Summit Proceedings

December, 2012

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 USA

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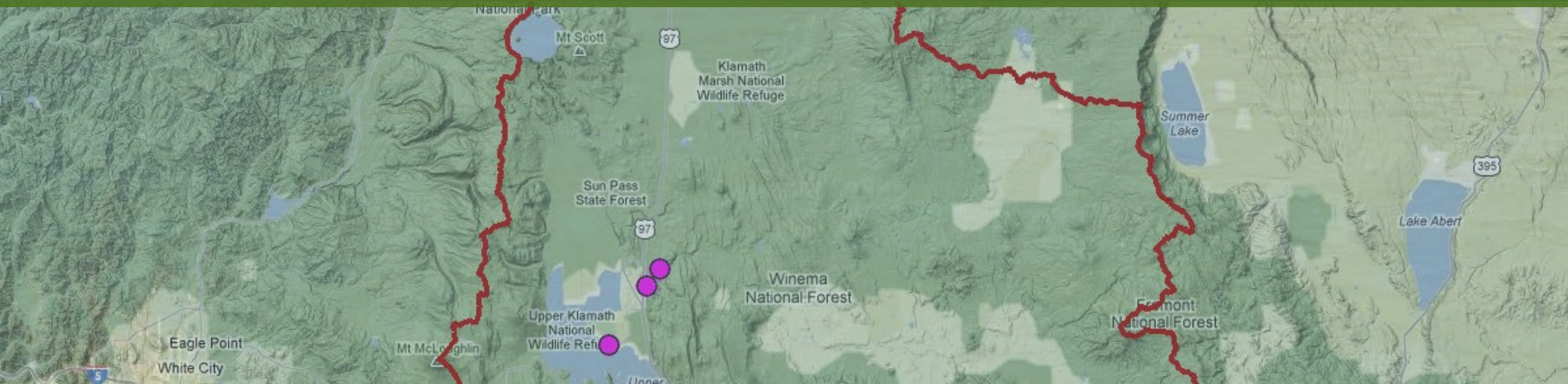


Summit Participants

U.S. Fish & Wildlife Service — Department of the Interior

OSU Oregon State University

Houston Engineering 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

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

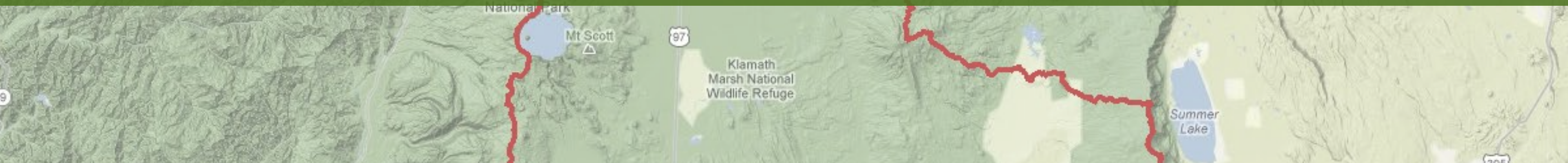
Dan Keppen & Associates

State of Oregon — WRD — Water Resources Department

NOAA Fisheries Service — National Oceanic and Atmospheric Administration

Klamath County

NRCS



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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 USA

AN APPLIED RESEARCH PROJECT FUNDED THROUGH THE CLIMATE AND SOCIETAL INTERACTIONS, SECTORAL APPLICATIONS RESEARCH PROGRAM (SARP) OF THE NATIONAL OCEANIC ATMOSPHERIC ADMINISTRATION CLIMATE PROGRAM OFFICE (NOAA-CPO)

Federal Funding Opportunity Number: NOAA-OAR-CPO-2012-2003041
Catalog of Federal Domestic Assistance Number: 11.431, Climate and Atmospheric Research
Program: Climate and Societal Interactions
Competition Name: Sectoral Applications Research Program
Competition Identification Number: 2241333
Focus Area: Coping with Drought Initiative

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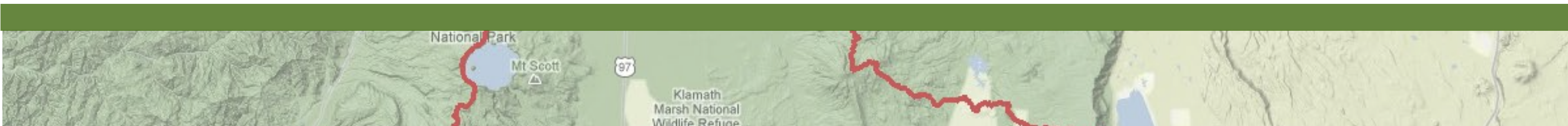

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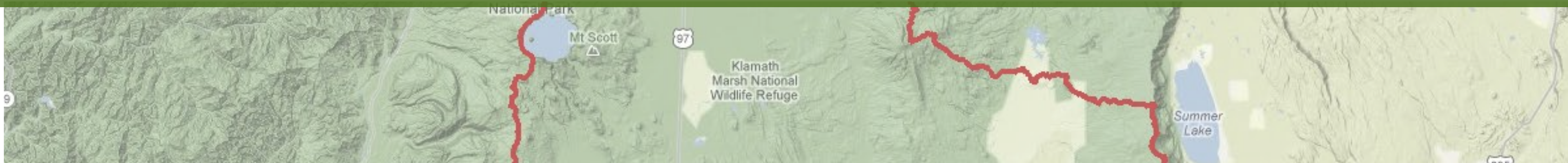


INTRODUCTION

The Climate and Societal Interactions Sectoral Applications Research Program (SARP) of the National Oceanic Atmospheric Administration Climate Program Office (NOAA-CPO) funded applied research in late September 2012 to better understanding the use of and diverse needs for climate and water supply forecast products within the Klamath River Basin, Oregon and California, USA (Figure 1). The applied research is being funded under Federal Opportunity No. NOAA-OAR-CPA-2012-2003041, Catalog of Federal Domestic Assistance No. 11.431, Climate and Atmospheric Research (Competition Identification No. 2241333), with a focus area of "Coping with Drought Initiative." An abstract providing a more thorough explanation of the applied research is included as **Appendix A**.

The Statement of Work for the applied research funded by the NOAA-CPO includes a number of tasks as follows:

- **Task 1:** Modify Klamath Basin Decision Support Systems (DSS) for Use as a Project Communication Tool
- **Task 2:** Organize, Conduct, and Document the Klamath Basin Water Supply and Drought Summit
- **Task 3:** Organize, Complete, and Document the Focus Group Meetings
- **Task 4:** Develop Stakeholder-Specific Products for Communicating Water Supply / Drought Risk
- **Task 5:** Complete a Final Summit Meeting
- **Task 6:** Complete Local Community Outreach Meeting
- **Task 7:** Watershed Viewer Enhancements

Phase I includes Tasks 1-4 and Phase II includes Tasks 5-7 of the applied research project. Only Phase I is currently funded by the NOAA-CPO.

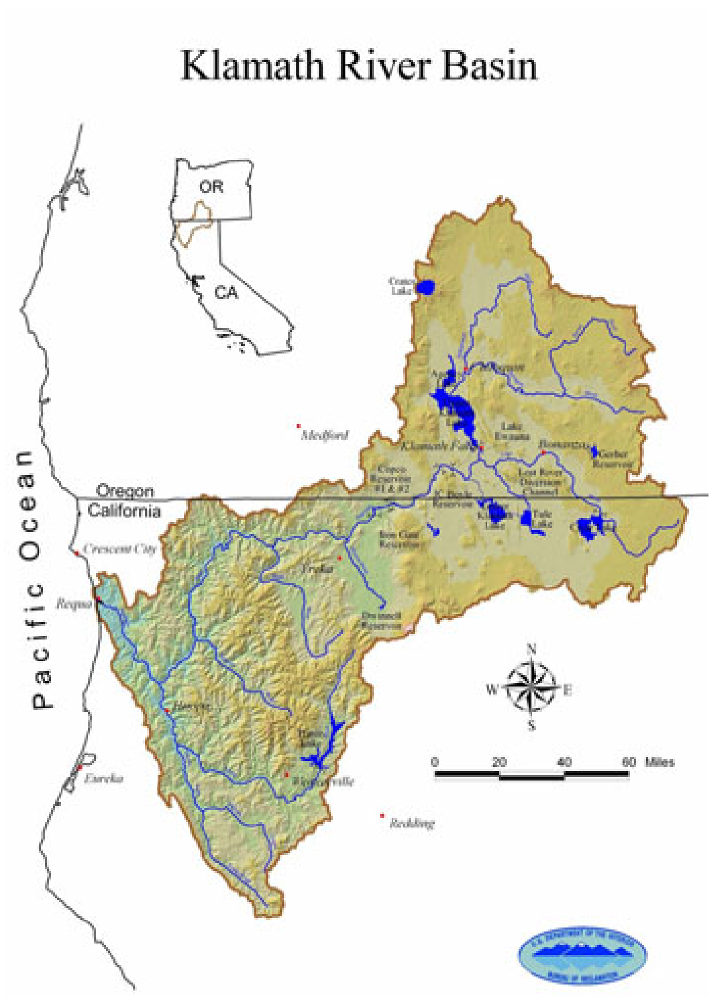
Task 2 consists of organizing and conducting a Summit within the Klamath Basin. The primary purpose of the Summit is to bring together key Klamath basin stakeholders, who use and rely on climate and water supply forecast products to make resource decisions. As originally envisioned, the Summit included formal presentations about water supply forecasting and the availability of climate products. Presenters included staff from the Natural Resources Conservation Service National Water and Climate Center (NRCS-NWCC) and the National Weather Service California Nevada River Forecast Center (NWS-CNRFC).

This Summit Proceedings summarizes the discussion from the Klamath Basin Summit held on December 10, 2012 within Klamath Falls, Oregon and is intended to complete grant obligations under Task 2. The preliminary agenda and list of invited and attending participants is included within **Appendix B**.

WATER SUPPLY FORECASTING PRESENTATIONS

The Summit afforded an opportunity for stakeholders who rely on and use water supply forecasts issued by the NRCS-NWCC and NWS-CNRFC to better understand the forecast process, the methods used, and uncertainty associated with forecasting seasonal water supplies. Formal

Figure 1: *Location of the Klamath Basin, Oregon, and California USA.*



presentations provided by Mr. Robert Hartman, Hydrologist-in-Charge with the NWS-CNRFC, Dr. David Garen of NRCS-NWCC, and Dr. Mark Deutschman of Houston Engineering, Inc. are included within **Appendix C**.

STAKEHOLDER SUMMARIES

A portion of the Summit included presentations by stakeholders within the Klamath Basin, who use climate and water supply forecasts products. Prior to the Summit, a list of questions focused on stakeholders' use of climate and water supply forecast products was provided to each participant (see **Appendix D**). These questions were also provided in a questionnaire prior to the Summit as a means to guide the discussion about how the current products are used and the need for additional information. After considerable discussion about the water supply forecasting methods, limitations, and means of improvement took place, the following summaries are focused on the specific decisions being made and the need for additional or revised climate and water supply forecast data products.

David Felstul

US Bureau of Reclamation

David Felstul described forecasting completed by the US Bureau of Reclamation (Reclamation) as it relates to operation of the Klamath Project. With regard to the use of climate and water supply forecast products issued by the NRCS-NWCC and the NWS-CNRFC, Reclamation uses the seasonal water supply forecasts issued by the NRCS-NWCC and the ensemble streamflow predictions. Reclamation uses the information to forecast future Upper Klamath Lake (UKL) levels. Specifically, to forecast future UKL levels, Reclamation uses average monthly precipitation for the months of March-October, ensemble streamflow predictions (ESP) from the Sacramento Soil Moisture Accounting Model (SAC-SMA), and historical estimated of the net UKL inflow. Reclamation uses the 90th, 70th, 50th, 30th, and 10th percentile ESP traces issued by the NWS-CNRFC for the purposes of estimating the future UKL level. The bimonthly seasonal water supply forecasts issued by the NRCS-NWCC are used by Reclamation to estimate water supply availability from UKL, and Gerber and Clear Lake Reservoirs. They also forecast the ability to achieve conditions imposed by the Biological Opinions and meet project water supply needs.

With regard to needs, the following suggestions were presented:

- Refinements to the ESP forecasts are desired – Reclamation's experience is that the historic estimated net UKL inflows are more consistent with regard to their operational experience than the current ESP forecasts;
- Improved means and methods in foreseeing cropping patterns, resulting in improved estimates in agricultural demands;

- Implement additional gaging (e.g., on the Wood River) that can be used to estimate the actual inflow to UKL. The current method estimated net UKL inflow based upon the change in UKL storage and surface outflow.
- Add information specific to project operation decision points (e.g., the lower refuge).

Ed Bair, Agricultural Producer

Klamath Irrigation District Board Member and Klamath Water and Power Authority (KWAPA) Board Chair

Mr. Bair provided his perspective about how climate and water supply forecast products issued by the NRCS-NWCC and the NWS-CNRFC are used for on-farm decision-making. Based on personal experience, each year is approached as if full water supply will be provided for agricultural production needs. An early decision not to plant or to plant a different type of crop because of a forecast shortage of water can be as costly if not more, to the agricultural producer and reduced yield from a shortage or water once planted. The decision to not plant a crop due to an apparent shortage of water, which is not realized during the growing season (i.e., there is ample supply) is extremely costly to the agricultural producer.

Decisions for the next year's farm operation begin as early as August or September of the year prior to spring planting. Agricultural inputs (e.g., fertilizer and chemical applications) as well as decisions to order seed begin this early. Inputs into the ground can begin in October of the year prior to planting. Attention to the water supply forecasts issued by the NRCS-NWCC begin during the late fall and early winter months. Forecasts are used to gauge future soil moisture condition and water supply availability. Consideration of crop types to plant begin as inputs into the field occur the previous fall, but can be changed as late as April of the following spring, relying in part on the seasonal water supply forecast. April is also the time when a final planting decision is made relative to the amount of water available for agricultural production.

Improved water supply forecasts (presumed to mean better accuracy) would be helpful to agricultural producers. Knowing the amount of water available for the growing season in April is critical to the farmer. The producer can make some alternative decisions (e.g., what type of crop, whether or not to plant a field) through April. After a crop is planted producers may face a water supply shortage if the water supply forecast exceeds actual availability. Producers primarily manage their risk by relying on groundwater as the source of water, rather than surface water. However, not all producers have available groundwater supply. When too much conservatism is built into the forecast, meaning the forecast underestimates actual water supply available, a rippling effect occurs. Reclamation tends to notify the irrigation districts and producers of a probable shortage. The percent exceedance values used by the NRCS-NWCC to communicate available water supply are understood by and helpful to the agricultural producer.

Jim Simondet and Jamie Montesi

National Oceanic and Atmospheric Administration, National Marine Fisheries Service

Hydrologist and staff with the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA-NMFS) begin relying upon seasonal water supply forecast volumes issued by the NRCS-NWCC as early as January. NOAA-NMFS is responsible for implementing the Biological Opinion (BiOP) issued for the Coho Salmon. The seasonal water supply forecasts provide valuable information about the volumes of water and flows available for fish in the coming year, and specifically for the Coho Salmon. Frequently updated seasonal water supply forecasts and estimates of monthly water supply volumes would be extremely helpful and useful. Improved forecast accuracy would also be useful, and perhaps additional SNOTEL sites could be used in the predictive models to improve accuracy. One goal of NOAA-NMFS is to mimic “natural hydrology” for the purposes of managing the fishery resource. Therefore, water supply forecasts or other information providing an indication of weekly and monthly volumes and flows would be very useful. Water supply forecasts for additional locations further downstream (e.g., at Keno Dam and Iron Gate Dam) would also be useful.

