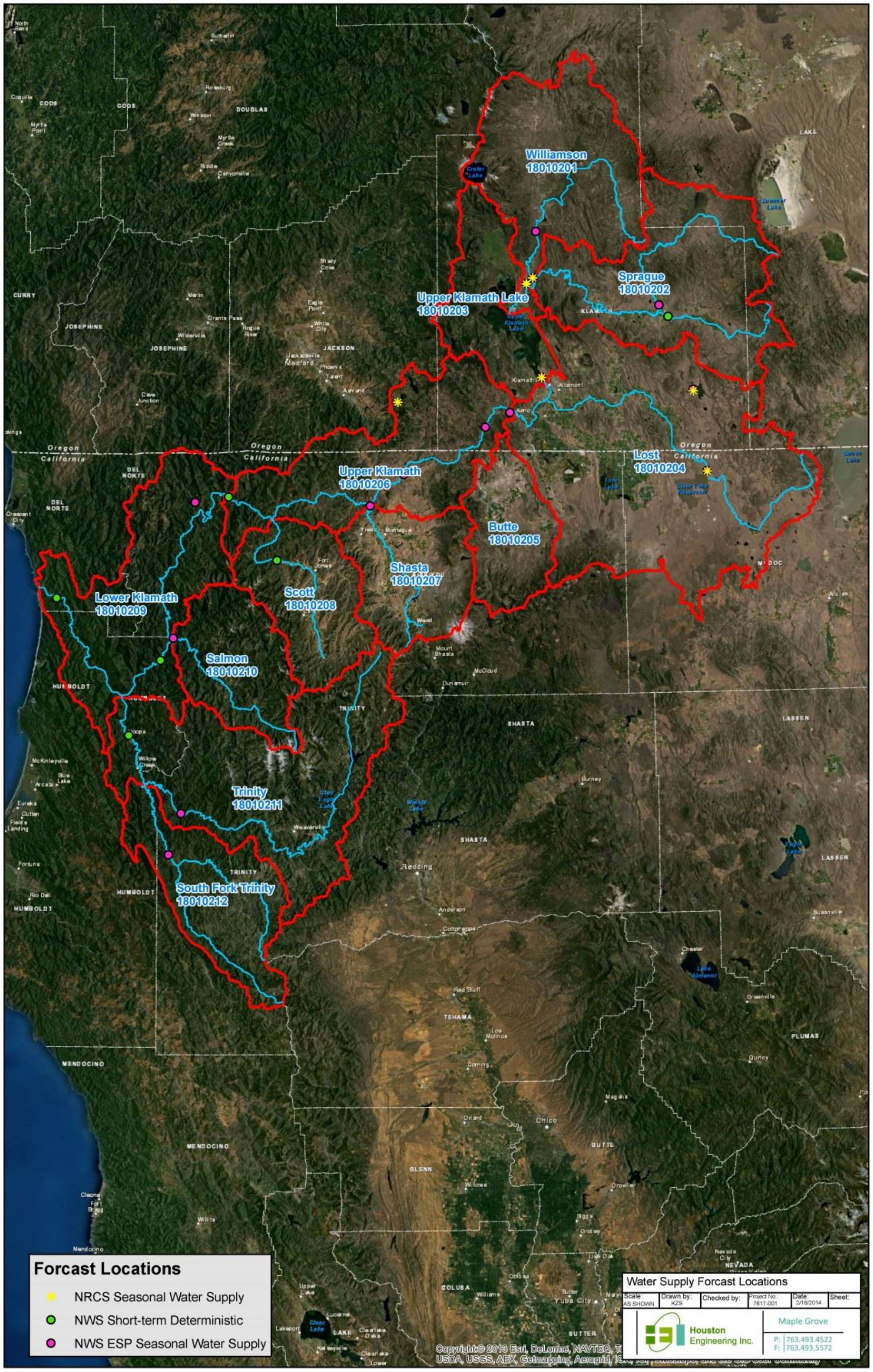


Figure 9. Water supply forecast locations in the Klamath Basin.



DATA PRODUCT DESIGN CONSIDERATIONS

Robust Data Tools and Applications

Both users and data providers desire robust methods for accessing, viewing and using data. The web is common vehicle for providing data, however technological advances are rapid, especially those related to the web. Technological advances are so rapid that the tools used to provide the data become dated and inoperable within as little time as a year or two. Therefore, the means and methods of providing data via the web generally require considerable maintenance and upkeep. Sustainable data tools and applications are defined here as those developed utilizing existing and reasonably foreseeable technologies with functionality lasting a minimum of three years and requiring limited maintenance. Some characteristics of robust data tools and applications include:

- The native quality controlled or provisional data (not images, graphs) must be accessible electronically via the web in a known and time invariant format (e.g., SHEP, NWS text product).
- The data must be available through a data API and automatically updated for use in server-side applications.
- Making the data available must fit within the "normal workflow process" of the agency providing the data – there should not be an expectation that the agency will "create something new" to serve the specific needs within the Klamath Basin.
- If there is a need to "create something new" resources may need to be made available by the user.
- Automatic error checking and web master notification of the failure to find and access the data is required.
- The data can be categorized into specific types for use in standard data charting, analysis and reporting tools.
- A library is needed of standard data charting, analysis and reporting, perhaps by data type. A user must be able to enter / upload / evaluate against specific resource metrics or criteria (i.e., decision criteria) they "upload" perhaps by data type (e.g., UKL lake levels).
- An understandable method of describing and understanding the data is needed. Perhaps separate "widgets" for forecast and measured data, that for any given location and type of data shows :
    - Present magnitude
        - Compared to historic / known years (specific previous time periods)
        - Categorized percentiles
        - Departure from normal (perhaps like above)
    - The direction of change (increasing, no change, decreasing)
    - The rate of change compared to historic (real years and percentiles)
    - Value compared to a criteria / metric
    - The probable final value (where will it end up)
- Need to increase value is the products by
    - Integrating the types and sources of data (e.g., rainfall and runoff graphs)
    - Comparison to metric / criteria

Perhaps the most common challenge is ensuring and maintaining data accessibility. Using web services to automate the process of accessing and retrieving data is critical. Databases integrated with the retrieval process for subsequent storage and data access following retrieval are also essential. Automated notification when the data retrieval process fails substantially increases sustainability.

Technology Considerations

Robust tools for access and providing the data to users requires the use of a suite of interacting and complimentary technologies. **Figure 10** is a schematic showing recommended technologies. These technologies can be categorized as: 1) external data source retrieval (i.e., web services); 2) server side applications for loading the retrieved data into databases (i.e., data loaders), storing the data for subsequent processing (data center) and geoprocessing; and 3) front-end applications including an applications interface, tools and applications to provide the data to the users.

Preferably, these technologies could be developed and provided to any entity for use in developing applications and tools to provide data. Through this research effort some of the technologies are being demonstrated, although insufficient funds are available to develop all technologies. For example, an interactive map application was built using open source technology and is available through klamathdss.org. Python scripts have also been developed to access and retrieve data from web services (see **Table 6**) and to load data into databases. These scripts have been made available via Github (https://github.com/heigeo/climata). The source code is freely available and can be used by data providers to retrieve data from other sources, and incorporate the data into their products to improve context.

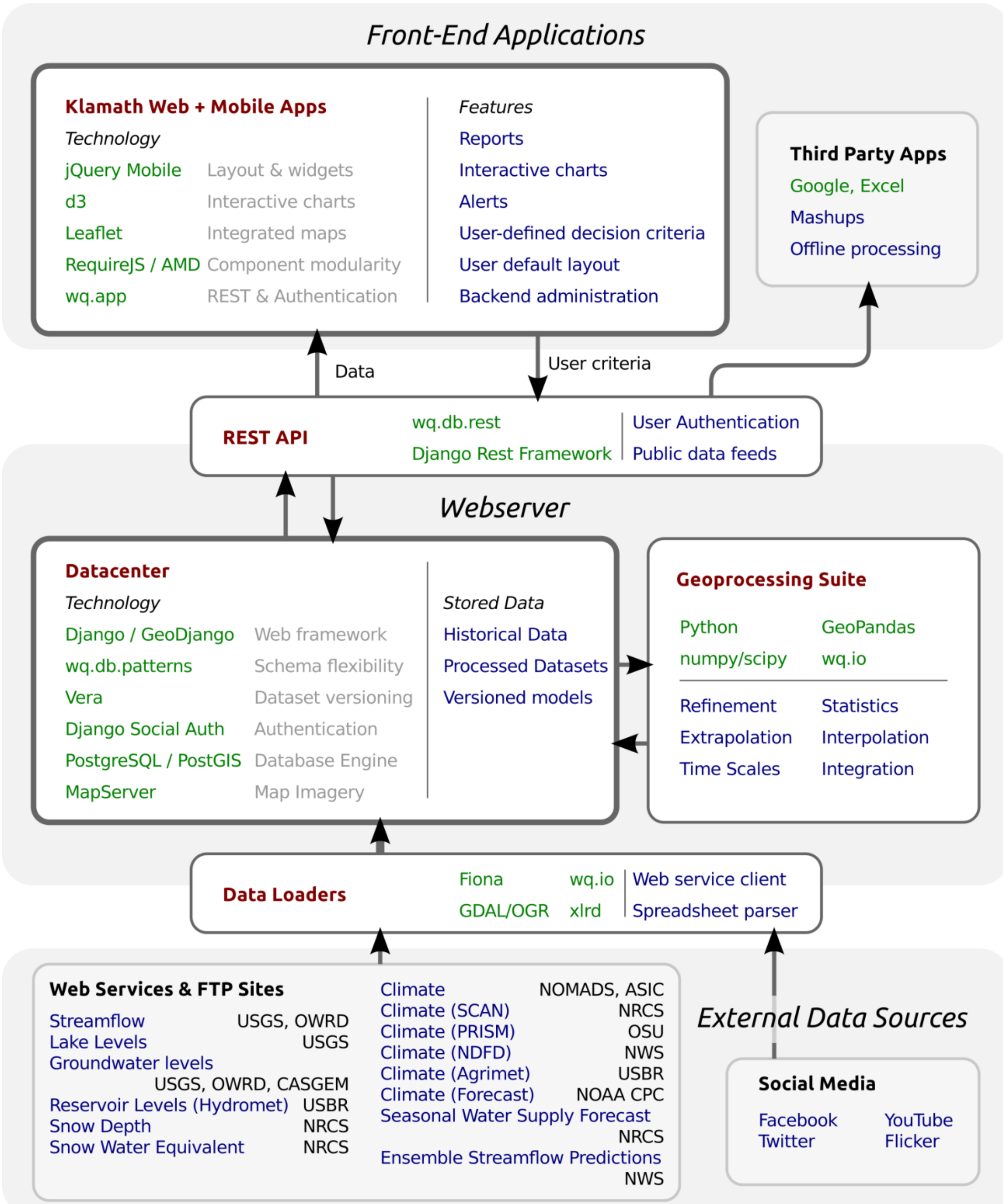
Wireframe Development

Describing and communicating the functionality of the front end applications for presenting the data can be achieved through wireframing. Wireframes are developed to present a visual and functional guide or "framework" for an application. The wireframe shows the "business processes" and is intended to communicate the idea or concept for accessing data. Wireframing shows the layout and functionality of the applications concept. Wireframes are created in advance of programming and show the:

- Type of data displayed;
- Range of functions available;
- Interrelationship between the data and functions;
- Means of displaying certain kinds of data; and
- Interaction with the application.

Wireframing for this research effort is the method used to show the interconnectedness among the resource issues being addressed by the Focus Groups, the data they need to address the issues, the means and methods for using the data and the specific criterion used to reach decisions. Wireframes for the front end application are shown in **Appendix G**.

Figure 10. Recommended technologies for robust web applications.



Application Development Probable Cost Range

As shown in **Figure 10**, our recommended technologies for the development of the application will leverage standard web technologies and widely used open source frameworks (to the extent possible), as well as more domain-specific capabilities provided by the "wq" framework (http://wq.io). Note that a particular emphasis is placed on modular, open source components. The goal is to ensure the widest possible reuse of each individual component, rather than to design a completely custom application stack that fulfills current project needs, but has limited reuse potential. We suggest that reusability is key to long-term sustainability as it opens up the possibility of distributing maintanence costs across several projects. Further, we suggest that small, single-purpose modular components are important for reusability, because:

- They are more straightforward to document, understand, and maintain, and
- Other projects may not be able or willling to utilize the entire application stack , and will instead want to pick-and-choose which components to incorporate.

As discussed above, there are three primary components that form the large-scale "modules" in the proposed technology stack. These are discussed in turn below.

Front-end applications

Our recommended platform for the front end software tools is a mobile-accessible HTML5 web application. While we anticipate that many initial users will use desktop computers to access the application, the number of tablet and smartphone users will likely overtake desktop users in the future. Thus, it is clear that the application should be built with a cross-platform solution that works on the widest possible range of devices.

With this in mind, we strongly advise against the use of browser plugins or native mobile application platforms, which are vendor-specific and inherently limit reusability across platforms. HTML5 provides all of the capabilities needed for this application, and is supported on essentially every major platform now and into the foreseeable future. Leveraging HTML5 also makes it possible to use a single programming language (JavaScript, together with HTML and CSS) rather than maintaining several parallel codebases in different languages.

With the current excitement around HTML5, it is not surprising that there are a growing number of competing JavaScript libraries for building front-end applications. We recommend jQuery Mobile, as it uniquely balances the need for mobile-friendly design with the importance of compatibility with standard web practices. Many other frameworks focus exclusively on mobile devices to the exclusion of older desktop browsers, and/or force the use of novel programming techniques that may not become part of the HTML5 standard in the future. Similarly, we recommend the use of d3.js for interactive charting as it is designed use with SVG, an HTML-like standard for representing scalable graphics. Other charting libraries render graphics using drawing commands that are unique to each library.

We recommend Leaflet for the embedded map components, largely because its small size and straightforward API make it relatively easy to integrate. To support the goal of long-term sustainability via modularity, we recommend leveraging RequireJS and the AMD standard for encapsulating the

JavaScript into re-usable components. Finally, we recommend wq.app, which brings all of the above together and adds a REST client for loading data from the server.

Of discussed technologies above, all are usable on currently used devices and browsers, with the exception of SVG, which is not available in Internet Explorer 8 and earlier. More investigation is needed to determine the relative importance of supporting the interactive charting capabilities for IE8 users, and/or providing an alternative in the form of "static" chart images.

Web server

We recommend the open source Apache webserver, together with MapServer for serving imagery data and recommend Python as the primary programming language for the web server and external data fetching components. Python is a natural choice for a number of reasons:

- There is a current and ongoing shift in the scientific computing community toward using Python for data analysis (c.f. http://scipy.org) that will significantly reduce the need for custom implementation of statistical functions.
- There exists a robust framework, Django, and related ecosystem of libraries that standardize many common webserver programming tasks (parsing input, generating output, etc.). In particular, the Django REST Framework and wq.db facilitate building robust REST websites and APIs.
- The Python language itself is very readable, which should make maintanence easier in the long term.

The Python components form a bridge between the database and the application. As far as the database platform, we suggest using PostgreSQL, an enterprise-quality open-source database engine with robust support for geographic data (PostGIS). PostgresSQL is increasingly the database of choice for Django projects in particular. Our proposed database structure is discussed in the next section.

External Data Sources

As discussed previously, there is need to incorporate data from a variety of external sources as part of regular operation. This "data fetch" part of the application is the most fragile and difficult to maintain, as it is dependent on the continuous and consistent operation of third-party web services. We suggest that this fragility can be mitigated in a number of ways:

- Storing most of the external and processed data in the local database to reduce the direct dependency on third-party servers.
- Standardizing the common aspects of data loading, so that only the "business logic" unique to each third-party web service needs to be maintained as technologies change.
- Maintaining the actual data loading code separately from the application, as a distinct standalone library (Climata) to maximize the reusability for other projects.
- Incorporating an administrative web interface that allows manual configuration of each data loader without additional programming effort.

We are aware of a number of related efforts to standardize and integrate data from a variety of sources, most notably WaterML and CUASHI. While compatibility with these standards will be explored, we suggest there are caveats that limit the applicability of these standards for this application. It is notable that few of the web services from which we suggest pulling data use these (or any) standards to represent the data. While this situation may improve in the future, we suggest that for the time being it is more important that the data loader technology can adapt to a variety of third party web services, rather than focusing only on standard formats.

As discussed above, there is a need to be able to track versions of reference datasets, especially when changes to the datasets will affect the output of forecasting models. In a typical version control system (such as that used to track software source code, or changes to Wikipedia), changes are usually identified by a date, a number, or an alphanumeric code. For example, an initial set of files is "revision 1". When the first change is made, the resulting set is "revision 2", and so on. Each revision is associated with a timestamp and the person making the change. Revisions can be compared with each other, with tools that highlight the specific changes to each revision.

While these versioning tools are useful, they require that any changes to data are explicitly registered when they are made. This usually means that the person changing the data needs to use specific software tools in order to ensure changes are registered. As noted above, we would like to avoid creating additional work for the agencies maintaining the source data. Thus, in order to accomplish versioning of third party data, we propose the use of the ERAV data model (see Sheppard et. al. 2014) which is built to handle versioning of data exchanged between multiple parties.

In addition to the capabilities for managing data versions, the ERAV data model is flexible enough to represent a wide variety of time series datasets. We envision the database structure for the Klamath application to follow the general layout shown in **Figure 11**. The structure is analagous to the Observations Data Model defined by CUAHSI, but adds explicit support for the ongoing integration and versioning of third-party data.

Costs, Maintenance and Funding

We estimate that the total cost to build an initial version of the application will be between $300,000 to $500,000, with an annual maintainance cost of $25,000 to $40,000. Rather then waiting until project completion for deployment, we suggest that open and ongoing prototyping, testing, and iteration will help ensure the application is useful to its target auidence. By leveraging the substantial effort that has been put into the various open source frameworks and libraries above, this cost is significantly lower than a proprietary, “from-scratch”, alternative would be. Ideally, the annual maintainance cost will lower somewhat as more of the components are reused and maintainence is shared between projects.

Data Retrieval, Storage, and Processing **$100,000**

- Database structure and metadata storage
- Scripts to load data from each third party web service
- Automated computation of statistics & indices
- Documentation

Front-end applications **$250,000**

- Interactive dashboard

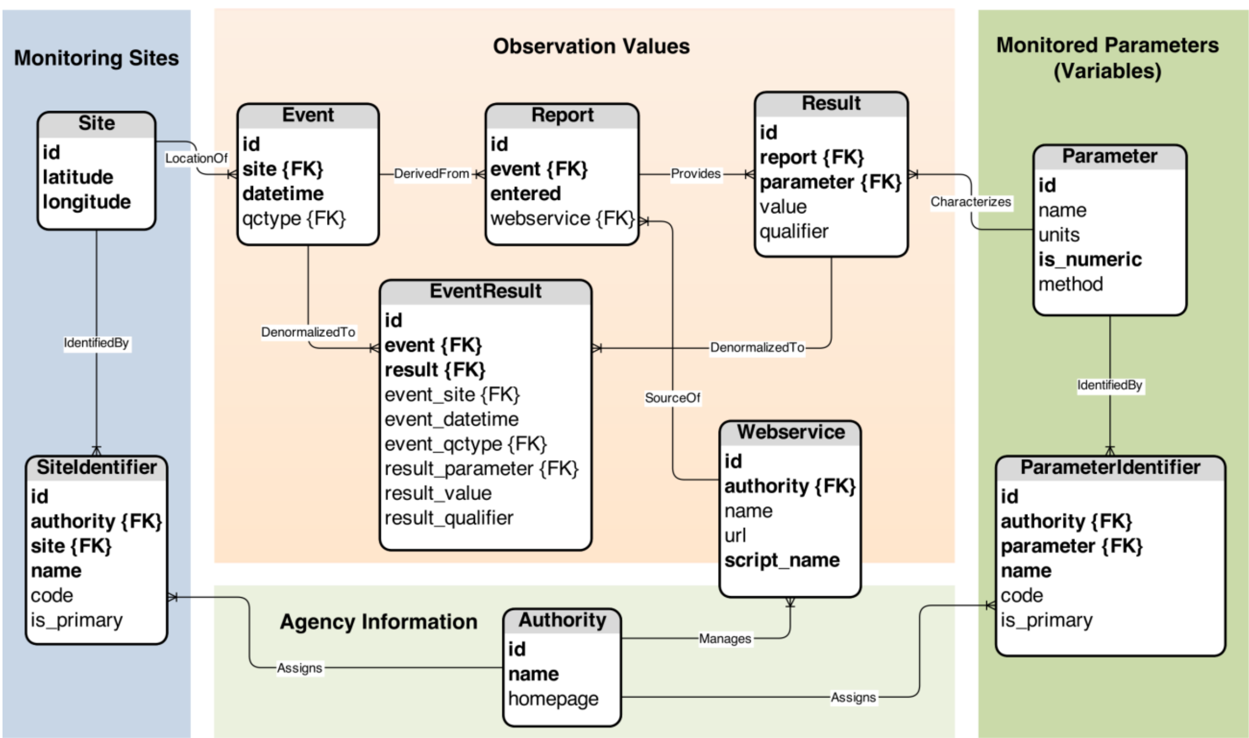
- Embeded map interfaces
- Standalone GIS map
- Advanced charts and data export
- User authentication and customization
- Documentation

Testing, Deployment, and Evaluation **$150,000**

- Prototyping, Testing and Revisions from feedback
- Experimental Evaluation (e.g. Usability Testing)
- Browser Compatibility (e.g. Internet Explorer 8)

Estimated Total **$500,000**

Figure 11. Simplified Database structure for the Klamath application.



RECOMMENDATIONS

Data users within the Klamath Basin and the western U.S. have a need for a diverse amount of data. The wireframes show a vision for developing a front-end application for providing these data to the user in a robust manner, founded upon this joint research effort. Developing a suite of robust technologies for harvesting climate and water related data from multiple sources and presenting those data in a consistent manner to the user has considerable benefit. These technologies could be developed and provided to the open source communities for use, as well as the federal agencies participating in this research project. We envison deployment of these technologies bot in Klamath, aws well as a second basin in order to promote reusability and sustainability.

Many of the data needs are unique to the Klamath Basin primarily because of the presence of the Klamath Project and existence of the Klamath Basin Restoration Agreement. Although the NRCS-NWSS and CNRFC are capable of providing the basic data necessary to meet the user's needs, providing data in a format necessary to meet the unique needs of the Basin is an unrealistic expectation. However, providing some of the basic data (e.g., streamflow discharge) in a different manner (as change in discharge between gages) increases value.

FOCUS GROUP PERSPECTIVES ON THE USER NEEDS REPORT AND CONCEPT WEB APPLICATION

A series of Focus Group meetings were completed on April 1 and 2, 2014 to present and receive comments on the draft User Needs Report. The meetings consisted of describing the types of comments and input sought by the researchers, a formal presentation of the preliminary research results, and discussion about preliminary research results and the value of the recommended application. Individual presentations were provided to:

- NOAA National Marine Fisheries, Arcata, California (April 1, 2014);
- Klamath Water and Power Authority (April 1, 2014);
- Tule Lake Irrigation District, Klamath Irrigation District, Klamath County Public Works Department, Oregon Department of Water Resources, Family Farm Alliance (April 2, 2014);
- Klamath County Board of Commission (April 2, 2014); and
- Bureau of Reclamation (April 3, 2014).

Because of a late scheduled meeting of the Klamath Basin Coordinating Council participants from each focus group were unable to participate.

Researchers opened each presentation describing the types of comments and input deemed useful in forming and finalizing the conclusions of the report. The types of comments and input deemed useful included:

- Are the decisions for your focus group which rely on the use of climate and water accurately described?

- Is the range of decisions identified for managing decision risk for your focus group real and practicable?
- Have the types of climate and water data and their temporal and spatial scales been accurately linked to your decisions and the specific criteria that cause a decision for action; and
- What is the relative value of the concept web application for presenting the water and climate data you need to assist with decision making?
- Is the value of the concept web application sufficient to warrant the use of the remaining grant dollars to begin application development? If so, which aspects of the application should proceed first?

A copy of the meeting agenda and presentation is included in **Appendix H.**

The focus group members generally agreed their decisions which relied upon climate and water data and the specific criteria causing action were properly described. Representatives from the Tule Lake Irrigation and Klamath Irrigation Districts recommended that the range of alternative decisions for agricultural producers include improved irrigation scheduling and therefore better water use efficiency because of the availability of climate and water data. Irrigation District representatives expressed an opinion that the real time availability of better information about the amount of precipitation, evaporation rates, the amount of the available water supply, and water supply demand (from crops, with irrigation recommendations) could potentially result in the use of reduced water amounts. Irrigation District representatives indicated the seasonal water supply forecasts issued by the NRCS-NWCC require some interpretation by them to improve relevance to the agricultural producer. Agricultural producers can struggle understanding the relationship between the forecast and the amount of water available on their farm. Products aimed at assisting producers schedule irrigation are needed.

Focus group participants universally represented a high value in the concept web application for presenting the water and climate data and expressed the desire to proceed with development. Based upon the information received from focus group participants and the amount of remaining grant dollars, focus group participants concurred with proceeding with two components of the concept web application: 1) a data loader applications interface to retrieve climate and water data (see **Figure 10**): 2) and the database (i.e., data center) to store the data retrieved (see **Figure 11**). The intent is to program these in a manner which can be distributed and used by a range of users as a desktop application.

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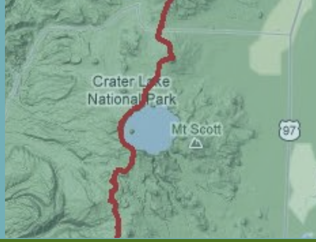
Appendix A



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Appendix B

- List of Questions
- Reason the Question is Important
- Actions Presented to Focus Group Participants

Focus Group Meeting Questions
Klamath NOAA Grant

The following are possible questions of routine interest to the focus groups. Specific types of information are to be identified to address each question during the concept design process.

1. General Users / Public
   a. **Question:** How much precipitation fell within the last day? Within the last three days? Within the last week? **Reasons and Actions**: Provide general information about the quantity of precipitation. The amount of precipitation is often of general interest. For the farmer the amount of precipitation is related to the need to irrigate crops and crop vigor. Expectations are the amount of precipitation will be used to communicate basin condition.
   b. **Question:** What is the amount of snowpack? Is the amount of snowpack increasing or declining? How much moisture is within the snowpack? **Reasons and Actions**: The amount of snow is directly related to the condition of the resource (e.g., ability to fill Upper Klamath Lake) and the amount of water available for irrigation. There is typically interest is whether the current amounts are "normal" and whether the melt rate is slower or faster than expected. Expectations are the information will be used to communicate basin condition.
   c. **Question:** What is the likelihood there will be adequate water within the basin this year to meet all of the needs? What are the odds of surplus water? What are the odds of a water shortage? **Reasons and Actions**: There is need to understand whether there is sufficient water in Upper Klamath Lake and the reservoirs (Clear Lake and Gerber), the snowpack and flowing in the streams compared to other years and normal. Other years may include those unusually dry or wet. Expectations are the information will be used to communicate basin condition.
   d. **Question:** What is the long term climate outlook? **Reasons and Actions**: The persistence of the current weather and the climatic conditions into the future is of general interest. The information is of value when considering the need for a drought declaration, as well as the probable amount of water required and available for irrigation and available within the rivers, UKL and basin reservoirs.
2. Klamath County
   a. **Question:** Is there a drought? What is the likelihood of drought? How long has the drought lasted? What does the future hold relative to drought? **Reasons and Actions**: Although different information is used by various entities to decide if a drought is occurring, a drought declaration is tied to many decisions. Under ORS 536.700 – 536.780 the County initiates through their Emergency Action Coordinator, a drought emergency declaration. Once declared drought relief can be provided through the Farm Service Agency as well special rules related to temporary water right transfers come into play. The ability to assess, demonstrate and declare drought at the subwatershed scale would be useful to the County.

The Klamath Basin Restoration Agreement (KBRA) also includes a provision for a drought plan. Water management actions are modified by drought and extreme drought conditions. The draft drought plan includes monitoring drought condition by a Technical Advisory Team. The designation of drought and extreme drought is tied to the forecast net UKL inflow.

b. **Question:** Are conditions likely to result in a flood or are flood conditions occurring? **Reasons and Actions**: The County is responsible for responding to flood conditions.

c. **Question:** Is there precipitation likely in the next few days? **Reasons and Actions**: The County is responsible for managing weeds. Spraying is used for weed control. The County can use this information to decide about whether to mobilize crews.

3. Fisheries & Natural Resource Manager & Klamath Tribe?

   a. **Question:** What is the current elevation of Upper Klamath Lake (UKL) and is the lake elevation rising, falling or constant? **Reasons and Actions**: The 2008 U.S. Fish and Wildlife Biological Opinion for UKL is tied to elevation. The Klamath Project 2012 Operation Plan and subsequent successor and related documents use and will likely continue to use these or similar elevations. The amount of water that is retained in the lake, flows into the Klamath River and to the Klamath Project for irrigation, is a function in part of these elevations. Reclamation's actions in terms of managing water are tied to these elevations. The 2012 Operation Plan indicated the historical demand for water for the April 1 through September 30 period is 350,000 kaf to 400,000 kaf. Specific actions include when to begin providing water for irrigation, the amount of water and whether reductions in the amount of water are needed.

   b. **Question:** What is the current flow rate at Iron Gate and is the flow rate increasing, declining or remaining the same? **Reasons and Actions**: The 2010 National Marine Fisheries Biological Opinion completed for the coho salmon requires specific minimum flows at Iron Gate. The Klamath Project 2012 Operation Plan and subsequent successor and related documents use and will likely continue to use these or similar elevations. The amount of water returned through the Klamath Straits drain affects these flows, as well as the amount of accretions and released from UKL.

   c. **Question:** At this moment, how much water is coming into UKL, being released from the lake through the A-Canal , into the Link River, arriving from the Lost River and flowing into the project, within storage in the Lost River Reservoirs (Clear Lake and Gerber) and being returned to the Klamath River from Klamath Straits Drain? What is expected to happen to these amounts of water in the future? Will the amounts increase, remain the same or decline? **Reasons and Actions**: A general understanding of the current and forecast (future) water volume, movement and distribution in the basin (including the Lost River) is needed for resource and irrigation management decisions. For example, the agencies (USFWS, NMFS, Reclamation) may (or may not) consider a short excursion beyond a biop criterion tolerable, if there is some certainty it will not persist. The specific actions affected are related to operation of the Klamath Project.

The Klamath Basin Restoration Agreement includes a requirement for development of an "On-Project Plan" which is currently being prepared by the Klamath Water and Power Agency (KWAPA). This plan will be used by KWAPA (and the irrigators, with direct effect upon the agricultural producers) to decide on the means of meeting surface water supply shortages, potentially including groundwater pumping, changing crop types, idling lands and similar means. The decisions of KWAPA as guided by Reclamation will likely be tied to the "allocation curve" which is based on the NRCS seasonal water supply forecasts. The KBRA also includes specific locations on the Klamath River called "Points of Diversion" where estimates of the amount of water provided to the Klamath Project are "limited" depending upon the amount of water available.

There are many potential actions associated with this question, including water delivery quantities in the basin, management of the ecological resource, and whether to pump and the amount of groundwater to pumped to supplement surface water supplies.

d. **Question:** What is the probable demand for water and specifically agricultural demand in the coming months? Do the coming months look like they will be warmer and dryer (or cooler and wetter) than normal and therefore the probable agricultural demand will be greater (or lower) than expected? **Reasons and Actions**: The reasons are related to the amount of water available in the basin. Reclamation uses various assumptions related to agricultural demand to forecast the future hydrologic condition for managing water. Information about current weather and future climate that affect the amount of evapotranspiration is useful.
e. **Question:** What are flows along the Klamath River (and other natural river systems)? **Reasons and Actions**: There are many ecological and resource quality issues and concerns related to river flow. These tend to be more "qualitative" in nature, but the trend is toward increasing quantification of the criteria. For example, the amount of sediment and geomorphic stability of a river is related to the dominant discharge, generally considered as the $Q_{1.5}$. Periodic flooding of the riparian area along a river is needed to sustain lateral connectivity and the flow of energy between the landscape and the river. The area inundated by the Q_{10} is sometimes used for assessing connectivity. Periodic flooding of the riparian area sustains wetland communities.
f. **Question:** Are low flow or climate conditions expected that would result in high water surface temperature and low dissolved oxygen levels in the Klamath and Lost Rivers? Are the current or future climate conditions and flow similar to when problems typically occur relative to water quality. **Reasons and Actions**: The amount of solar radiation, surface air temperature, wind speed and flow rates affect surface water temperature, and therefore the oxygen holding capacity of water. The wind speed affects the mixing characteristics of UKL. This information could be useful for describing and forecasting conditions when water quality problems and the exceedance of water quality standards occur.
g. **Question**: Many of the general questions from above will be of interest to this group.

4. Agricultural Producer & Agriculture Extension
    a. **Question:** Those of the other groups apply to this group.
    b. **Question:** What is the current general condition of crops across the area; i.e., are they stressed (or not) due to the amount of moisture. **Reasons and Actions**: This information is useful to the agricultural producer to understand current crop conditions. This information could also be useful to a variety of users, including the County (when considering the need for a drought disaster declaration), the Farm Services Agency (when considering decisions about crop insurance), to the Extension Service (on the need for communication with producers) and Dept. of Water Resources. The information may be used in drought related designations.
    c. **Question:** What is the soil moisture condition? **Reasons and Actions**: This information is useful to the agricultural producer and extension service to understand current soil moisture condition at the landscape scale (not on a specific field). The information about current and future soils moisture could be related to decisions by an agricultural producer to apply water.
5. Klamath Water And Power Authority / Reclamation / Irrigation Districts
    a. **Question:** To what extent will the Water User Mitigation Program (WUMP) and / or the actions in the (future) On Project Plan be needed in the coming year? What is the estimated amount of water that needs to be realized by the WUMP? **Reasons and Actions**: The WUMP is a program operated by KWAPA with involvement from Reclamation to address the shortage in surface water for agricultural production. The program also affects the amount and distribution of water available in the Basin. The use of water by the project is tied Reclamations Operation Plan and in the future to an "allocation curve" within the KBRA (as well as the seasonal water supply forecast of the NRCS). As the available supply diminishes the amount available for irrigation declines to a minimum value in accordance with the allocation curve. Actions taken by KWAPA are currently related to the WUMP program; e.g., asking for signups for groundwater pumping and paying for groundwater, how much groundwater to pump (subject to water rights and other limitations), whether to ask for land idling, how much land to idle, and describing and document the quantity of water saved (and left in the Klamath River).
    b. **Question:** How much water is "saved" by the demand management (i.e., land idling) aspect of the WUMP? In what portions of the On Project Plan Area will the water be "realized." **Reasons and Actions**: Some estimate of the amount of water saved is helpful for demonstrating fiscal accountability. The ability to document water saved and reduced diversion of surface water from the Klamath River System is a component of the KBRA. Actions may include making adjustments to the various KWAPA administered programs.
    c. **Question:** How much groundwater is needed through the Groundwater Pumping Program of the WUMP to supplement surface water supplies? ? In what portions of the

On Project Plan Area will the water be "realized." **Reasons and Actions**: Some estimate of the amount of water provided is helpful for demonstrating fiscal accountability. The ability to document the amount of water pumped and reduced diversion of surface water from the Klamath River System is a component of the KBRA. Actions may include making adjustments to the various KWAPA administered programs.

d. **Question:** How much water is expected to be available to the On Project Plan Area?
   i. What is the current elevation of Klamath Lake and is the lake elevation trend rising, falling or constant? How does the current lake level compare to the action levels identified within the BiOP?
   ii. What is the current flow rate at Iron Gate and is the flow rate trend increasing or declining? How does the current flow rate compare to the action levels identified within the BiOP?
   iii. At this moment, how much water is coming into the lake, being released from the lake and being returned to the Klamath River from Straits Drain.
   iv. How much water is there in the snowpack / fell as rain over the basin during the last week. Is there enough moisture to keep the lake level up?
   v. How much water is being released from the lake now and is there a sense of the agricultural demand in the next month.
   vi. From a long term perspective (say 90 days) what is the chance that the lake level will fall below the BiOP or enough water won't be delivered downstream on the Klamath River.
   vii. How much water is in storage on the east side in Clear Lake and Gerber Reservoirs?

   Reasons and Actions: Many of these are described in previous portions of this document.

e. **Question:** What are the current groundwater levels and probable near-term future trends in level within the On Project Plan Area? **Reasons and Actions**: There are regulatory limitations on the amount of ground water which can be used. Decisions about whether more ground water can be used to supplement surface water needs are likely. The weather and climate influence on agricultural demand is useful information.

f. **Question:** Those of the other groups apply to this group related to agricultural crop demand and water needs.

6. Lower Klamath Wildlife Refuge
   a. **Question:** Those of previous groups apply to this group. However, this information needs to be at a finer spatial scale, specific to the refuge. For example, related to a water balance for the refuge. This might include the amount of water being delivered from the Tule Lake Sumps and returned to the Klamath River via Klamath Straits Drain.
   b. **Question:** What is the estimated evapotranspiration rate from the wetland area? **Reasons and Actions**: The influence of weather and climate on evapotranspiration rates is related to the USFWS's need to provide water to maintain wetland water levels within refuge wetlands.