Mark Stuntebeck, Manager

Klamath Irrigation District (KID)

Mr. Stuntebeck described various aspects of the decision-making process relative to the availability and distribution of the water supply within KID. Information about the water supply available to the Klamath Project and KID is provided through Reclamation, using the seasonable water supply forecasts issued monthly beginning in January by the NRCS-NWCC. KID relies on the April 1 forecast to understand the available water supply for the irrigation season, which formally begins April 1. Once the irrigation season begins, the District is responsible for “handing out” the available water to agricultural producers within their boundary. KID’s operation is more complicated than some of the other Irrigation District’s relying on project water, because they serve not only the member agricultural producers, but deliver water to several other Irrigation Districts and contract users.

When the actual water supply volume is less than the forecast volume, the primary challenge faced by KID is getting water to its patrons. There is limited ability to manage risk when facing a shortage of water, as the only alternative decision is to deliver water preferentially to A-contract users and in general less water to the producers. There is some limited ability to “move” water to another field. However, the primary means of addressing a water shortage is reliance upon the Water User Mitigation Program (WUMP) operated by KWAPA and reducing the amount of water available to non A-contract water users.

Greg Addington, Executive Director

Klamath Water Users Association (KWUA)

Mr. Addington provided a very brief description of KWUA's reliance on climate and water supply forecast products issued by the NRCS-NWCC and NWS-CNRFC. The KWUA is a non-profit corporation which represents Klamath Irrigation Project farmers and ranchers. The KWUA primarily relies on the seasonal water supply forecast products for making internal policy decisions. These decisions include interacting with Reclamation on project operational implications, the BiOPs issued by NOAA-NMFS and the US Fish and Wildlife Service, and the means and methods to address pending water shortages affecting agricultural producers.

Hollie Cannon, Executive Director

Klamath Water and Power Authority (KWAPA)

Mr. Cannon indicated an understanding that one of the primary sources of information affecting the accuracy of the seasonal water supply forecasts issued by the NRCS-NWCC and the forecasting of the NWS-CNRFC, is the ability to predict future climate. The KWAPA relies heavily on the seasonal water supply forecasts issued by the NRCS-NWCC as KWAPA is responsible for implementing the Water User Mitigation Program (WUMP). The WUMP is a program operated by KWAPA through a cooperative agreement with Reclamation. The WUMP is intended to supplement surface water supply shortage by contracting for groundwater pumping and land idling. The WUMP is also focused on developing and implementing innovative methods of providing an alternative or additional water supply to agricultural producers. Two land idling programs were operated by KWAPA in 2012. One program focused on entire irrigation season for producers whose water supply source is the Clear Lake Reservoir. The second program focused on idling land for a portion of the irrigation season for producer's land served by supplies from Upper Klamath Lake, the Klamath River, and the Clear Lake Reservoir.

KWAPA relies on the seasonal water supply forecasts issued by the NRCS-NWCC as early as January to gain a general sense of the amount of surface water supply available and understand the general level of need for the WUMP programs. During January, WUMP program policies are being established for the coming irrigation season. KWAPA relies on the seasonal water supply forecasts to gain some early understanding of the probable participation level in their programs based on the availability of surface water supplies for the coming irrigation season.

KWAPA relies on the April 1 seasonal water supply forecast issued by the NRCS-NWCC as the final forecast to confirm decisions about the level of supplementation needed to ensure that each farm wanting to irrigate has water. The earlier accurate information about the seasonal water supply is available to KWAPA, the more helpful the information. KWAPA typically relies on the 70% exceedance seasonal water supply forecast issued by the NRCS-NWCC and "hopes for" the 50% (or better) seasonal water supply forecast volume. In essence, the planning process needs to be developed based on the worst conditions to ensure a sufficient level of program participation, even though these conditions may not be realized. Interest in KWAPA's programs needs to be solicited early in the calendar year.

David Mauser

US Fish and Wildlife Service (USFWS), Klamath Basin National Wildlife Refuge

Within the Basin's refuge system, Lower Klamath National Wildlife Refuge (LKNWR) is most problematic in terms of available water supply, primarily because its biological needs are greatest and water delivery priority within the Klamath Project is low. Based on biological need, the volume of water needed can be categorized by three time periods: June-August (waterbird breeding season), September-November (fall waterfowl migration), and February-April (spring waterfowl migration). LKNWR receives water after the Coho, UKL BiOps, and agricultural demands are met. From the time water is released from the winter snowpack, through Upper Klamath Lake and into the Klamath Project, there are a considerable number of factors influencing the supply available to the refuge. Because water is limited to LKNWR, the ability to maximize capture of water when available is of primary importance. In recent years, limited water availability has resulted in increased recirculation of water within the Refuge and a reduction in water released through the Straits Drain. In the long run, recirculation of water on the Refuge may lead to salt accumulation resulting in reduced soil productivity for both agriculture and wildlife habitats.

Terry Fisk

US Fish and Wildlife Service (USFWS)

Mr. Fisk is involved with Biological Opinions issued by the US Fish and Wildlife Service and National Marine Fisheries Service for water levels within UKL and flows in the Klamath River. The USFWS is cooperating with Reclamation, NMFS, Tribes, and representatives of the Klamath Project to develop a hydrologic model for the Upper Klamath Basin including UKL. The model is being used in the "re-consultation" process under the Endangered Species Act with Reclamation and NMFS. The re-consultation process is developing a Proposed Action that will be implemented by Reclamation between 2013 and 2023. It is planned to affect operation of the Klamath Project for the coming (2013) irrigation season. Information about water supply availability (from issued forecasts and additional tools that may be developed) is needed for decision making and planning in the future. As a result of the re-consultation process, the Proposed Action envisions different water management scenarios based on two time periods: October-February and March-September. The October-February period is based on real-time management when information about water supply availability, based on forecasts and current conditions, is important to meet fall/winter flow and delivery targets. It is also significant because an understanding about the likelihood of refilling the lake following the irrigation season is needed. The lake must be refilled whenever possible while satisfying downstream flows on the Klamath River at Iron Gate Dam to meet Coho Salmon flow needs. The March-September period is based on allocations and represents the time period, particularly between March and June, when decisions about the amount of water available to the Klamath Project, the Klamath River, and UKL are made.

Coordination between the NRCS-NWCC and the NWS-CNRFC when issuing the water supply forecasts is preferred, even though coordination may or may not improve forecast skill. Alternatively, the NRCS-NWCC and the NWS-CNRFC forecasts could be provided separately. (Note that separate forecasts would likely be quite valuable, based on the discussion during the Summit). Water supply forecast volumes for weekly time periods would be valuable. Daily and weekly forecast volumes will play a more important role in the future as the day-to-day water management decisions of the Proposed Action must be coordinated with PacifiCorp in order to provide required volumes of water that PacifiCorp can accommodate within its power production and reservoir management requirements.

A range of websites are visited to glean climate and resource information throughout the year (e.g., flow rate, reservoir water level). However, most planning for each water year is conducted beginning in November and December and continues through the spring. These websites are visited to gain an understanding of future water supply availability (e.g., snow water equivalent). There is interest in providing remotely sensed data products and the application of physically-based models to the Basin.

Dennis Linthicum, Commissioner

Klamath County

Mr. Linthicum expressed the need for tools which can be accessed and used by a broad spectrum of skill levels and users. Tools should be tailored to the needs of a specific end-user or user group. A clearinghouse of common information and data is needed for informed decision making.

Lani Hickey

Klamath County Public Works Department

Ms. Hickey described her involvement in developing the Klamath County Decision Support System. When making decisions at the County and local governmental level people with a range of technical backgrounds are involved. Tools are, in general, needed to make decisions. These tools must include both real-time information (e.g., flows in the river or water levels in a reservoir) and forecast information. Being able to compare the current condition to an average water year or other types of water years, including historic water years, is valuable. Flooding and drought are issues commonly addressed by the County, who is responsible for making drought declarations. The County is large and information about road flooding is important.

Preferably, tools would be implemented using a “one-stop” shopping approach and should include mobile applications that can be accessed from the field.

Larry Dunsmoor

Klamath Tribes

Mr. Dunsmoor indicated there are two periods of time where water supply forecast information is needed: October-February and March-September. The October-February period represents a legacy period from the previous year's irrigation season, when there is need to refill UKL. There may be value in utilizing the NWS-CNRFC ESP forecasts for this time period (and other time periods), which has not occurred to date. Using "hindcasts" to understand the historical accuracy of the ESP model results would be helpful to improve use as a decision tool, not only for the October-February period but other time periods as well. The accuracy of the net UKL inflow estimate should also be improved, which requires obtaining and using daily or weekly UKL outflow information from PacifiCorp for the Westside Canal diversion at the Link River Dam. The accuracy of the water budget estimate can also be improved by better accounting for trends in groundwater contributions by gaging flows from major groundwater sources (e.g. head of the Wood River, heads of Spring Creek, Fort Creek, Crooked Creek, etc.).

With regard to the time scale of water supply forecast information, there is preference for a relatively short forecast time step, because the data can always be averaged or accumulated for longer forecast time periods. The March-September time period is important because decisions are being made for a variety of purposes including the amount of water available for the project, the amount of water released downstream to satisfy Klamath River flows for Coho, and the ability to attain UKL lake levels for the sucker Biological Opinion. Forecasts with a shorter time step for this period are needed.

There are several needs related to water supply forecasting and modeling that would be helpful to improve forecasts of base flows. Mr. Dunsmoor presented a plot of residuals from June NRCS forecasts (net inflow forecasted minus net inflow observed) by year, which showed June-September base flows to average about 16,000 acre-feet lower than forecasted since the year 2000 (Figure 2).

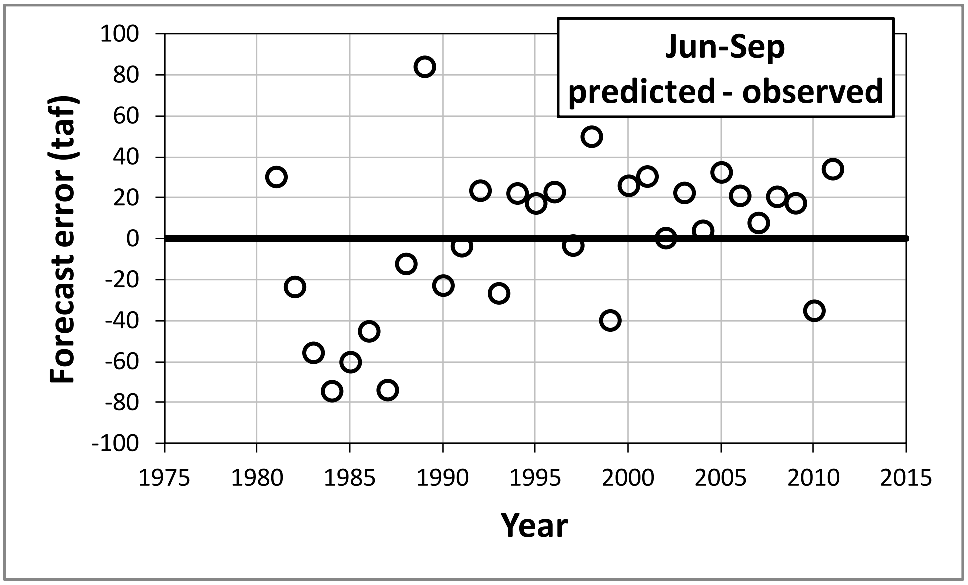


Figure 2: *Error in the 50% exceedence forecast for June-September net inflow into Upper Klamath Lake over time. Errors show a trend over time. During the past ten years forecasts have been consistently higher than observed.*

Forecasts with a shorter time step than the seasonal periods are also needed. Mr. Dunsmoor feels that accounting for the groundwater component of UKL inflow in the NRCS-NWCC water supply forecast models may improve accuracy. By including groundwater as an independent variable in the forecast models, better estimates of baseflow may result. This would require some index of groundwater (e.g., from USGS model or measured groundwater discharge at index locations) into the NRCS-NWCC forecast models.

Another important hydrological component where forecasts would be useful is the net accretion/decretion between Link River and Keno dams, and between Keno and Iron Gate dams. These components of the water budget can be large, and therefore are important considerations for water management decisions. Additional forecast locations corresponding with key resource decisions would be useful. For example, forecasting the flow emanating from the eastern portion of the Lost River catchment (above Harpold Dam) would be helpful for making water management decisions in the Project. Considering some index of soil moisture as an independent variable in the NRCS-NWCC statistical models should be considered. Reclamation should adopt a data publication process that subjects data to quality assurance procedures before being used to generate forecasts.

Summit Perspectives

The Summit provided an excellent opportunity for those issuing and relying on climate and water supply forecast products to meet and discuss a variety of issues. The Summit afforded an opportunity for stakeholders to describe how they presently use climate and water supply forecast products, when the decisions using the products are made during the year, the type of decisions made, how uncertainty in the water supply forecast is managed, and alternative decisions made based on uncertainty in the water supply forecasts.

Using the results from the Summit and subsequent focus group meetings, the intent of this applied research is to develop additional “design concepts” for climate and water supply forecast products specific to the needs of Stakeholders. The ability of the NRCS-NWCC and NWS-CRNFC to ultimately implement these products depends upon a variety of factors. Some of these factors include consistency with the agency’s mission, the ability to fit within the forecasting workflow processes, staff limitations, and perhaps user expectations exceeding technical feasibility. Regardless of these limitations, this applied research project is intended to identify the range of desired products to inform future decisions about user needs.

The Principal Investigators perceived several themes based on the Summit discussion, which may be useful in subsequent Tasks. These themes are summarized in Table 1.

Table 1: *Common themes expressed during the Klamath Basin Summit.*

Theme	Description
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). Practically, however, in terms of water use and management, resource issues and decision-making the volume of water is still quite large (c.a. 50,000 acre-feet). The general perception is that “improved accuracy” is desirable. The desire for improved 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 UKL inflow is presently used for evaluating the seasonal water supply forecast accuracy. The “known” net UKL inflow is in fact estimated by Reclamation based on a water budget for Upper Klamath Lake, which includes potentially important water budget terms (e.g., evapotranspiration). The error in the net UKL inflow estimate is not

Theme	Description
	quantified. To improve accuracy, additional streamflow gaging and monitoring is needed. When asked about the "desired forecast accuracy" providing a specific numeric value proved challenging. Reclamation communicated the need for a seasonal water supply forecast accuracy of 5%.
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 issues is aligning the percent exceedance values.
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).
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.
User Sophistication	User sophistication 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.

Theme	Description
Climate and Forcing Data	Climate products (e.g., precipitation depths, the amount 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.
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 sophistication. 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 or indices of soil moisture are of value.

The Table provides a summary of the more common themes and is intended to provide a general framework for the conceptual design of revised and additional climate and water supply forecast products.

A considerable portion of the Summit became focused on the need to improve forecast accuracy, in addition to discussion on the need for new climate and water supply forecast products. Important considerations related to forecast accuracy include:

- Methods to manage decision risk. Additional sources of climate and water supply information are needed. Decisions should not rely solely on the seasonal water supply forecast issued by the NRCS-NWCC. This is because there is little increased accuracy in seasonal volume forecasts to be expected from routine forecasts issued using statistical modeling. Workshop participants provided several suggestions for potential forecast improvement. However, because of limitations associated with the forecasting workflow process, most of the suggestions are challenging to implement operationally or there are inadequate human resources to pursue them. One option to address this problem would be local funding for a dedicated forecast staff.
- When asked, few participants had specific recommendations with regard to their “desired” level of forecast accuracy. The exception is Reclamation, which identified a desired accuracy in the seasonal water supply forecast of 5% of UKL net inflow. This

level of accuracy is "more accurate" than could be estimated even with being able to measure every term in the water budget equation used by Reclamation to estimate UKL net inflow. In reality, forecast users should be more interested in the reliability of the forecasts (ability to accurately describe the uncertainty without bias).

- Evaluations of forecast accuracy for UKL net inflow and bias based upon residual analysis should be placed within proper context. When evaluating the accuracy of the seasonal water supply forecast (or any forecast), the UKL net inflow is not "perfectly known." The UKL net inflow is an estimate of the gain in water with an unknown error (because it is not quantified) based upon a water budget equation applied by Reclamation. The methods and data for computing UKL net inflow have changed through time, most recently due to adjustments to the estimated terms in the water balance equation (e.g., outflow from the west side canal and adjustments to the elevation - storage relationship with affect storage). As a starting point to address this, forecasters and forecast users would benefit from the development and agreement of a historical inflow record at a daily time step.

- The Ensemble Streamflow Prediction (ESP) technique used by the NWS-CNRFC may or may not offer better seasonal volume accuracy, but certainly supplements the seasonal water supply forecast. Verification of ESP accuracy is needed. The ESP technique does offer the possibility of additional forecast time periods, more frequent forecast updates, and the integration of current weather and climate forecasts. In any case, forecast verification statistics should be made available so that forecast users know the uncertainty, bias, and reliability of all forecasts from this technique.

- Rather than expecting large increases in forecast accuracy, stakeholder decisions should be tied to various levels of forecast uncertainty (e.g., percent exceedance levels) and past experience. Users need a well thought-out strategy for decision making given uncertain water supply forecasts, regardless of the level of forecast uncertainty. Relying on additional and multiple climate and water supply forecast products seems prudent.

Subsequent phases of this research project are focused on developing additional and "enhanced" climate and water supply forecast products.

Summit Proceedings
December, 2012

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 USA

AN APPLIED RESEARCH PROJECT FUNDED THROUGH THE CLIMATE AND SOCIETAL INTERACTIONS, SECTORAL APPLICATIONS RESEARCH PROGRAM (SARP) OF THE NATIONAL OCEANIC ATMOSPHERIC ADMINISTRATION CLIMATE PROGRAM OFFICE (NOAA-CPO)

Federal Funding Opportunity Number: NOAA-OAR-CPO-2012-2003041
Catalog of Federal Domestic Assistance Number: 11.431, Climate and Atmospheric Research
Program: Climate and Societal Interactions
Competition Name: Sectoral Applications Research Program
Competition Identification Number: 2241333
Focus Area: Coping with Drought Initiative

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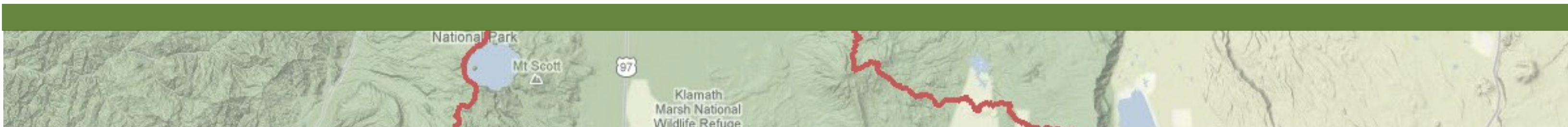
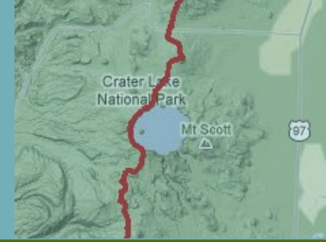


Appendix A



Abstract

ABSTRACT: The magnitude of fiscal resources expended, number of scientific studies completed, variety and amount of data collected, and public interest and social conflict within the Klamath Basin, (Oregon and California, USA) is a testament to its standing as one of the most important, complex, and critical watersheds in the United States. During the last decade and certainly since 2001 when the US Bureau of Reclamation (BOR) temporarily ceased water delivery to the agricultural production community because of the presence of federally endangered species, the people and agencies managing resources within the Klamath Basin have experienced immeasurable challenges. These challenges result from the multiple and sometimes conflicting use of water and need for a reliable water supply.

Agricultural production, recreation, tribal trust, endangered species, power generation, and domestic uses all are dependent upon the water resources of the Klamath Basin. Daily decisions related to the management of the Basin's resources rely upon the seasonal water supply forecasts, which through 2009, were issued jointly by the Natural Resources Conservation Service, National Water and Climate Center (NRCS-NWCC) and the National Weather Service (NWS) California-Nevada River Forecast Center (CNRFC). As of 2010, the NRCS-NWCC and NWS-CNRFC are issuing independent though collaborative forecasts.

Although daily decisions rely upon and use the forecasts issued by the NRCS-NWCC and the NWS-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 decision risk. The problem addressed by this research is developing the information necessary to address the lack of knowledge about and develop products that address the use of water supply forecasts for water supply and drought related decision making.

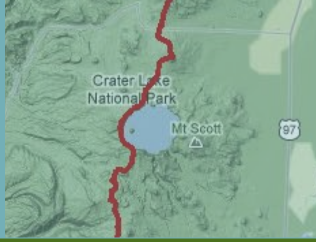
The rationale is to use the Stakeholder community within the Klamath Basin as a "test-bed" for the conceptual development of a suite of improved and enhanced water supply and drought communication products, which are effective at communicating decision risk and tailored to the specific resource decisions among the Stakeholders. By using the Klamath Basin as a test-bed, a basin with a very broad range of resource issues and Stakeholders, the project results are expected to be applicable to other western basins within the U.S. facing similar challenges.

The proposed work 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 will result in products able to inform mitigation and adaptation choices supported by sustained, reliable and timely climate services as well as understanding vulnerabilities to climate.

The proposed work will be initiated by convening a "Klamath Basin Water Supply and Drought Management Summit" where basin forecast agencies describe the status of forecast science, uncertainty and trends. Stakeholder focus group workshops will be used to identify, define and document water supply and drought decision products. A proceedings will document the results from the focus group workshops and include specific action steps and recommendations for developing

improved products for communicating water supply availability, drought risk and uncertainty. Expectations are that one outcome from this research will be guidance to the NWS and the NRCS for Stakeholder specific products to communicate water supply and drought risk for daily decision making. The products will be applicable not only to the Klamath Basin, but other western Basins facing similar water supply, drought and resource management challenges.

Appendix B



Preliminary Agenda and Participants

RESEARCH SUMMIT OUTLINE

From Fisheries Manager to Family Farmer: Improved Products for Communicating Water Supply and Drought Risk for Daily Decision Making within the Klamath Basin, California and Oregon, USA

Meeting Date: December 10, 2012
Meeting Start Time: 9:00 AM Pacific Time
Meeting Location: Room 219
Klamath County Government Center
305 Main Street
Klamath Falls, OR 97601

Topic 1: Research Project House Keeping (Mark Deutschman, HEi) 9:00 - 9:30

1. Goal(s) for this research
2. How we got here
3. Funding entity
4. Timeline for completion of the research
5. Means of disseminating information
6. Participants, participant interests and roles
7. Expected outcomes
    a. Clearly identify user water supply information needs
    b. Identify means of providing the information needs
    c. Use of information in decision making in Klamath Basin
    d. Concepts for NRCS / NWS to provide stakeholder specific information
8. Money available for travel and processing travel reimbursement requests
9. Self -Introductions

Topic 2: Current Framework for Forecasting
(Robert Hartman, NWS & David Garen, NRCS) 9:30 – 11:30

1. Agency mission and forecast information
    a. NRCS National Water and Climate Center
    b. National Weather Service California - Nevada Forecast Center
2. Current sources of information
    a. Water and climate related data
    b. Forecast information
3. Common methods for communicating water supply information and drought condition
4. Using space, time and duration to describe the water needs, available supply and drought
5. Brief Introduction to understanding the types of water supply forecast models used
    a. Statistical
    b. Deterministic
6. Information used in / which the models are dependent upon (i.e., forcing data / independent variables)
7. Summary / description of efforts to improve models

Lunch (provided by Subway) 11:30 – 12:15

Topic 3: Understanding Forecast Uncertainty and Error and Risk Management Decisions (Stephanie Johnson OR Mark Deutschman, HEi) 12:15 – 1:00

1. Methods for characterizing certainty
2. Certainty of current methods
3. Relationship between decision risk and uncertainty

Topic 4: Water Supply Forecast Users and User Needs (Lead: Individual Participants) (15 minutes each) 1:00 – 3:30 (9 presenters) (15 minute break in the middle)

1. Identification and description of select stakeholder groups using the water supply forecasts
2. Discussion of the needs of individual stakeholder groups and user specific decisions
    a. Project Operations
        i. Jason Phillips OR Dave Felstul (Reclamation)
    b. Agriculture
        i. Ed Bair (KWAPA)
        ii. Willie Riggs (Extension Service)
    c. Fisheries
        i. Jim Simondet OR James Montesi (NOAA NMFS)
    d. Water Users / Irrigation Districts
        i. Mark Stuntebeck (KID) OR Brad Kirby (TID)
        ii. Hollie Cannon (KWAPA) OR Greg Addington (KWUA)
    e. Wildlife
        i. Ron Cole or David Mauser (FWS)
    f. County Government
        i. Lani Hickey
    g. Native American Nations
        i. Larry Dunmoor (Klamath Tribes)

Topic 5: Wrap Up and Next Steps (Lead: HEi) 3:30 – 4:00

1. Summary and recap meeting
2. How to provide feedback / follow-up on specific comments / ideas
3. Development of proceedings
4. Focus group meetings
5. Final outcomes

DECEMBER 2012 SUMMIT MEETING - KLAMATH COUNTY GOVERNMENT CENTER

Summit Attendance	Presentation Confirmed?	Title	First Name	Last Name	Job Title	Company	Business Street	Business Street 2	Business City	Business State	Business Postal Code
Y	Y	Mr.	Greg	Addington	Executive Director	Klamath Water Users Association	735 Commercial St, Suite 3000	PO Box 1402	Klamath Falls	OR	97601
Y	Y	Mr.	Ed	Bair	Agricultural Producer	Bair Farms	8728 Springlake Road		Klamath Falls	OR	97603-8614
Y	Y	Mr.	Hollie	Cannon	Executive Director	Klamath Water and Power Agency	735 Commercial St, Suite 4000	PO Box 1282	Klamath Falls	OR	97601
N		Mr.	Brian	Charlton		OSU Extension Service	6491 Washburn Way		Klamath Falls	OR	97603
N		Mr.	Ron	Cole	Refuge Manager	US Fish & Wildlife Service	Klamath Basin National Wildlife Refuge Complex	4009 Hll Road	Tulelake	CA	96134
Y		Dr.	Mark	Deutschman	PE	Houston Engineering Inc	6901 E. Fish Lake Road, Suite 140		Maple Grove	MN	55369
Y	Y	Mr.	Larry	Dunsmoor	Environmental Contact	Klamath Tribes	501 Chiloquin Boulevard	PO Box 436	Chiloquin	OR	97624
Y	Y	Mr.	Dave	Felstul	Hydrologist	Klamath Basin Area Office	Bureau of Reclamation	6600 Washburn Way	Klamath Falls	OR	97603
Y	Y	Mr.	Terry	Fisk	Hydrologist	U.S. Fish and Wildlife Service	1936 California Avenue		Klamath Falls	OR	97601
Y		Dr.	David	Garen	Hydrologist (Co-PI)	USDA-NRCS	NWCC	1201 NE Lloyd Boulevard, Suite 802	Portland	OR	97232
Y		Mr.	Robert	Hartman	Hydrologist In Charge (Co-PI)	National Weather Service California	Nevada River Forecast Center	3310 El Camino Avenue, Room 227	Sacramento	CA	95821-6373
Y		Ms.	Lani	Hickey	Natural Resources Manager	Klamath County Public Works Department	Government Center	305 Main Street	Klamath Falls	OR	97601
Y		Dr.	Stephanie	Johnson	PE	Houston Engineering Inc	6901 E. Fish Lake Road, Suite 140		Maple Grove	MN	55369
N		Mr.	Dan	Keppen	PE	Dan Keppen & Associates Inc	317 S 7th St		Klamath Falls	OR	97601
Y	Y	Mr.	Brad	Kirby	Assistant Manager	Tulelake Irrigation District	2717 Havlina Road	PO Box 699	Tulelake	CA	96134-0699
N		Ms.	Jolyne	Lea	Hydrologist	USDA-NRCS	NWCC	1201 NE Lloyd Boulevard, Suite 802	Portland	OR	97232
Y		Mr.	Dennis	Linthicum	County Commissioner	Klamath County Government Center Building	305 Main Street		Klamath Falls	OR	97601
Y		Mr.	Dave	Mauser	Wildlife Biologist	US Fish & Wildlife Service	Klamath Basin National Wildlife Refuge Complex	4009 Hll Road	Tulelake	CA	96134
Via Computer		Mr.	James	Montesi	Hydrologist	NOAA - National Marine Fisheries Service SW Region	1655 Heindon Road		Arcata	CA	95521
N		Mr.	Tom	Perkins	Supervisory Hydrologist	USDA-NRCS	NWCC	1201 NE Lloyd Boulevard, Suite 802	Portland	OR	97232
N		Mr.	Jason	Phillips	Area Office Manager	Klamath Basin Area Office	Bureau of Reclamation	6600 Washburn Way	Klamath Falls	OR	97603
N		Dr.	Kelly	Redmond	Regional Climate / Deputy Director	Divison of Atmospheric Sciences, Western Region Climate C	2215 Raggio Parkway		Reno	NV	89512-1095
N		Mr.	Willie	Riggs	Director of Agricultural Experiment Static	Klamath Basin Research & Extension Center	6941 Washburn Way		Klamath Falls	OR	97603
?	N	Mr.	Richard	Roseberg		OSU Extension Service	6491 Washburn Way		Klamath Falls	OR	97603
Y		Mr.	Dave	Simeral		Divison of Atmospheric Sciences, Western Region Climate C	2215 Raggio Parkway		Reno	NV	89512-1095
Via Computer	Y	Mr.	Jim	Simondet	Klamath Supervisor/Coordinator	NOAA - National Marine Fisheries Service SW Region	1655 Heindon Road		Arcata	CA	95521
Y		Mr.	Stan	Strickland	Director	Klamath County Public Works Department	Government Center	305 Main Street	Klamath Falls	OR	97601
Y		Mr.	Mark	Stuntebeck	Manager	Klamath Irrigation District	6640 KID Lane		Klamath Falls	OR	97603
Via Phone		Mr.	Marc	Van Camp	PE	MBK Engineers	1771 Tribute Road, Suite A		Sacramento	CA	95815-4401
Y		Mr.	Scott	White	Watermaster	Department of Water Resources Klamath Falls	5170 Summers Lane		Klamath Falls	OR	97603

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541-885-2513		terry_fisk@fws.gov
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707-825-5171		Jim.Simondet@noaa.gov
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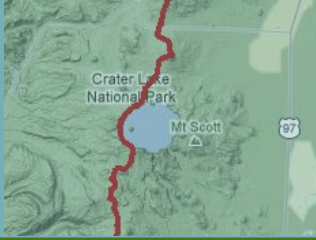
541-883-4182		Scott.C.White@wrd.state.or.us

Appendix C



Summit Presentation Materials


From Fisheries Manager to Family Farmer: Improved Products for Communicating Water Supply and Drought Risk for Daily Decision Making within the Klamath Basin, California and Oregon, USA
Research Summit
Klamath Falls, Oregon
December 10, 2012
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.