Appendix C

Alert Categories, Description, Data Type, and Criterion

Alert Categories, Description, Data Type and Criterion

Category	Description	Type	Data		Criterion			Reference
			Time Scale	Spatial Scale / Locations	Description	Value	Units	
Water Supply Availability								
	Volume allocated to irrigation supply within the Klamath Project	Surface water volume	March through October	Upper Klamath Lake Inflow (Net)	April 1 – September 30 volume forecast by the NRCS-NWCC for their forecast issued on March 1	Forecast volume If <= 287,000 then 387,000 If > 287,000 but less than 569000 then 378 + {42.64 x [(Forecast Volume – 287)/282}*1000 If > 569,000 then 445,000	Acre-feet	
			November through February		Seasonal volume	45,000	Acre-feet	
	Volume allocated to the Lower Klamath Wildlife Refuge	Surface water volume	March through October;	Upper Klamath Lake Inflow (Net)	April 1 – September 30 volume forecast by the NRCS-NWCC for their forecast issued on March 1	If <= 287,000 then 48,000 If > 287,000 but less than 569000 then 48 + {7.64 x [(Forecast Volume – 287)/282}*1000 If > 569,000 then 60,000	Acre-feet	
			November through February		Seasonal volume	35,000	Acre-feet (values given are in 1000 acre-feet)	
Water Supply Demand								
	Historic estimated agricultural demand (from Reclamation Modsum model)	Surface water volume	April through October	A Canal	Seasonal volume	61% of annual demand based on historic annual supply as follows: 408.2 (1981); 354.9 (1982); 358.4 (1983); 386.0 (1984); 423.2 (1985); 424.4 (1986); 444.8 (1987); 452.9 (1988); 407.4 (1989); 442.7 (1990); 440.1 (1991); 391.9 (1992); 365.5 (1993); 426.6 (1994); 356.5 (1995); 399.4	Acre-feet (values given are in 1000 acre-feet)	

Alert Categories, Description, Data Type and Criterion

						(1996); 423.9 (1997); 362.3 (1998); 447.8 (1999); 446.0 (2000); 422.3 (2001); 477.1 (2002); 404.2 (2003); 4605. (2004); 424.8 (2005); 410.1 (2006); 452.7 (2007); 401.4 (2008); 389.7 (2009); 380.7 (2010); 367.4 (2012)		
			April through October	Station 48 and Miller Hill	Seasonal volume	22% of annual demand based on historic annual supply; use numbers above	Acre-feet (values given are in 1000 acre-feet)	
			March through September	North Canal	Seasonal volume	6% of annual demand based on historic annual supply; use numbers above	Acre-feet (values given are in 1000 acre-feet)	
			March through September	Ady Canal	Seasonal volume	11% of annual demand based on historic annual supply; use numbers above	Acre-feet (values given are in 1000 acre-feet)	
	Volume at Klamath Basin Restoration Agreement Points of Diversion	Surface Water Volume	March through October	Points of diversion locations	Volume from March 1 through October 31	Actual cumulative volume from all points of diversion compared to volume allocated to agriculture (above)	Acre-feet (values given are in 1000 acre-feet)	
			November through February		Volume from November 1 through February 28	Actual cumulative volume from all points of diversion compared to volume allocated to agriculture (above)	Acre-feet (values given are in 1000 acre-feet)	
	Volume delivered to Lower Klamath Lake Wildlife Refuge from the Klamath Project	Surface Water Volume	March through October	Pumping Plant D	Volume from March 1 through October 31	Actual cumulative volume from pumping plant compared to volume allocated to agriculture (above)	Acre-feet (values given are in 1000 acre-feet)	
			November through February	Pumping Plant D	Volume from November 1 through February 28	Actual cumulative volume from pumping plant compared to volume allocated to agriculture (above)		

Alert Categories, Description, Data Type and Criterion

Lake and Reservoir Levels and volumes								
	Maximum temporary flood level	Elevation	Monthly	Upper Klamath Lake	Threshold elevation on last day of month (operationally use average daily)	Variable depending upon April through September 50% Seasonal Water Supply Forecast volume (issued that month) Drier Conditions defined as forecast < = 710,000 acre feet October (4141.40) November (4141.60) December (4141.80) January (4142.30) February (4142.70) March (4143.10) April (4143.30) Wetter Condition defined as forecast > 710,000 acre feet October (4141.40) November (4141.60) December (4141.80) January (4142.00) February (4142.40) March (4142.80) April (4143.30)	Reclamation datum = 1.78 + 1929 NGVD	
		Elevation	Annual	Clear Lake Reservoir	Maximum instantaneous (operationally use average daily)	4543.0	Reclamation datum = 1.78 + 1929 NGVD	
		Elevation	Annual	Gerber Reservoir	Maximum instantaneous (operationally use average daily)	4835.4	Reclamation datum = 1.78 + 1929 NGVD	
		Elevation	Annual	Wilson Reservoir	Maximum instantaneous (operationally use average daily)	None given	Reclamation datum = 1.78 + 1929 NGVD	

Alert Categories, Description, Data Type and Criterion

	Operating Level	Elevation	Daily	Upper Klamath Lake	Maximum instantaneous (operationally use average daily)	Complicated formula	Reclamation datum = 1.78 + 1929 NGVD	
		Elevation	March 2 – September 30	Clear Lake Reservoir	Maximum instantaneous (operationally use average daily)	4537.4 ; end of September minimum value of 4520.6	Reclamation datum = 1.78 + 1929 NGVD	
		Elevation	March 2 – September 30	Gerber Reservoir	Maximum instantaneous (operationally use average daily)	4836.0; end of September minimum value of 4798.1	Reclamation datum = 1.78 + 1929 NGVD	
		Elevation	March 2 – September 30	Wilson Reservoir	Maximum instantaneous (operationally use average daily)	None given	Reclamation datum = 1.78 + 1929 NGVD	
	User defined level	Elevation	Specify	Specify from pull down menu	Specify from pull down menu	User entered	Specify from pull down menu as 1988; 1929; Reclamation	
	Environmental Carry over volume	Water volume	Daily	Link River stations	Link river release – Ady Canal Diversion – North Canal Diversion – Lost River Diversion	Computed value	Cubic feet per second	
	Upper Klamath Lake Fill Rate	Elevation change	November 15 to April 30	Upper Klamath Lake	Difference between the actual fill rate of UKL compared to the average fill rate to reach elevation 4142.80 on March one	<= -0.02 0 > 0.03 Wet	Feet per day	
Streamflow								
	Minimum spring and summer flows for Coho Salmon and fishery resource	Streamflow discharge	March through September	Iron Gate Dam	Average daily minimum	March (1000); April (1325); May (1175); June (1025); July (900); August (900); September (1000)	Cubic feet per second	
			October and November	Iron Gate Dam	Average daily minimum	1000	Cubic feet per second	
			December, January and February	Iron Gate Dam	Average daily minimum	950	Cubic feet per second	
	Maximum spring and summer flows for Coho Salmon and fishery resource	Streamflow discharge	July, August and September	Iron Gate Dam	Average daily maximum	Value depends upon environmental water amount (EWA): EWA Volume <= 320,000: July	Cubic feet per second	

Alert Categories, Description, Data Type and Criterion

						(1000); August (1050); September (1100) EWA Volume > 320,000 but less than 1,500,000; July (1500); August (1250); September (1350) EWA Volume > 1,500,000; July (1500); August (1250); September (1350)		
	Williamson River streamflow	Streamflow discharge	Daily	Williamson River (gage)	Average daily discharge	None	Cubic feet per second	
	Proportion of previous days Williamson River average daily discharge targeted for release from link river dam	Streamflow discharge	Daily	Williamson River (gage)	Average Daily DIscharge	Varies by month; linear interpolation between values given October < 500 (1) 650 (1.25) 1000 (2.0) >=4000 (2.3) November < 500 (1) 1173 (1.25) 3192 (2.0) >=4000 (2.3) December, January, February <450 (0.85) 800 (0.9) 1000 (1.5) 2000 (1.9) >=4000 (2.3)	Proportion of previous days flow targeted for release from link river dam	
	Volume accretions below Link River Dam	Streamflow discharge	Daily	Link River Dam and Iron Gate Dam	Iron Gate Dam monthly, daily average discharge – Link River Dam, monthly daily average discharge	Varies by month; linear interpolation between values given	Proportion of previous days flow	

Alert Categories, Description, Data Type and Criterion

						October -58 (1.2) 198 (1.2) 397 (1) 501 (1) > = 585 (0.4) November 43 (1.2) 163 (1.2) 377 (1) 494 (1) > = 566 (0.4) December 60 (1.2) 171 (1.2) 342 (1) > = 415 (0) January 140 (1) 258 (1) 410 (1) > = 473 (0) February 303 (1) 354 (1) 525 (1) > = 589 (0)	targeted for release from link river dam	
	Link River Dam Release Target	Streamflow discharge	Daily	Link River Dam	Flow rate release from Link River dam	Computed	Cubic feet per second	
	User defined stage alert (low)	Elevation	Specify from pull down menu; set default 90% exceedance elevation	Specify from pull down menu	User entered	User entered	Specify from pull down menu as 1988; 1929; Reclamation	

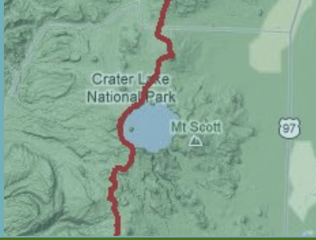
Alert Categories, Description, Data Type and Criterion

	User defined stage alert (high)	Elevation	Specify from pull down menu; set default to 100 year flood	Specify from pull down menu	User entered	User entered	Specify from pull down menu as 1988; 1929; Reclamation	
	User defined streamflow alert (low)	Streamflow discharge	Specify from pull down menu; set default 90% exceedance elevation	Specify from pull down menu	User entered	User entered	Cubic feet per second	
	User defined streamflow alert (high)	Streamflow discharge	Specify from pull down menu; set default to 100 year flood	Specify from pull down menu	User entered	User entered	Cubic feet per second	
	Ecological important discharge	Streamflow discharge	2-year return period and 10-year return period events	Specify from pull down menu	Specify from pull down menu	User entered	Cubic feet per second	
	User defined streamflow accretion (low)	Streamflow discharge	Specify from pull down menu; set default 90% exceedance elevation	Specify from pull down menu	User entered	User entered	Cubic feet per second	
	User defined streamflow acreetion(high)	Streamflow discharge	Specify from pull down menu; set default to 100 year flood	Specify from pull down menu	User entered	User entered	Cubic feet per second	
Groundwater								
	User defined groundwater elevation (low)	Elevation	Specify from pull down menu; set default 90% exceedance elevation	Specify from pull down menu	User entered	User entered	Cubic feet per second	
	User defined groundwater elevation (high)	Elevation	Specify from pull down menu; set default 10%	Specify from pull down menu	User entered	User entered	Cubic feet per second	

Alert Categories, Description, Data Type and Criterion

			exceedance elevation					
Agricultural								
	Number of growing degree days	Days	Daily	Specify from pull down menu	User entered	User entered	days	
	User defined soil moisture (low)	Moisture content	Specify from pull down menu; set default 90% exceedance elevation	Specify from pull down menu	User entered	User entered	millimeters	
	User defined soil moisture (high)	Moisture content	Specify from pull down menu; set default 10% exceedance elevation	Specify from pull down menu	User entered	User entered	millimeters	
Indices								
	Upper Klamath Lake Index	Volume	September 1 to current day	Upper Klamath Lake inflow	Upper Klamath Lake cumulative inflow September 1 through current day minus one day divided by period of record maximum cumulative net inflow since September1 through current day minus one day. The resulting value is scaled between zero and one.	Dry conditions index value < 0.3	dimensionle ss	
	KWAPA WUMP Index	Daily precipitation and snow water equivalent	Water Year	Annie Springs, Sun Pass, Sevenmile Marsh, Taylor Butte, Crazyman Flat, Cold Springs Camp, Fourmile Lake, Billie Creek Divide, Swan Lake Mountain, Quartz Mountain, Gerber Reservoir, Strawberry and Crowder Flats.	Year to date precipitation depth compared to average and year to date snow water equivalent compared to median for Annie Springs, Sun Pass, Sevenmile Marsh, Taylor Butte, Crazyman Flat, Cold Springs Camp, Fourmile Lake, Billie Creek Divide, Swan Lake Mountain, Quartz Mountain, Gerber Reservoir, Strawberry and Crowder Flats.	Average daily value for all locations cumulative since November 1	inches	

Appendix D



Decision Timelines

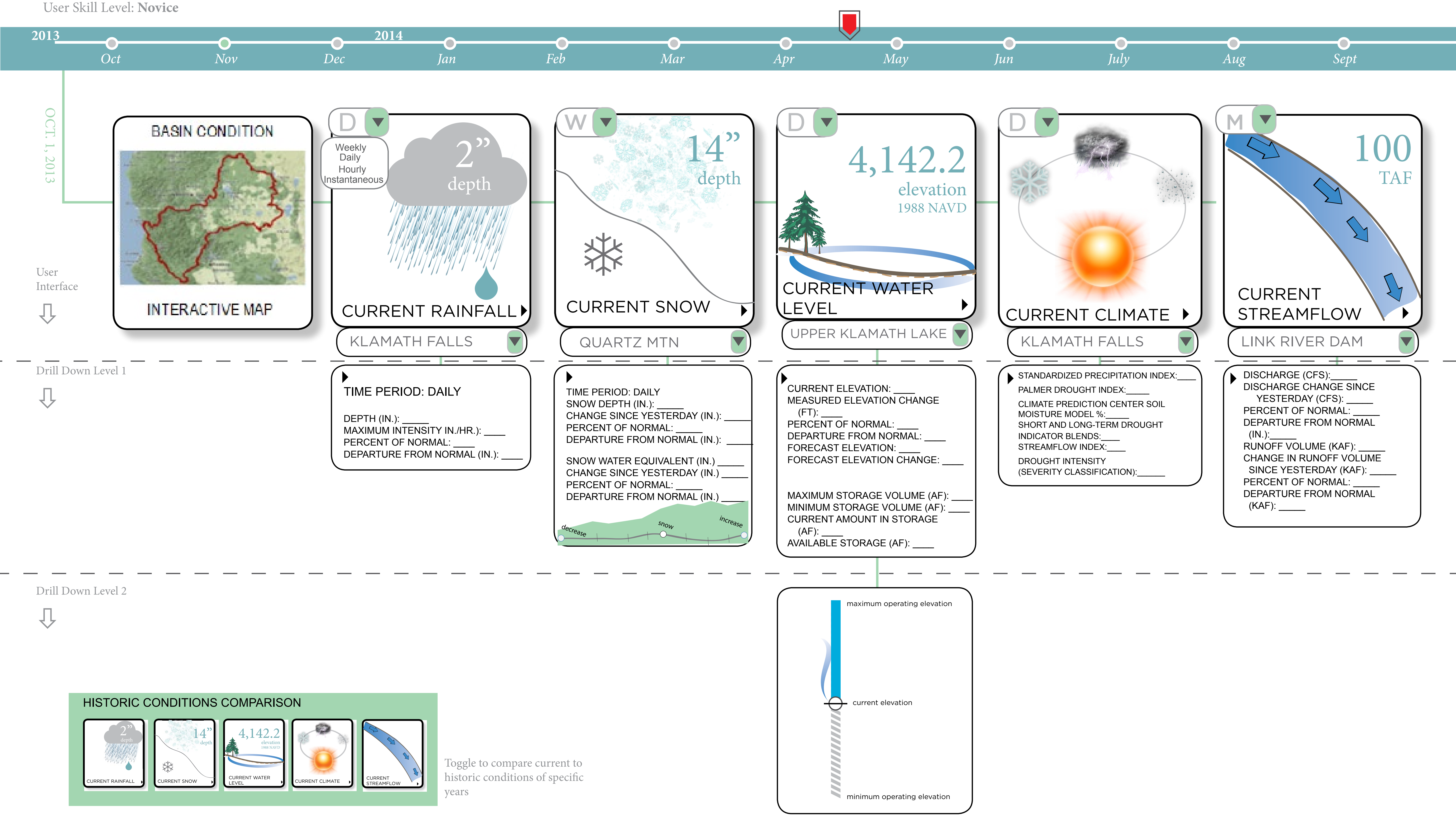
General User

Purpose: Obtain general information about climate and water-related information in the basin.
User Skill Level: **Novice**

Decision(s): The decisions for this user are expected to be related to performing daily activities and gaining general information about conditions within the basin.

Information needs: As shown in the data pods below.

Today's Date: 10/1/2013
Station Location:



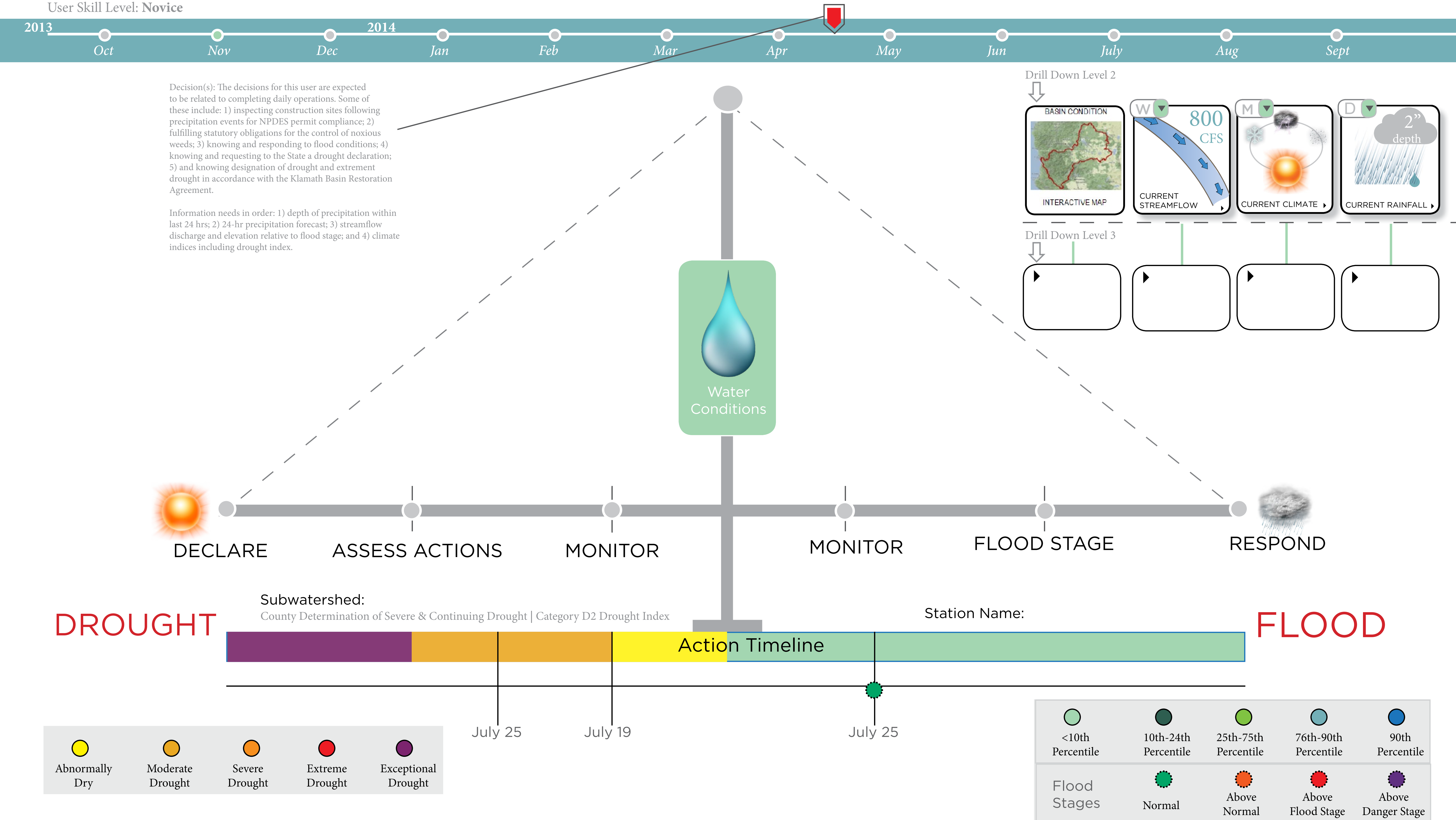
Klamath County

Today's Date: 10/1/2013
Station Location:

Purpose: Provide information for drought declarations, flood response, daily county operations (road construction and noxious weed control) and general water supply availability
User Skill Level: **Novice**

Decision(s): The decisions for this user are expected to be related to completing daily operations. Some of these include: 1) inspecting construction sites following precipitation events for NPDES permit compliance; 2) fulfilling statutory obligations for the control of noxious weeds; 3) knowing and responding to flood conditions; 4) knowing and requesting to the State a drought declaration; 5) and knowing designation of drought and extrement drought in accordance with the Klamath Basin Restoration Agreement.

Information needs in order: 1) depth of precipitation within last 24 hrs; 2) 24-hr precipitation forecast; 3) streamflow discharge and elevation relative to flood stage; and 4) climate indices including drought index.



Fisheries & Natural Resource Manager & Klamath Tribe

Purpose: Evaluate current and forecast conditions with regard to the existing biological opinions and the quality of ecosystem services.

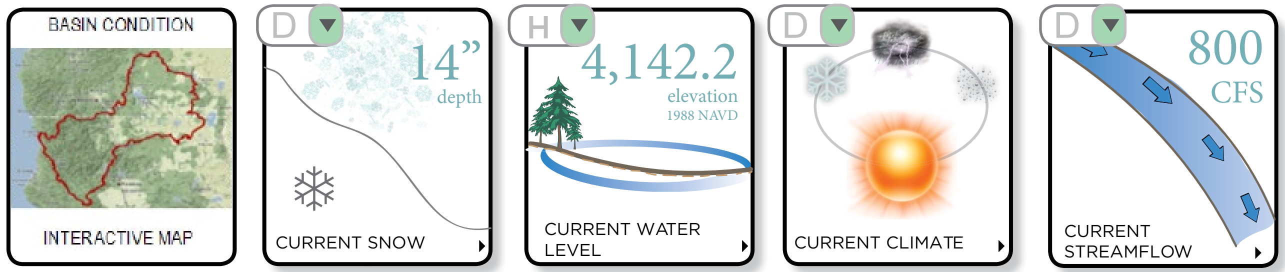
User skill level: **Intermediate**

Decision(s): The decisions for this user are expected to be related to whether current water levels, flows, and volumes are presently sufficient or forecast to be sufficient for providing ecological functions and services, largely expressed by specific criteria identified by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service in their joint Biological Opinion.

Information needs: 1. Storage volumes in UKL, Clear Lake and Gerber Reservoirs (see current water level pod on p.1)
2. Current release rate from Link River Dam, A-canal, Gerber Reservoir and Clear Lake
3. Estimated UKL inflow volume (today, cumulative water year) estimated from Williamson below Sprague gage
4. Most recent NRCS seasonal water supply 50% forecast (Mar - September, but the months will change)
5. Flows
6. Cumulative volumes for points of diversion

Today's Date: 10/1/2013
Station Location:

2013 Oct Nov Dec 2014 Jan Feb Mar Apr May Jun July Aug Sept



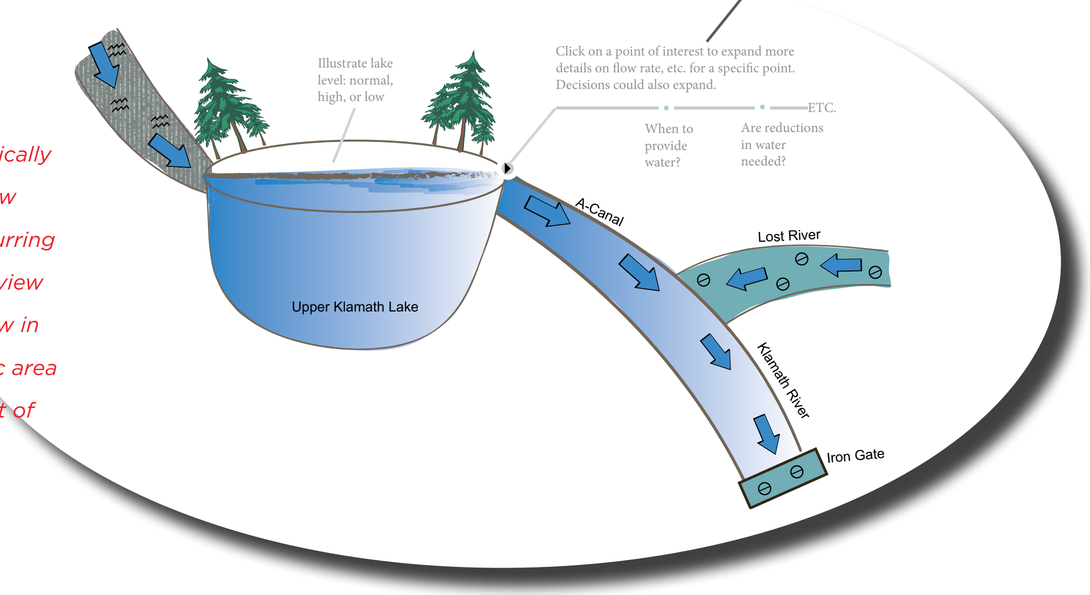
Drill Down Level 2

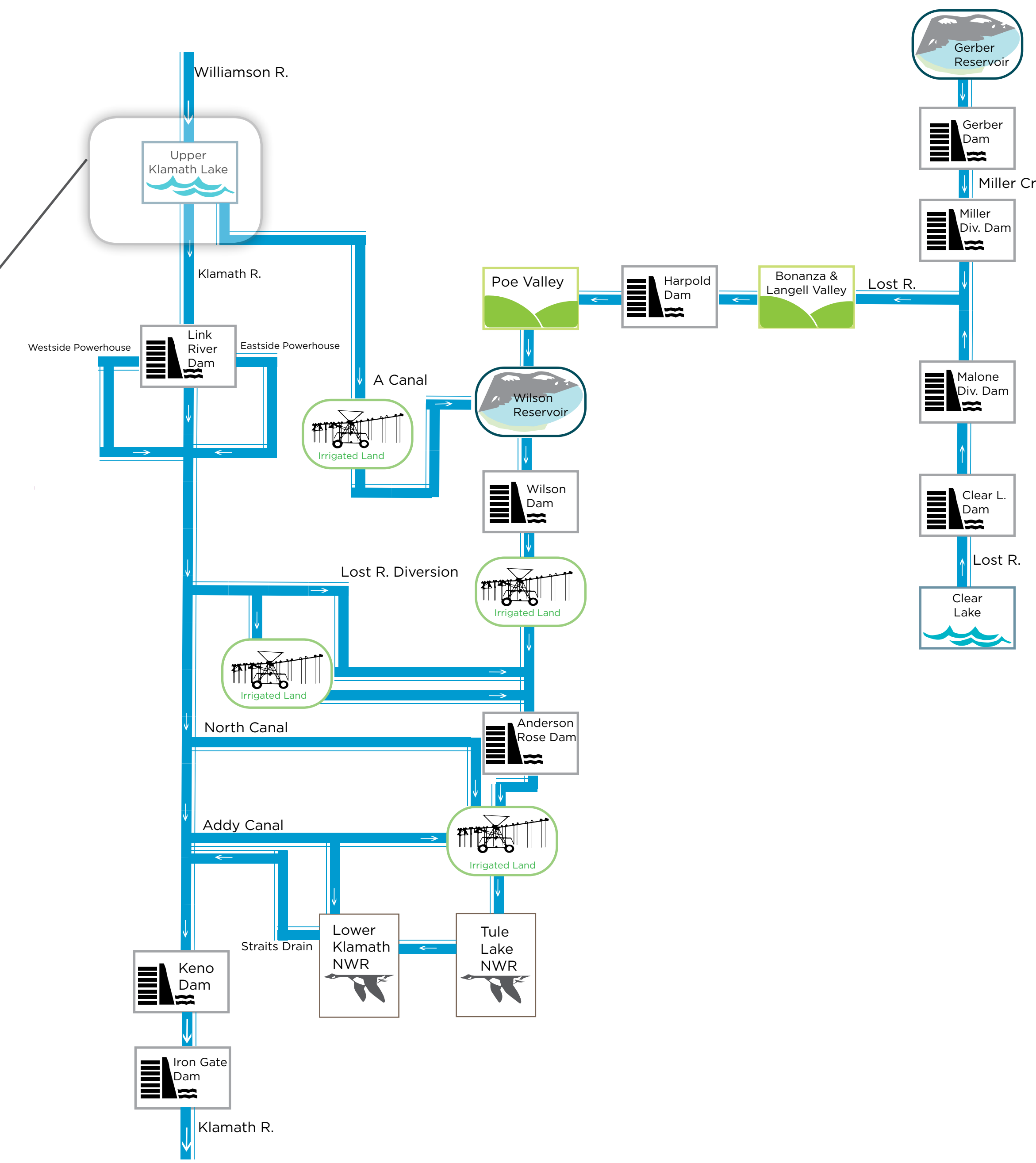
TIME PERIOD: DAILY
DEPTH (IN.): ____
MAXIMUM INTENSITY IN./HR.): ____
PERCENT OF NORMAL: ____
DEPARTURE FROM NORMAL (IN.): ____

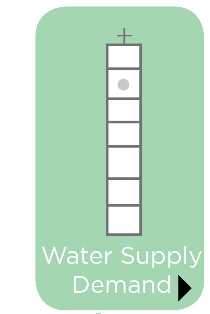
HISTORIC: 1999
DEPTH (IN.): ____
MAXIMUM INTENSITY IN./HR.): ____
PERCENT OF NORMAL: ____
DEPARTURE FROM NORMAL (IN.): ____

User Interface

Note: This timeline would graphically illustrate all areas of interest, how they're related, and what is occurring throughout the basin. User can view the "big picture", but also narrow in on more details for their specific area of interest by clicking their point of interest.







AVERAGE MONTHLY PROJECT DEMAND (KAF): ____
AVERAGE WATER YEAR CUMULATIVE PROJECT DEMAND (KAF): ____
CURRENT MONTH KBRA POINTS OF DIVERSION VOLUME (KAF): ____
IRRIGATION SEASON KBRA POINTS OF DIVERSION VOLUME (KAF): ____
WINTER SEASON KBRA POINTS OF DIVERSION VOLUME (KAF): ____
CURRENT MONTH REFUGE VOLUME (KAF): ____
REFUGE IRRIGATION SEASON VOLUME (KAF): ____
REFUGE WINTER SEASON VOLUME (KAF): ____

Pattern in the river graphic would indicate flow trend:

= Flow Rate Increasing = Flow Rate Constant = Flow Rate Decreasing

Agricultural Producer

Purpose: Provide information to the agricultural producer about recent weather conditions and current crop and vegetation conditions in the Basin.
User skill level: **Novice**

Decision(s): The decisions for this user are expected to be related to those made by an agriculture producer with a primary crop type of potatoes.
Decisions include:

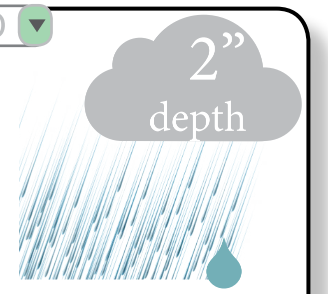
- What crops to plant
- Proportion of acreage allocated to each crop (When to apply water to assure yield)
- Winter application to saturate soil pre-planting during crop growth
- Weather conditions affecting farm operation including the application of herbicides, pesticide and fungicides

Information needs: 1) current precipitation; 2) probable water supply availability; 3) soil moisture and indices related to dryness and need for irrigation; 4) current flows in the irrigation system; 5) plant / crop vigor; 6) extent and severity of dry (drought) conditions; 7) forecast precipitation

Today's Date: 10/1/2013
Station Location:

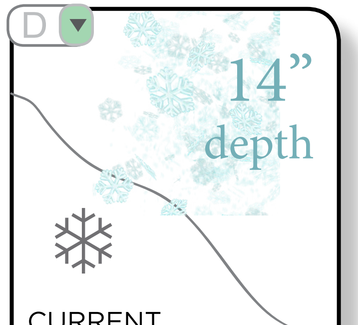
2013 Oct Nov Dec 2014 Jan Feb Mar Apr May Jun July Aug Sept

D

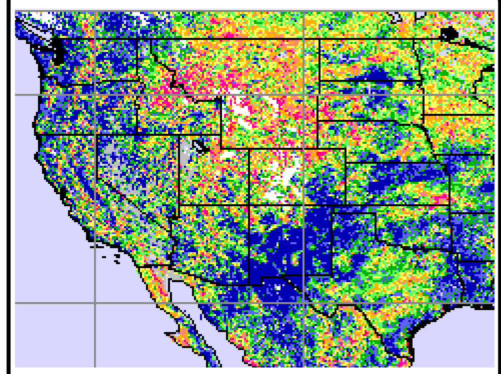


CURRENT RAINFALL

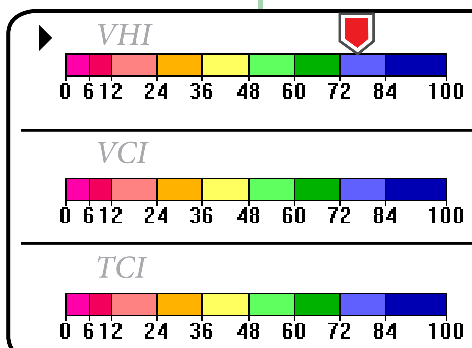
D

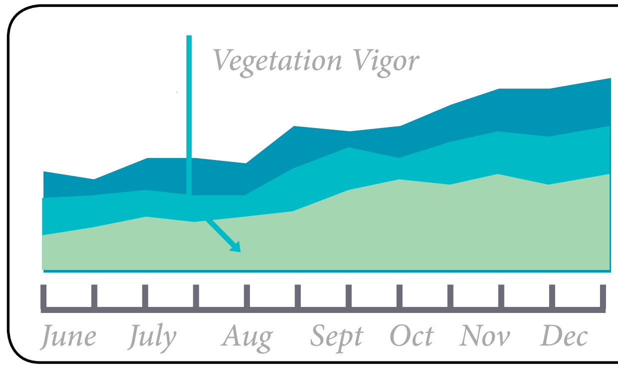


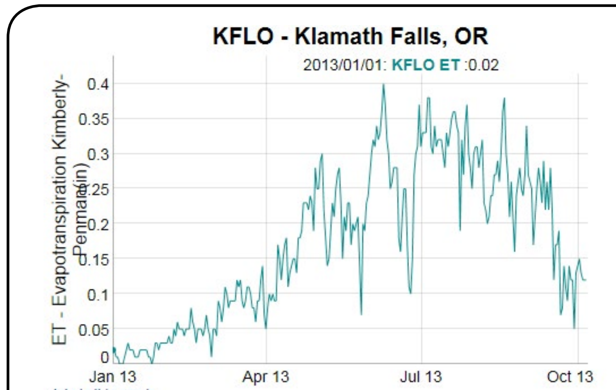
CURRENT SNOW



VEGETATION HEALTH



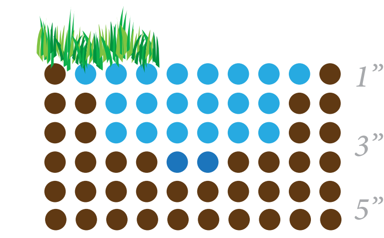




GROWING DEGREE DAYS

Temperature 92°

Y

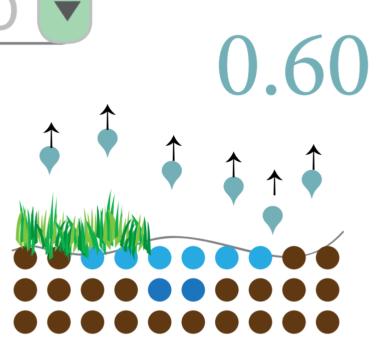


CURRENT SOIL MOISTURE

KLAMATH FALLS

Current Soil Temperature 105°

D

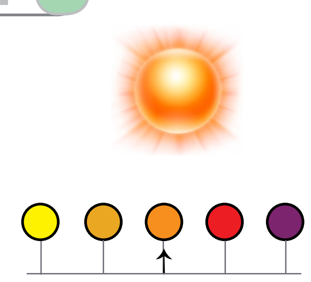


EVAPOTRANSPIRATION RATE

KLAMATH FALLS

AVERAGE MONTHLY ET KFLO:
1.07

Y



DROUGHT

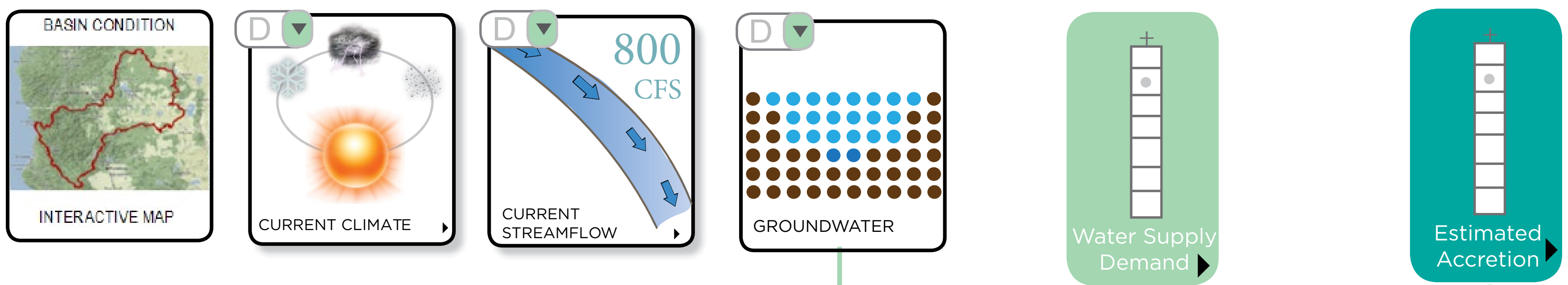
KLAMATH FALLS

Water Users and Suppliers

Today's Date: 10/1/2013
Station Location:

Purpose: Provide information about current and forecast water supplies and climate conditions affecting water supplies.
User skill level: **High**

2013 Oct | Nov | Dec | 2014 Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sept



Decision(s): The decisions for this user are expected to be related to operation of the Klamath Project, the supply of water available for the irrigation crops, and the need for water use mitigation programs within the Klamath Project: 1) the release of water from the various reservoirs;

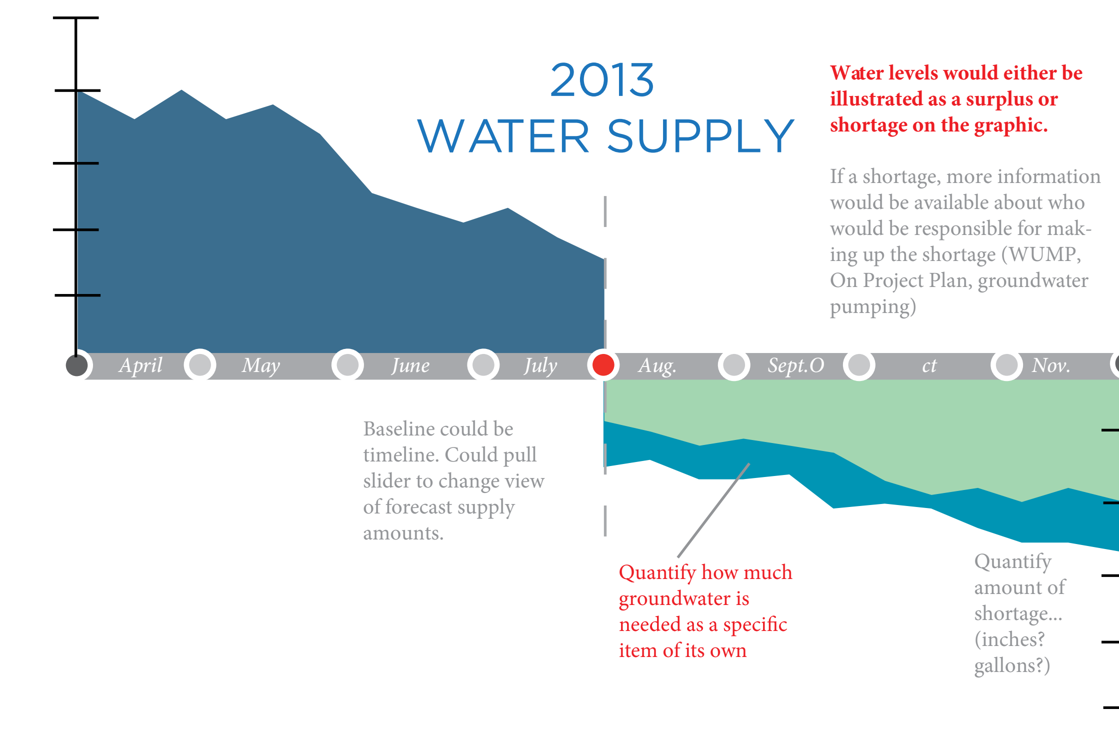
Information needs: 1) current precipitation; 2) probable water supply availability; 3) soil moisture and indices related to dryness and need for irrigation; 4) current flows in the irrigation system; 5) plant / crop vigor; 6) extent and severity of dry (drought) conditions; 7) forecast precipitation

CURRENT WATER LEVEL (CFS.):
CHANGE SINCE YESTERDAY (CFS.):
PERCENT OF NORMAL:
DEPARTURE FROM NORMAL (FT.):
IRRIGATION SEASON (APR - OCT)
DRAWDOWN (FT.):
RESIDUAL DRAWDOWN NEXT YEAR (FT.):
ANNUAL MAXIMUM DRAWDOWN (FT.):
INTER-ANNUAL DRAWDOWN (FT.):
DECADAL DRAWDOWN (FT):
LONG-TERM DRAWDOWN(FT):

AVERAGE MONTHLY PROJECT DEMAND (KAF): ____
AVERAGE WATER YEAR CUMULATIVE PROJECT DEMAND (KAF): ____
CURRENT MONTH KBRA POINTS OF DIVERSION VOLUME (KAF): ____
IRRIGATION SEASON KBRA POINTS OF DIVERSION VOLUME (KAF): ____
WINTER SEASON KBRA POINTS OF DIVERSION VOLUME (KAF): ____
CURRENT MONTH REFUGE VOLUME (KAF): ____
REFUGE IRRIGATION SEASON VOLUME (KAF): ____
REFUGE WINTER SEASON VOLUME (KAF): ____

LINK RIVER TO KENO DAM (KAF): ____
KENO DAM TO KLAMATH STRAITS DRAIN (KAF):____
STRAITS DRAIN TO IRON GATE (KAF): ____

SHORTAGE
UNLIKELY



Water levels would either be illustrated as a surplus or shortage on the graphic.

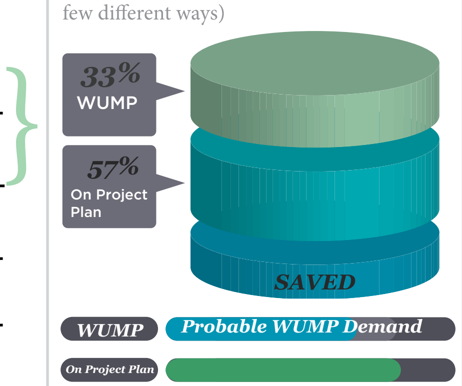
If a shortage, more information would be available about who would be responsible for making up the shortage (WUMP, On Project Plan, groundwater pumping)

Baseline could be timeline. Could pull slider to change view of forecast supply amounts.

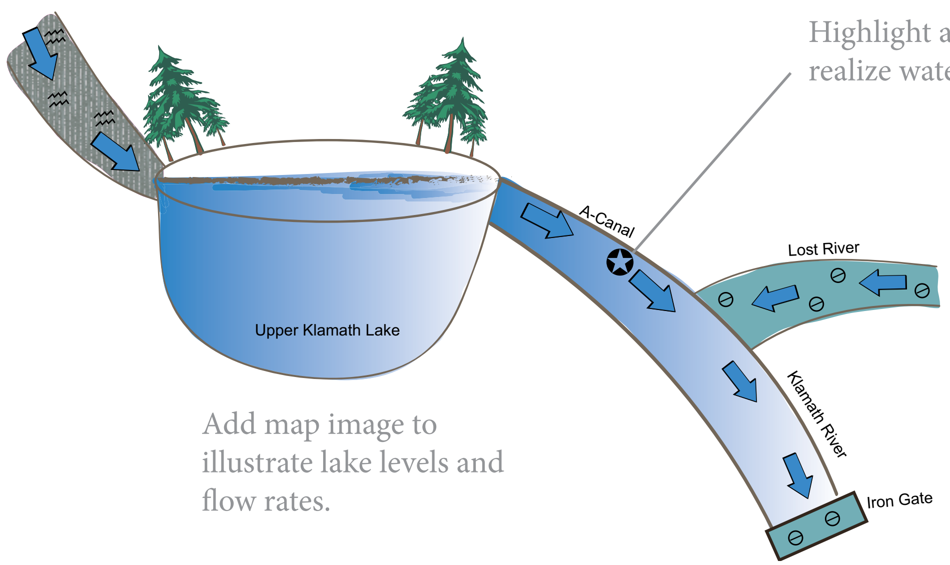
Quantify how much groundwater is needed as a specific item of its own

Quantify amount of shortage... (inches? gallons?)

For shortage amount, give prediction for how much will be contributed by each program... (this could be represented in a few different ways)



SHORTAGE
LIKELY



Highlight areas that will realize water supply.

Add map image to illustrate lake levels and flow rates.

Lower Klamath Wildlife Refuge

A lot of the same information from other groups will apply here, but at a more localized scale. The water balance in the refuge will be a concern.

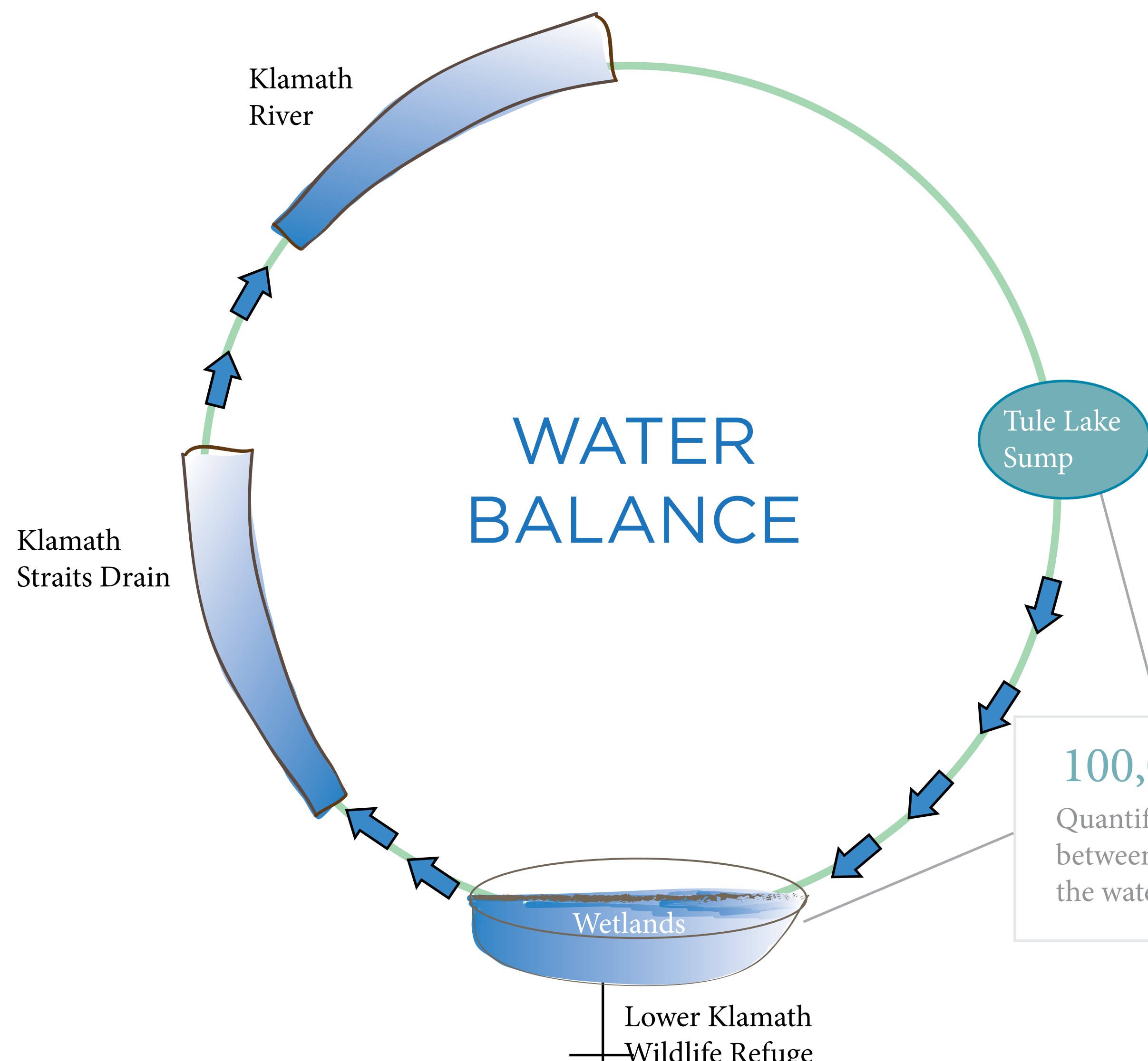
Expand for decision

QUESTIONS:

1. What is the water balance for the refuge?
2. What is the estimated evapotranspiration rate?

DECISIONS:

- What is the amount of water being delivered to Klamath river from Tule Lake Sumps?
- Evapotranspiration rates are related to USFWS's need to provide water to wetlands.



100,000 gallons

Quantify amount of water moving between the waterbodies, and how the waterbodies are related.

Could include any other info from other timelines that would be fitting.

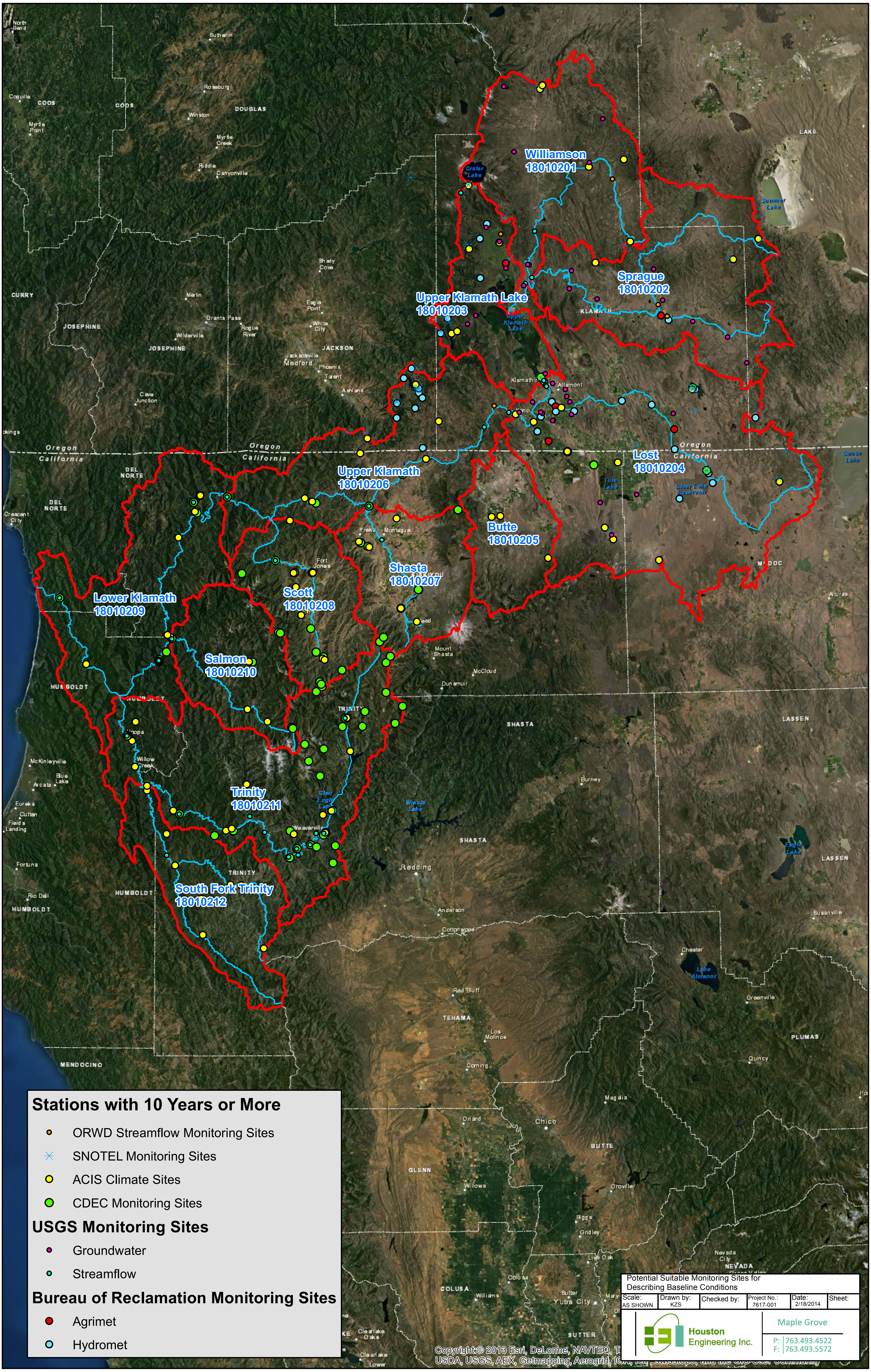
EVAPOTRANSPIRATION RATE

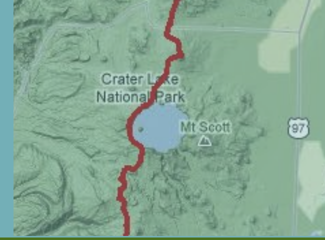
BASIN CONDITION

INTERACTIVE MAP

Appendix E

Map Stations with a Minimum of 10 years of Record in the Klamath Basin


Williamson
18010201
Sprague
18010202
Upper Klamath Lake
18010203
Lost
18010204
Butte
18010205
Upper Klamath
18010206
Shasta
18010207
Scott
18010208
Lower Klamath
18010209
Salmon
18010210
Trinity
18010211
South Fork Trinity
18010212
Oregon
California
Stations with 10 Years or More
ORWD Streamflow Monitoring Sites
SNOTEL Monitoring Sites
ACIS Climate Sites
CDEC Monitoring Sites
USGS Monitoring Sites
Groundwater
Streamflow
Bureau of Reclamation Monitoring Sites
Agrimet
Hydromet
Potential Suitable Monitoring Sites for Describing Baseline Conditions
Scale: AS SHOWN
Drawn by: KZS
Checked by:
Project No.: 7617-001
Date: 2/18/2014
Sheet:
Houston Engineering Inc.
Maple Grove
P: 763.493.4522
F: 763.493.5572



Appendix F

Wireframes for Front-End Application

The Specification

[Type the document subtitle]

[Your Name]

[Pick the date]

[Type the abstract of the document here. The abstract is typically a short summary of the contents of the document. Type the abstract of the document here. The abstract is typically a short summary of the contents of the document.]

Table of Contents

[To update the table of contents, right click the message below and select Update Field (F9 on PC, ⌥⇧⌘U on Mac).]

No table of contents entries found.

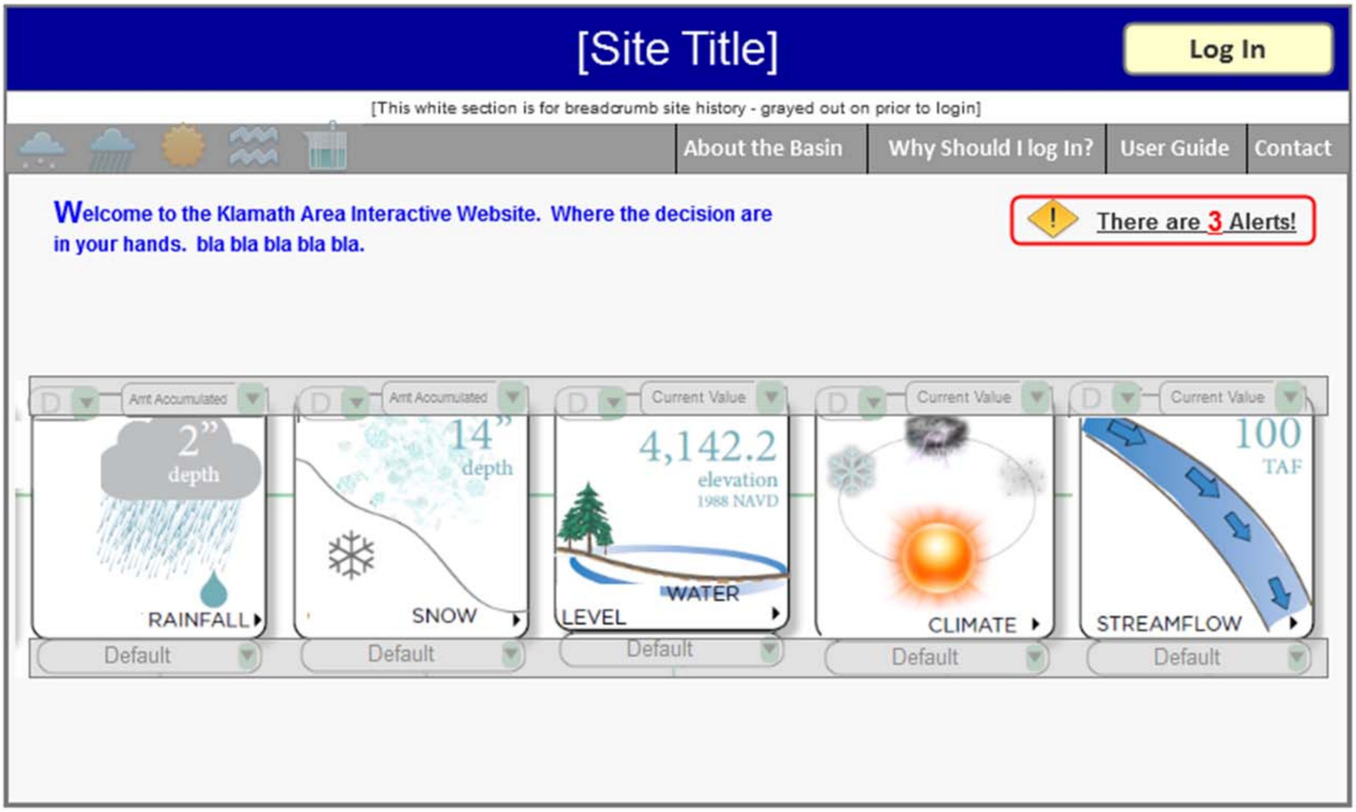
1. Pages

1.1. Page Tree

- Home
  - SocialMedi_Auth
  - Other_Auth
  - Dashboard
    - Dashboard_COG
      - Configuration
      - Settings
        - Account Settings
        - Emails
        - Notification Center
  - streamwater_overview
    - collapseable_info_window
    - Map Interaction w/ right panel
  - interactive Map
    - basemaps
    - measurement/location
    - draw
    - info tool
    - Search
    - print