Topic 1: Housekeeping

Housekeeping

- Mobile phones off please
- Rest rooms
- Lunch
- Participant list
- Participation – discussion oriented
- Disseminating information - see grants web page (www.klamathdss.org)
- Reimbursement requests
- Acknowledgments / thanks

Research Summit Outline

Topic 1:	Research Project House Keeping (9:00)
Topic 2:	Current Framework for Forecasting (9:30)
Lunch	Delivered (11:30)
Topic 3:	Understanding Forecast Uncertainty and Error and Risk Management Decisions (12:15)
Topic 4:	Water Supply Forecast Users and User Needs (1:00)
Topic 5:	Wrap Up and Next Steps (3:30)

Participant Introductions

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

KLAMATH COUNTY

Klamath Water and Power Agency
KWAPA

OSU
Oregon State
UNIVERSITY

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

NATIONAL WEATHER SERVICE

DAN KEPPEN & ASSOCIATES

NRCS

KLAMATH
Water Users
Association

NOAA FISHERIES SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

THE KLAMATH TRIBES
KLAMATH-MODOC-YAHOOSKIN

STATE OF OREGON
WRD
WATER RESOURCES DEPARTMENT

MBK ENGINEERS
CONSULTING ENGINEERS

HoustonEngineering Inc.

How Did We Get Here?

- Firm began DSS work in 1999
- Concept (DSS) briefings organized by Dan Keppen in 2008
- Began Klamath DSS in 2009 on behalf of Klamath County
- Developed Klamath Basin DSS functional requirements document to guide effort
  - Web page
  - BasinViewer
  - Restoration Project Viewer
  - Water Supply Forecast Tracking Tool
- Member of On-Project Plan team
- Successfully applied for and completed other NOAA grants
- Lead to NOAA grant submittal for Klamath Basin

Grant Award

- National Oceanic and Atmospheric Administration (NOAA), Climate Program Office, SARP grant
- Sectoral Applications Research Program (SARP) – focused on stakeholders within key socioeconomic sectors (e.g., water resources, agriculture, health, etc.) grappling with pressing climate-related issues.
- Coping with Drought "focus" – in support of National Integrated Drought Information System means applications research addressing human populations coping with drought within the U.S. or U.S. transboundary areas
- Investigators: Deutschman, Hartman, Garen, Johnson, Hickey
- Amount: 178k (year 1); hopefully year 2
- One year; will ask for second year

Research Tasks

Task 1. Modify Klamath Basin DSS for Use as a Project Communication Tool (FY1)

Task 2. Organize, Conduct and Document the Klamath Basin Water Supply and Drought Summit (FY1)

Task 3. Organize, Complete and Document the Focus Group Meetings (FY1)

Task 4. Develop Stakeholder Specific Products for Communicating Water Supply / Drought Risk (FY1)

Task 5. Complete a Final Summit Meeting (FY2)

Task 6. Complete Local Community Outreach Meeting (FY2)

Task 7. Watershed Viewer Enhancements (FY2)

- Funded; Not funded

MD3

Applied Research Outcomes

- Research focused on practical applications
  - o Understanding the (water supply related) decisions which need to be made
- Information specific to water supply forecasts and water availability within the Klamath Basin
- Develop concepts for “new water supply information products” targeted to specific decision-making groups
- Evaluate ability to implement concepts within existing forecasting framework of NWS and NRCS
- Transferability to other locations

Slide 9

MD3 who does what.

Some of the concept / products - fit in workflow.
Mark Deutschman, 11/14/2012

Some Current Needs

- Operation of the Klamath Project
- Achieving Biological Opinions
- Amount of water for the refuges
- Decisions related to agricultural production
- Options to address water shortages (e.g., water bank)
- Drought plan (per KBRA)
- On-project plan (per KBRA)
- Adjudication
- Many others?
- *Your opportunity to identify water supply products specific to your decisions and needs*

Power of Shared Data

When everyone has the same information and data of known quality, the discussion shifts from arguing about whose data is “right” to the use of data for real-world problem solving

Paraphrased from an early discussion with:

Ray Bennett, Colorado Division of Water Resources, Project Manager for Development of the Colorado Decision Support System

Streamflow Forecasting in the Klamath Basin: Techniques and Issues

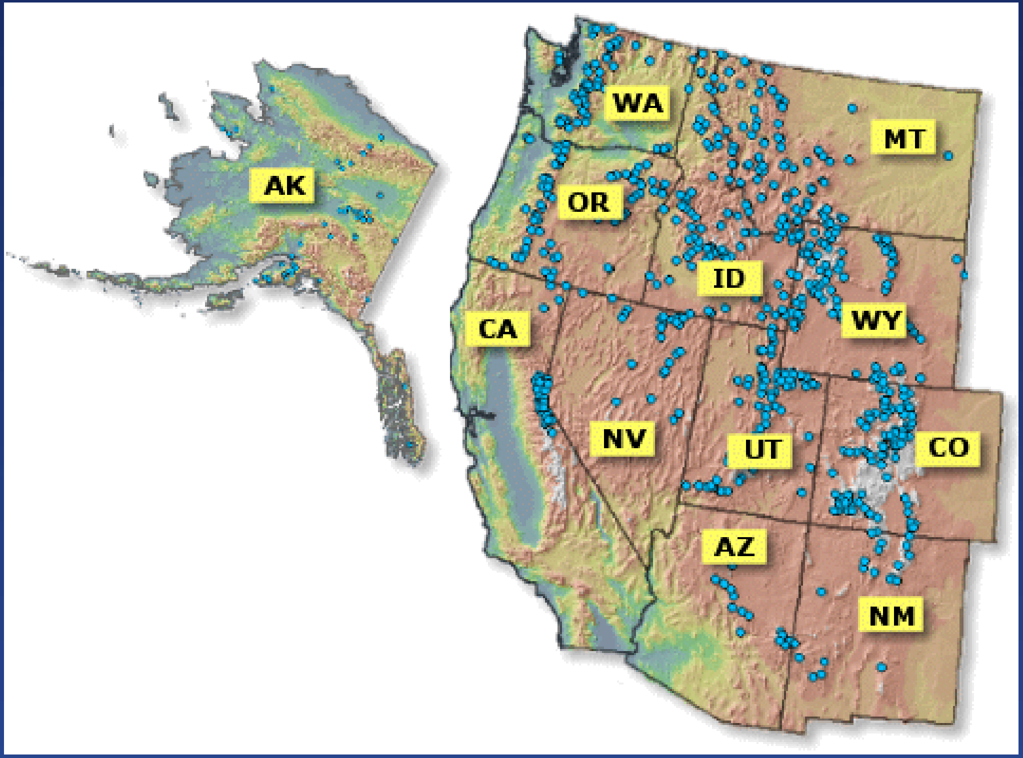
David C. Garen, Ph.D.

USDA Natural Resources Conservation Service
National Water and Climate Center
Portland, Oregon

Presented at
Klamath Basin research project workshop
Klamath Falls, Oregon
10 December 2012

NRCS Snow Survey and Water Supply Forecasting Program

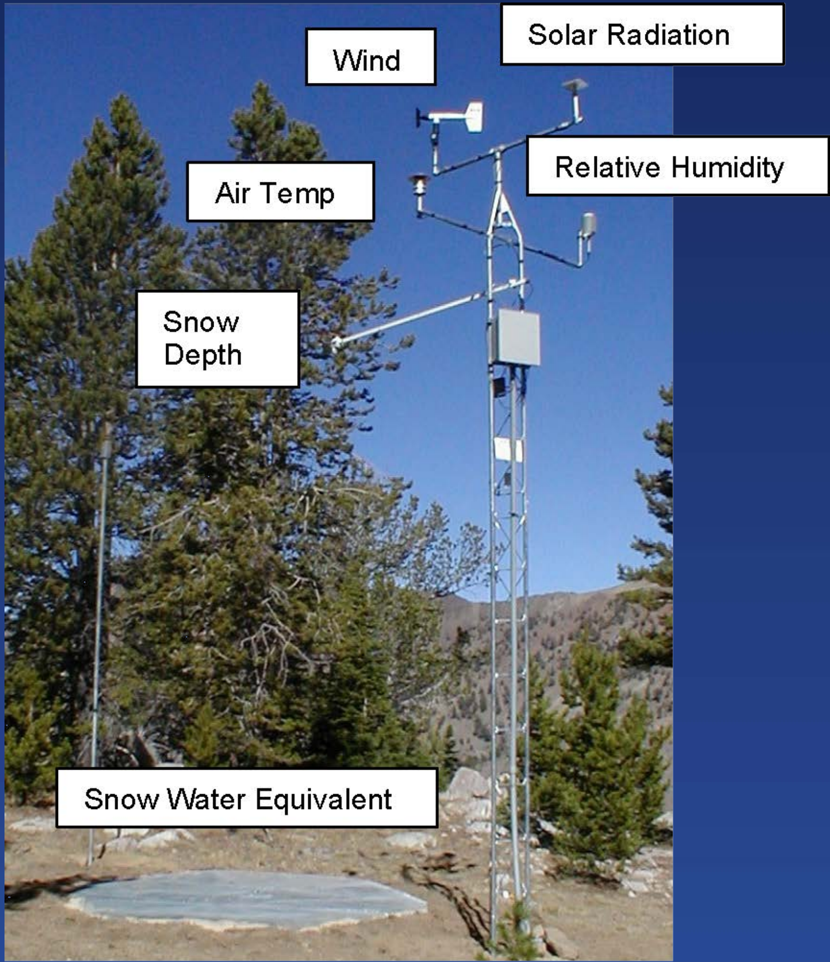
- Data collection
- Water supply forecasts
- Climate services



United States Department of Agriculture
Natural Resources Conservation Service

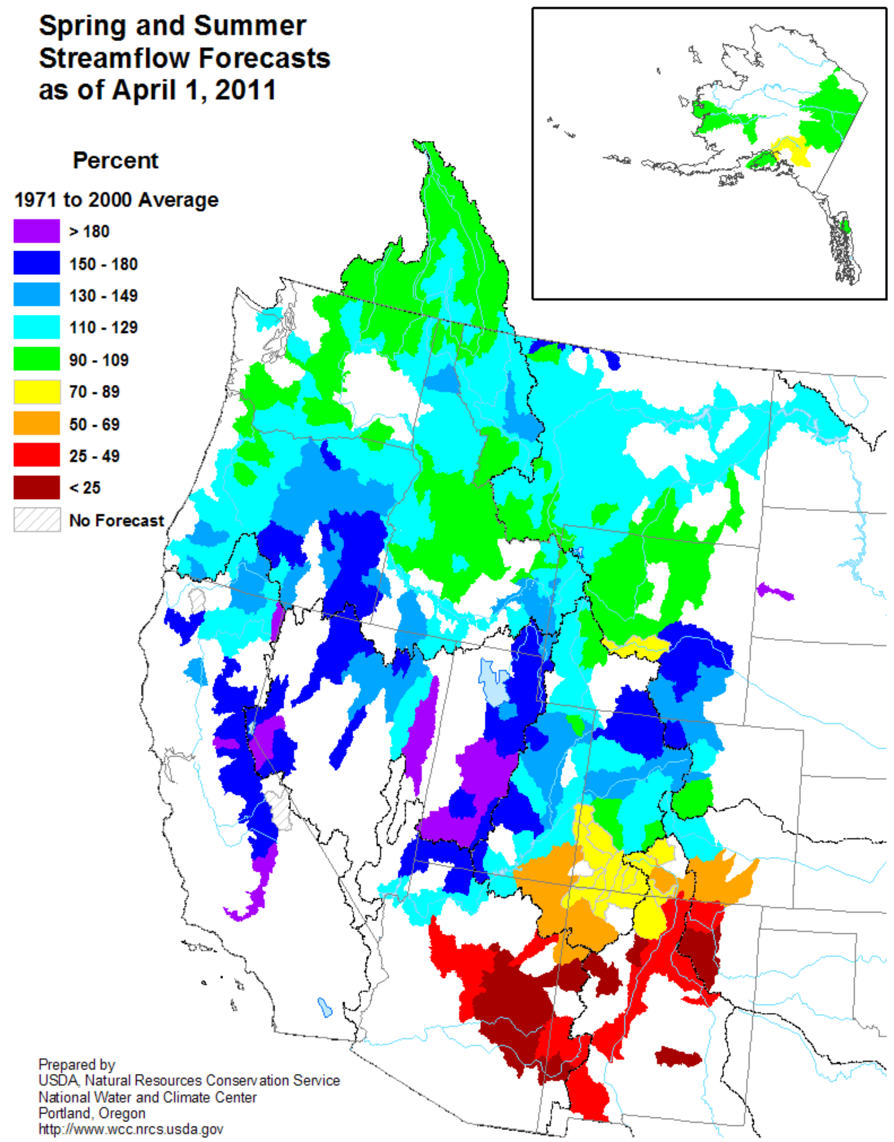
SNOTEL Network

Currently over 800 sites
in 13 western states
http://www.wcc.nrcs.usda.gov/snow



Water Supply Forecasting

- Seasonal streamflow volume
- Published January through June
- Cooperative effort with National Weather Service
- Over 700 forecast points in western US



Types of Models Used for Hydrological Forecasting

There is a spectrum of models, depending on physical basis and mathematical form:

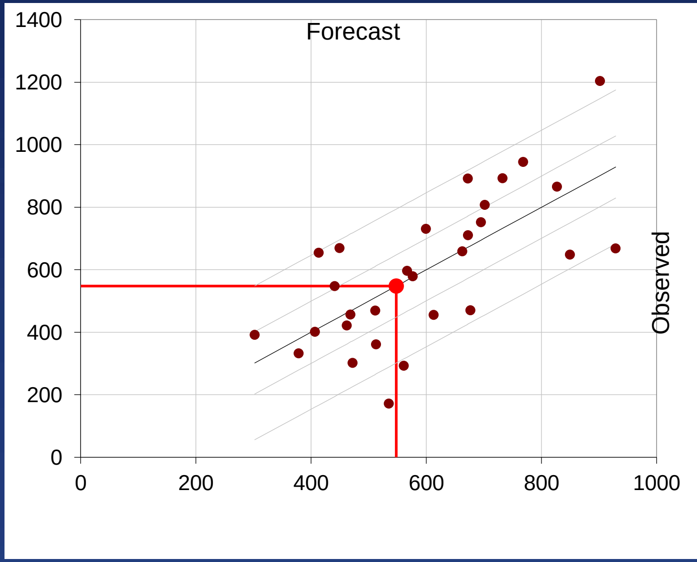
Empirical: Based on highly simplified mathematical relationships, usually data-driven, including statistical models

Conceptual: Based on mathematically convenient components that correspond to, but are abstractions / simplifications of, physical processes

Physically-based: Based closely on mathematical representations of the process physics

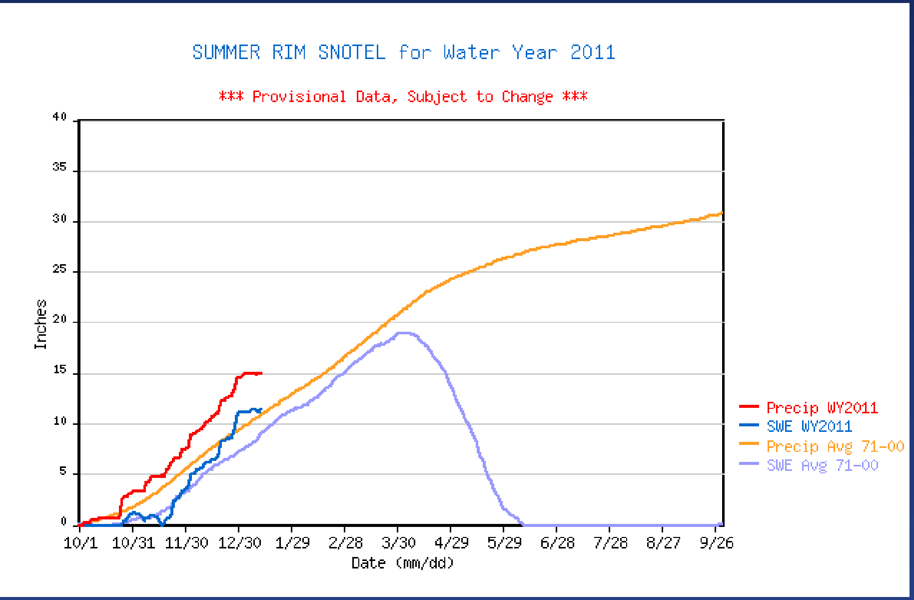
Statistical Modeling: Techniques

- Regression models: Principal components or Z-score
- Optimization: Time period and variable search
- Jackknife (cross-validation) test
- Linear or transformed target variable



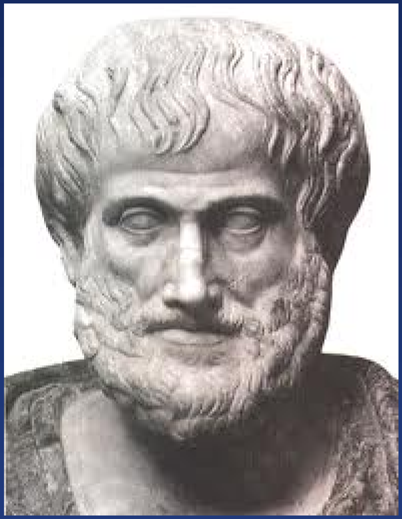
Statistical Modeling: Standard Data

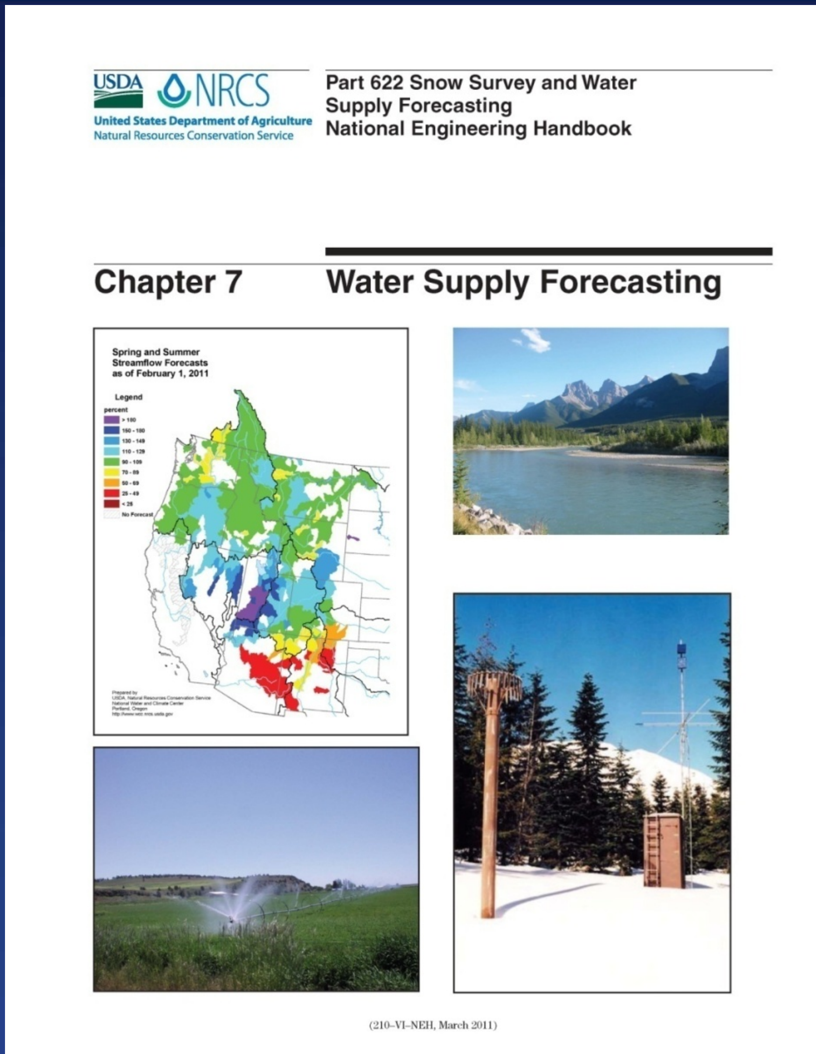
- SNOTEL: SWE, precipitation, temperature
- Snowcourse: SWE
- NWS cooperative network: precipitation
- USGS: streamflow
- Climate teleconnection indices



Model Building Philosophy

- Robust models
- Month-to-month consistency
- Physically meaningful and explainable
- Statistically valid
- Operationally useful





United States Department of Agriculture
Natural Resources Conservation Service

Part 622 Snow Survey and Water Supply Forecasting
National Engineering Handbook

Chapter 7 Water Supply Forecasting

(210–VI–NEH, March 2011)

Official Documentation

http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=32039.wba

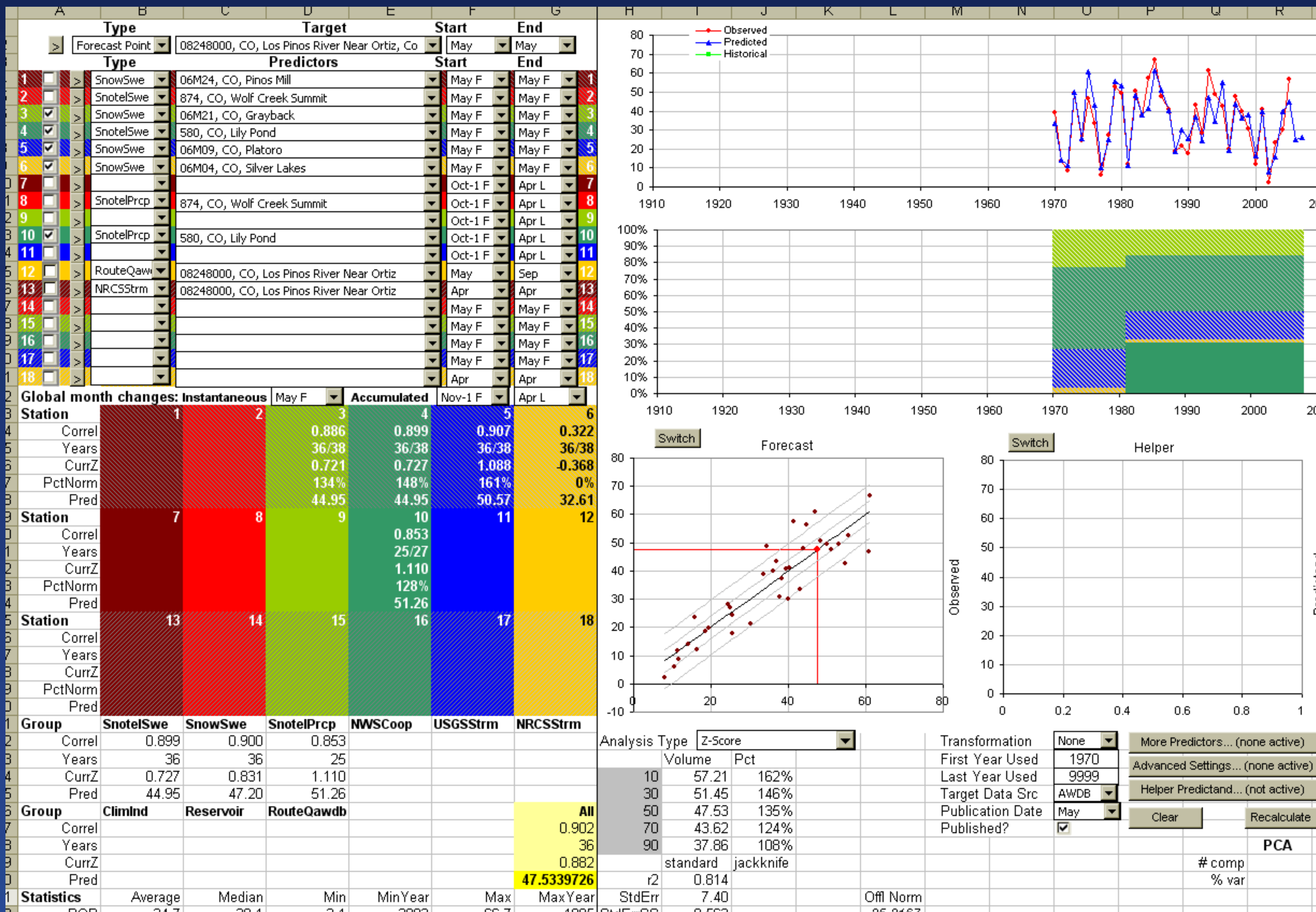
VIPER:
Visual Interactive Prediction and Estimation Routines

VIPER is our software environment containing all of the statistical algorithms that we employ plus equation management and operational forecasting utilities.

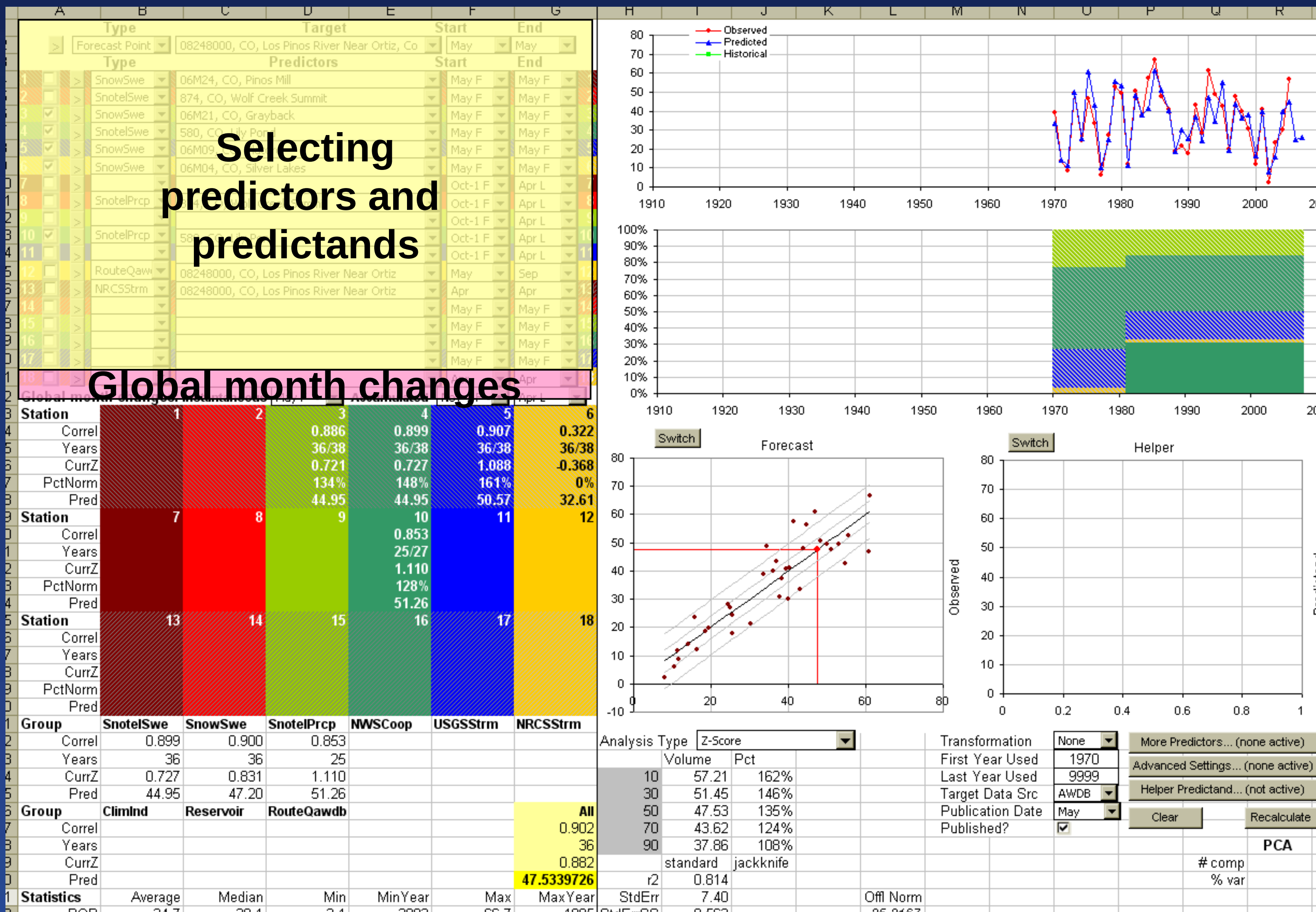
VIPER is an Excel spreadsheet application with macros and with live web-based data retrieval from the NRCS-NWCC and USGS databases.