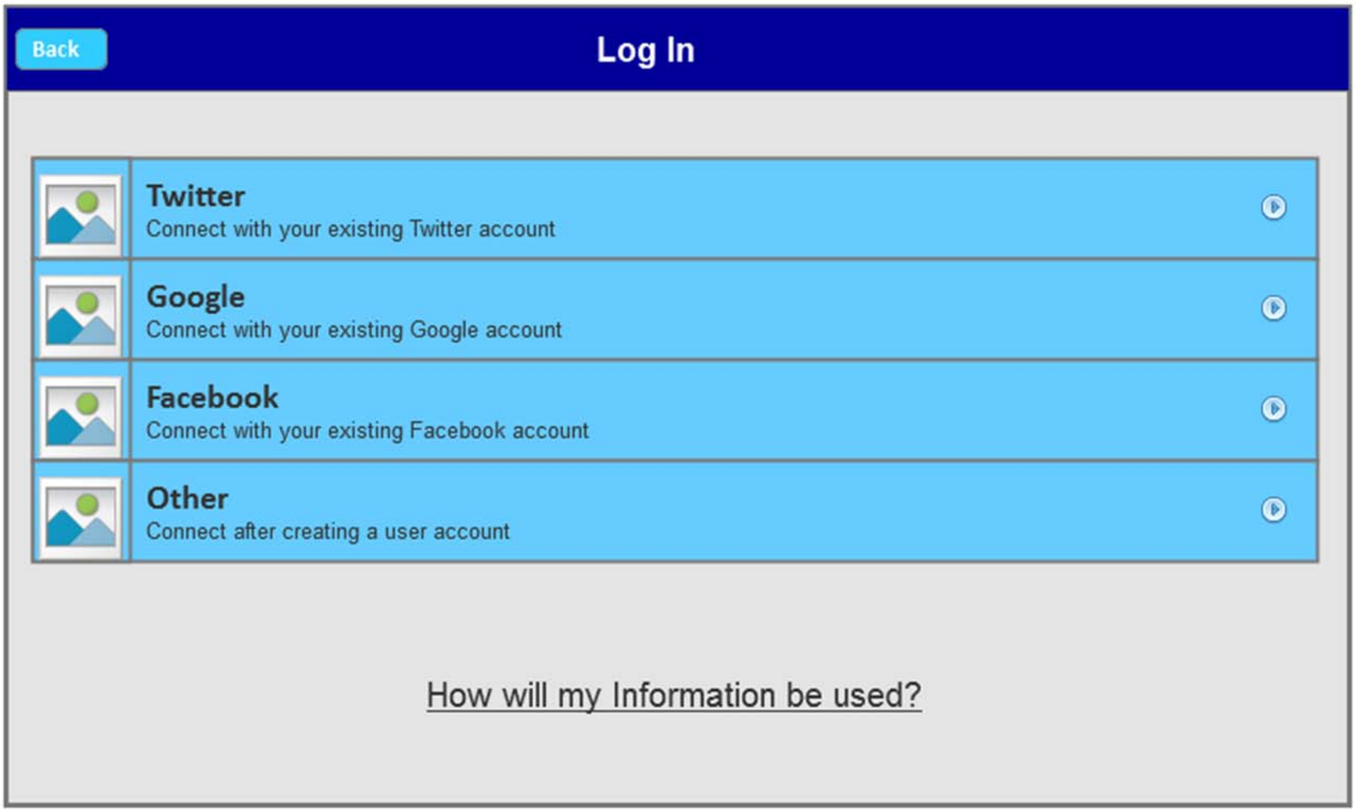
1.2. Home

1.2.1. User Interface



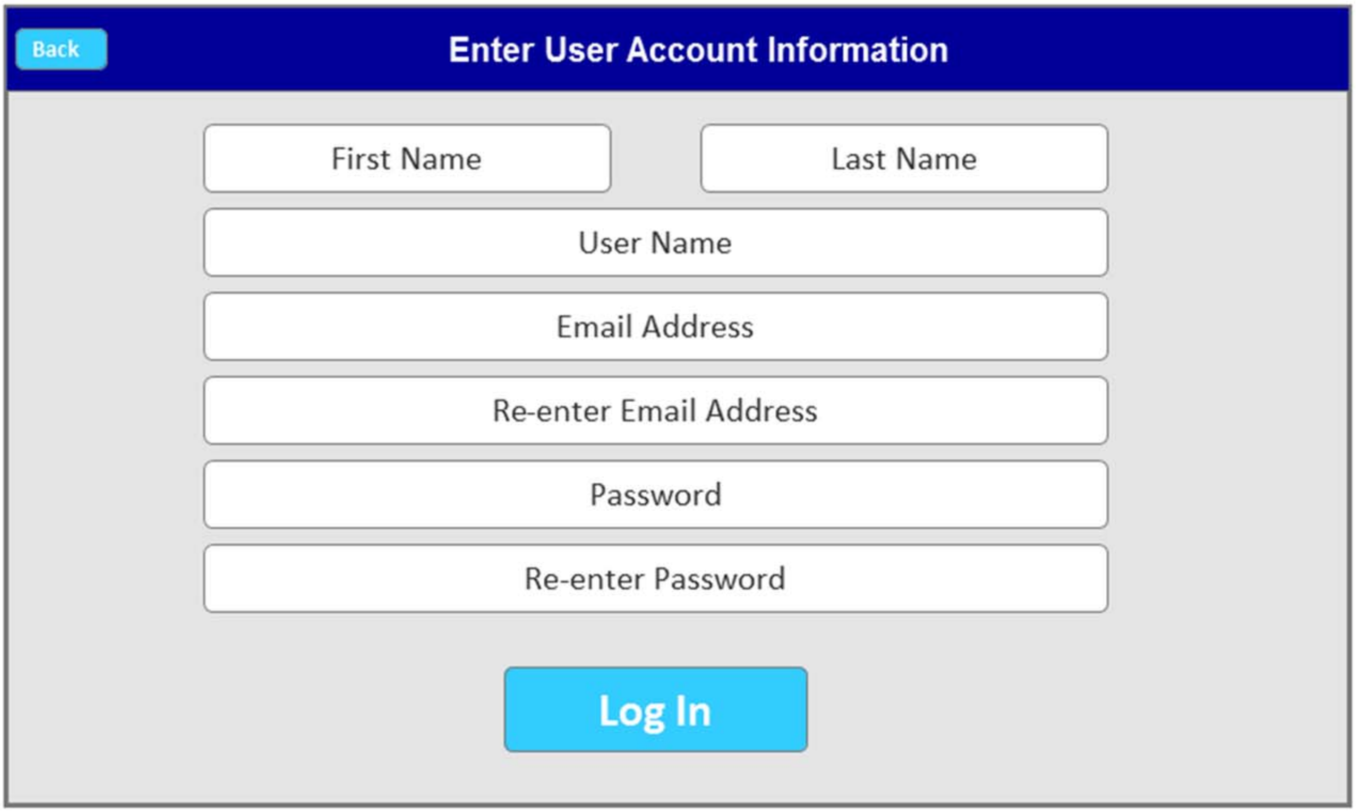
1.3. SocialMedi_Auth

1.3.1. User Interface



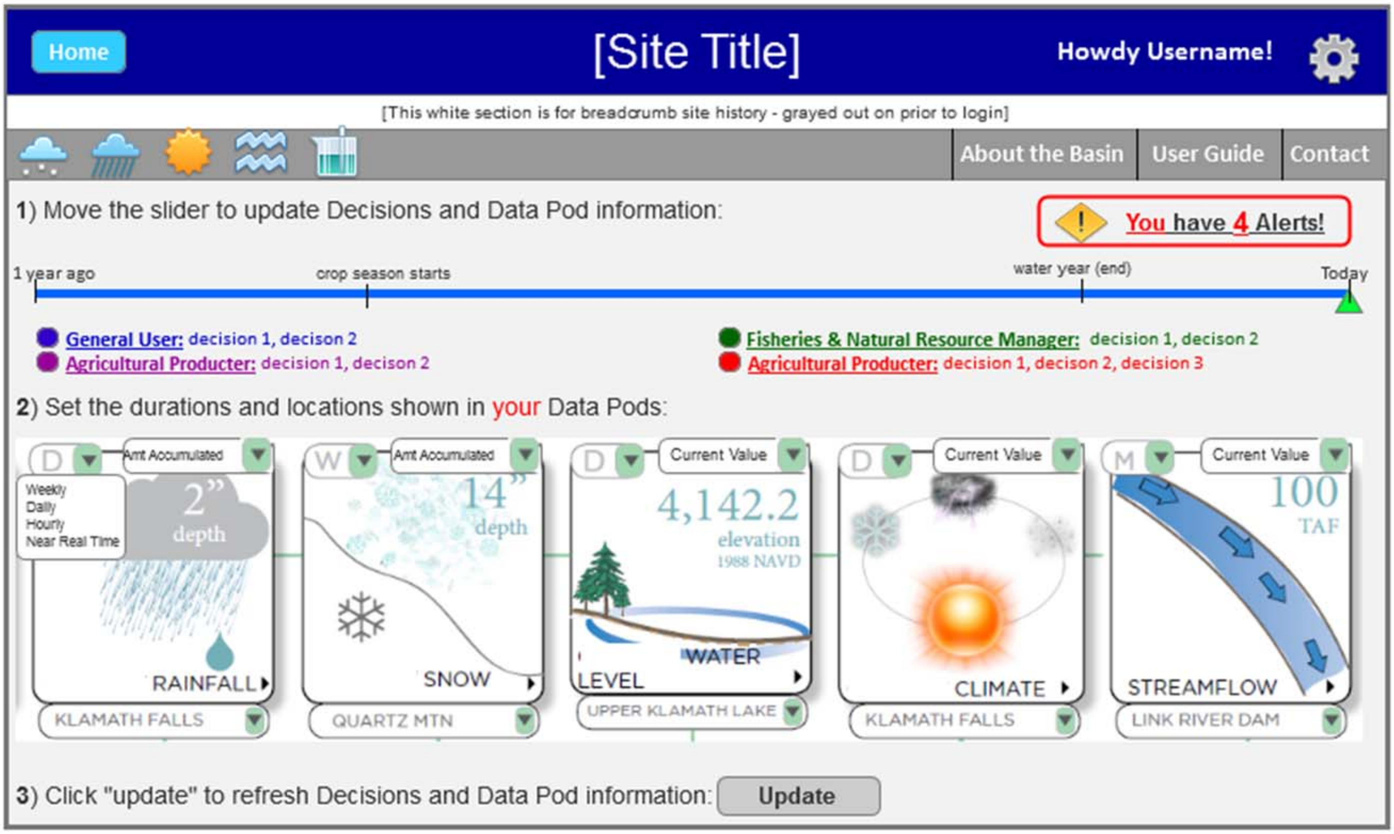
1.4. Other_Auth

1.4.1. User Interface



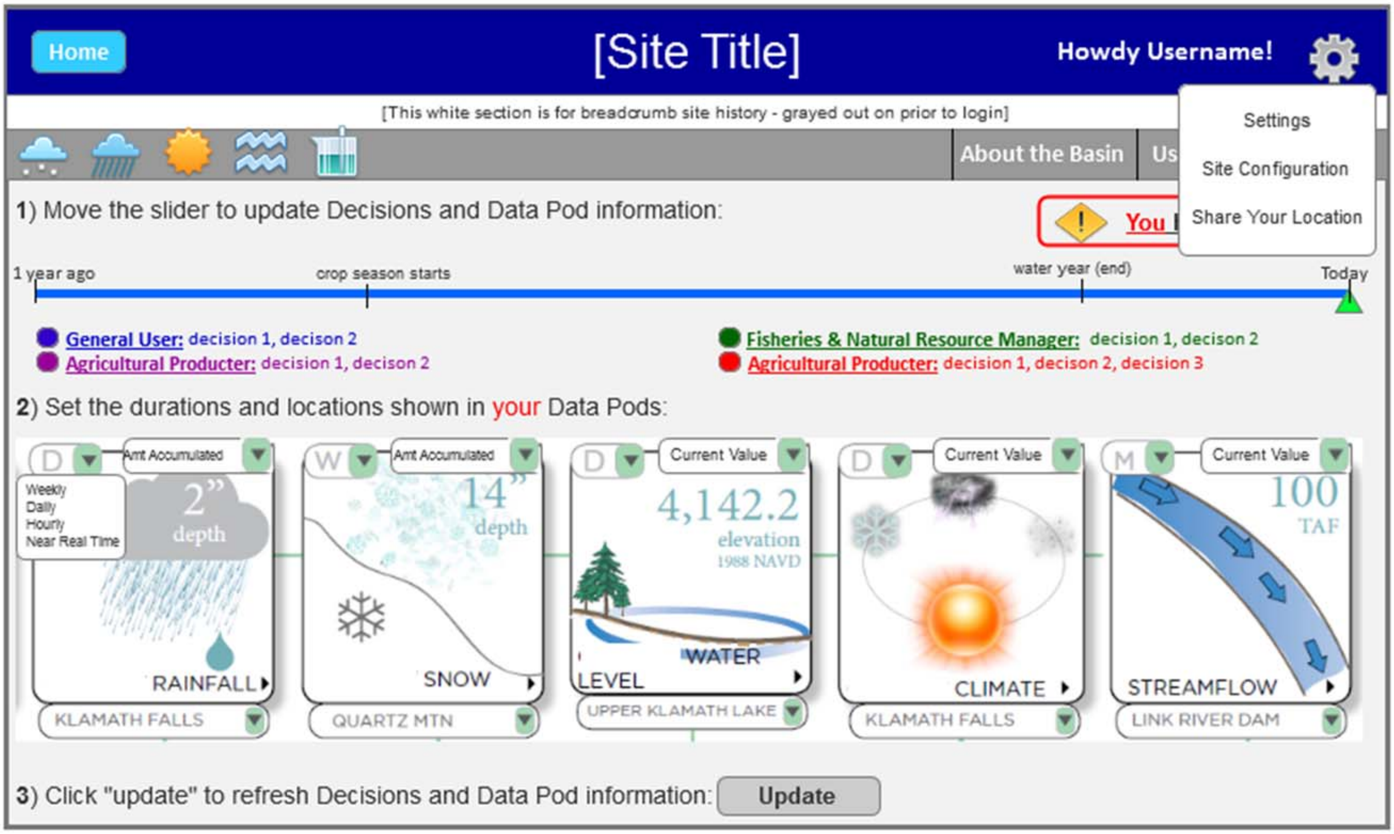
1.5. Dashboard

1.5.1. User Interface



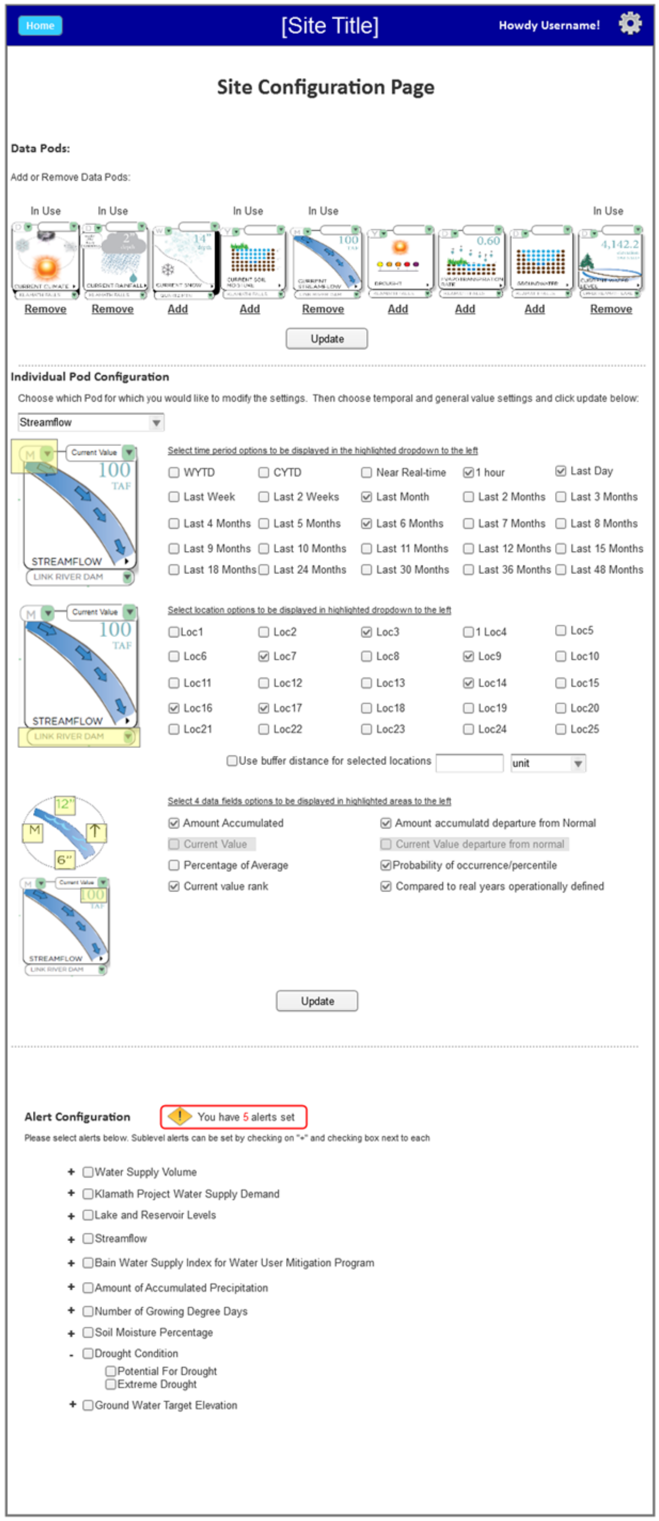
1.6. Dashboard_COG

1.6.1. User Interface



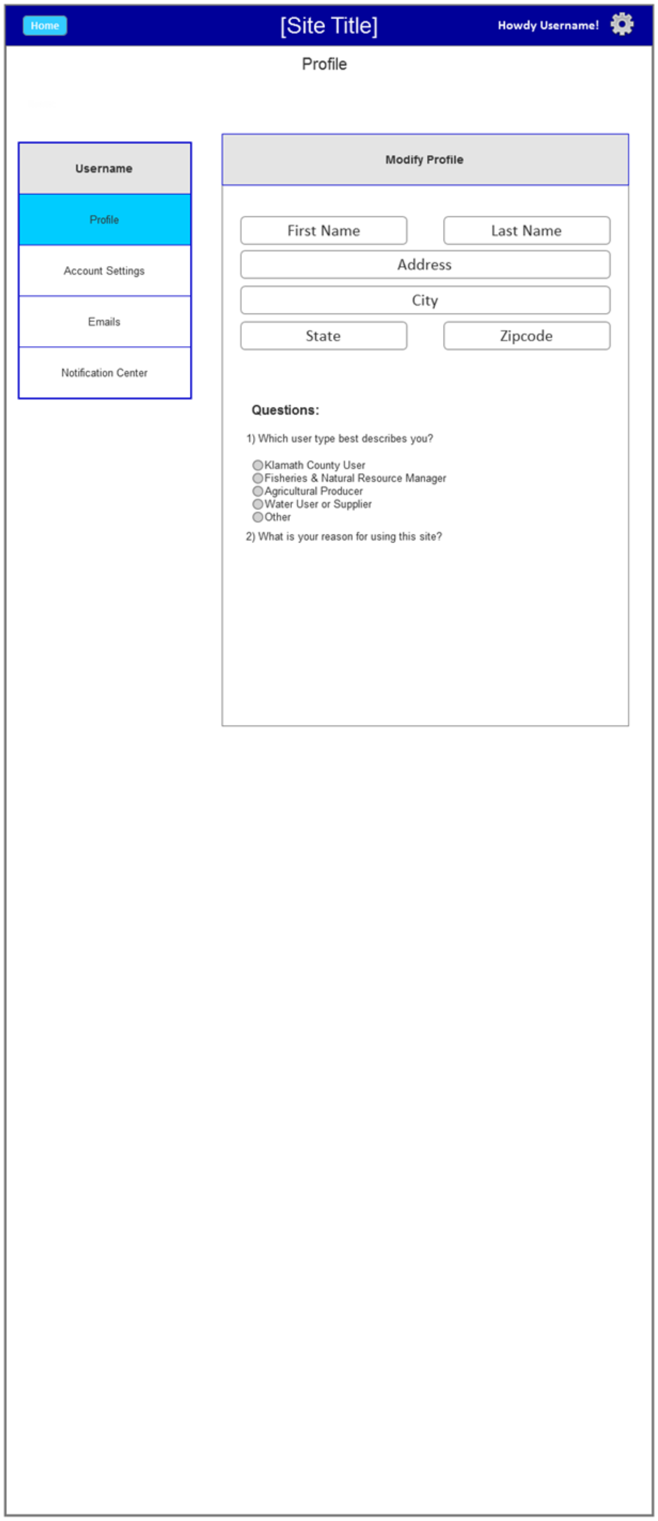
1.7. Configuration

1.7.1. User Interface



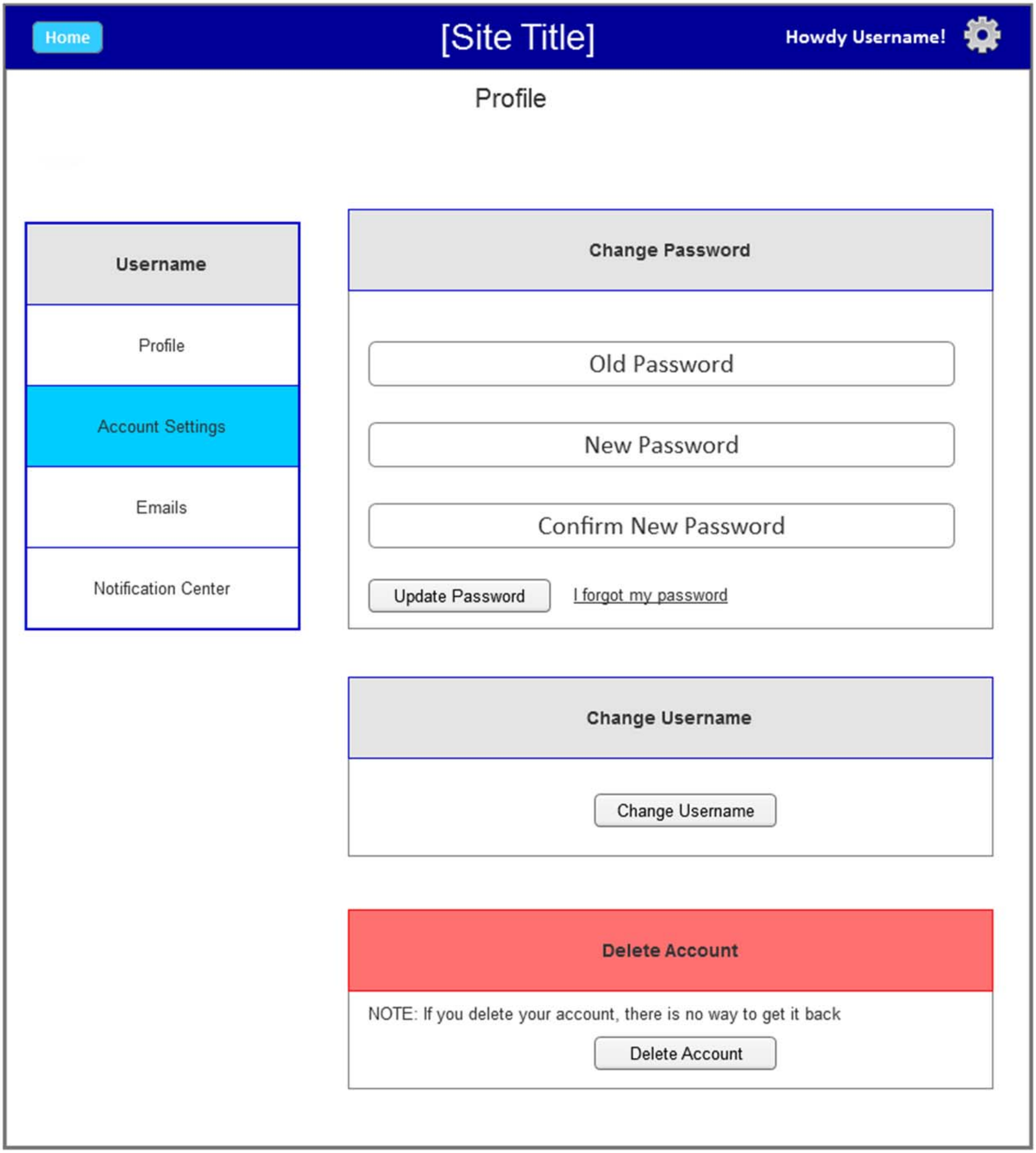
1.8. Settings

1.8.1. User Interface



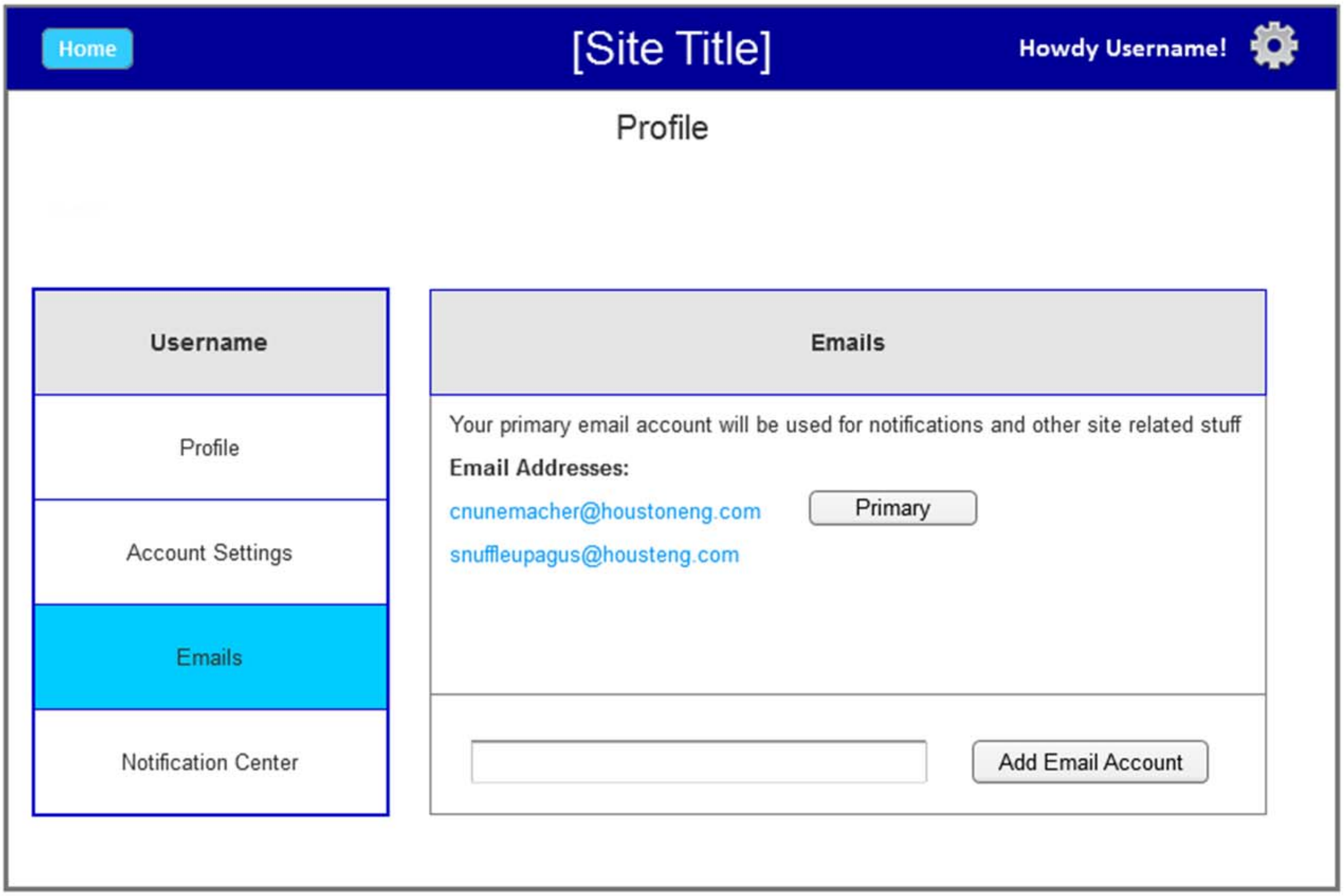
1.9. Account Settings

1.9.1. User Interface



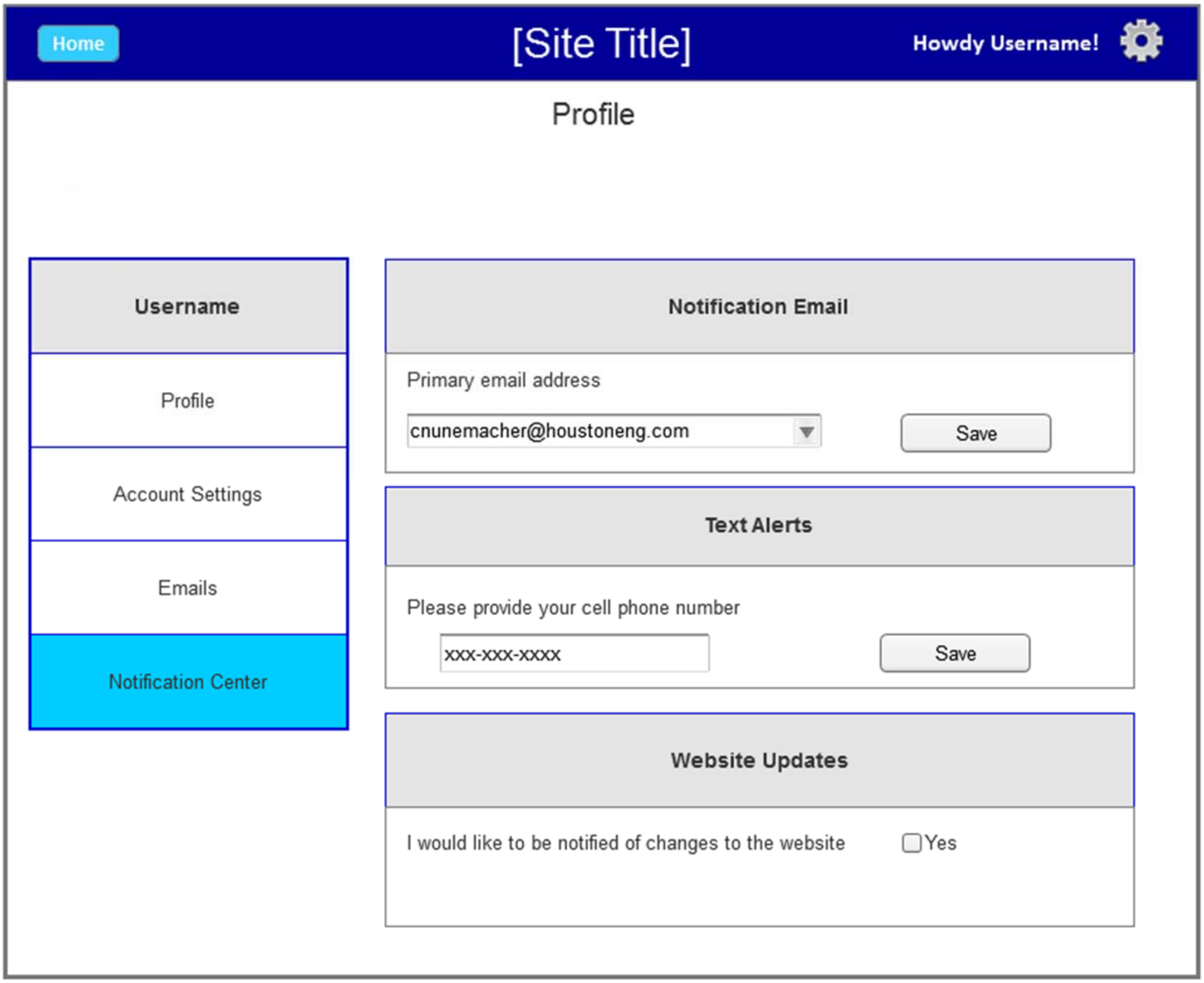
1.10. Emails

1.10.1. User Interface



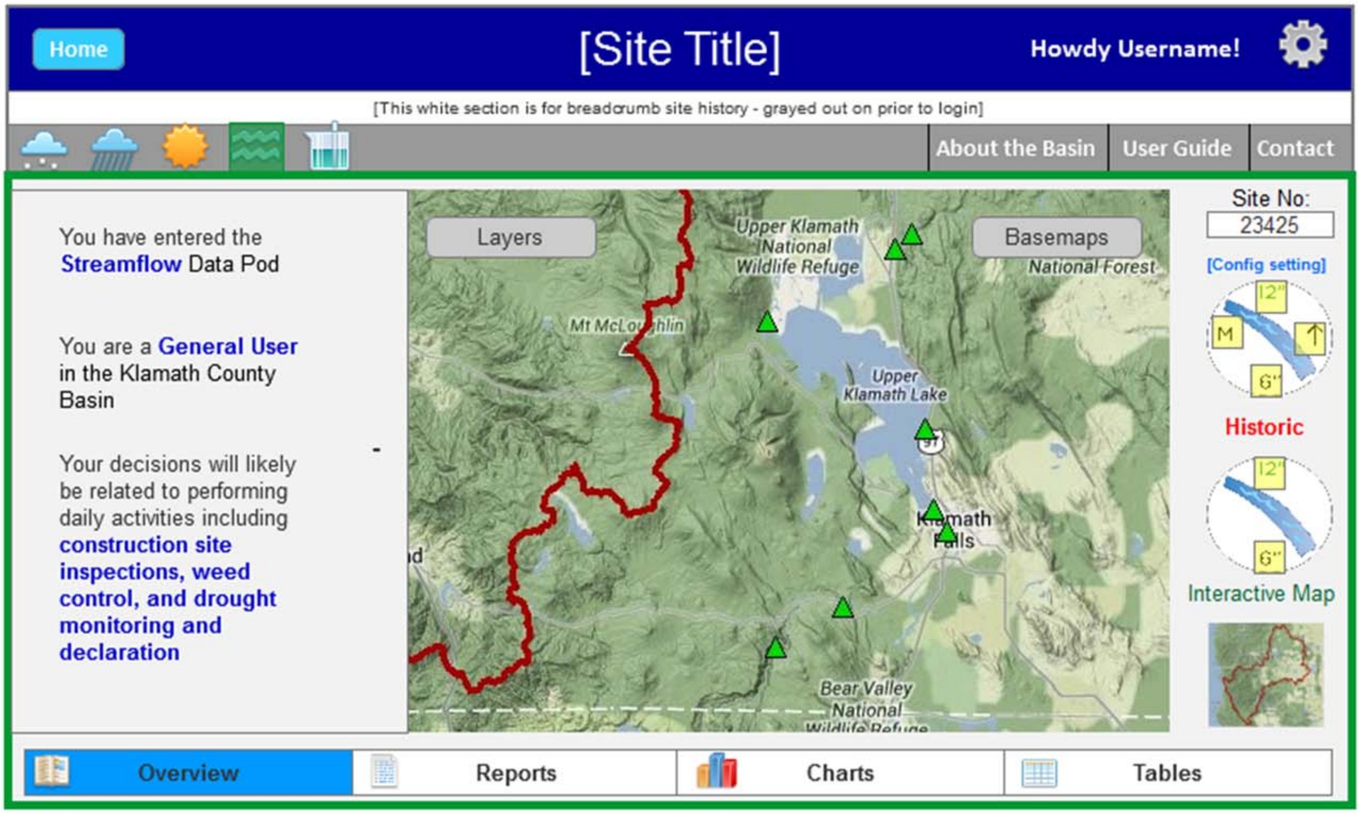
1.11. Notification Center

1.11.1. User Interface



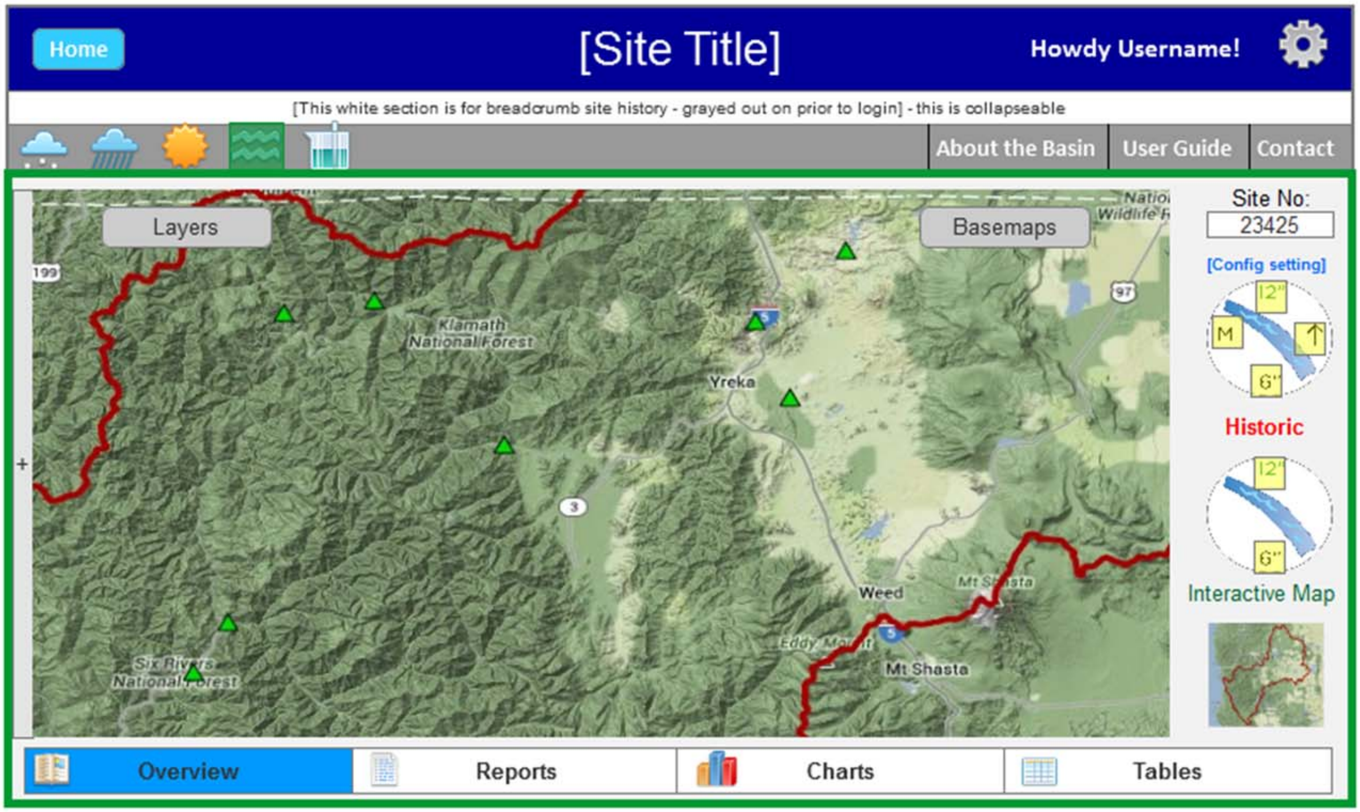
1.12. streamwater_overview

1.12.1. User Interface



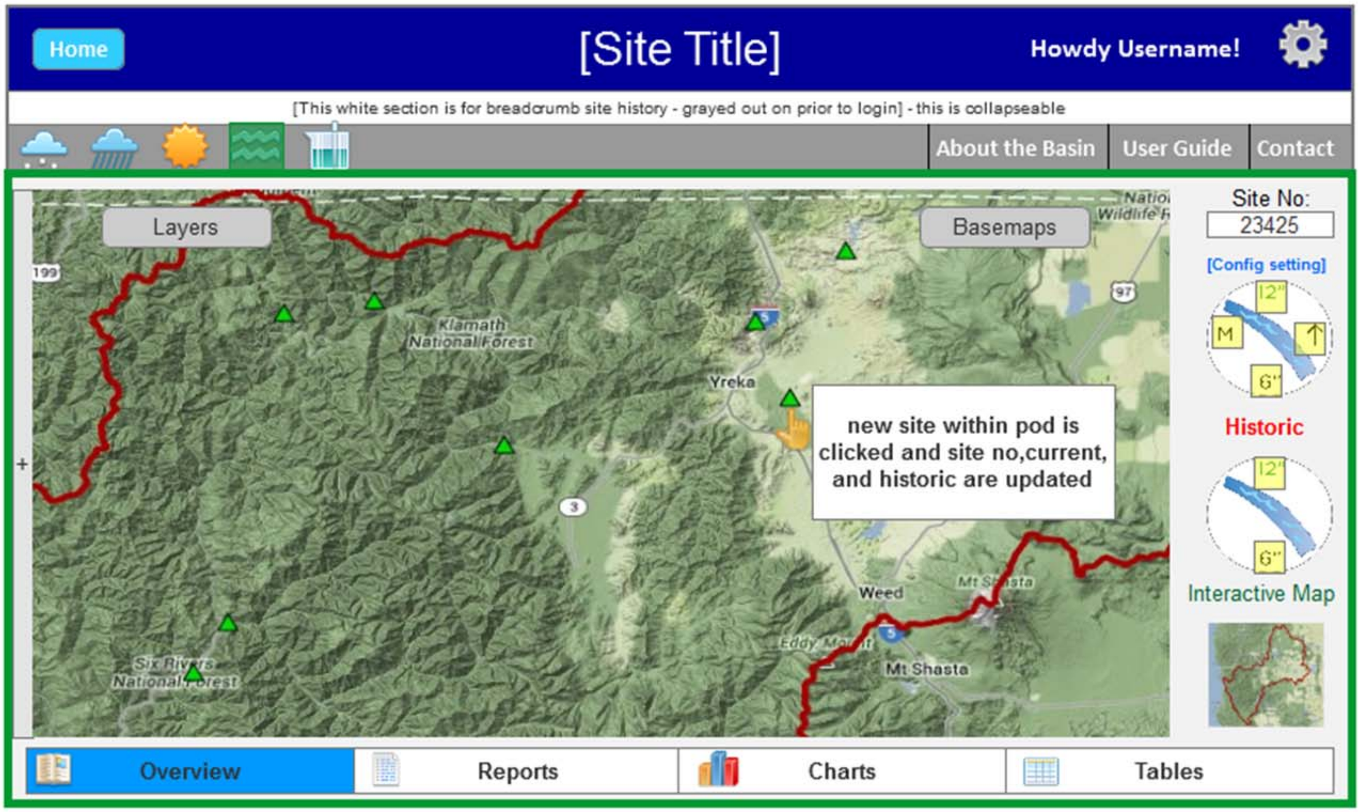
1.13. collapseable_info_window

1.13.1. User Interface



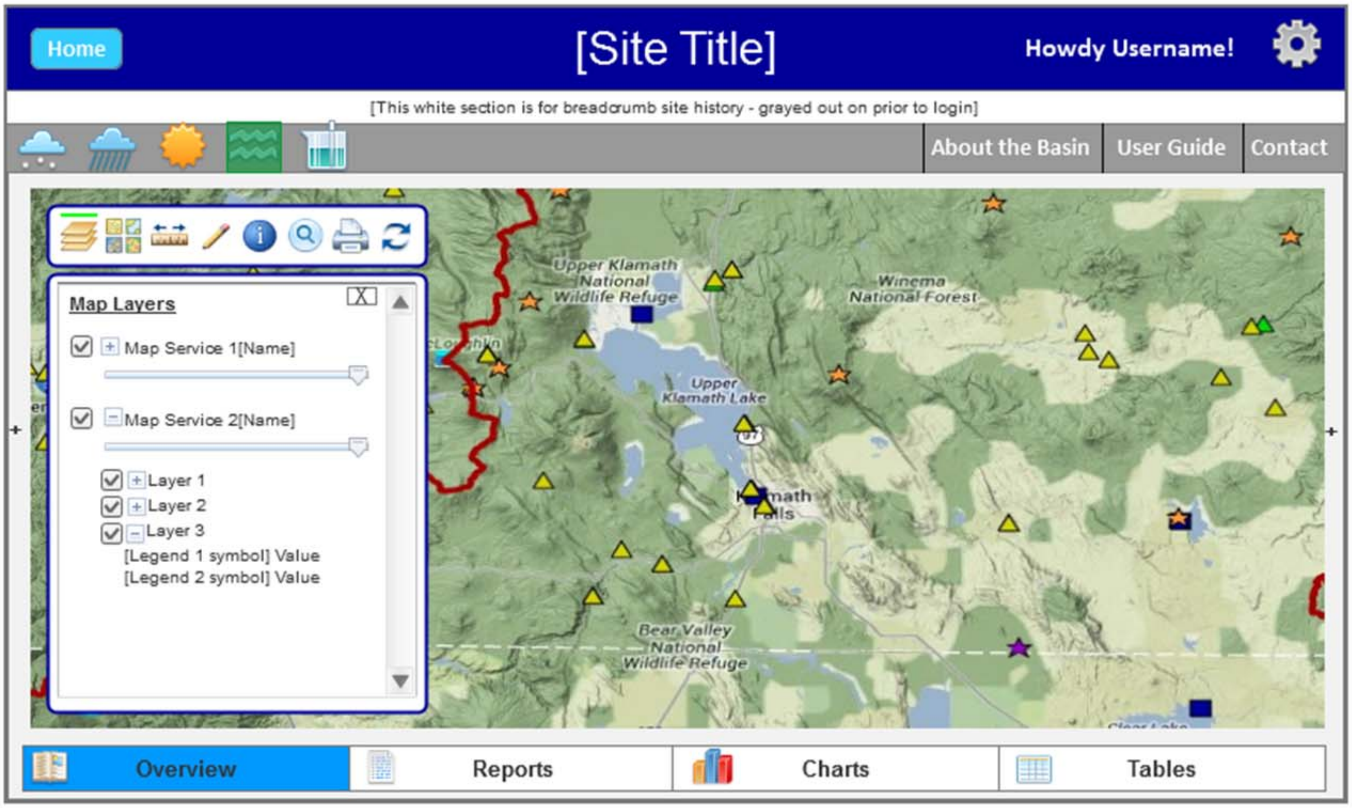
1.14. Map Interaction w/ right panel

1.14.1. User Interface



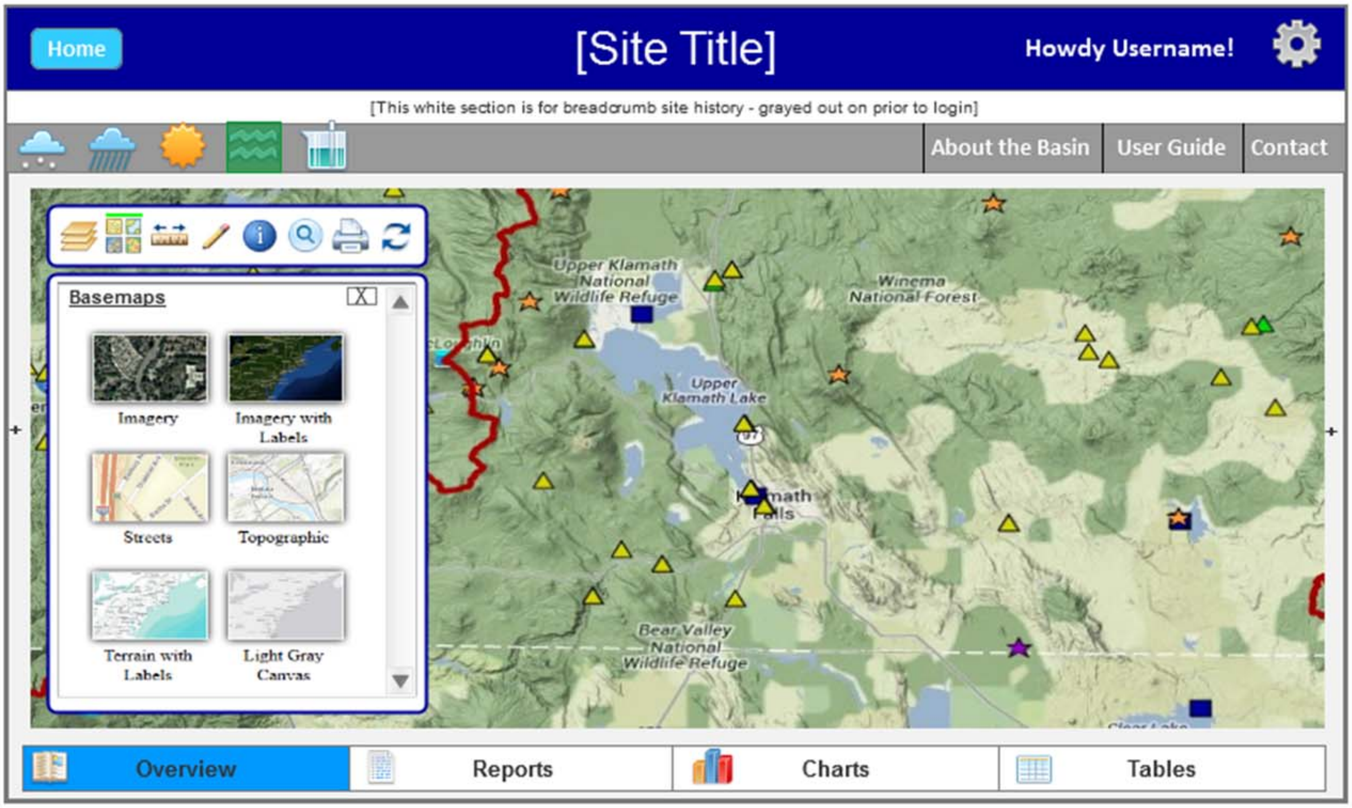
1.15. interactive Map

1.15.1. User Interface



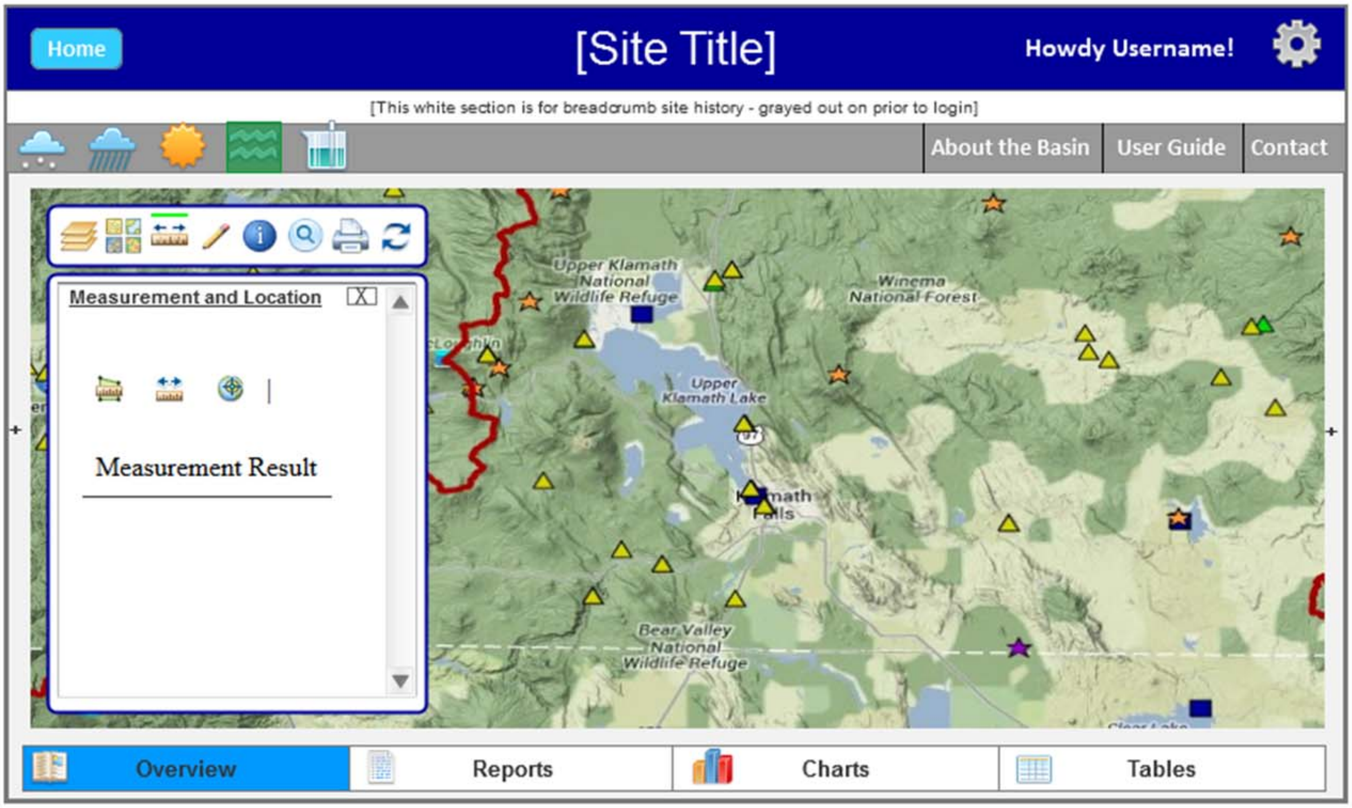
1.16. basemaps

1.16.1. User Interface



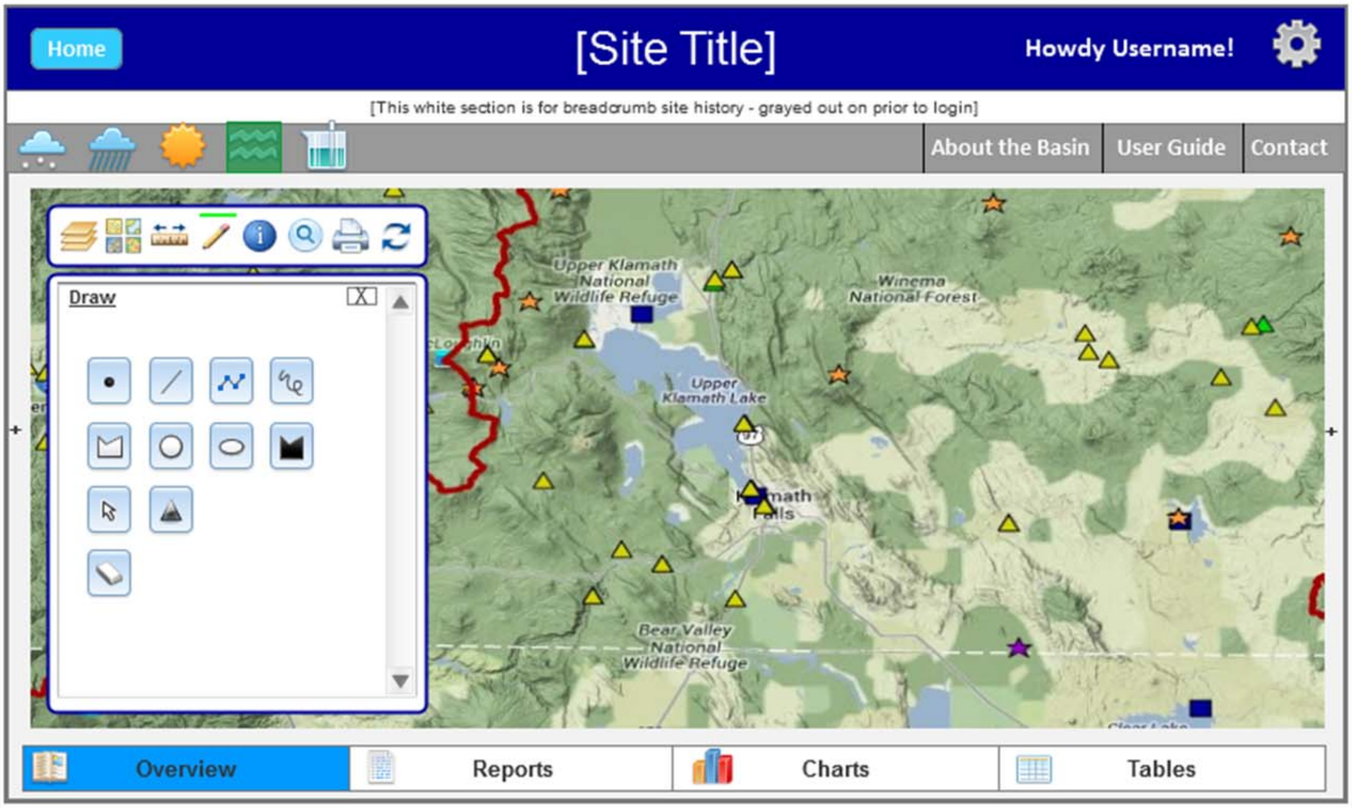
1.17. measurement/location

1.17.1. User Interface



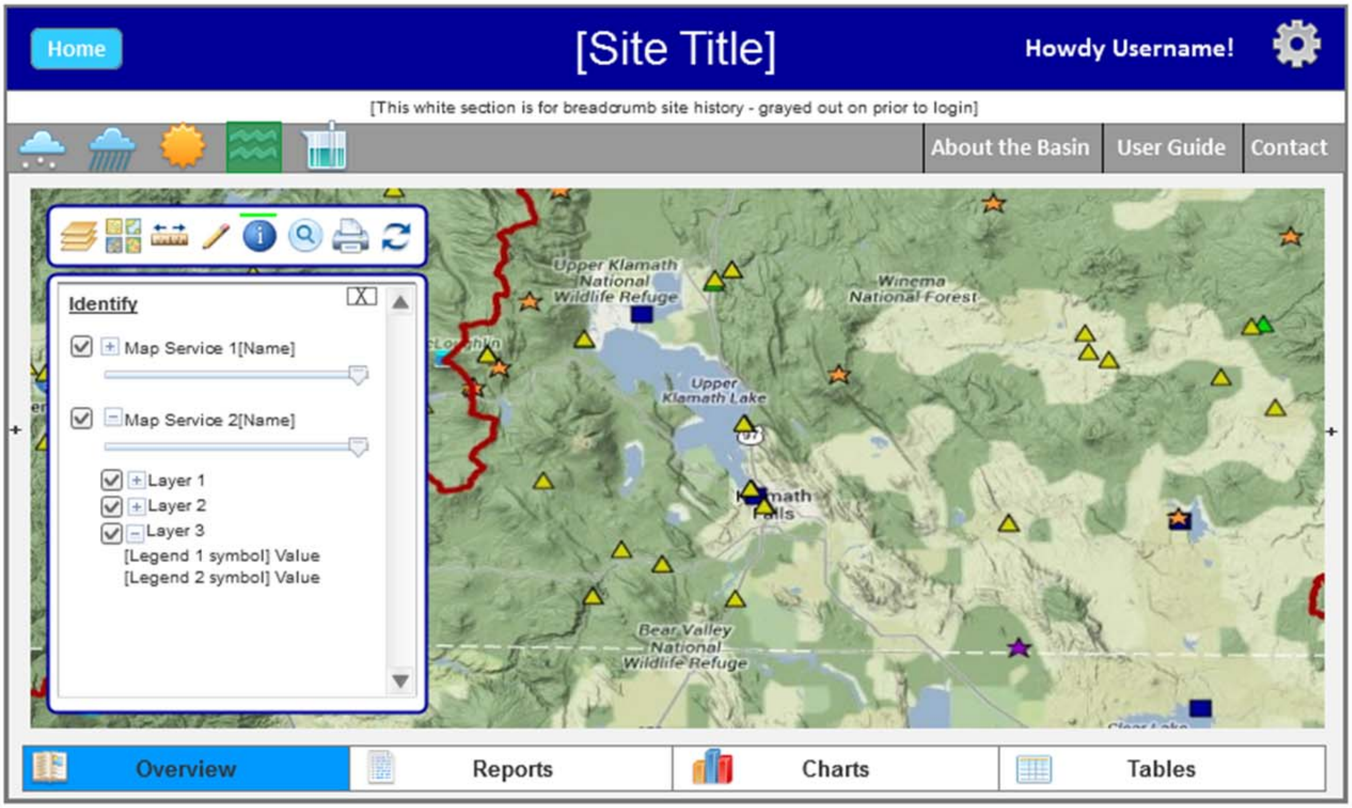
1.18. draw

1.18.1. User Interface



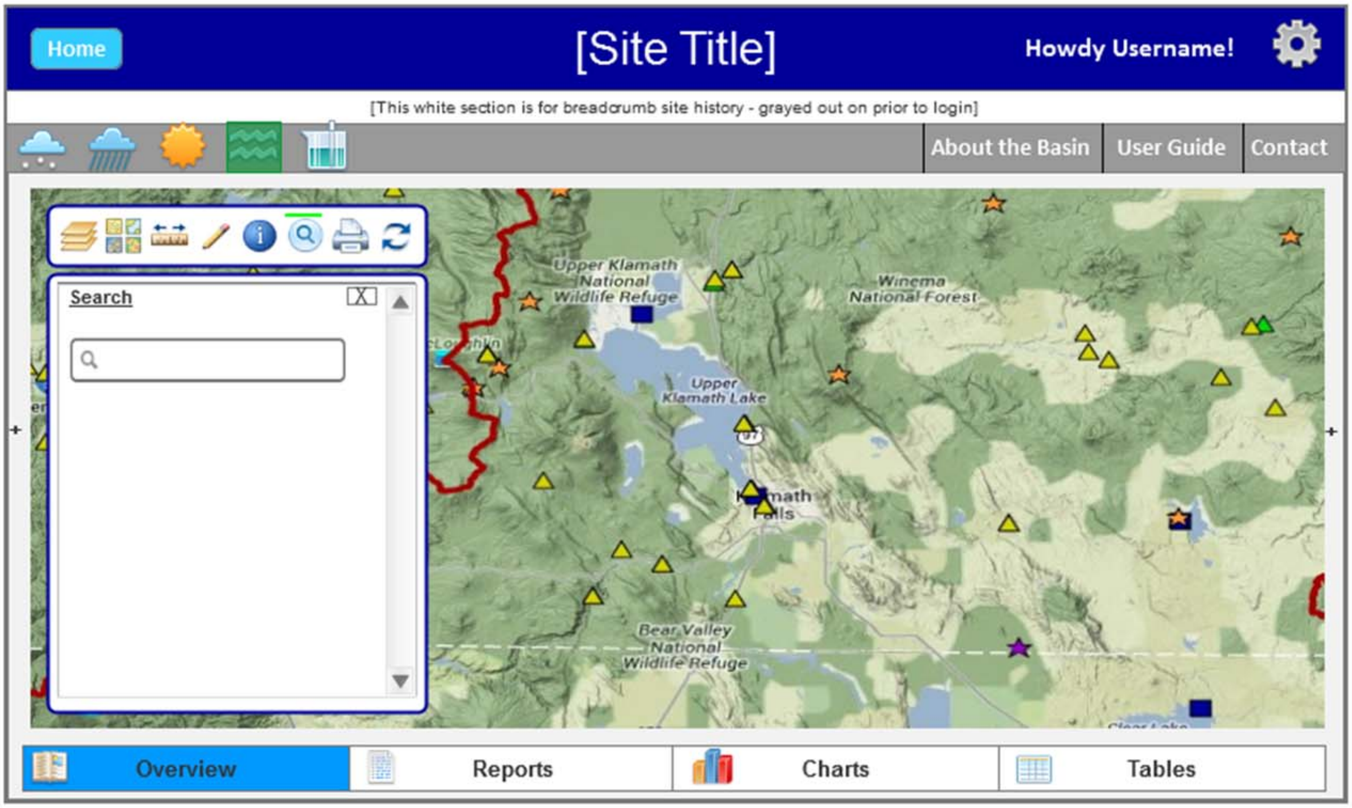
1.19. info tool

1.19.1. User Interface



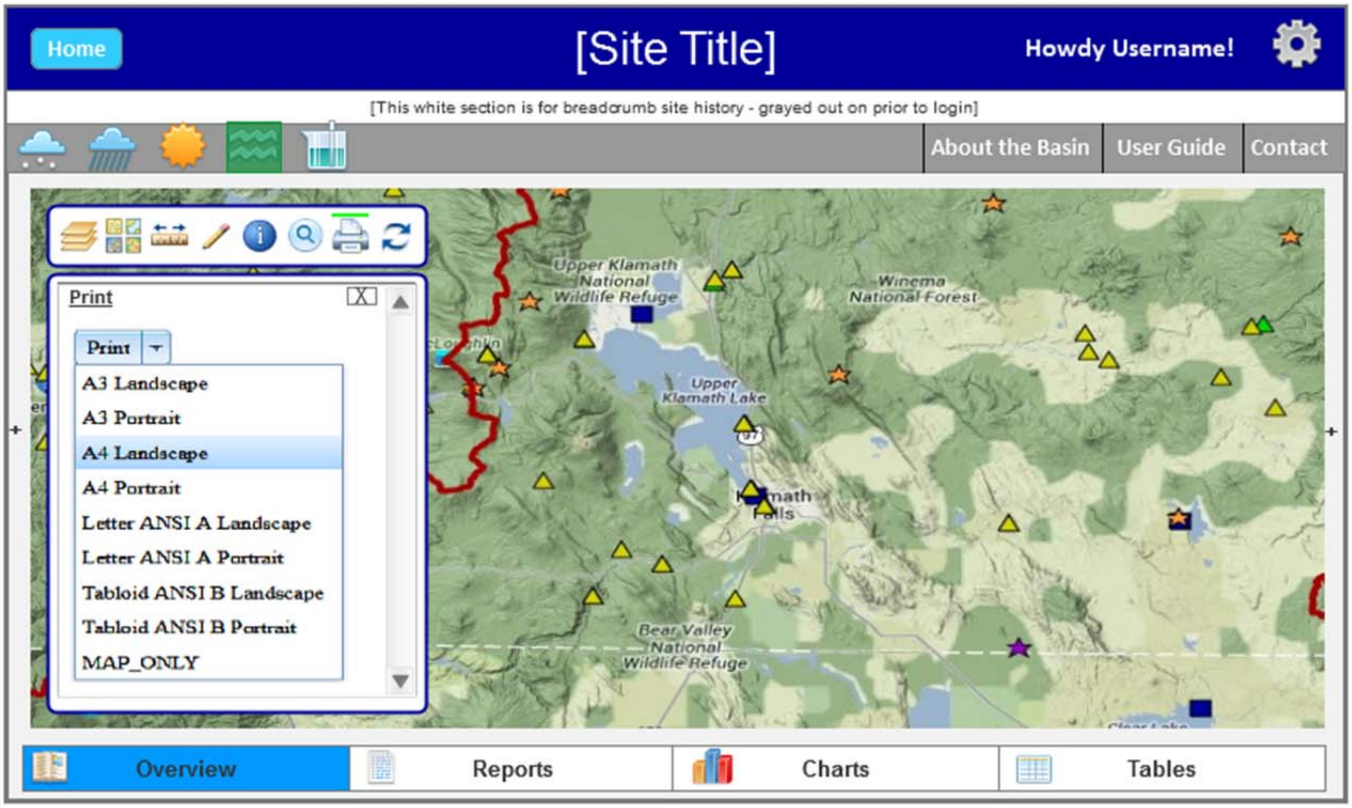
1.20. Search

1.20.1. User Interface



1.21. print

1.21.1. User Interface



Appendix G

Final Focus Group Meeting Agenda and Presentation

User Needs Requirements

April 2, 2014 ● Klamath Falls, OR

From Fisheries to Family Farmer:
Improved Products for Communicating
Water Supply, Drought, and Climate Change Risk for
Daily Decision-Making Within the Klamath Basin

This work is funded under a grant from the Sectoral Applications Research Program (SARP) of the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office. The views expressed represent those of the author(s) and do not necessarily reflect the view or polices of NOAA.

Outline for Today

1. Meeting reasons, SARP purpose, vision & feedback
2. Present results from the applied research:
   - How we got here
   - Lessons learned & focus group process
   - Data use challenges
   - Recommended methods to increase data value
   - Managing decision risk through alternative decisions
3. Tools and design considerations (a solution):
   - Robustness
   - Concept application
4. Feedback

Reasons for this meeting

- Presentation by another “expert” from outside the Basin
- Somebody else that thinks they can solve our problems
- Another study to place on the shelf
- I had nowhere else to go, so I came here
- Another consultant working on a government grant
- See if Deutschman got it right

Sectoral Applications Research Program (SARP)

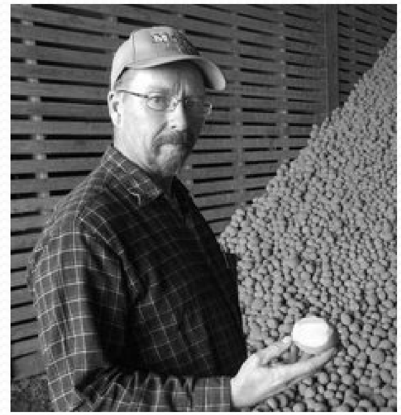
- Focus on how various socioeconomic sectors address climate and water issues (using data)
- Current priorities are water resources management initiatives (e.g., coping with drought)
- Must understand how climate and water data are used for decision-making
- Recognize the need for tools and methodologies for decision-making
- Recognize the need to develop improved tools and methodologies

Our Research Vision

- Better understand reliance on climate and water data delivered by federal agencies as case study for western US
- Identify, describe, and document stakeholder community decisions relying on climate and water data
- Recommend methods and tools to improve data delivery, use, and value
- Streamline resource discussions to make them more efficient
- Implement recommendations

Your Participation

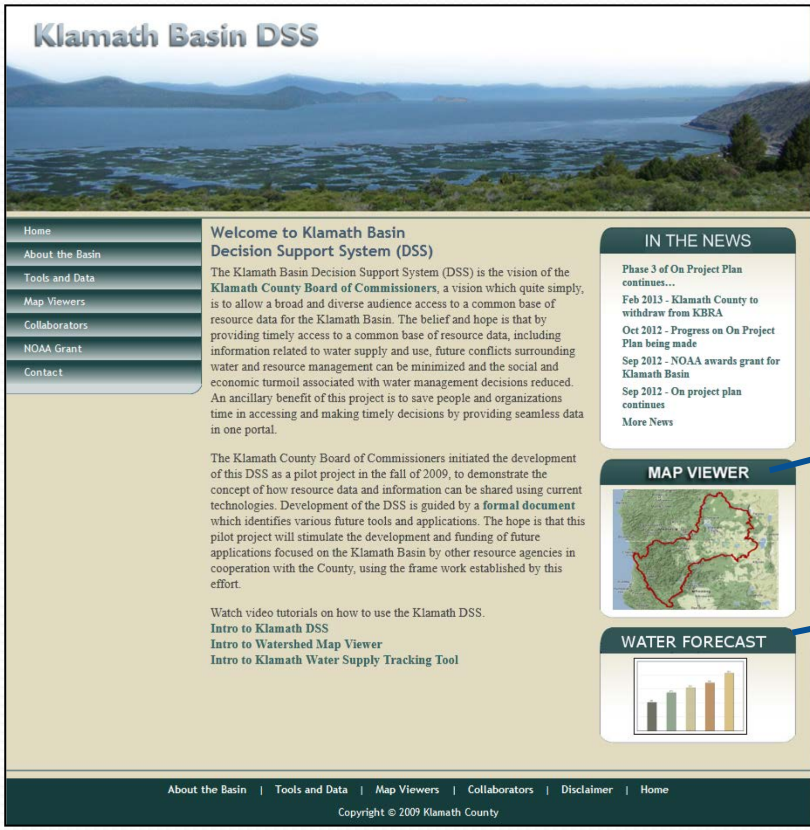
- Are your needs and decisions identified properly?
- Are there really alternative decisions based on data risk?
- Have we correctly connected your decisions to data needs, the criteria for action, and your actions?
- Is there value in the tools, methods, and concept presented?
- Proceed with development?

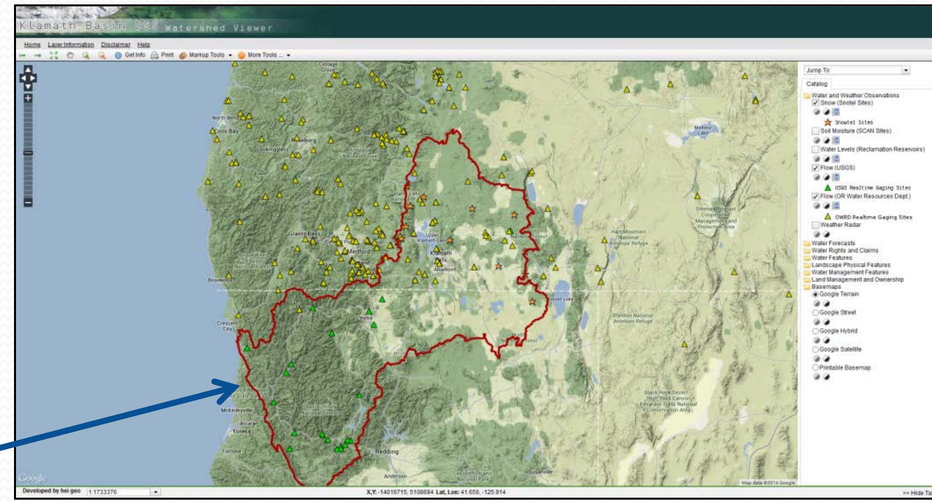


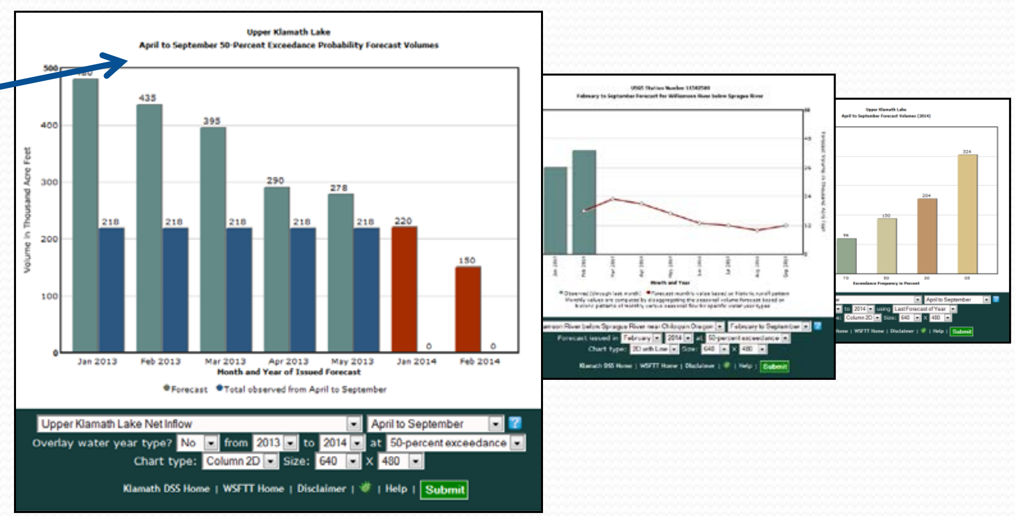
Research Summary

Providing Recommendations to Improve Tools and Methodologies for Communicating Information and Enhancing Decisions

How Did We Get Here?







Participants

U.S. Fish & Wildlife Service

OSU Oregon State University

HoustonEngineering Inc.

National Weather Service

U.S. Department of the Interior Bureau of Reclamation

Klamath Water Users Association

MBK Engineers Consulting Engineers

The Klamath Tribes Klamath . Modoc . Yahooskin

Klamath Water and Power Agency KWAPA

National Oceanic and Atmospheric Administration NOAA U.S. Department of Commerce

Dan Keppen & Associates

State of Oregon WRD Water Resources Department

Klamath County

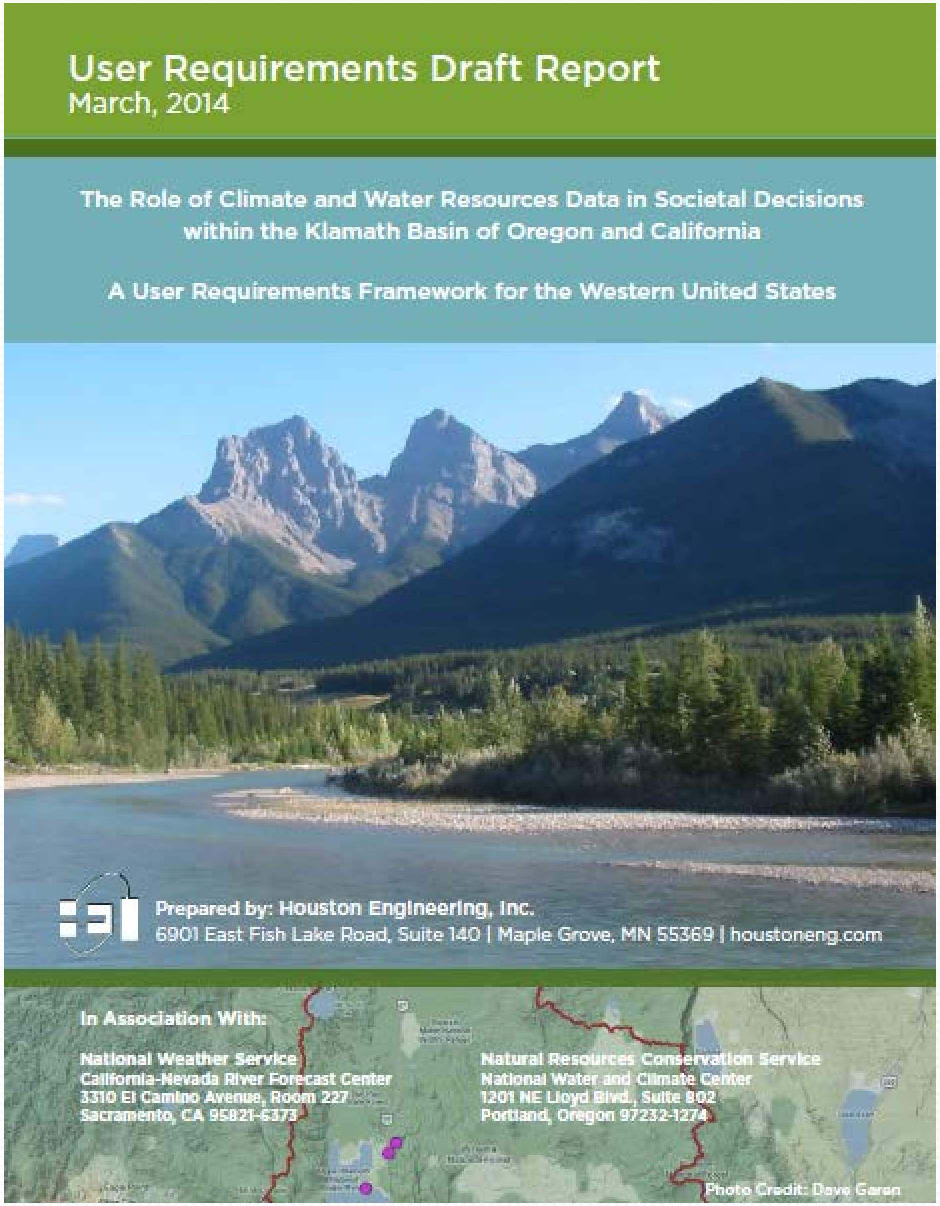
NOAA Fisheries Service

NRCS

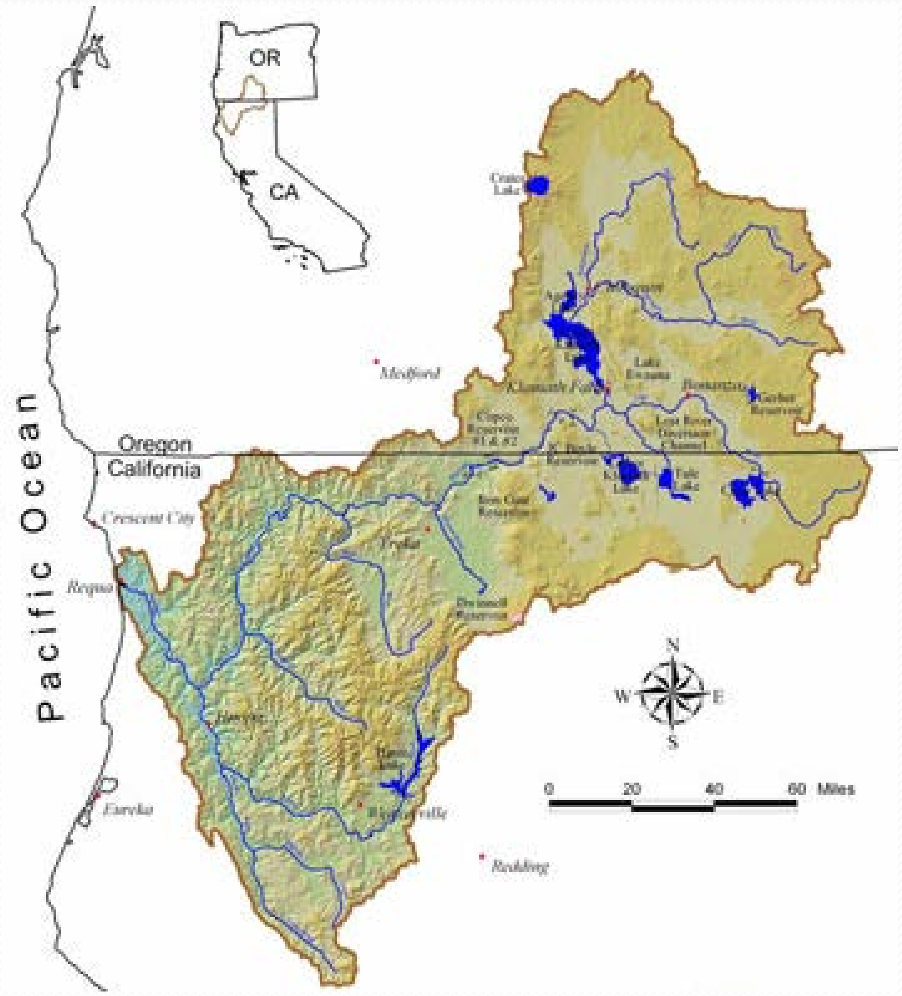
Report

- Draft report
- Finalize after meeting
- Download it:

  http://ftp.houstoneng.com:443/main.html?download&weblink=7c4be79fe400fe22b82f5e7f423fd9e3&realfilename=3.10.14_UserRequirementsReport.pdf



Location



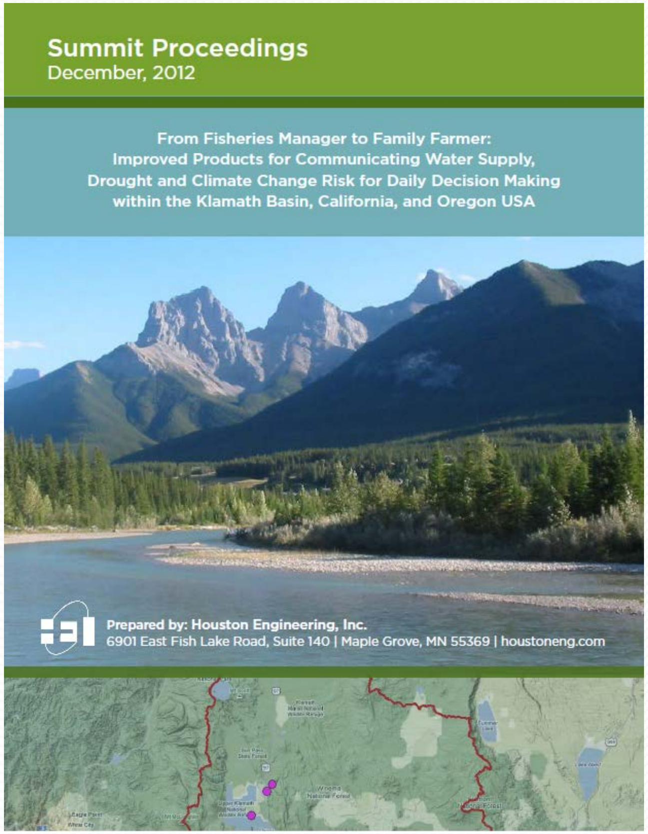
- Using the Klamath Basin as the geographic focus
- Results intended to be generalized to the Western US

Lessons Learned – Use of Climate and Water Data in Decision-Making

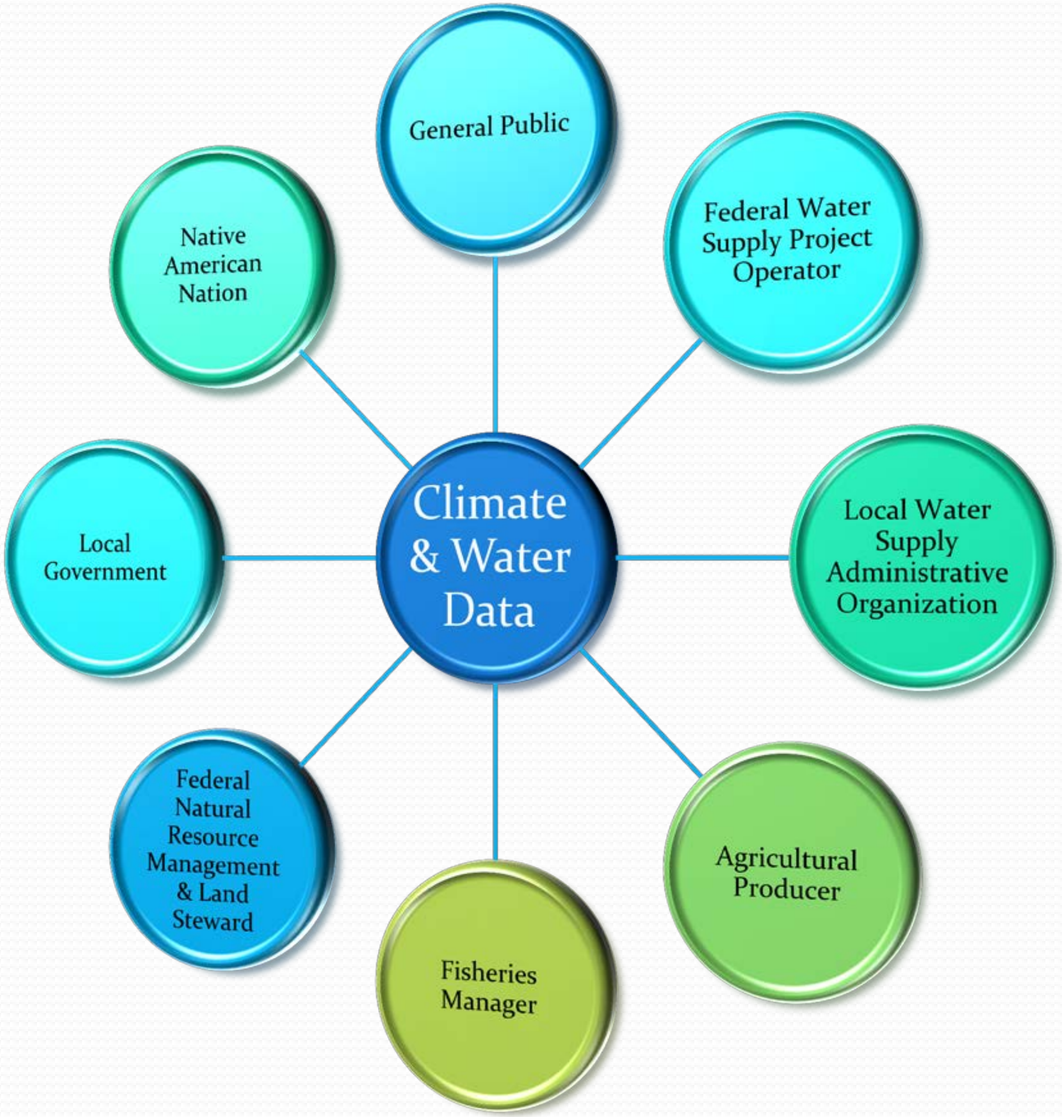
Linking the Data, Question, Decision, and Action

Process

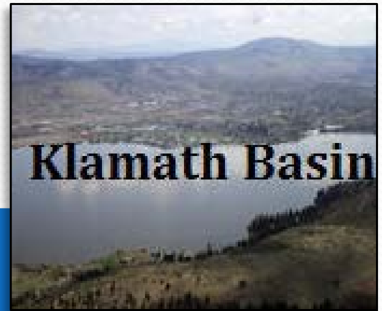
- Focus group approach
- Workshops to frame the issues
- Defined the questions
- Completed research
- Linked questions, decisions, criteria for action, and actions
- Recommend tools and data for decision-making
- **Reality check**
- Develop



Data Users (Focus Group Categories)



Water Supply Forecasts



Water Supply Forecast Accuracy

- From a statistical sense, accuracy of water supply forecasts is good.
- From a practical perspective, the forecast error represents a large volume of water.
- The desired greater accuracy unlikely to be achieved.

Water Supply Forecast Uncertainty

- Generally understand how forecast uncertainty is expressed.
- Alternative decisions to manage risk poorly defined.
- Need to continue improvements in communicating uncertainty.