United States Department of Agriculture
Natural Resources Conservation Service

VIPER Main Interface



VIPER Main Interface



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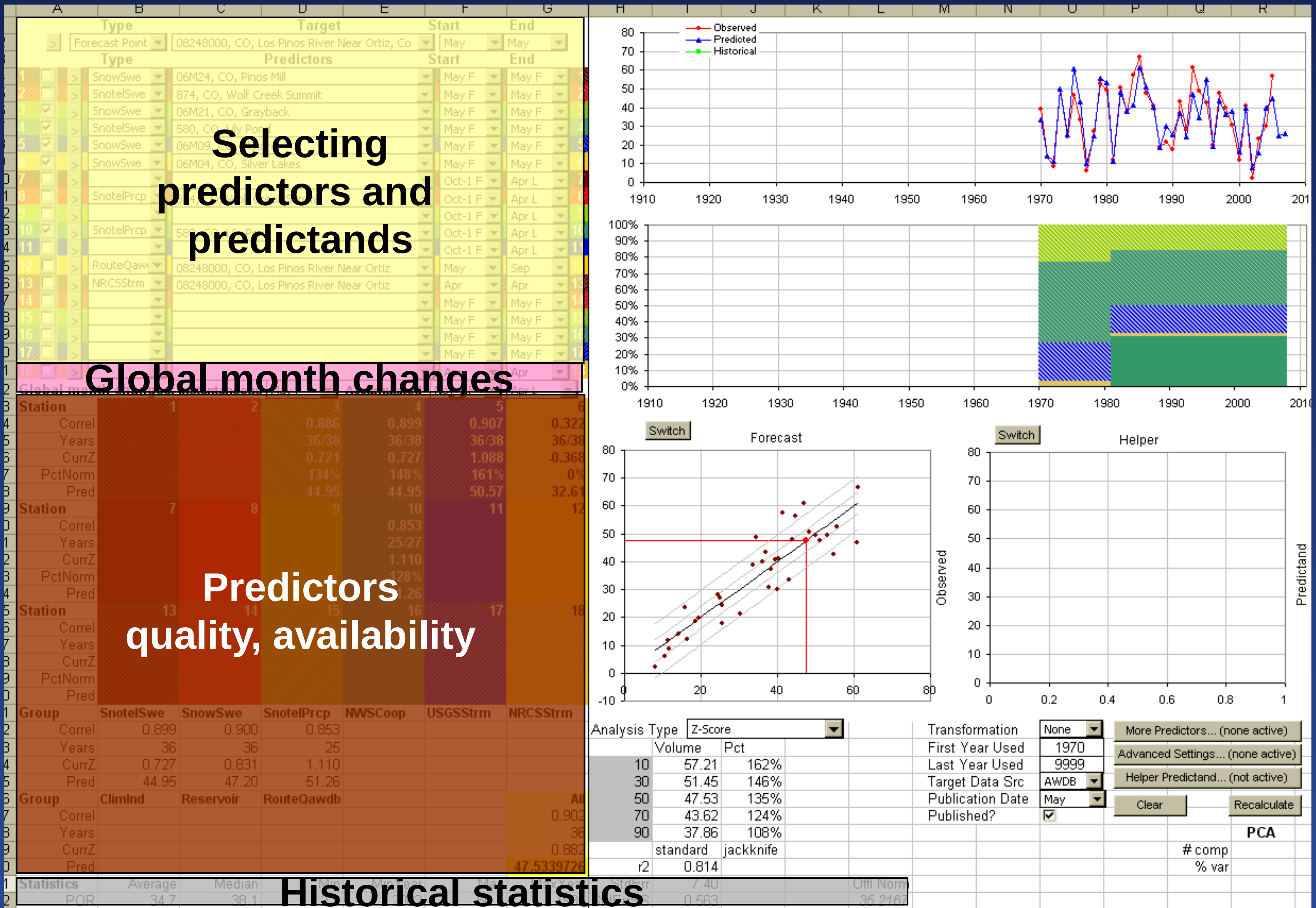

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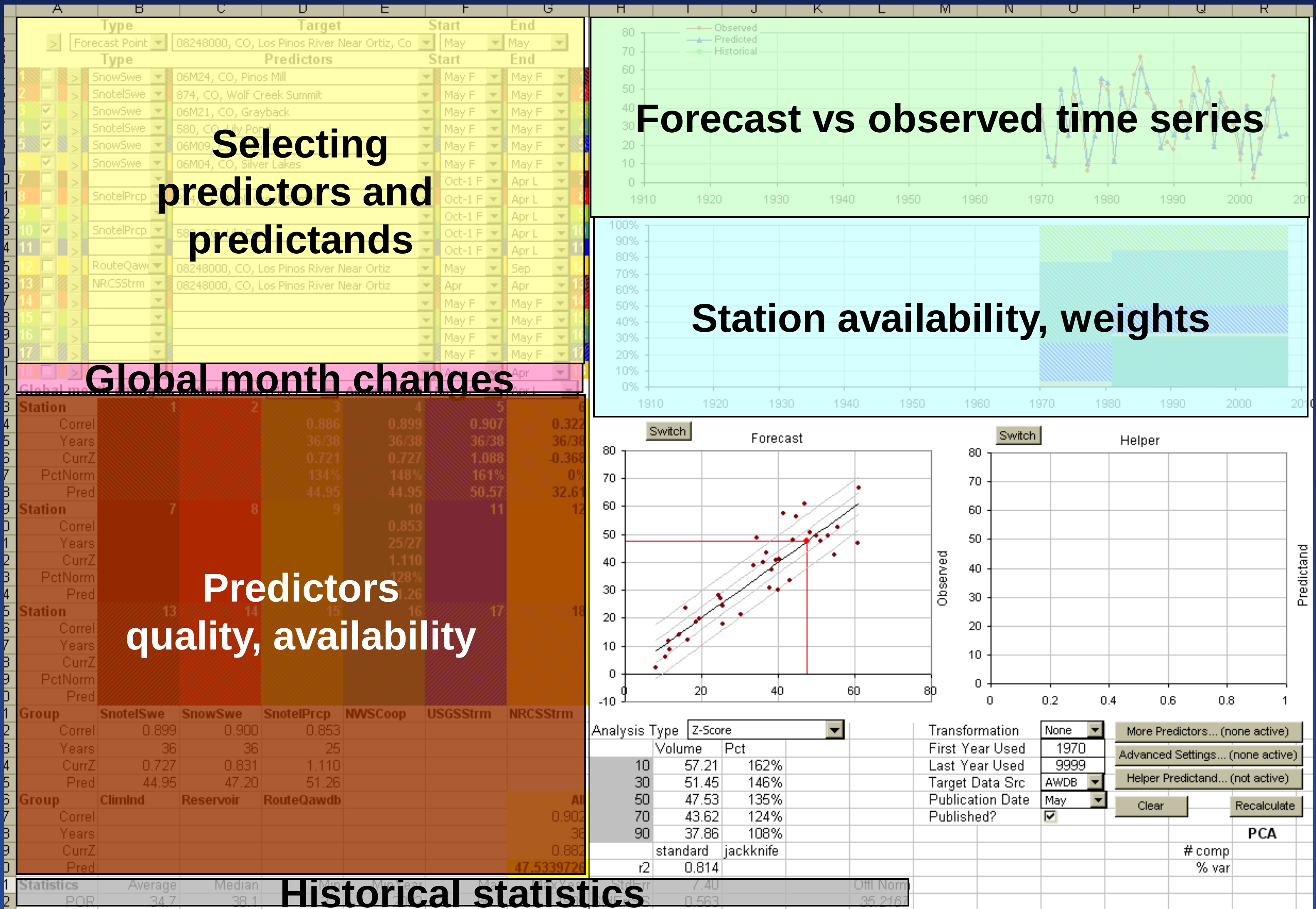

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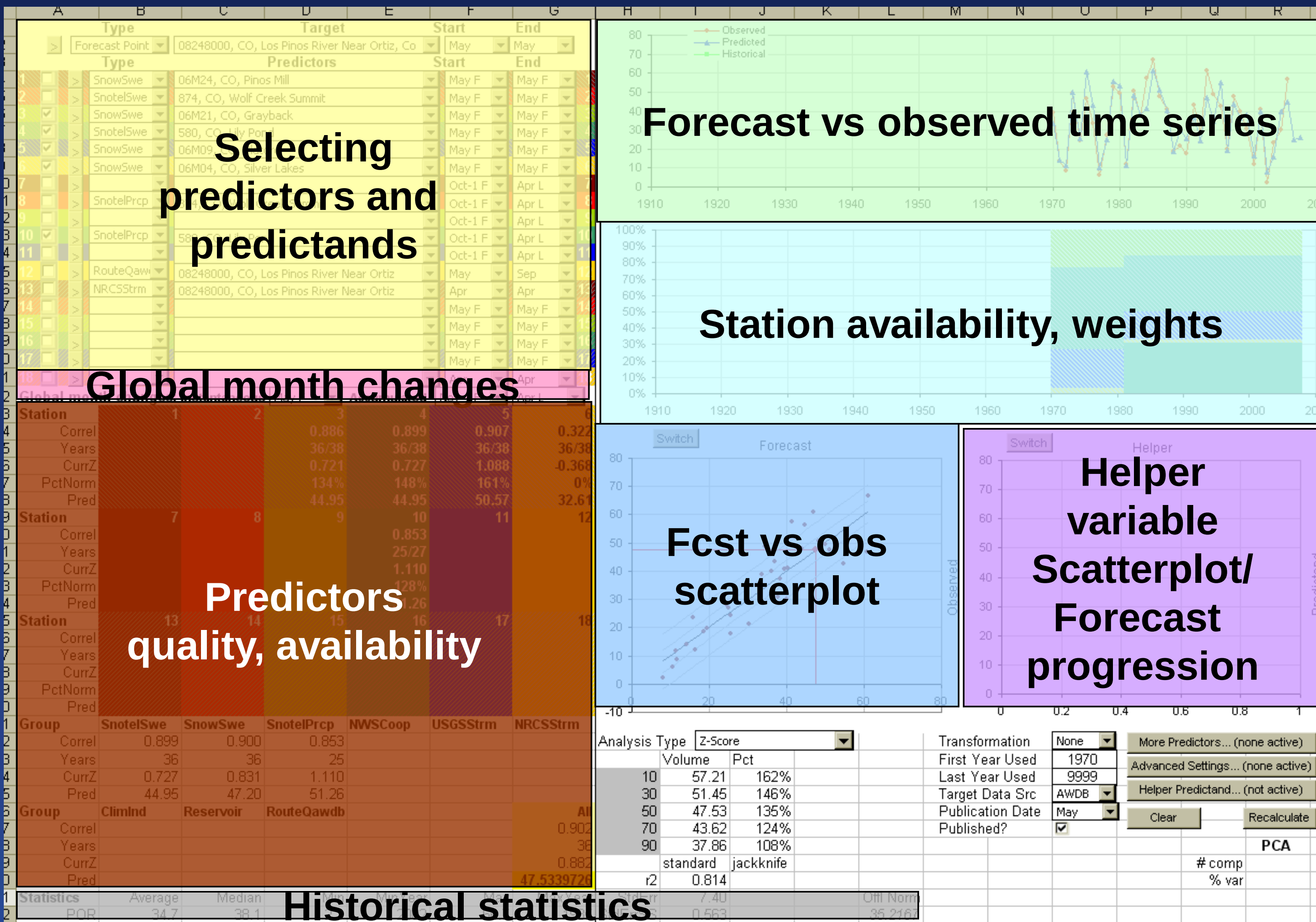

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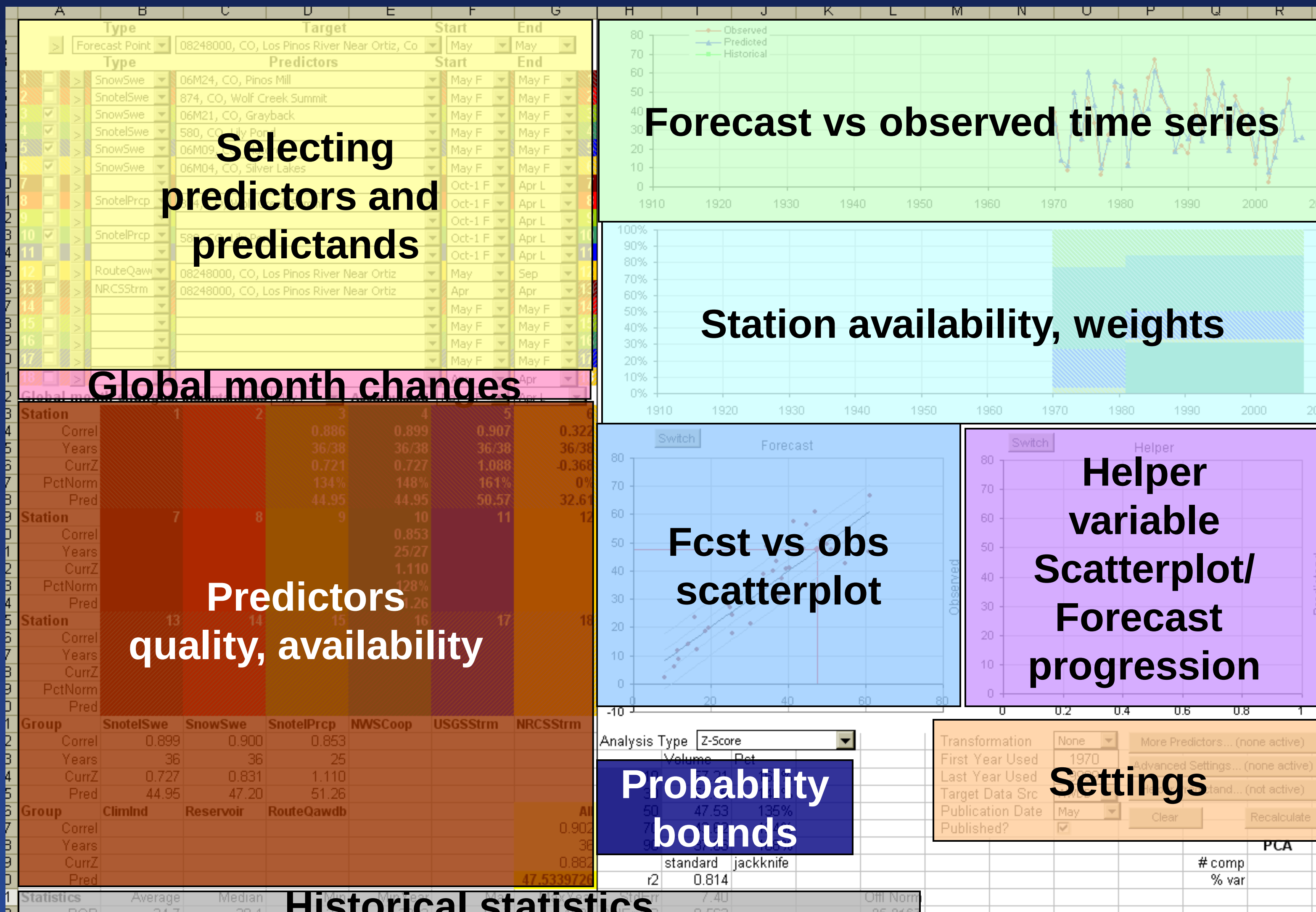


VIPER Main Interface

Selecting the target and predictors -- closeup:

	Type	Target	Start	End
>	Forecast Point	11501000, OR, Sprague Nr Chiloquin	Apr F	Sep L

#	✓		Type	Predictors	Start	End	#
1	✓	>	SnotelSwe	756, OR, Silver Creek	Apr F	Apr L	1
2	✓	>	SnotelSwe	794, OR, Strawberry	Apr F	Apr L	2
3	✓	>	SnotelSwe	800, OR, Summer Rim	Apr F	Apr L	3
4	✓	>	SnotelSwe	810, OR, Taylor Butte	Apr F	Apr L	4
5	✓	>	SnotelPrcp	706, OR, Quartz Mountain	Oct-1 F	Mar L	5
6	✓	>	SnotelPrcp	756, OR, Silver Creek	Oct-1 F	Mar L	6
7	✓	>	SnotelPrcp	794, OR, Strawberry	Oct-1 F	Mar L	7
8	✓	>	SnotelPrcp	800, OR, Summer Rim	Oct-1 F	Mar L	8
9	✓	>	SnotelPrcp	810, OR, Taylor Butte	Oct-1 F	Mar L	9
10	✓	>	USGSStrm	11501000, OR, Sprague River Near Chiloquin	Mar F	Mar L	10
11	✓	>	SOI	TNI, NA, Tni Climate Index	Oct-1 F	Jan L	11
12		>			Oct-1 F	Feb L	12
13		>			Oct-1 F	Feb L	13
14		>			Oct-1 F	Feb L	14
15		>			Mar F	Mar F	15
16		>			Oct-1 F	Jan L	16
17		>			Oct-1 F	May L	17
18		>			Mar F	May L	18

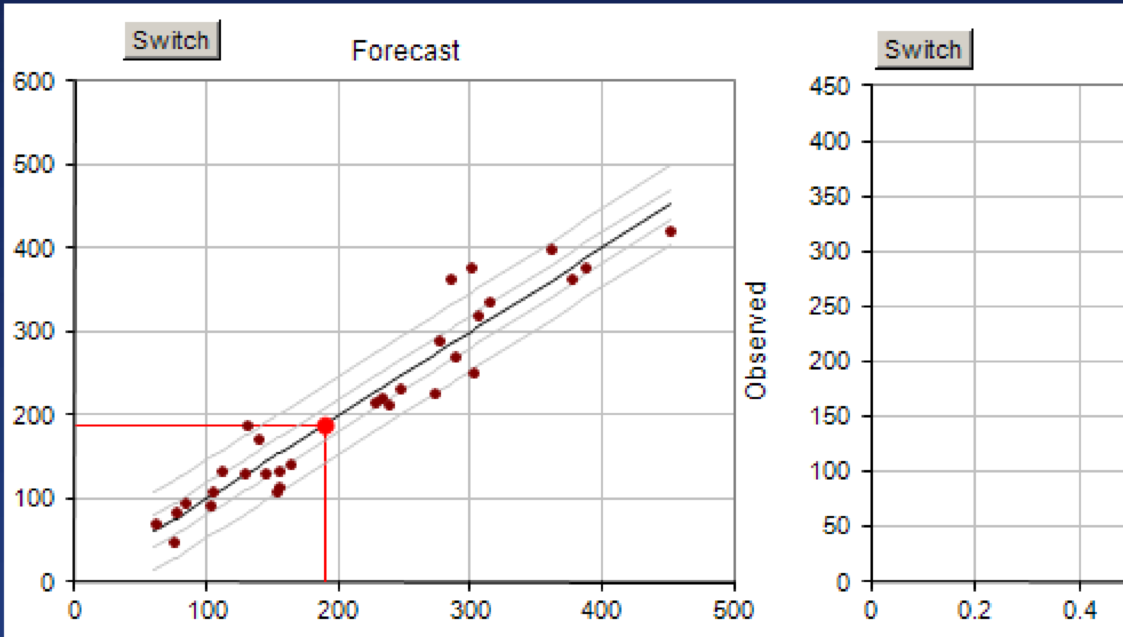
VIPER Main Interface

Individual variable stats -- closeup:

Station	1	2	3	4	5	6
Correl	0.802	0.737	0.884	0.695	0.793	0.859
Years	31/31	31/31	31/31	31/31	31/31	31/31
CurrZ	0.180	-0.247	-0.405	0.693	-0.688	0.071
PctNorm	121%	51%	83%	226%	81%	110%
Pred	230.57	194.17	174.50	268.20	153.62	221.23
Station	7	8	9	10	11	12
Correl	0.901	0.817	0.824	0.761	0.623	
Years	31/31	31/31	31/31	31/31	31/31	
CurrZ	-0.685	-0.273	-0.429	-0.618	0.686	
PctNorm	76%	89%	79%	55%	-343%	
Pred	145.62	189.60	174.99	161.98	262.19	
Station	13	14	15	16	17	18
Correl						
Years						
CurrZ						
PctNorm						
Pred						

VIPER Main Interface

Forecast vs. observed and other stats -- closeup:



Analysis Type	Principal Components				Transformation	None
Forecast	Volume	Pct			First Year Used	1981
10	236.26	113%			Last Year Used	9999
30	208.35	99%			Target Data Src	USGS
50	189.41	90%			Publication Date	April
70	170.47	81%			Published?	☑
90	142.56	68%				
	standard	jackknife				
r2	0.913	0.901				
StdErr	33.43	35.73		Offl Norm		
StdErrSS	0.700	0.680		210		

VIPER Main Interface

Single predictor variable scatterplot -- closeup:

Cross-Correlation

X-Variable

Predictor 3

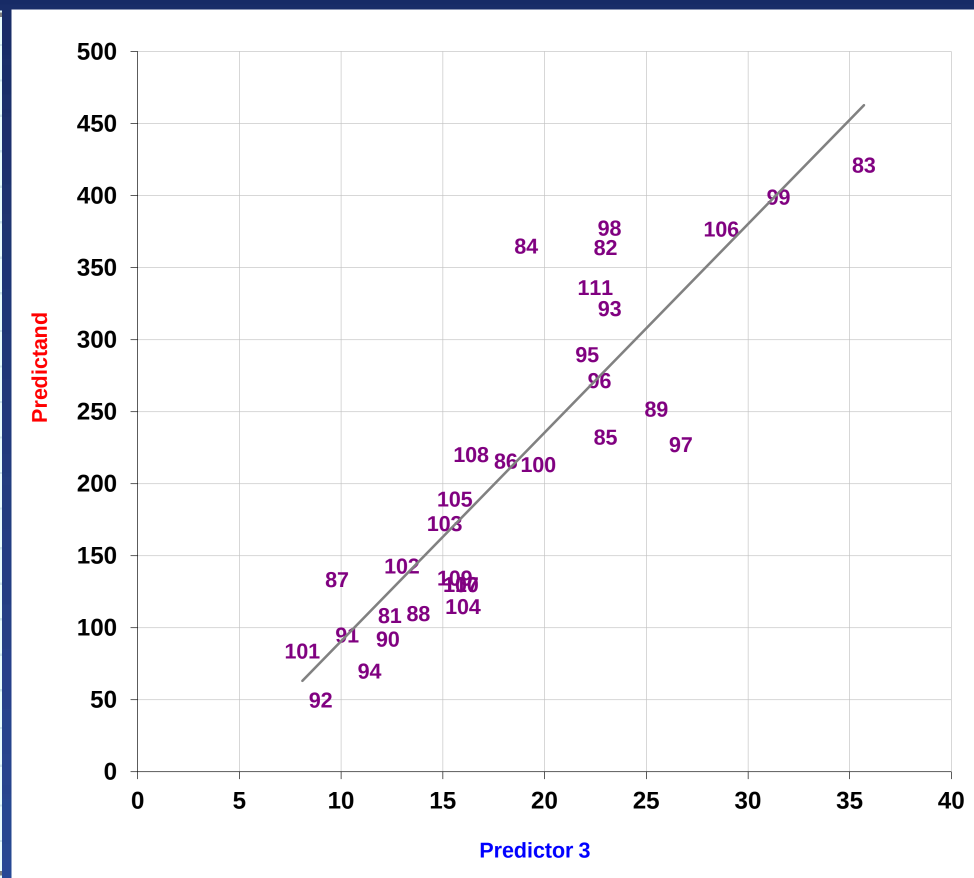
Transformation: None

Y-Variable

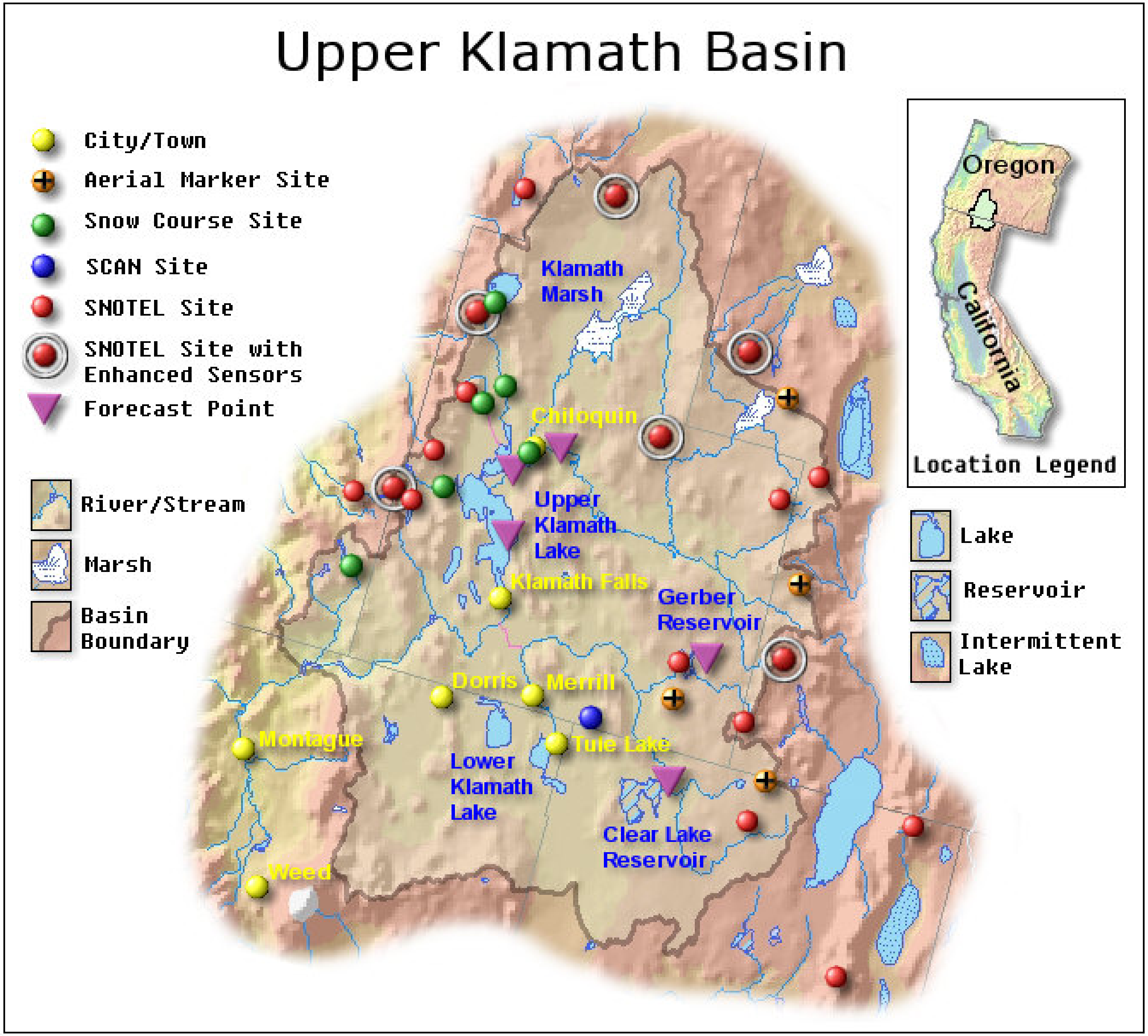
Predictand

Transformation: None

Slope	14.4847	
Intercept	-54.3562	
R	0.884	
R2	0.782	
	X	Y
Original	15.8	
Estimated		174.502
O - E		



NRCS Data Sites



Sprague Predictor Variables

SPRAGUE	Jan	Feb	Mar	Apr	May	Jun
SWE:						
Silver Creek	Jan	Feb	Mar	Apr	Apr	---
Strawberry	Jan	Feb	Mar	Apr	---	---
Summer Rim	Jan	Feb	Mar	Apr	May	Jun
Taylor Butte	Jan	Feb	Mar	Apr	---	---
PRECIPITATION:						
Quartz Mountain	Oct-Dec	Oct-Jan	Oct-Feb	Oct-Mar	Oct-Apr	Oct-May
Silver Creek	Oct-Dec	Oct-Jan	Oct-Feb	Oct-Mar	Oct-Apr	Oct-May
Strawberry	Oct-Dec	Oct-Jan	Oct-Feb	Oct-Mar	Oct-Apr	Oct-May
Summer Rim	Oct-Dec	Oct-Jan	Oct-Feb	Oct-Mar	Oct-Apr	Oct-May
Taylor Butte	Oct-Dec	Oct-Jan	Oct-Feb	Oct-Mar	Oct-Apr	Oct-May
STREAMFLOW:						
Sprague R. / Chiloquin	Nov-Dec	Nov-Dec	Nov-Dec	Mar	Apr	May
CLIMATE INDEX:						
Trans-Niño Index	Sep-Nov	Oct-Dec	Oct-Jan	Oct-Jan	Oct-Jan	Oct-Jan

Upper Williamson Predictor Variables

U. WILLIAMSON	Jan	Feb	Mar	Apr	May	Jun
SWE:						
Annie Spring	Jan	Feb	Mar	Apr	May	---
Chemult Alt.	Jan	Feb	Mar	Apr	---	---
Sevenmile Marsh	Jan	Feb	Mar	Apr	May	Jun
Silver Creek	Jan	Feb	Mar	Apr	---	---
PRECIPITATION:						
STREAMFLOW:						
Upper Williamson	Nov-Dec	Nov-Dec	Nov-Dec	Mar	Apr	May
CLIMATE INDEX:						
Trans-Niño Index	Sep-Nov	Oct-Dec	Oct-Jan	Oct-Jan	Oct-Jan	Oct-Jan

Williamson and Upper Klamath Lake

The forecast for the Williamson is simply the sum of the Sprague and Upper Williamson (with appropriate error analysis).

The forecast for Upper Klamath Lake inflow is a simple linear regression with the Williamson as the predictor.

Statistics	Jan Apr-Sep	Feb Apr-Sep	Mar Apr-Sep	Apr Apr-Sep	May May-Sep	Jun Jun-Sep
Jackknife std. error:						
Sprague	81.45	64.76	55.48	35.73	31.42	16.58
Upper Williamson	25.21	22.98	22.80	17.95	13.01	8.61
Williamson	96.02	76.76	66.79	43.32	37.54	21.93
Upper Klamath Lake	136.21	103.82	88.84	63.17	52.64	38.25
Mean (1981-2010):						
Sprague	210	210	210	210	141	73
Upper Williamson	143	143	143	143	105	76
Williamson	354	354	354	354	246	149
Upper Klamath Lake	476	476	476	476	317	181
JSE / Mean:						
Sprague	0.388	0.308	0.264	0.170	0.223	0.227
Upper Williamson	0.176	0.161	0.159	0.126	0.124	0.113
Williamson	0.271	0.217	0.189	0.122	0.153	0.147
Upper Klamath Lake	0.286	0.218	0.187	0.133	0.166	0.211

What Affects Forecast Accuracy?