Climate & Water Data Needs

Temporal and Spatial Scales

- Generally more data are needed at a finer spatial scale.
- Scale is driven by the temporal and spatial scale of issues.
- Generally shorter time periods needed.

Dependence on Data

- Rely daily on climate and water data for making decisions.
- User expertise varies widely.

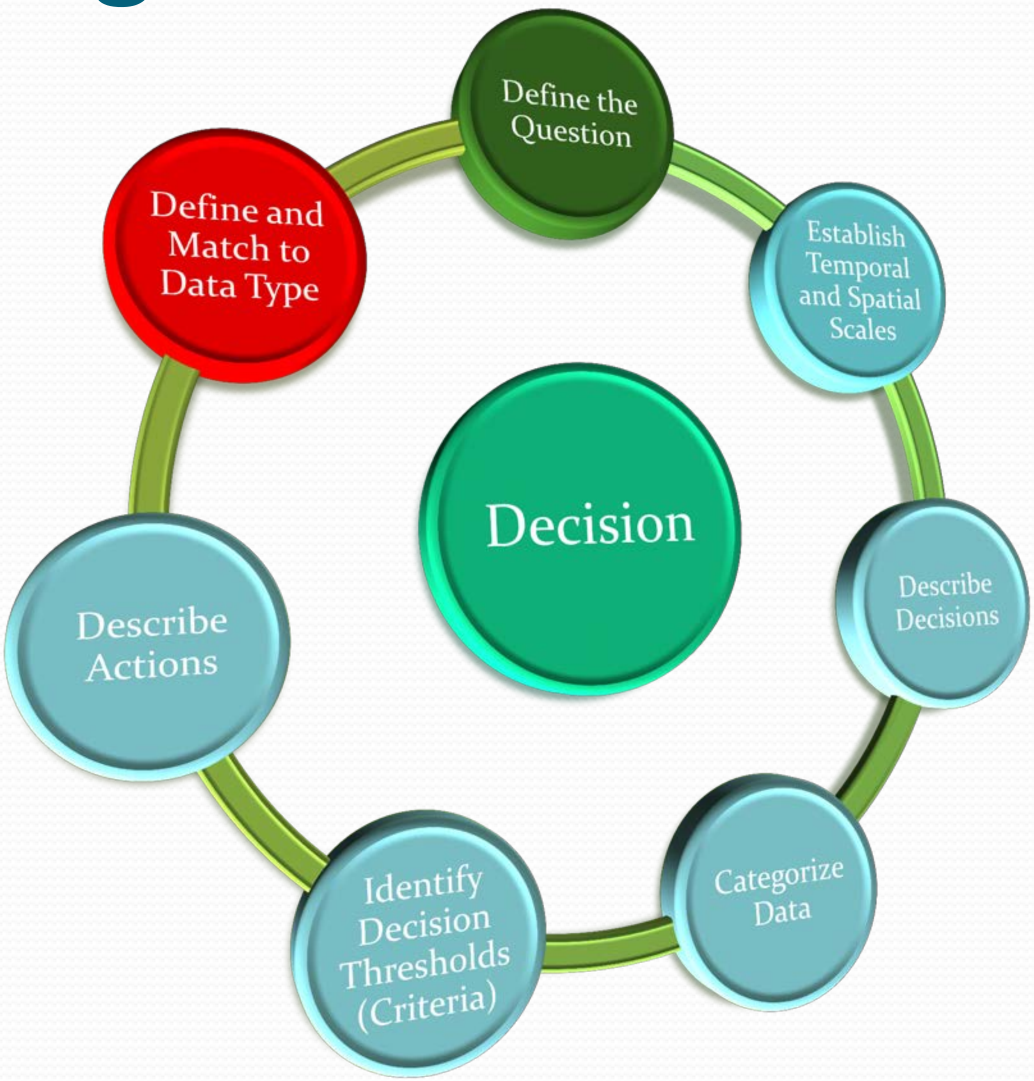
Recognizing Data Use Challenges

- User Diversity
- User Technical Expertise
- User Decision Domain
- Multidisciplinary Resource Decisions
- Communicating Uncertainty
- Integrating Data
- Decision Linkage

Data Use Challenges

- User Diversity
- User Technical Expertise
- User Decision Domain
- Multidisciplinary Resource Decisions
- Communicating Uncertainty
- Integrating Data
- Decision Linkage

Defining the Decision Linkage



Climate and Water Data

Data Type

- Surface air temperature;
- Precipitation;
- Snowfall (depth);
- Growing degree days;
- Snow water equivalent;
- Streamflow;
- Groundwater elevation;
- Lake/reservoir surface water elevation ;
- Soil Moisture; and
- Evapotranspiration.

Temporal Scale

- Instantaneous (near real-time, generally 15-minute);
- 1-hour;
- Last 1-day;
- Last 7 days;
- Last 14 days;
- Last 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 18, 24, 30, 36, 48, 60, and 72 months, ending on the last day of the latest month;
- Water Year To Date (WYTD); and
- Calendar Year to Date (CYTD).

Decision Timelines

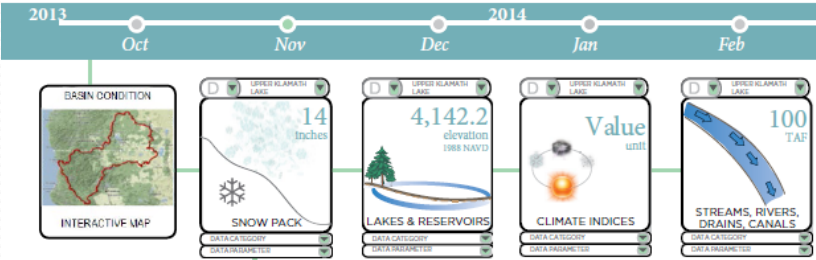
Fisheries & Natural Resource Manager & Klamath Tribe

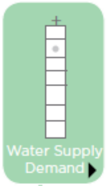
Purpose: Evaluate current and forecast conditions with regard to the existing biological opinions and the quality of ecosystem services.
User skill level: Intermediate

Decision(s): The decisions for this user are expected to be related to whether current water levels, flows, and volumes are presently sufficient or forecast to be sufficient for providing ecological functions and services, largely expressed by specific criteria identified by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service in their joint Biological Opinion.

Information needs: 1. Storage volumes in UKL, Clear Lake and Gerber Reservoirs (see current water level pod on p.1)
2. Current release rate from Link River Dam, A-canal, Gerber Reservoir and Clear Lake
3. Estimated UKL inflow volume (today, cumulative water year) estimated from Williamson below Sprague gage
4. Most recent NRCS seasonal water supply 50% forecast (Mar - September, but the months will change)
5. Flows
6. Cumulative volumes for points of diversion

Today's Date: 3/1/14
Station Location:



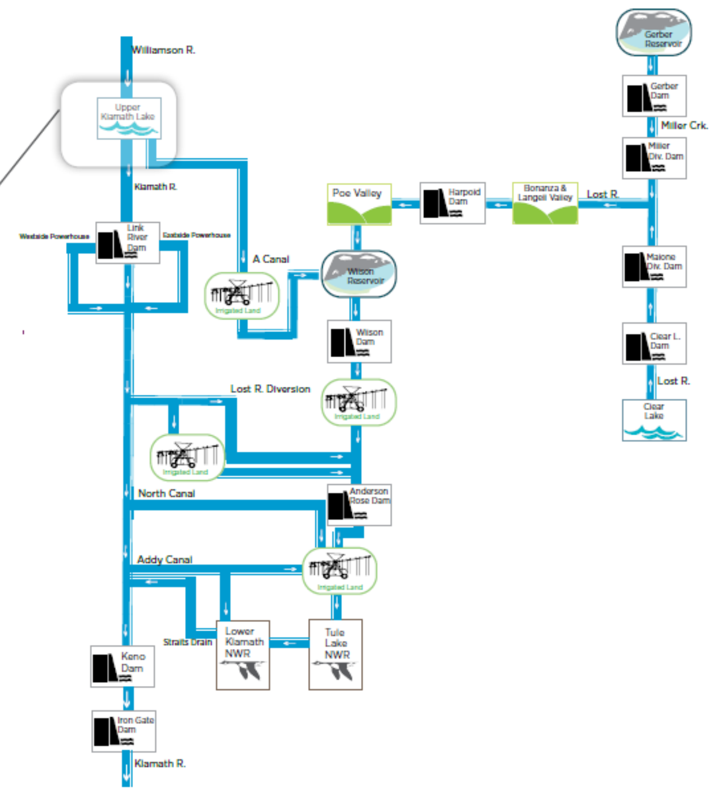


Drill Down Level 2

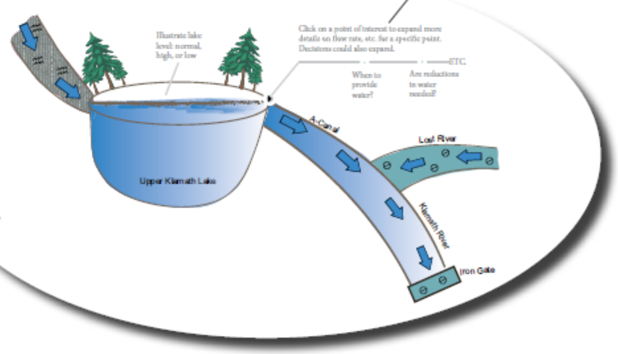
- TIME PERIOD: DAILY
- DEPTH (IN.): ____
- MAXIMUM INTENSITY IN./HR.): ____
- PERCENT OF NORMAL: ____
- DEPARTURE FROM NORMAL (IN.): ____
- HISTORIC: 1999
- DEPTH (IN.): ____
- MAXIMUM INTENSITY IN./HR.): ____
- PERCENT OF NORMAL: ____
- DEPARTURE FROM NORMAL (IN.): ____

User Interface

- AVERAGE MONTHLY PROJECT DEMAND (KAF): ____
- AVERAGE WATER YEAR CUMULATIVE PROJECT DEMAND (KAF): ____
- CURRENT MONTH KBRA POINTS OF DIVERSION VOLUME (KAF): ____
- IRRIGATION SEASON KBRA POINTS OF DIVERSION VOLUME (KAF): ____
- WINTER SEASON KBRA POINTS OF DIVERSION VOLUME (KAF): ____
- CURRENT MONTH REFUGE VOLUME (KAF): ____
- REFUGE IRRIGATION SEASON VOLUME (KAF): ____
- REFUGE WINTER SEASON VOLUME (KAF): ____



Note: This timeline would graphically illustrate all areas of interest, how they're related, and what is occurring throughout the basin. User can view the "big picture", but also narrow in on more details for their specific area of interest by clicking their point of interest.



Pattern in the river graphic would indicate flow trend: = Flow Rate Increasing = Flow Rate Constant = Flow Rate Decreasing

Data Inventory (same data from multiple sources)

	Type of Data	Name of Dataset	Shortest Measured Interval	Source of the Data	Entity Responsible for Data Management	Link
Measured						
Precipitation	Climate	Local Climatological Data Publication	Hourly (from 1945) Daily (from 1930) **Available by state or station	National Climatic Data Center	NOAA (Satellite and Information Service - NESDIS)	http://www.ncdc.noaa.gov/IPS/hpd/hpd.html
Evaporation	Climate	Monthly Average Pan Evaporation	Monthly Average over certain period of years **Only avail. For certain sites	WRCC	NOAA??	http://www.wrcc.dri.edu/htmlfiles/westevap.final.html
Solar Radiation	Climate	Solar Hourly Series for day of - / -/ -	Hourly (from 2003) **Only available at certain stations	National Water and Climate Center	USDA – Natural Resources Conservation Service	http://www.wcc.nrcs.usda.gov/nwcc/inventory
Wind Speed	Climate	Local Climatological Data Publication	Every 3 Hours Daily (from 1945) **Available by state or station	National Climatic Data Center	NOAA (NESDIS)	http://www.ncdc.noaa.gov/IPS/lcd/lcd.html
Wind Direction	Climate	Local Climatological Data Publication	Every 3 Hours Daily (from 1945) **Available by state or station	National Climatic Data Center	NOAA (NESDIS)	http://www.ncdc.noaa.gov/IPS/lcd/lcd.html
Sky Cover	Climate	Local Climatological Data Publication	Daily (from 1945) **Available at certain sites	National Climatic Data Center	NOAA (NESDIS)	http://www.ncdc.noaa.gov/IPS/lcd/lcd.html

Documenting Decision Linkage

Category	Description	Type	Data		Criterion			Reference
			Time Scale	Spatial Scale / Locations	Description	Value	Units	
Water Supply Availability								
	Volume allocated to irrigation supply within the Klamath Project	Surface water volume	March through October	Upper Klamath Lake Inflow (Net)	April 1 – September 30 volume forecast by the NRCS-NWCC for their forecast issued on March 1	Forecast volume If <= 287,000 then 387,000 If > 287,000 but less than 569000 then 378 + {42.64 x [(Forecast Volume – 287)/282}*1000 If > 569,000 then 445,000	Acre-feet	
			November through February		Seasonal volume	45,000	Acre-feet	
	Volume allocated to the Lower Klamath Wildlife Refuge	Surface water volume	March through October;	Upper Klamath Lake Inflow (Net)	April 1 – September 30 volume forecast by the NRCS-NWCC for their forecast issued on March 1	If <= 287,000 then 48,000 If > 287,000 but less than 569000 then 48 + {7.64 x [(Forecast Volume – 287)/282}*1000 If > 569,000 then 60,000	Acre-feet	
			November through February		Seasonal volume	35,000	Acre-feet (values given are in 1000 acre-feet)	

Data Use Challenges

- User Diversity
- User Technical Expertise
- User Decision Domain
- Multidisciplinary Resource Decisions
- Communicating Uncertainty
- Integrating Data
- Decision Linkage

Managing Uncertainty with Decision-Making

Focus Group	Decision Actions	Range of Options
Agricultural Producer	Acreage Planted	• All arable land • Some portion of arable land • Fallow arable land
	Source of Water	• Use of surface water supply only • Use of surface water supply and supplemental supply (e.g., ground water) • Use of supplemental supply only • Fallow
	Crop Types	• High water demand crops (e.g., orchards) • Mix of high water demand and low water demand • Low water demand crop (pasture)
Federal Water Supply Project Operator	Delivery of Water Supply	• Decrease Rate • Maintain current rate • Increase rate • Stop Delivery
Local Water Supply Administrative Organization	Need for Water User Mitigation Program	• Volume of supplemental water supply needed • Amount of acreage fallowed
Irrigation District	Delivery of Water Supply	• Proportion of lands served • Range of water supply provided (up to full)
Fisheries Manager	Fish Harvest	• Alter harvest limits in response to anticipated impacts of instream flow allocations
	Challenge Flow Allocations	• Petition Reclamation • File lawsuit

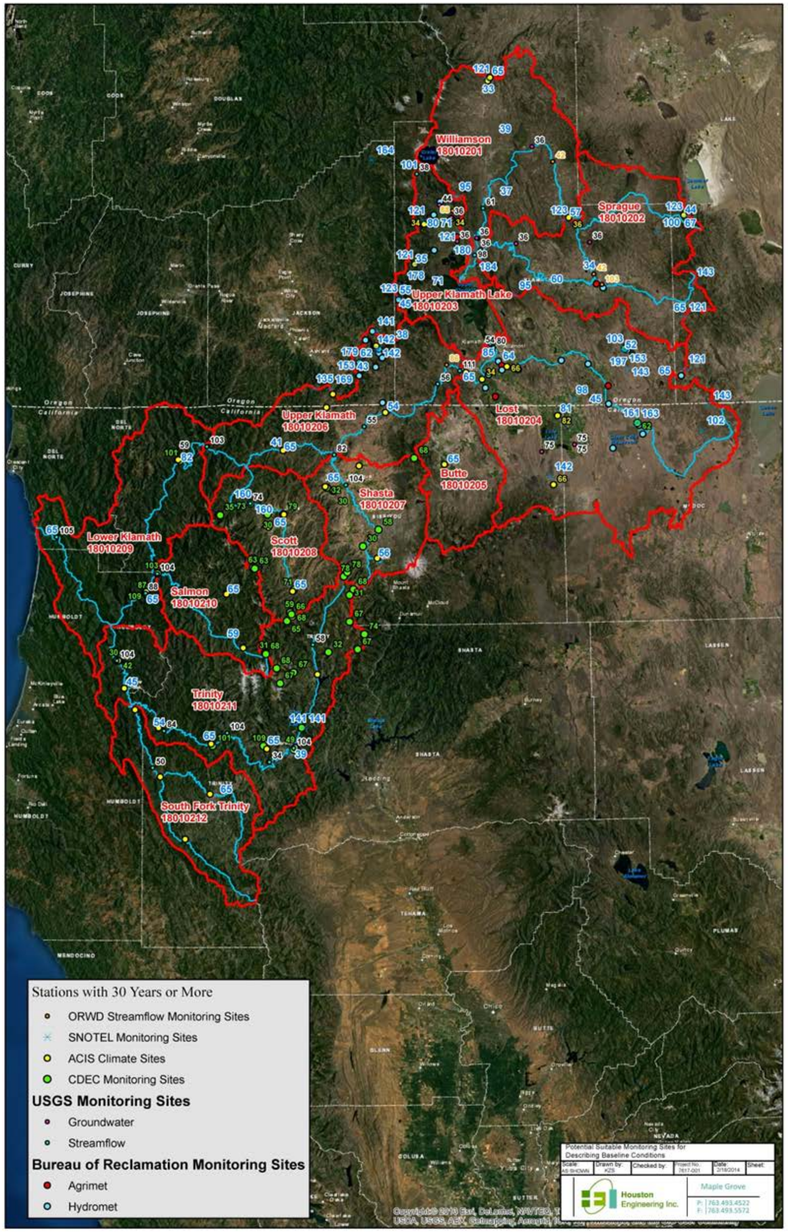
Data Use Challenges

- User Diversity
- User Technical Expertise
- User Decision Domain
- Multidisciplinary Resource Decisions
- Communicating Uncertainty
- Integrating Data
- Decision Linkage

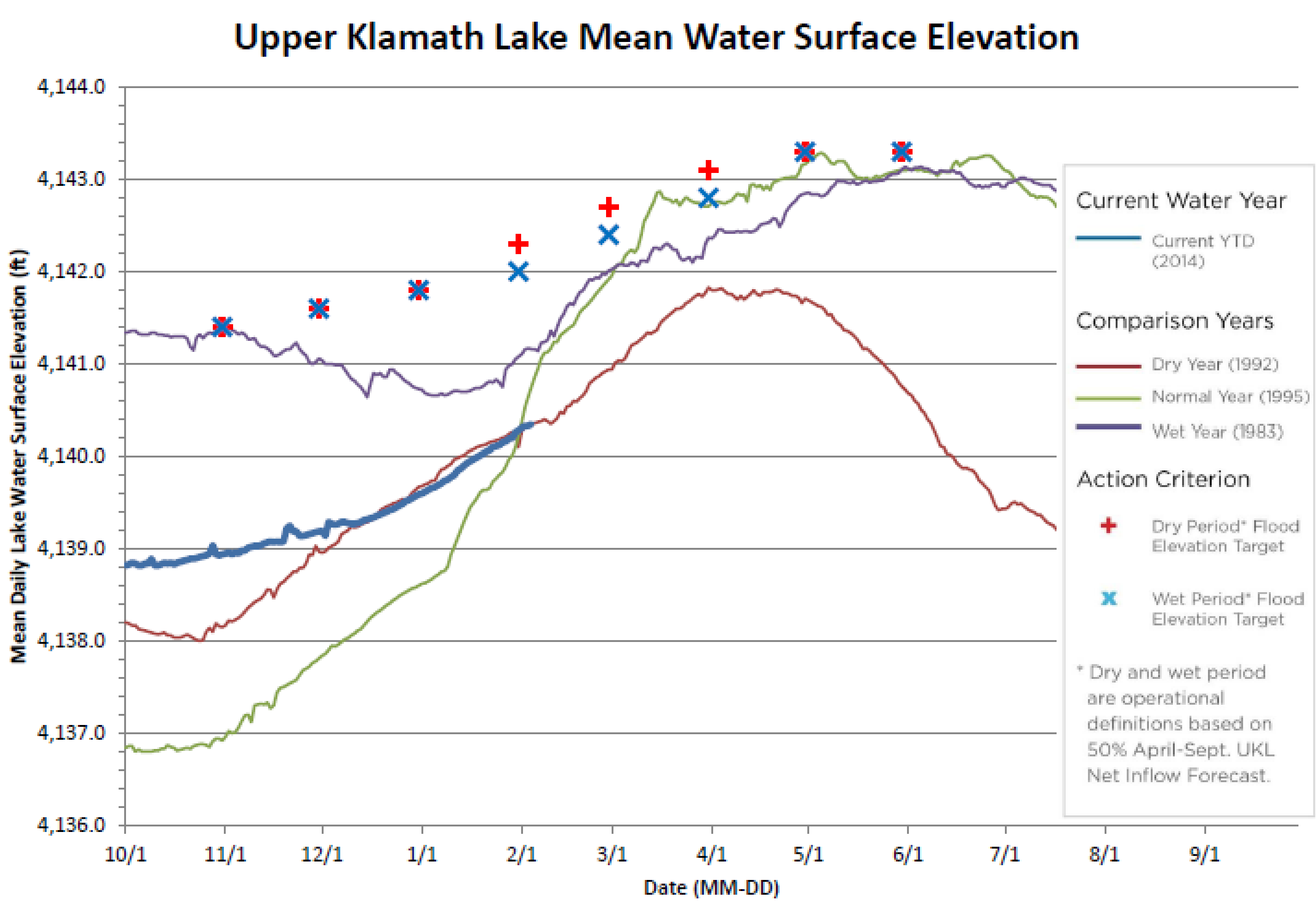
Establishing Context

- Compare current time period to some baseline condition
- Show data in comparison to one or more values where the value(s) result in a decision
- Display information for a specific period of time with which the user has firsthand knowledge or experience
- Display information along with historical ranges and percentiles for the period of record
- Integrate measured and forecast information into a single graph
- Provide the opportunity to compare data for inferential purposes

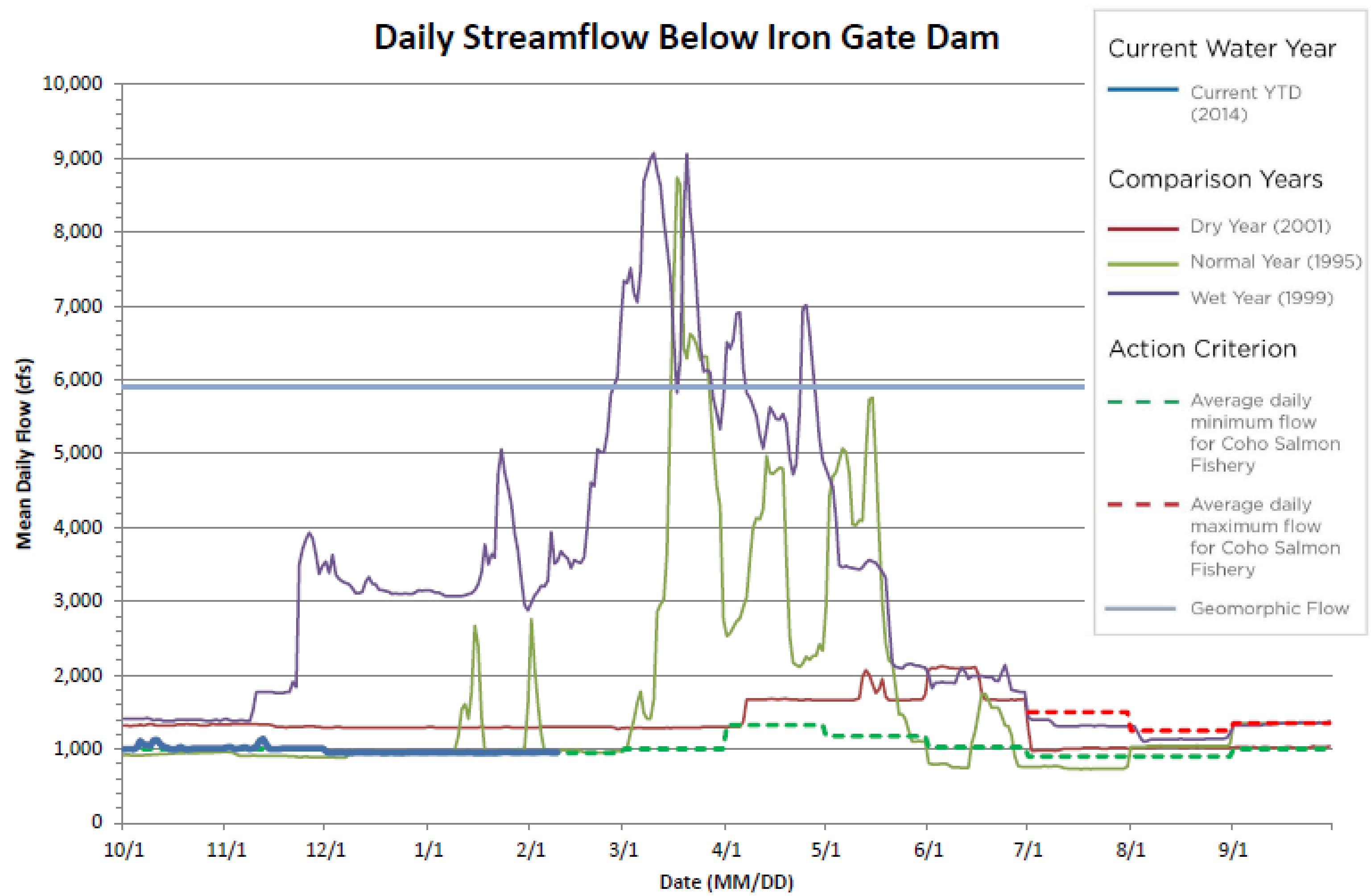
Baseline Conditions for Climate and Water Data



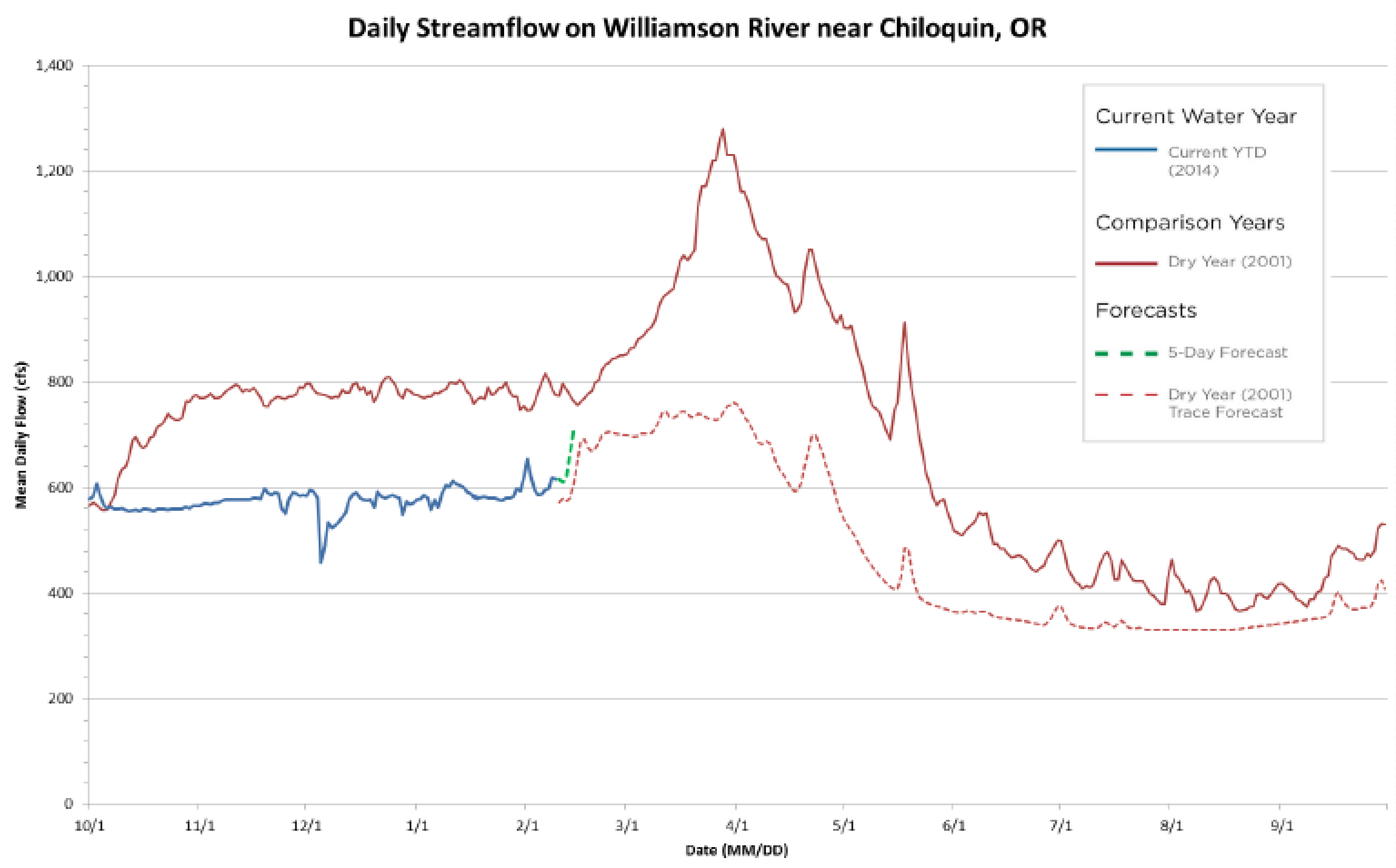
Using Baseline Condition



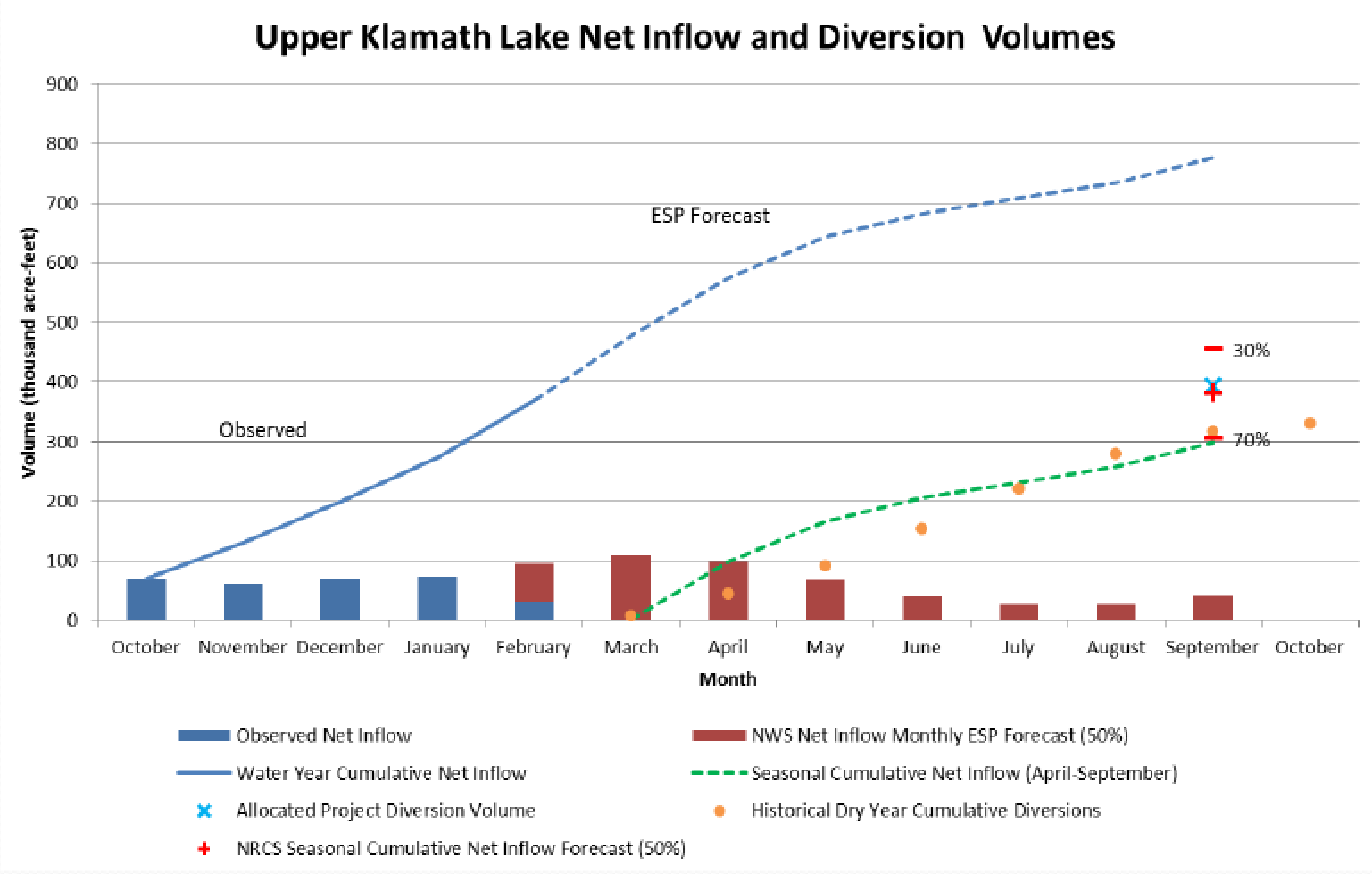
User Defined Criteria



Integrating Forecasts & Real Years

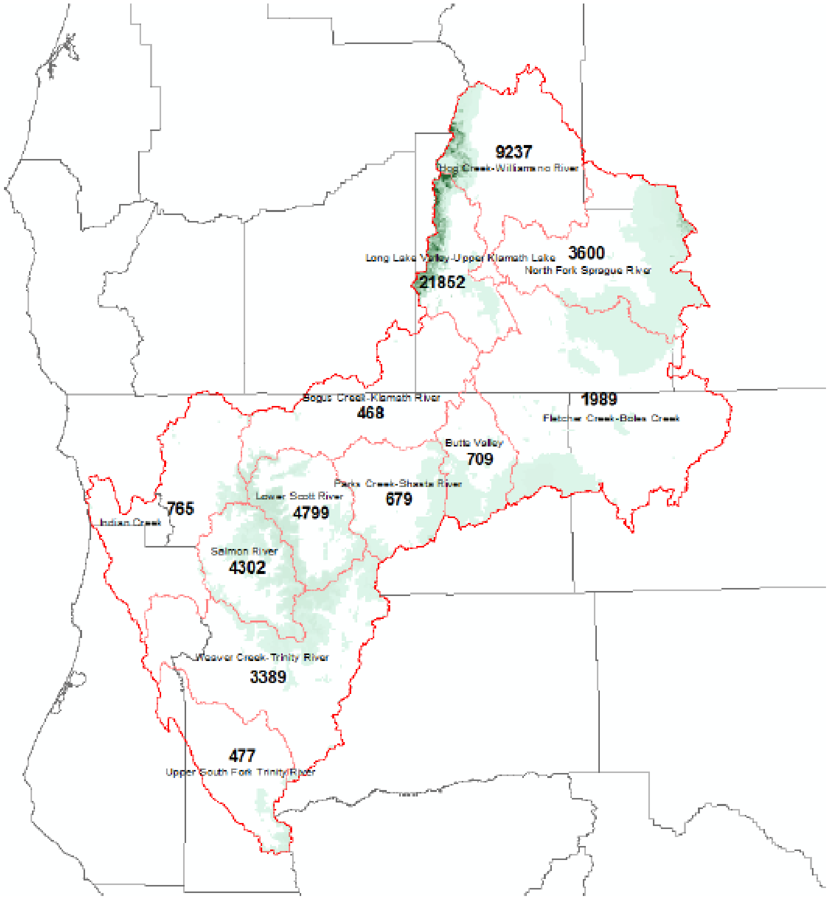


Integrating Forecasts



Alternative Presentation Methods

- Intensity of Supplemental Water Program
- Compare estimated water volume in snow pack plus volume in storage to seasonal water supply forecast



SWE in af on January 31, 2014 (from NOHRSC)

Tools and Design Considerations

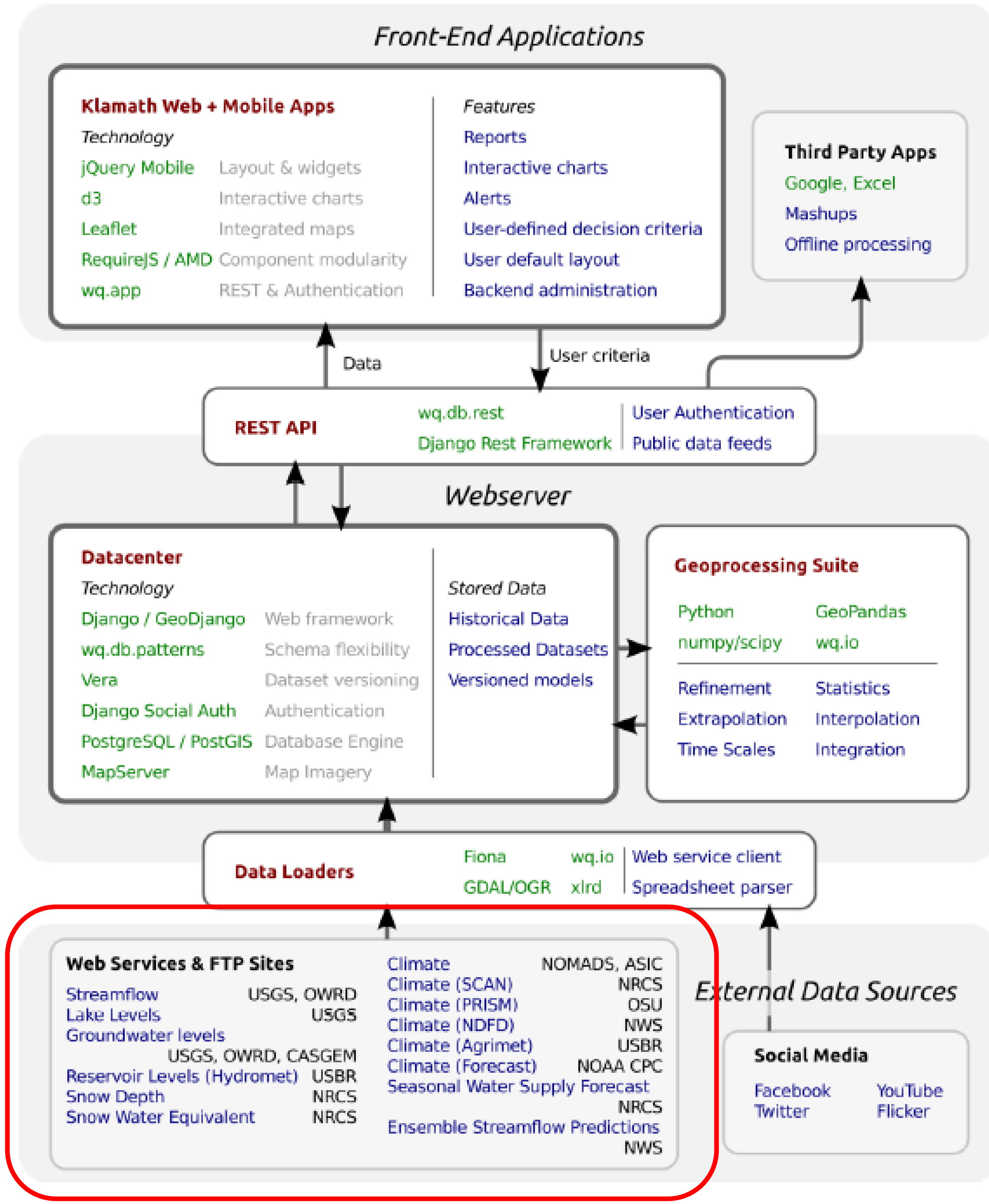
Implementing the Recommendations –
Designing and Building Robust Tools and Applications

1. Robust Tools and Apps
2. Recommended Platform
3. Wireframes

Defining Robust Tools and Apps

- User access to standardized, time invariant, (e.g., SHEP, NWS text product) electronic data (not images, graphs)
- Available through a data Application Interface (API)
- Data must fit within the "normal workflow process"
- Users provide resources to ingest newly created data
- Automatic error checking of web servics and web master notification for system failures
- Data categorization for use in standard data charting, analysis, and reporting tools.
- Standard data charting, analysis, and reporting (by data type?)
- Users enter, upload, and evaluate against specific decision criteria
- Understandable method of describing and understanding the data

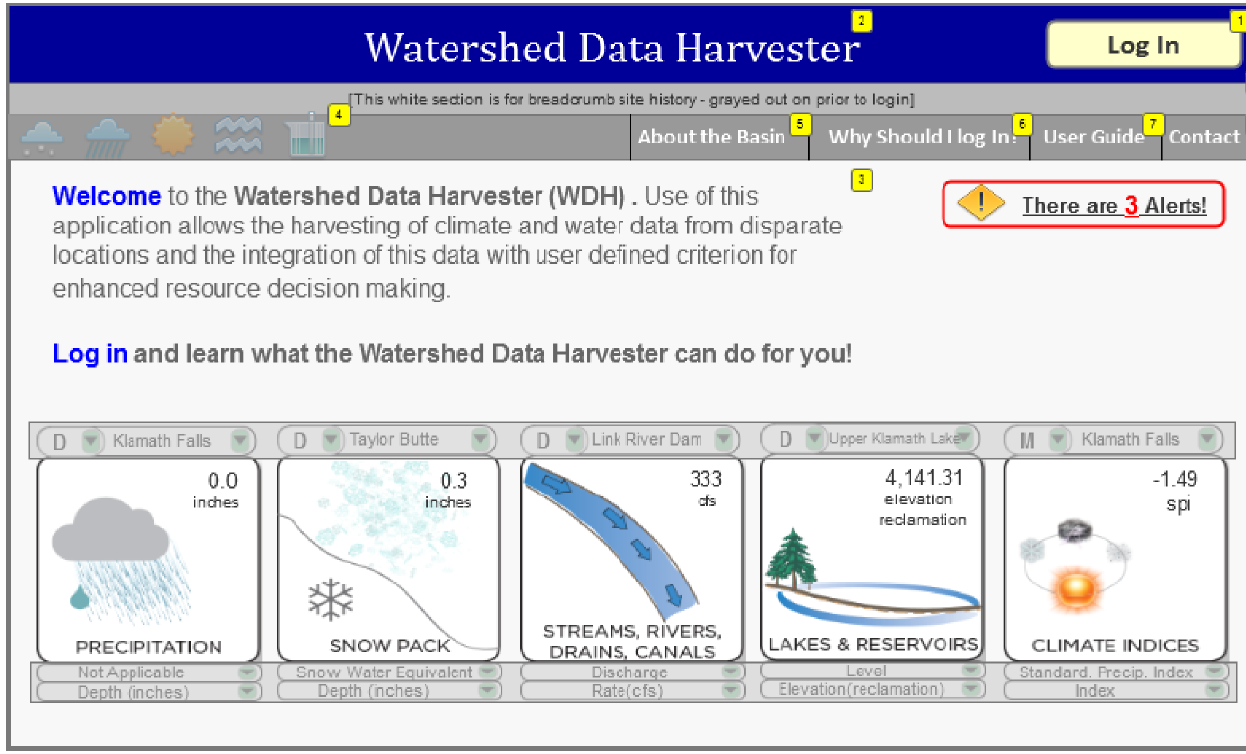
Recommended Technologies



Wire Framing

1.2. Home

1.2.1. User Interface

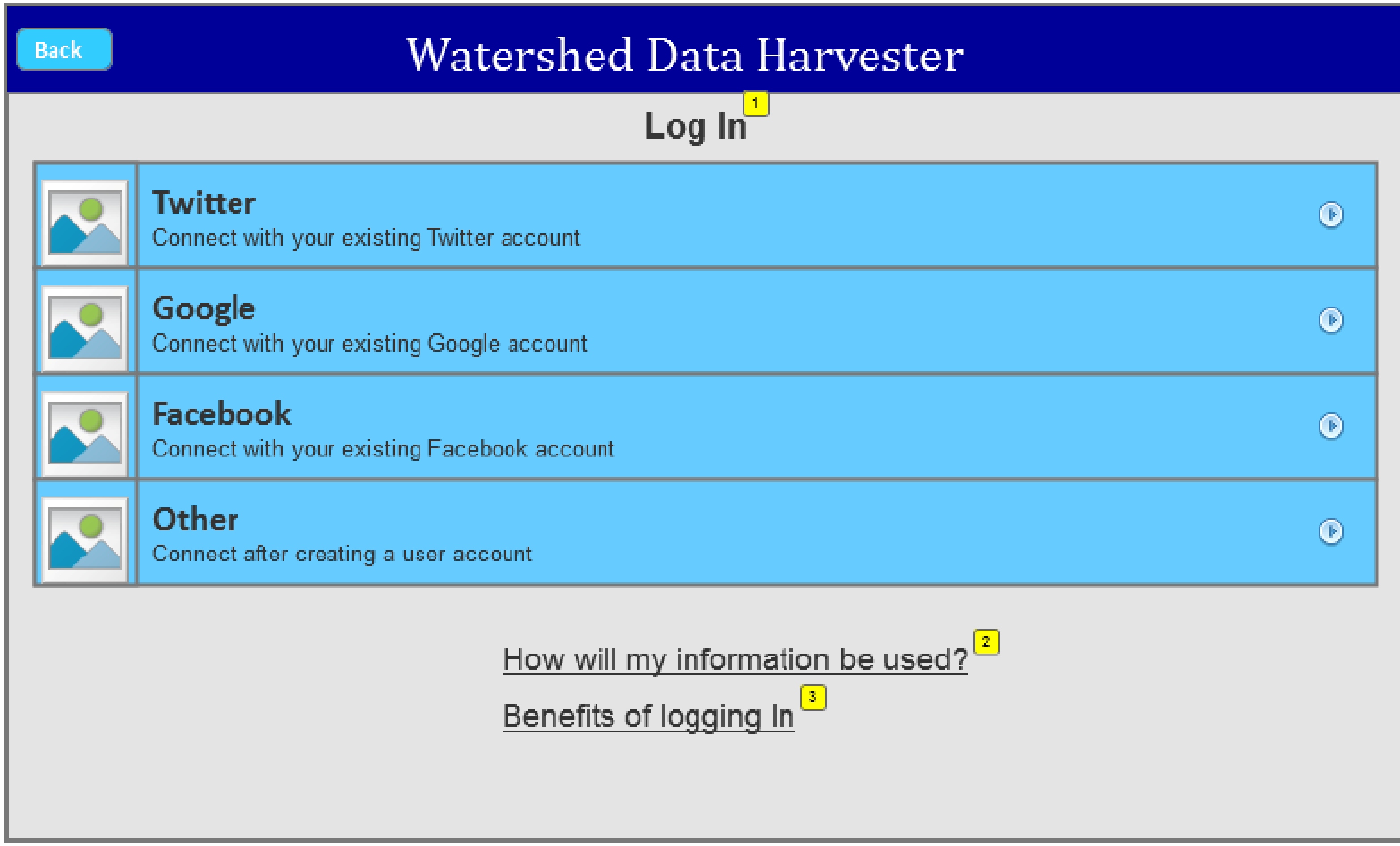


1.2.2. Widget Table

Footnote	Label	Description
1	Log In	A visitor must authenticate himself/herself to access the site. After account information has been obtained, the next visit will take the user to the customizable Dashboard page
2	Site Title	Site title for now
3	Welcome Text	Welcome Text
4	Pod Access Menu	This is not assessible until and the user is authenticated
5	About the Basin	This link takes user to a page that gives information about the basin
6	Why Should I login in?	This link takes user to a page that explains the benefits of logging in and how the information gathered about the user will make their site experience better.
7	User Guide	This link will take a user to a page that will explain different functionality present within the site.
8	Contact	This link will take the user to a page that will display key contact information
9	Breadcrumb Trail	This section is not active prior to login

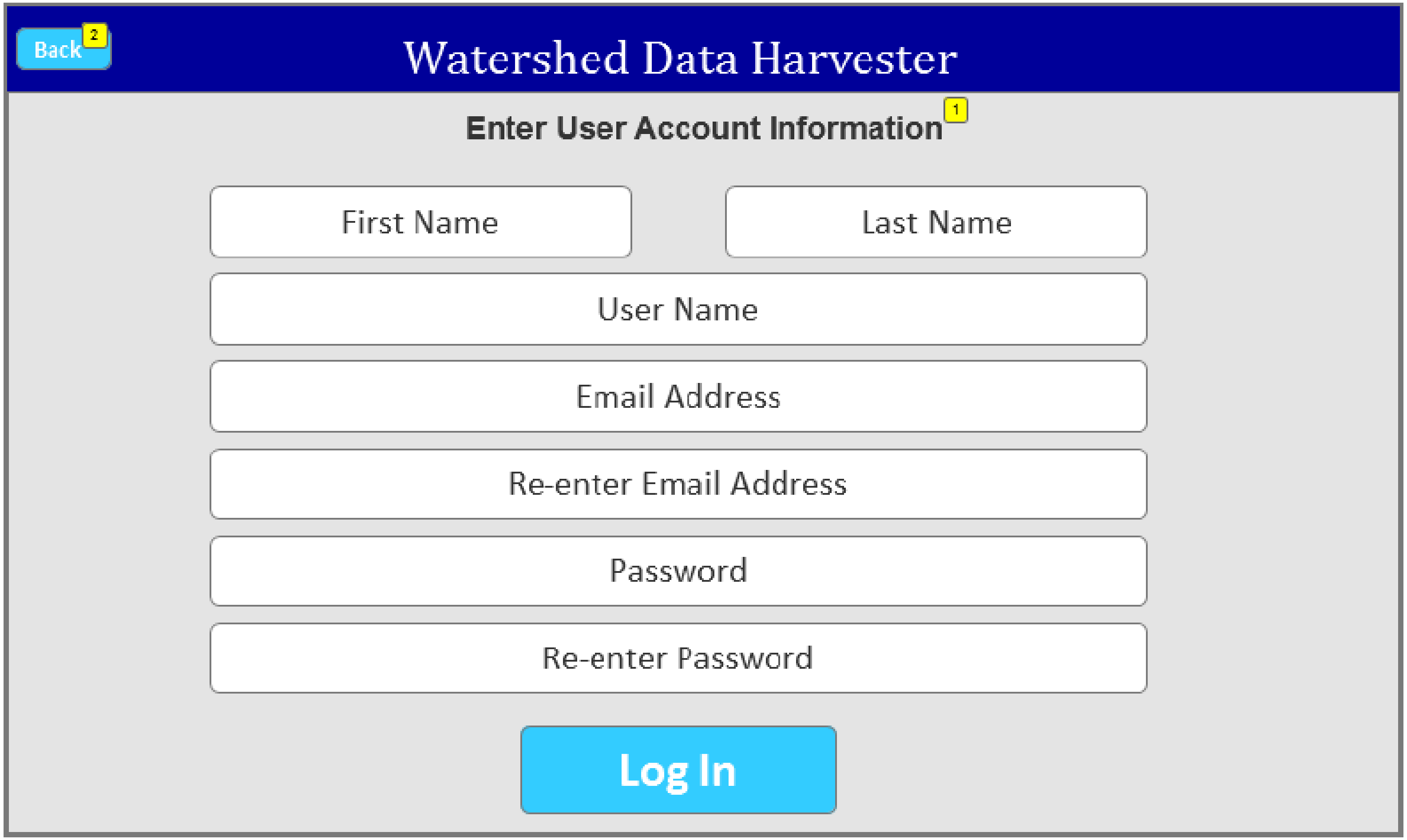
1.3. Social Media Authentication and LogIn

1.3.1. User Interface



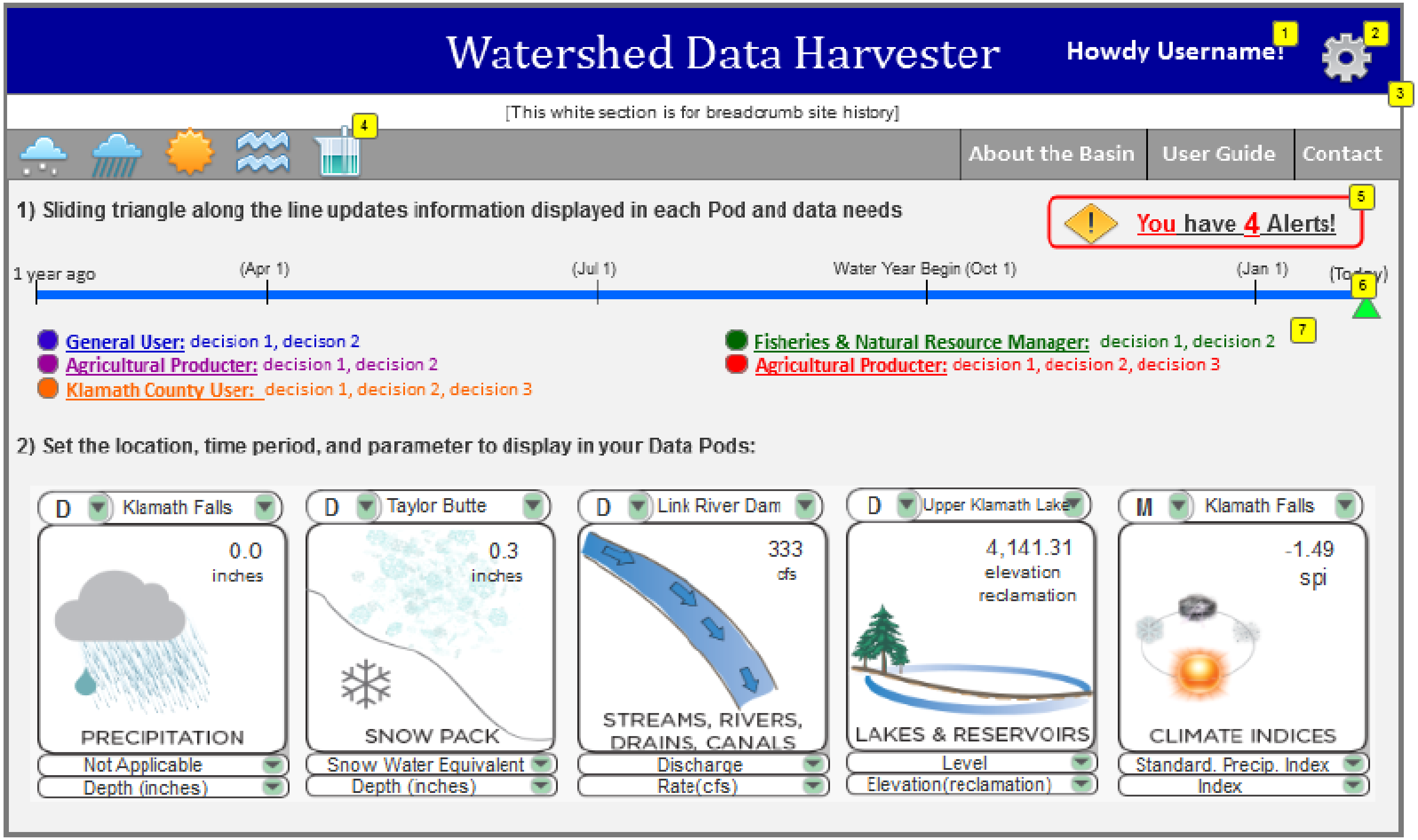
1.4. Traditional Authentication and LogIn

1.4.1. User Interface



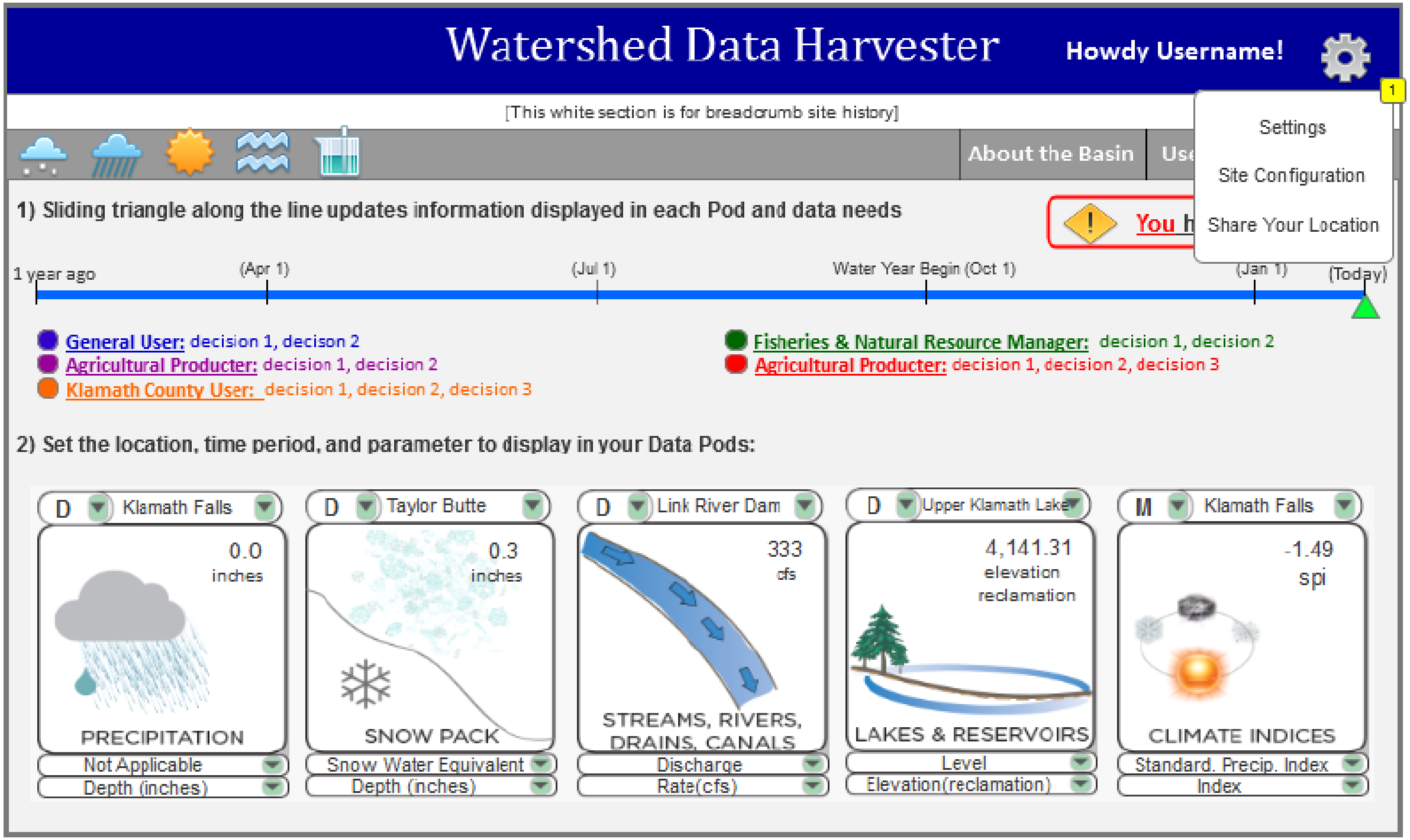
1.5. Dashboard

1.5.1. User Interface



1.6. Dashboard_Config_Menu

1.6.1. User Interface



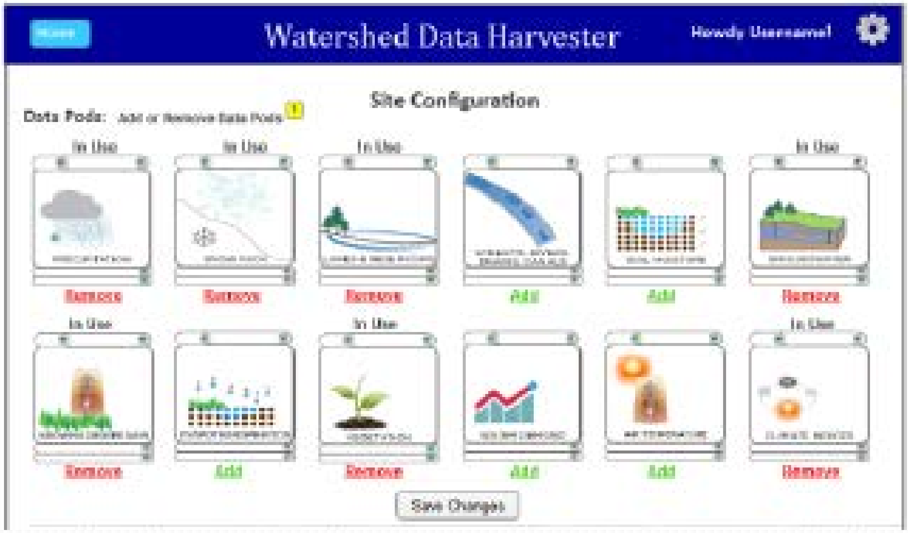
Configuration

1.7. Configuration

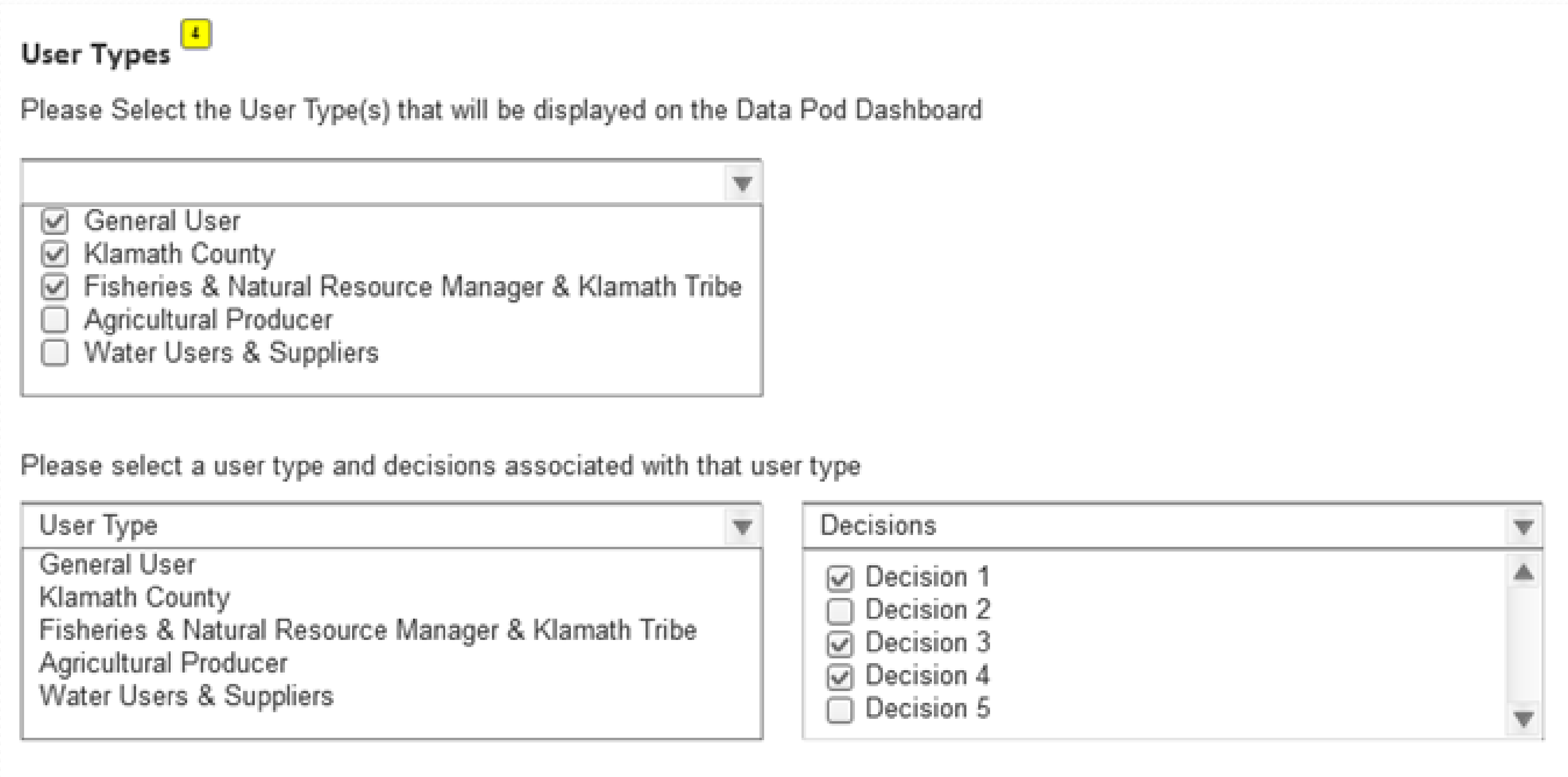
1.7.1. User Interface

Select User Type

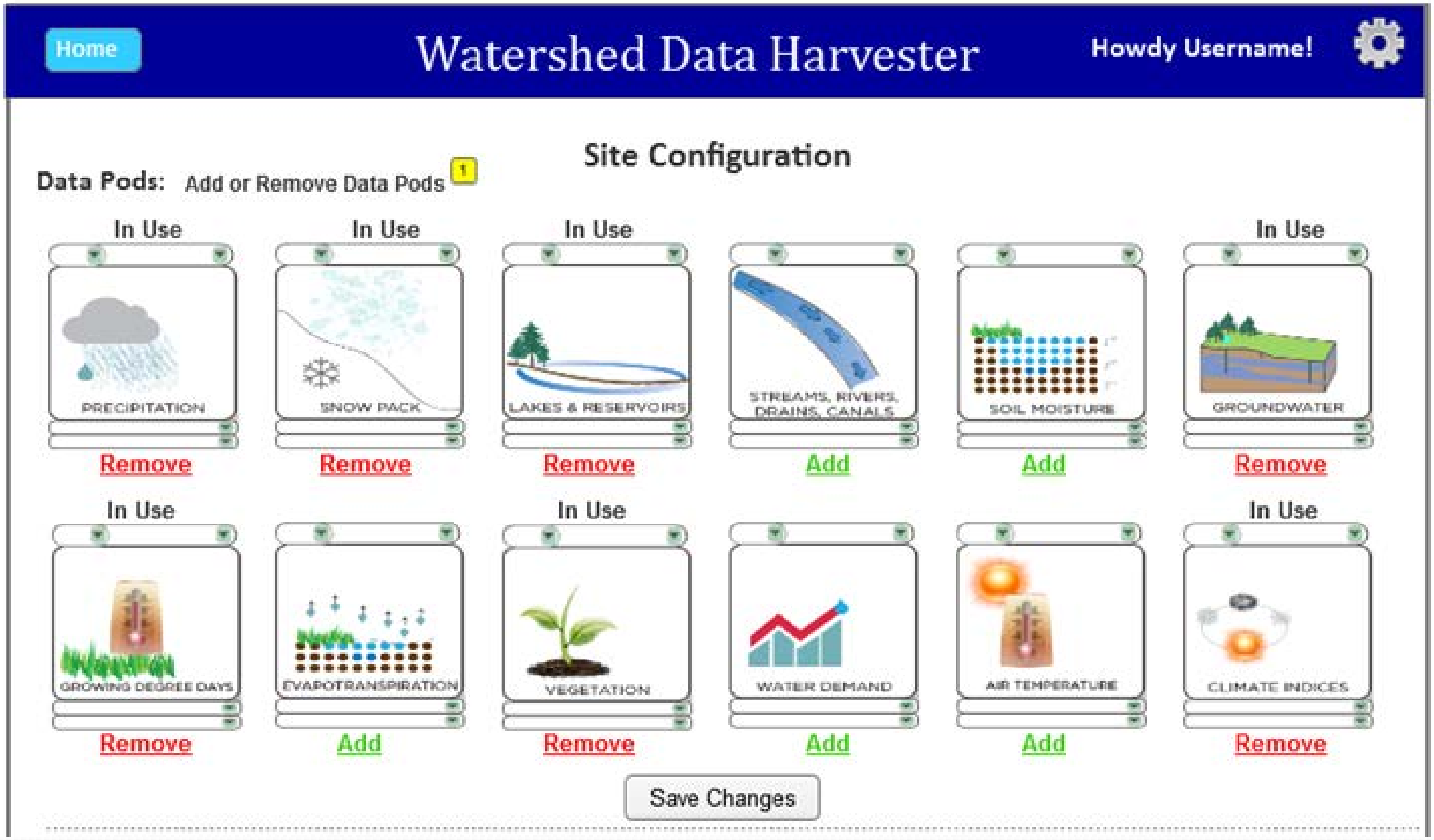
Pods (data types)
Time period
Locations
Pod Parameters
Alerts



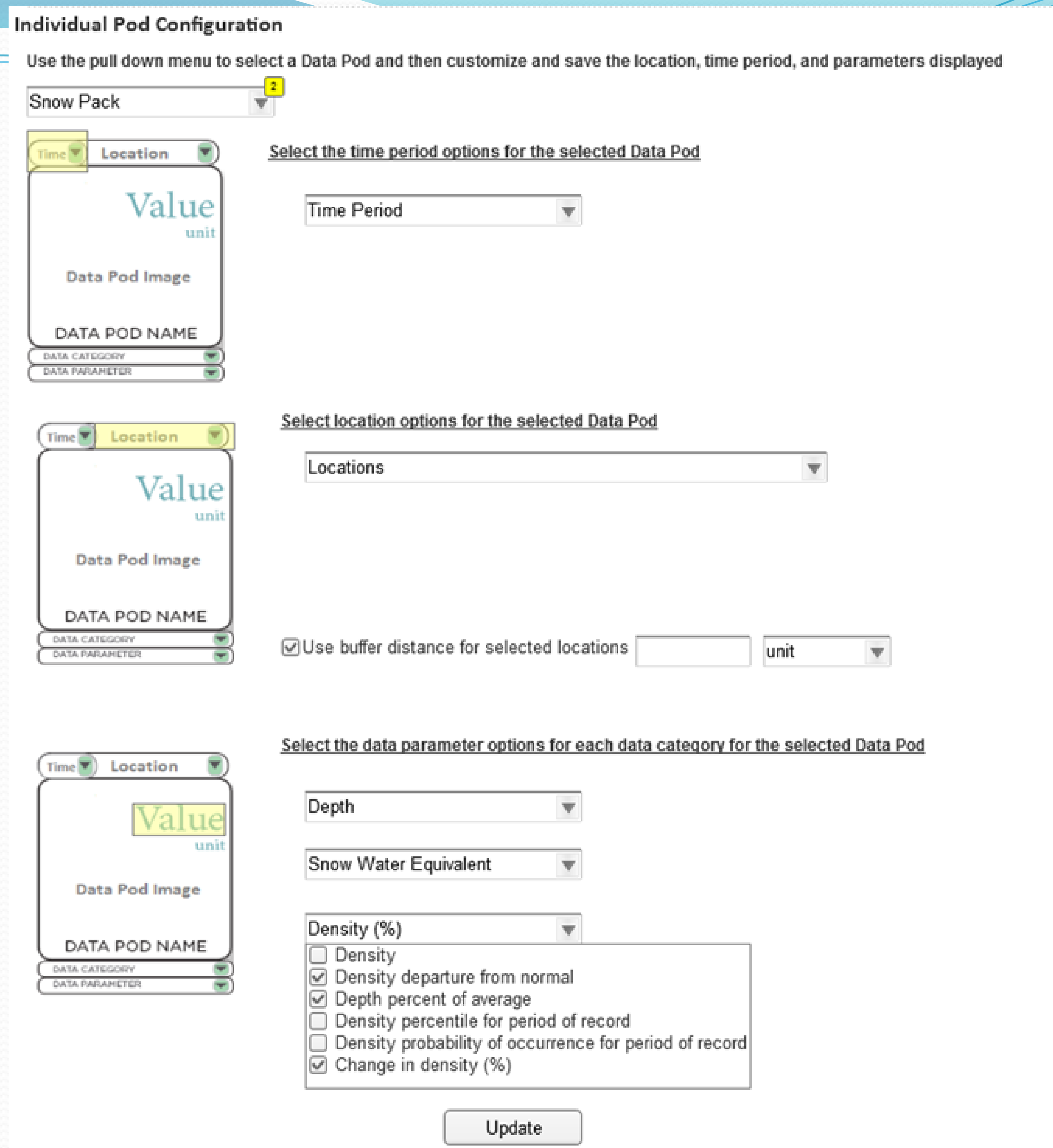
Default User Type



Configure Dashboard Pods



Configure Pod Data



Configure Alerts

Alert Configuration 3 ⚠ You have 5 alerts set

Select default alerts by category or subcategory to receive automatic notification by email or text as resource condition apporaches pre-set criterion

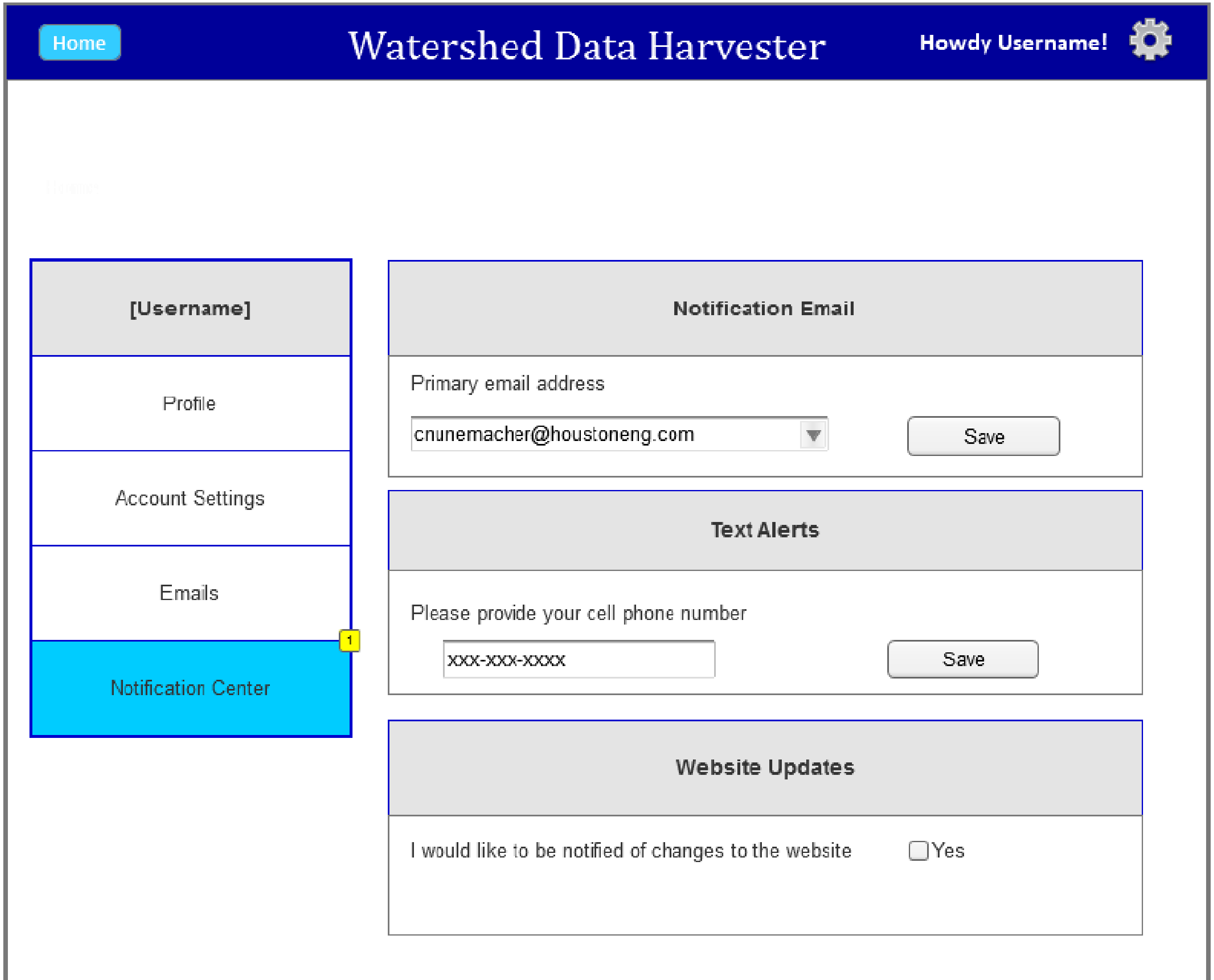
- + ☐ Water Supply Availability
- + ☑ Water Supply Demand
- + ☐ Lake and Reservoir Levels and Volumes
- + ☑ Streamflow
- + ☐ Groundwater
- + ☐ Agricultural
- \- ☑ Indices
  - ☑ Extreme Drought
  - ☑ Standardized Precipitation Index
  - ☑ Drought Index
  - ☑ Palmer (Drought Severity) Index
  - ☑ KWAPA Water User Mitigation Program Index

Configurable Alert Options

- Alert Levels (these all have a time and space aspect)
- Water Supply Volume
  - Klamath Project for irrigation
  - Lower Klamath National Wildlife Refuge
- Klamath Project water supply demand
- Lake and Reservoir Levels
  - Maximum temporary flood elevation
  - Maximum operating elevation
  - End of irrigation season minimum operating elevation
  - Current amount of water in storage
  - Remaining useable storage volume
  - Average flow release rate through dam
  - Rate of reservoir filling
  - Carry over volume
  - Ecological elevation
- Streamflow
  - Williamson River streamflow rate
    - William River streamflow threshold
    - Proportion of Upper Klamath Lake inflow from Williamson River
  - Volume accretions to the Klamath River below Link River Dam
  - Iron Gate Dam
    - Minimum flows for Coho Salmon
    - Summer maximum flow targets
  - Rate of discharge target
  - Accumulated volume target
  - Maximum stage alert level (flood)
  - Minimum stage alert level
  - Point of diversion
- Basin water supply index for Water User Mitigation Program
- Amount of accumulated precipitation
- Number of growing degree days
- Soil moisture percentage
- Drought condition
  - Potential for drought
  - Extreme drought
- Groundwater target water elevation in well

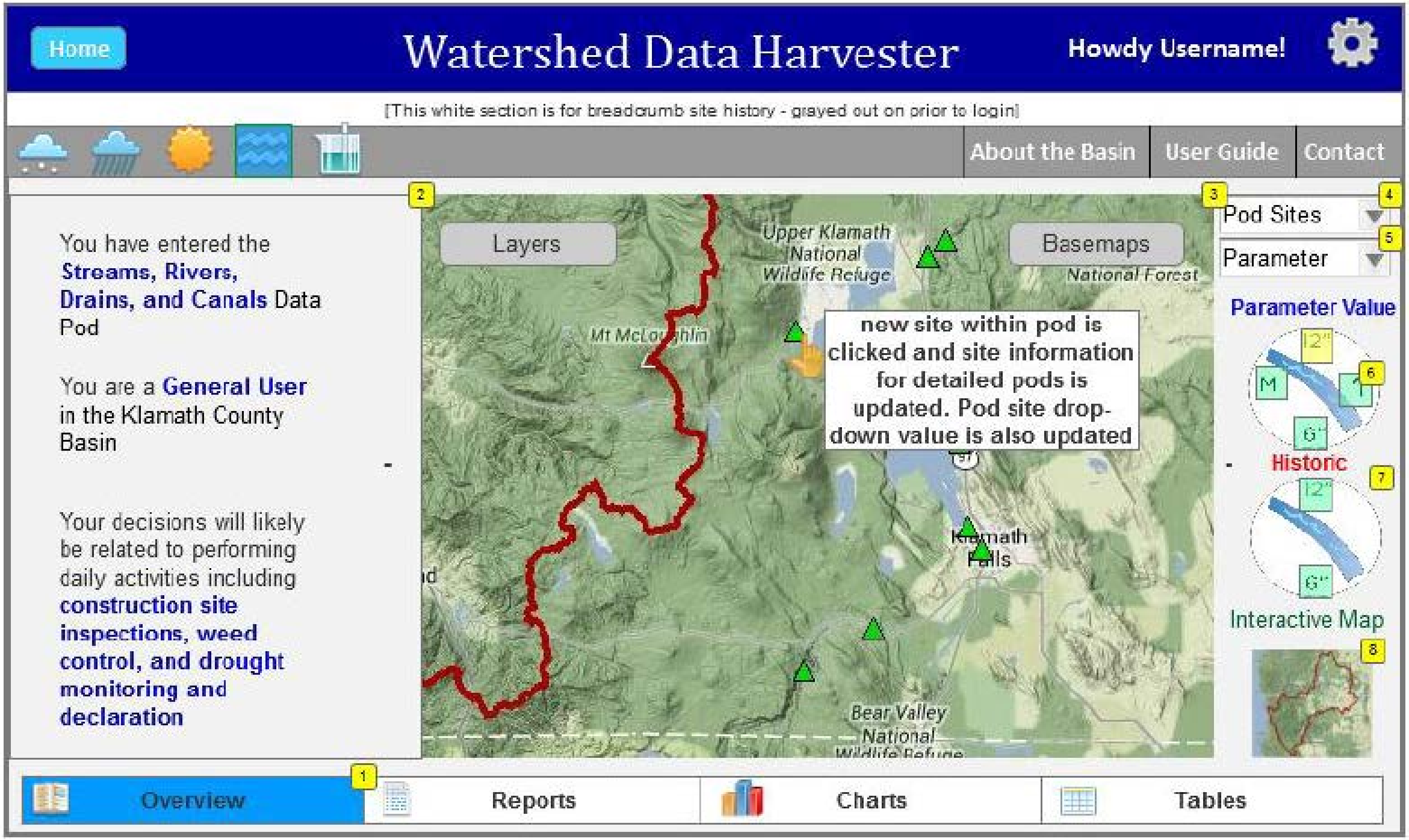
1.11. Notification Center

1.11.1. User Interface



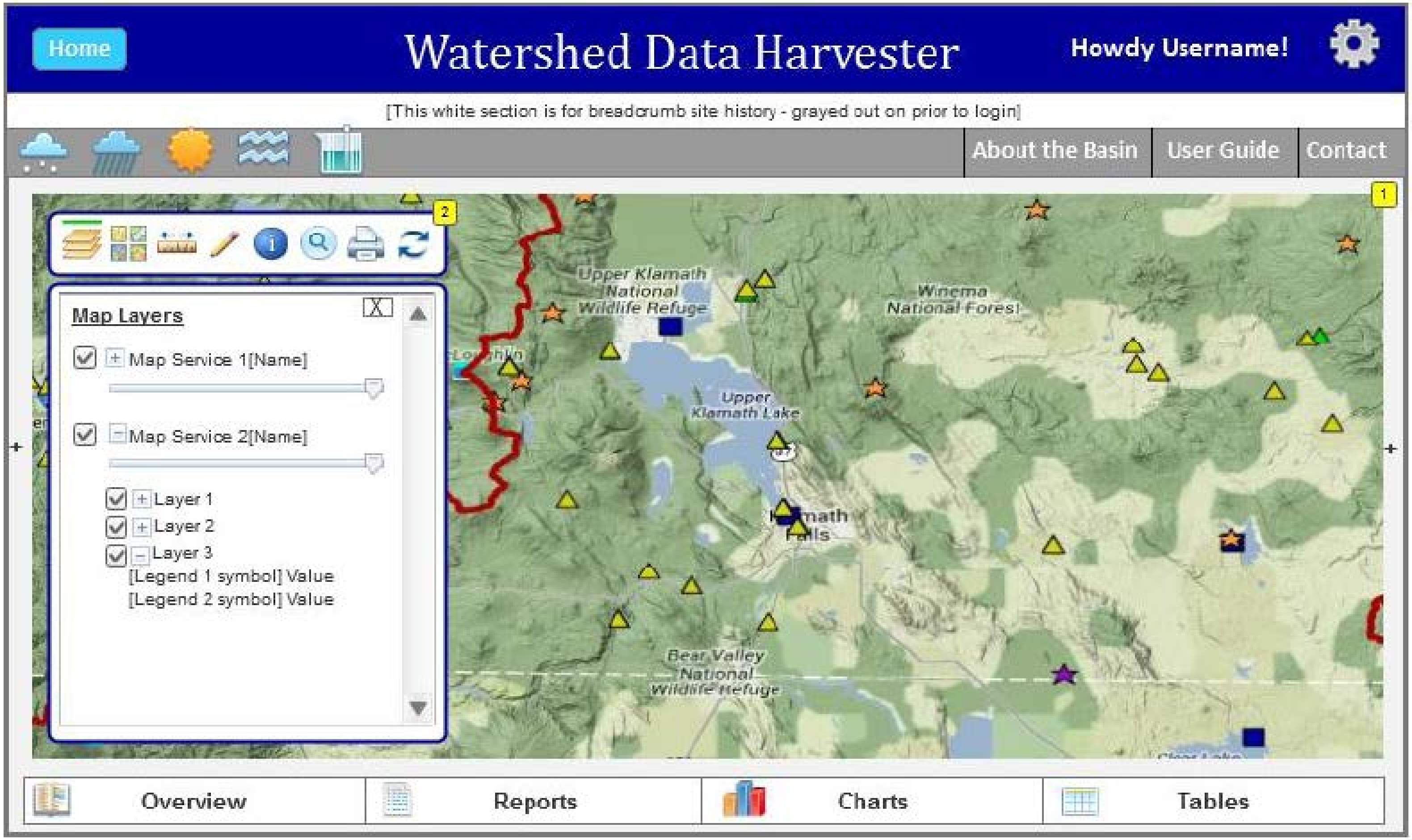
1.12. Streams_overview_page

1.12.1. User Interface



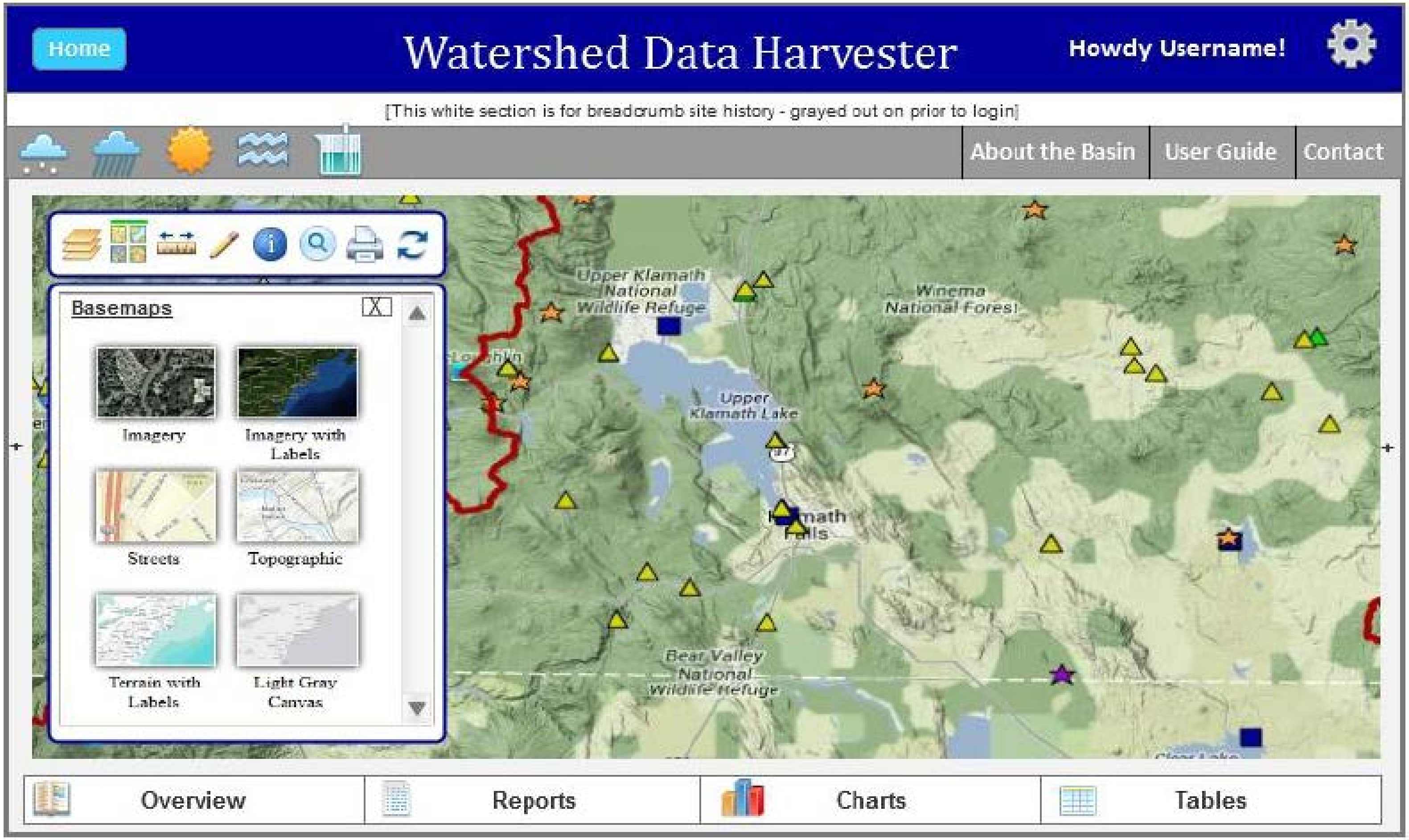
1.14. Interactive Map

1.14.1. User Interface



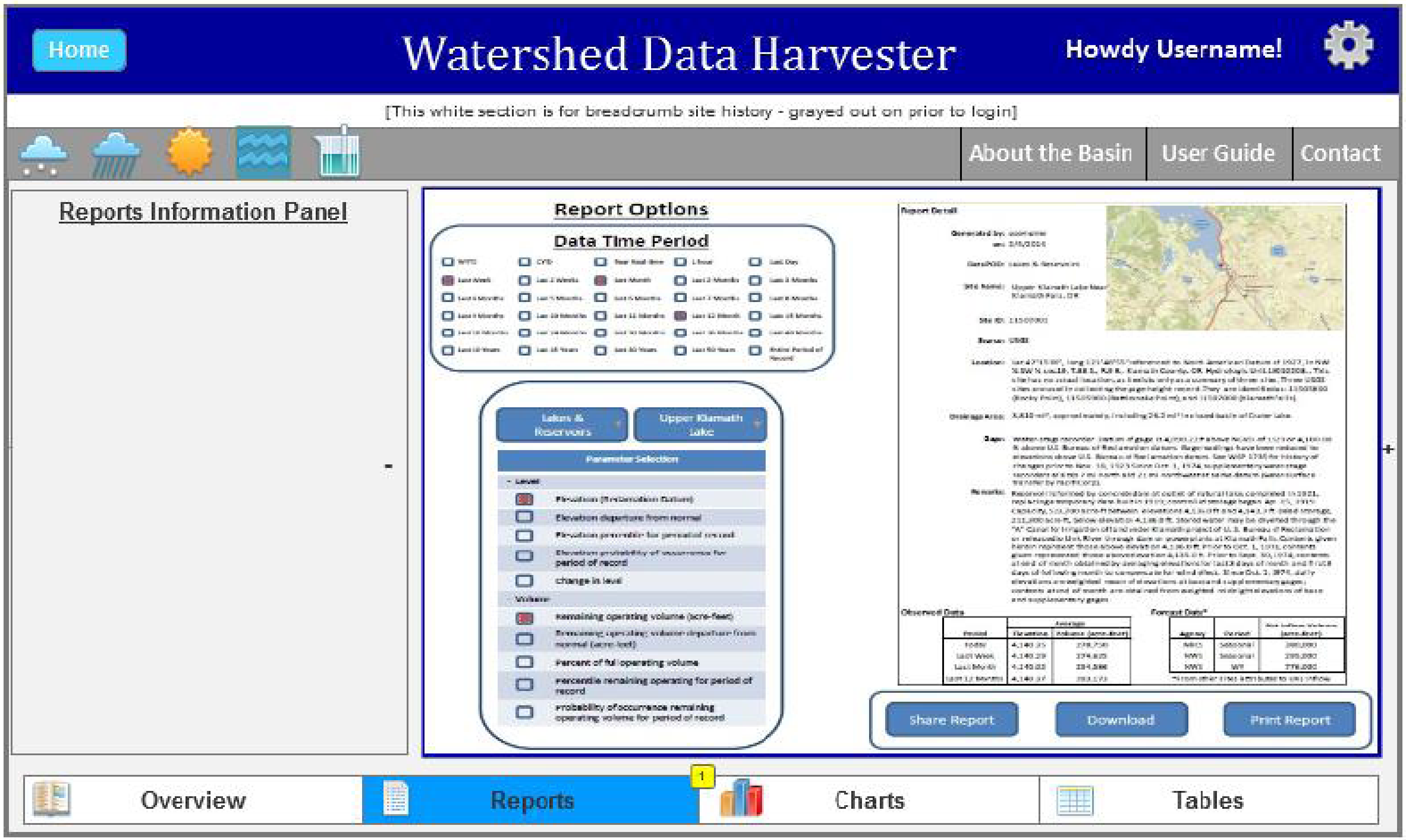
1.15. Basemaps

1.15.1. User Interface



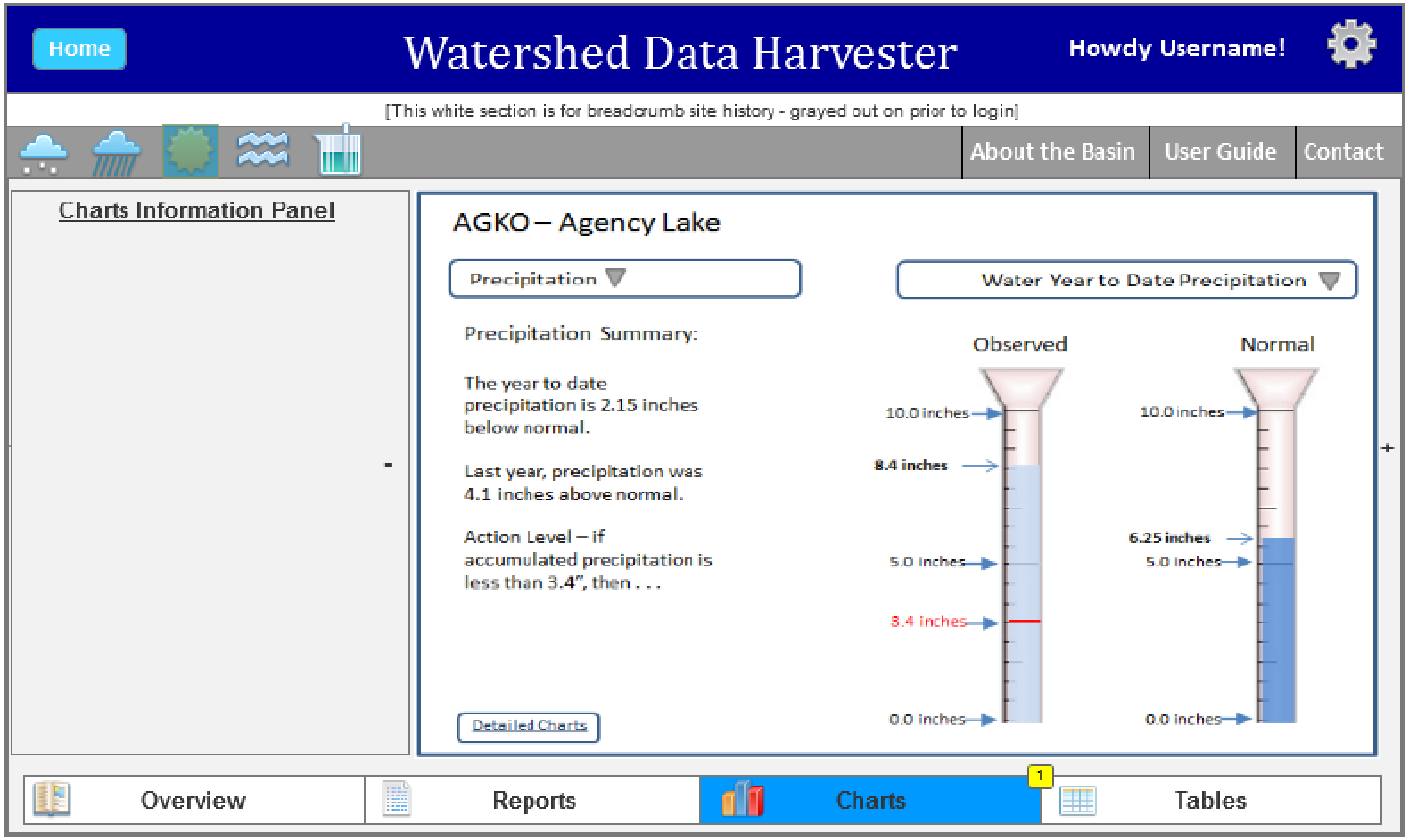
1.21. Reports Page

1.21.1. User Interface



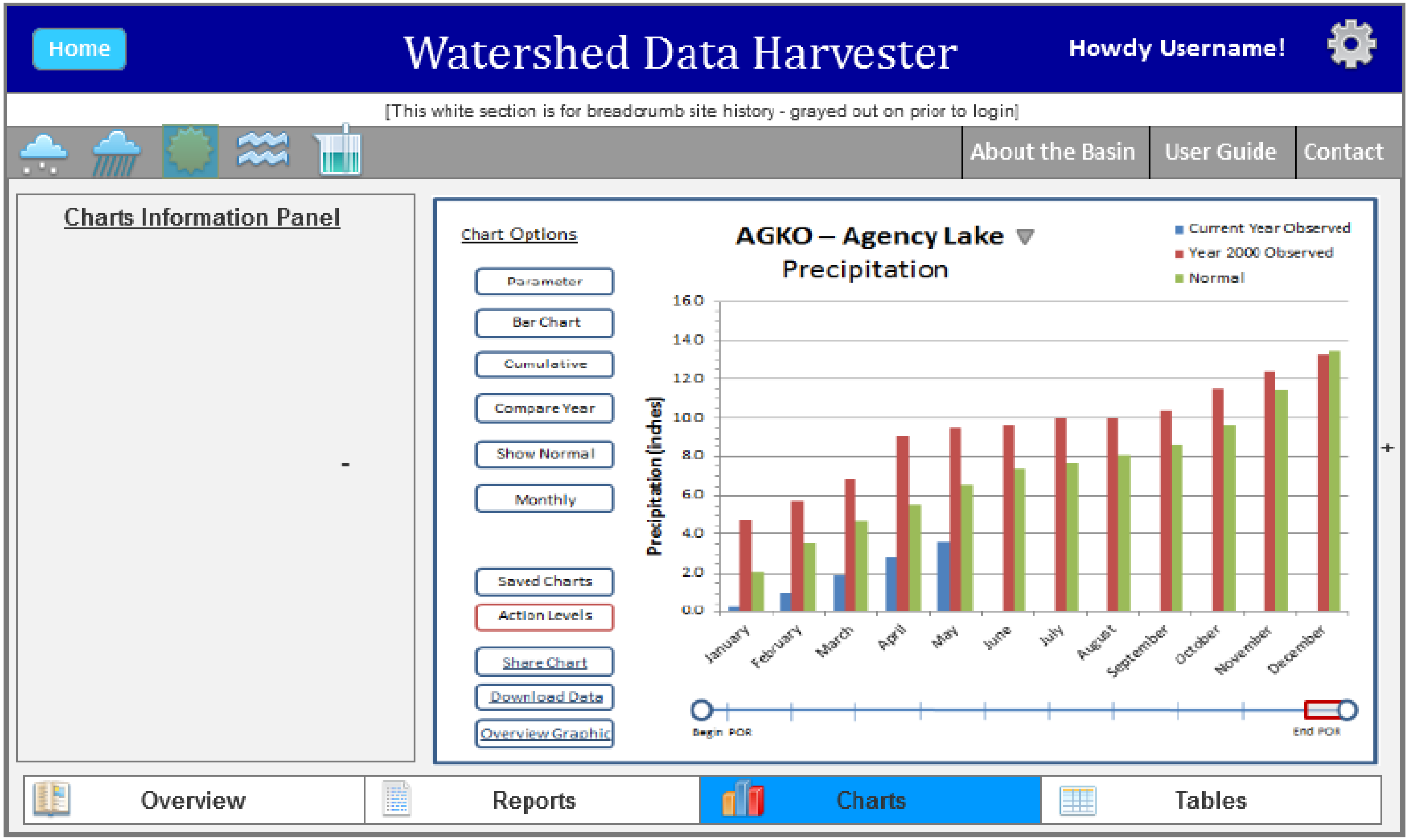
1.22. Charts Page

1.22.1. User Interface



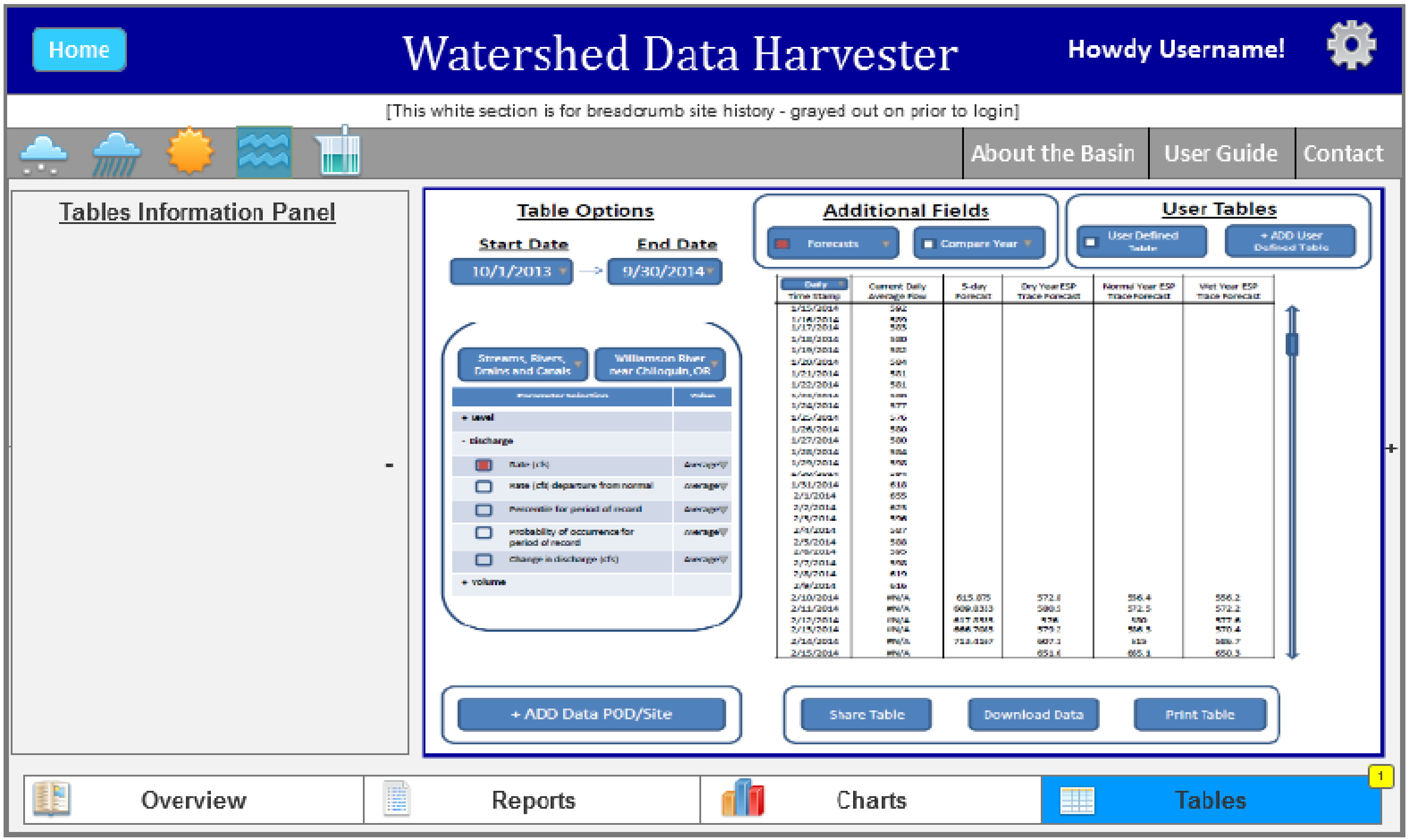
1.23. Detailed Charts Page

1.23.1. User Interface



1.24. Tables Page

1.24.1. User Interface



Configurable for Flexible Use

- Sum cumulative runoff volumes => points of diversion
- Subtract gage station flows => Klamath accretions
- Drought indices at local scale => sub County declarations
- User defined criterion and alert levels
- Water supply index for WUMP program

Your Participation

- Are your needs and decisions identified properly?
- Are there really alternative decisions based on data risk?
- Have we correctly connected your decisions to data needs, the criteria for action, and your actions?
- Is there value of the tools, methods and concept presented?
- Proceed with development?

Thanks for participating!

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California-Nevada River Forecast Center
3310 El Camino Avenue, Room 227
Sacramento, CA 95821-6373

Phone: (916) 979-3056
Alan.Haynes@noaa.gov

The end

And the answer to the reason for being at this meeting is?

- ❑ Presentation by another “expert” from outside the Basin
- ❑ Somebody else that thinks they can solve our problems
- ❑ Another study to place on the shelf
- ❑ I had no where else to go, so I came here
- ❑ Another consultant working on a government
- ☑ See if Deutschman got it right

Forecast Accuracy

Forecast Accuracy
Based On 1981 - 2011 Reconstructed Forecast
April - September Seasonal Volumes

	Median (50%) Forecast							
	Williamson River				UKL Net Inflow*			
Forecast Date	Median Forecast Value (KAF)	Jacknife Standard Error (KAF)	Mean Absolute Error (KAF)	Mean Percent Difference	Median Forecast Value (KAF)	Jacknife Standard Error (KAF)	Mean Absolute Error (KAF)	Mean Percent Difference
1 January Forecast	319.3	96.0	71.3	22.7%	426.7	136.2	106.9	27.1%
1 February Forecast	358.2	76.8	52.6	16.1%	482.7	103.8	75.6	18.4%
1 March Forecast	365.9	66.8	48.9	16.0%	493.8	88.8	69.4	17.9%
1 April Forecast	307.5	43.3	32.4	9.6%	511.8	63.2	46.5	10.1%

	70% Exceedance Forecast							
	Williamson River				UKL Net Inflow*			
Forecast Date	Median Forecast Value (KAF)	Jacknife Standard Error (KAF)	Mean Absolute Error (KAF)	Mean Percent Difference	Median Forecast Value (KAF)	Jacknife Standard Error (KAF)	Mean Absolute Error (KAF)	Mean Percent Difference
1 January Forecast	268.8	---	80.5	22.0%	354.5	---	114.7	24.2%
1 February Forecast	317.5	---	61.6	17.3%	427.7	---	85.7	18.4%
1 March Forecast	330.4	---	34.5	16.1%	446.7	---	77.8	17.7%
1 April Forecast	284.5	---	35.8	11.2%	478.3	---	52.5	11.6%

"Known" UKL Net Inflow is an estimated value from BOR MODSUM (water balance) model (not measured).

Mean percent difference computed from absolute values of (forecast volume - measured volume) divided by measured volume.

Observed April through Steptember volumes were 344.8 and 473.03 kaf for the Williamson River and Upper Klamath Lake (UKL) Net Inflow respectively.

February 27, 2014

FROM FISHERIES MANAGER TO FAMILY FARMER: IMPROVED PRODUCTS FOR COMMUNICATING WATER SUPPLY, DROUGHT AND CLIMATE CHANGE RISK FOR DAILY DECISION MAKING WITHIN THE KLAMATH BASIN, CALIFORNIA AND OREGON

Focus Group Meeting
Grant Award NA12OAR4310096

Location: Public Works Conference Room #232
Klamath County Government Center, 305 Main Street, Klamath Falls, OR

Date and Time (PACIFIC TIME)
April 2, 2014 9:00 – 11:00

PRELIMINARY AGENDA

- Welcome and introductions (10 minutes)
- Vision for the applied research / desired outcomes (10 minutes)
- Review of grant status (purpose, work completed & remaining work) (20 minutes)
- Meeting purposes (10 minutes)
- Review of participant roles (5 minutes)
- Presentation of research results (30 minutes)
- Feedback / discussion (30 minutes)
- Next Steps (5 minutes)
- Adjourn

This work is funded under a grant from the Sectoral Applications Research Program (SARP) of the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office.

Team Viewer Instructions

National Oceanic and Atmospheric Administration, Climate Program Office
Sectoral Applications Research Program Grant
Award No. NA12OAR4310096

February 27, 2014

April 2, 2014 Meeting Via Team Viewer (9:00 – 11:00 Pacific Time)

Please join the meeting, by clicking on this link:
http://go.teamviewer.com/v7/m56700697

Meeting ID: **m56-700-697**

April 2, 2014 Meeting Via Team Viewer (1:00 – 3:00 Pacific Time)

Please join the meeting, by clicking on this link:
http://go.teamviewer.com/v7/m93397522

Meeting ID: **m93-397-522**

FOR VOICE

Dial 763-493-4522 and ask for conference bridge 6201

This work is funded under a grant from the Sectoral Applications Research Program (SARP) of the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office.

Places to Stay That Accept Government Rates in Klamath Falls With Shuttles

Best Western Olympic Inn (http://www.olympicinn.com/)
2627 South Sixth Street, Klamath Falls OR 97603; 1-541-882-9665

Holiday Inn Express (http://www.holidayinnexpressklamathfalls.com/)
2430 S. 6th St, Klamath Falls OR 97603; 1-541-884-9999; 1-888-465-4329

Comfort Inn and Suites (http://www.comfortinn.com/hotel-klamath_falls-oregon-OR016)
2500 South 6th St, Klamath Falls OR 97601; 1-541-882-1111 – Government Rate is $76.00 plus tax (as of 11-01-12)

If you don't rent a car, we will arrange transportation for you to the Government Center.

Per diem rate is $82 per night.

Meeting Date: April 2, 2014

Meeting Start Time: 9:00 AM Pacific Time & 11:00 PM Pacific Time

Lunch: Refreshments will be provided

Meeting Location:
Room 219, Klamath County Government Center
305 Main Street
Klamath Falls, OR 97601

This work is funded under a grant from the Sectoral Applications Research Program (SARP) of the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office.

Reimbursement Request Form

National Oceanic and Atmospheric Administration, Climate Program Office
Sectoral Applications Research Program Grant
Award No. NA12OAR4310096

Name of Traveler ______________________ ______________________
First Name Last Name

Address to Mail Check ______________________
Street Address / P.O. Box / Suite #

____
City / State / Zip Code

Contact Phone Number ______________________

Contact Email ______________________

Date of Departure ______________________

Destination ______________________

Date of Return ______________________

Reimbursement

Airline $ ______________________

Motel / Hotel Receipts $ ______________________

Ground Transportation $ ______________________

Meals ______________________
Date of 1st Travel Day Date of Last Travel Day

____
No. of Days x @ Rate = Total Meal Cost

I certify the above expenditures by me for travel expenses for the time period indicated are true and accurate. I understand that this reimbursement is subject to federal regulations, procedures and guidelines. (see http://www.gsa.gov/portal/category/21287 for rates).

______________________ ______________________
Travelers Signature: Date:

Return to: Mark Deutschman
Houston Engineering, Inc.
Suite 140, 6901 East Fish Lake Road
Maple Grove, MN 55369
(763) 493-4522
mdeutschman@houstoneng.com

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