Listed in general order of importance (greatest to least):

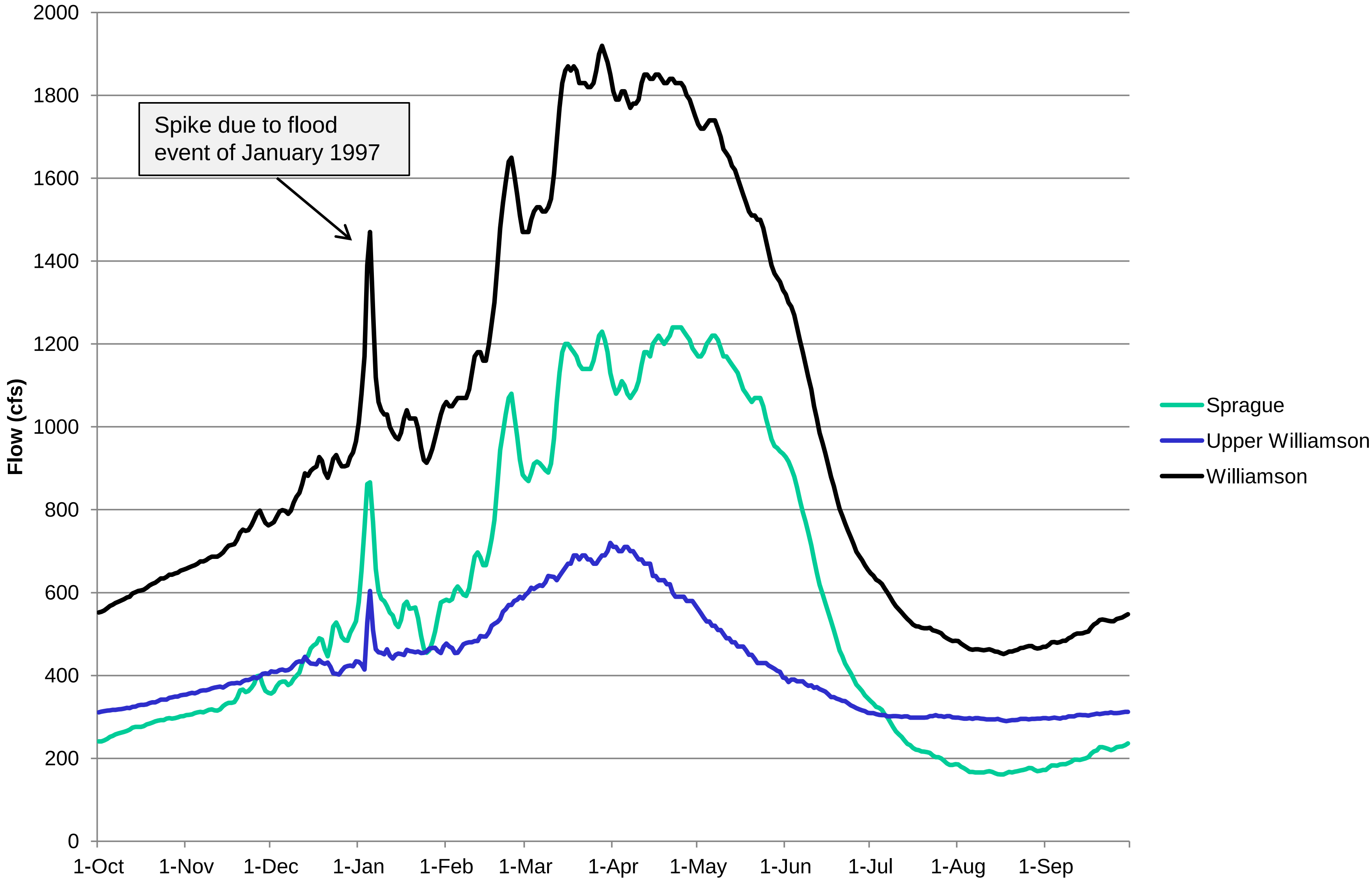
- Hydrologic regime -- snow-dominated regimes are highly predictable, rain-dominated regimes are not
- Future weather (after forecast issuance)
- Model limitations and approximations -- some relevant processes inadequately represented
- Limitations in monitoring network to depict basin hydrometeorological state
- Data errors

What Physical Characteristics of the Klamath Basin Affect Forecast Accuracy?

- Fairly predictible snowmelt-dominated regime ... BUT ALSO:
- High spatial variability of terrain, climate, snow dynamics
- Ungaged diversions
- Groundwater interactions
- Large shallow lake with significant evaporation

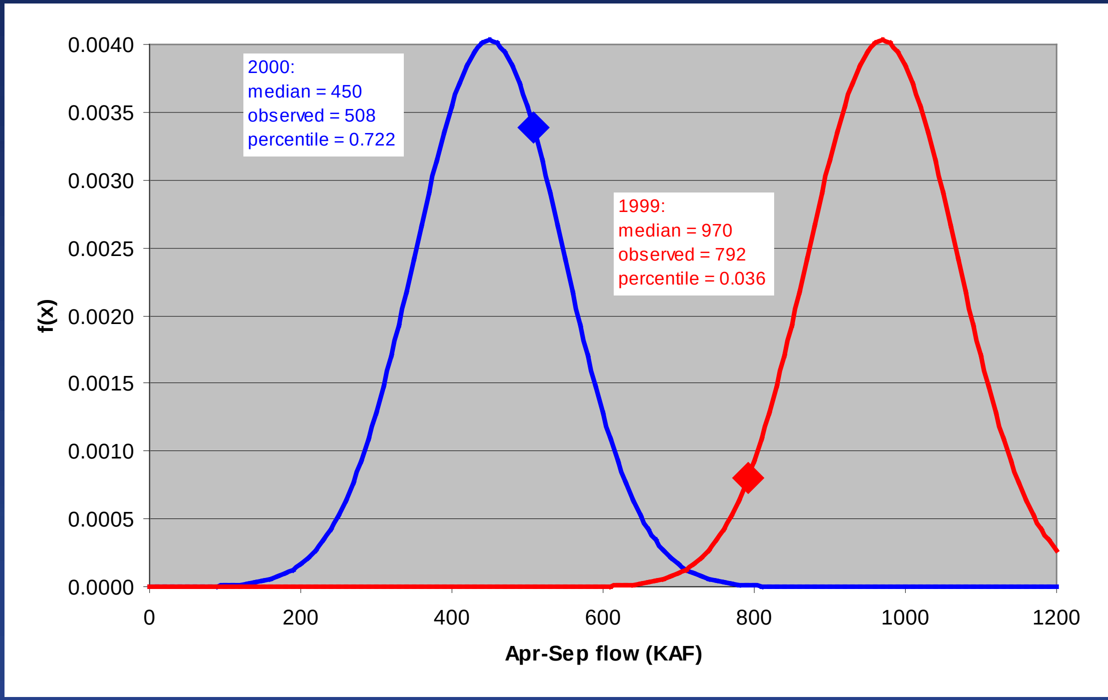
==> That is, this basin contains some physical process complexities that are difficult to represent adequately in mathematical models. This leads to an inherent uncertainty in predicting the system.

Average Daily Hydrographs, 1981-2010



Forecast Uncertainty

- Usual regression assumptions of homoscedasticity and normal distribution of errors
- Forecast is interpreted as a conditional probability distribution
- NRCS publishes five values at different exceedance levels (90, 70, 50, 30, 10%)



Forecast Uncertainty

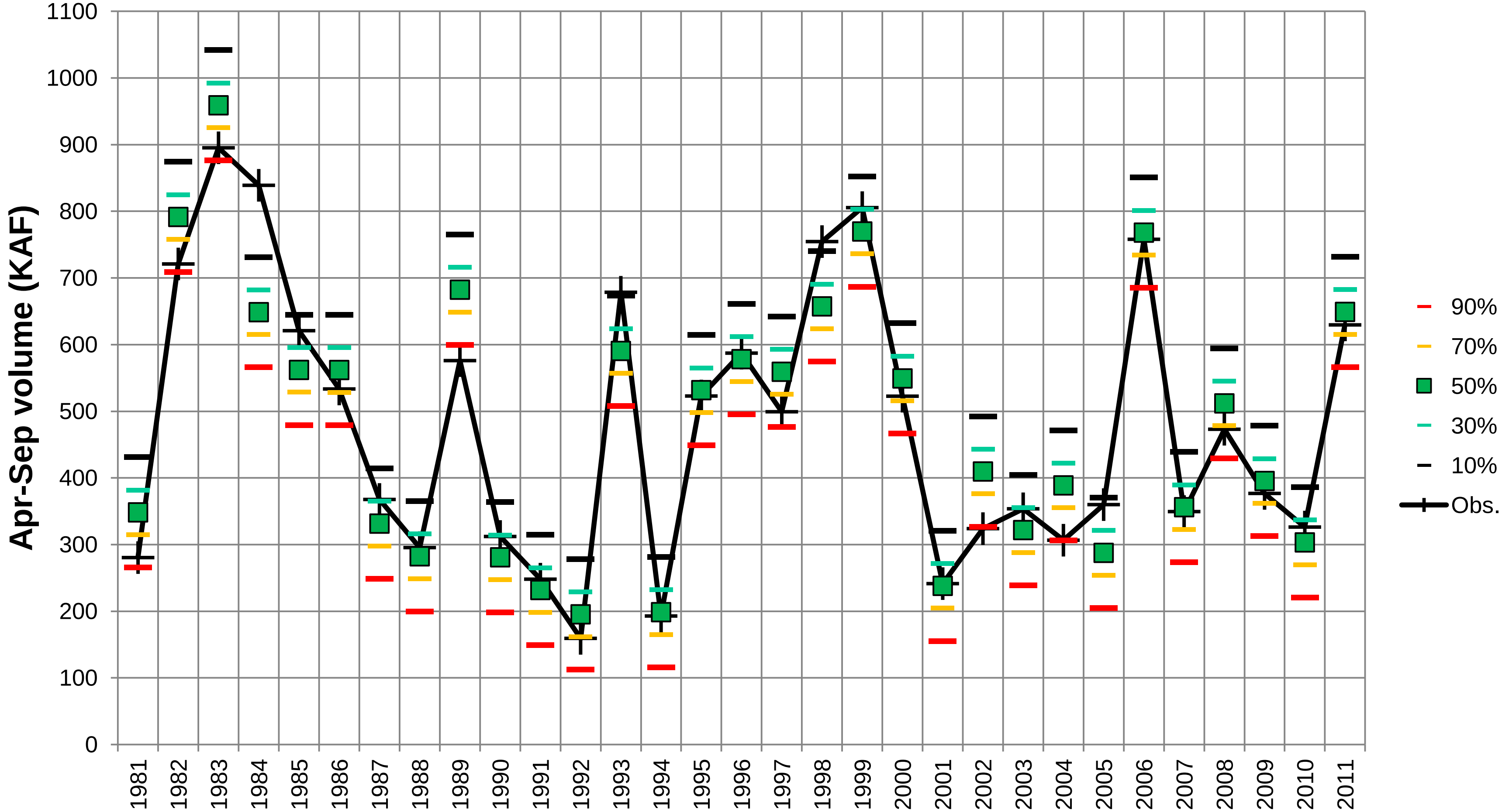
KLAMATH BASIN
Streamflow Forecasts - April 1, 2012

Forecast Pt / Forecast Period	<=== Drier === Future Conditions === Wetter ===>						
	============== Chance of Exceeding * ==============						
	90% (1000AF)	70% (1000AF)	50% (1000AF)	50% (% AVG.)	30% (1000AF)	10% (1000AF)	30 Yr Avg (1000AF)
Sprague R nr Chiloquin							
APR-JUL	112	140	160	78	180	210	205
APR-SEP	135	165	185	80	205	235	230
Upper Klamath Lk Inflow (1)							
APR-JUL	230	300	330	78	360	430	425
APR-SEP	295	365	400	78	435	505	515
Williamson R bl Sprague R nr Chiloquin							
APR-JUL	200	235	255	80	275	310	320
APR-SEP	250	285	310	81	335	370	385

United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

Upper Klamath Lake Observed Flows and 1 April Reconstructed Forecasts, Apr-Sep Volume, 1981-2011

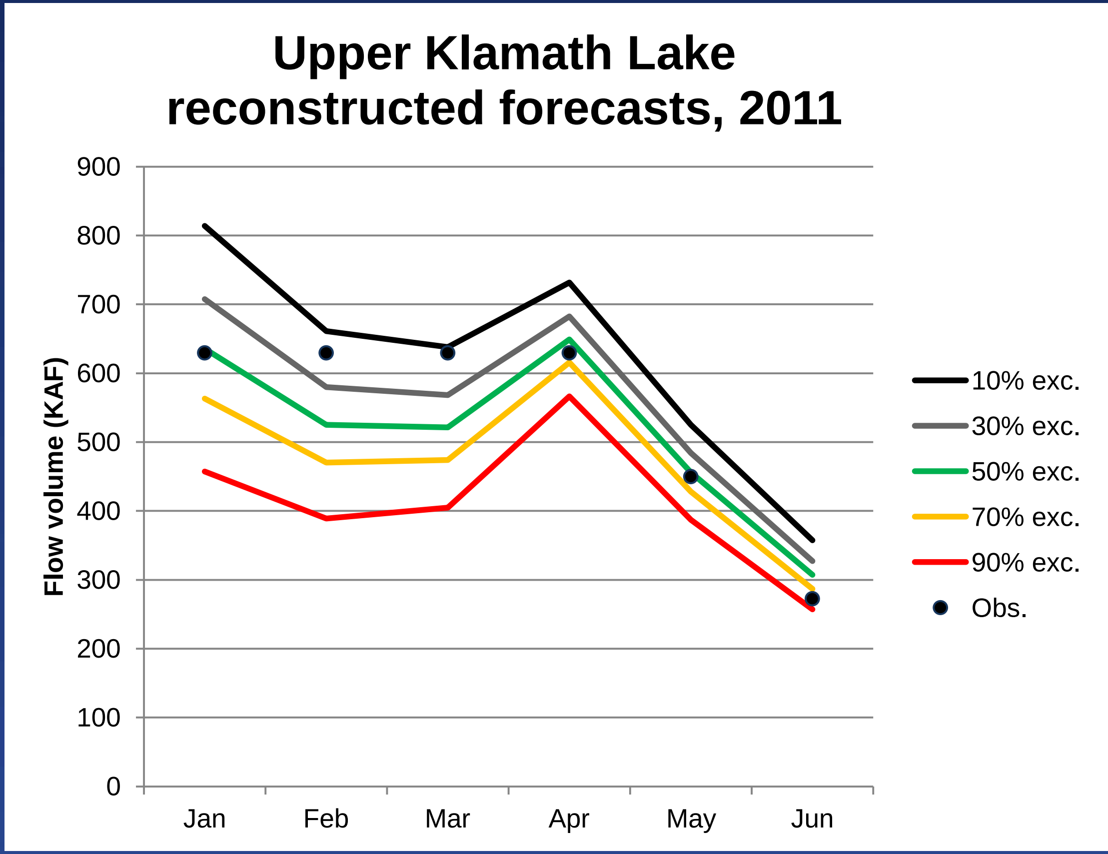


United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

Forecast Progression During Season

Forecasts, as they are updated, reflect changing conditions. The skill of the forecasts increases as the winter season progresses. Once into the spring season, forecast skill generally decreases a bit due to the forecast period being only a portion of the whole snowmelt period.



Understanding and Interpreting Forecasts: Story Lines

The forecasts and their progression during the season should tell a coherent story. Their ups and downs should be able to be interpreted in terms of current weather and hydrologic events.

Hydrologic forecast models, if constructed in a consistent and physically meaningful way, should respond appropriately to the current hydrometeorology, and the changes in forecasts should therefore be understandable.

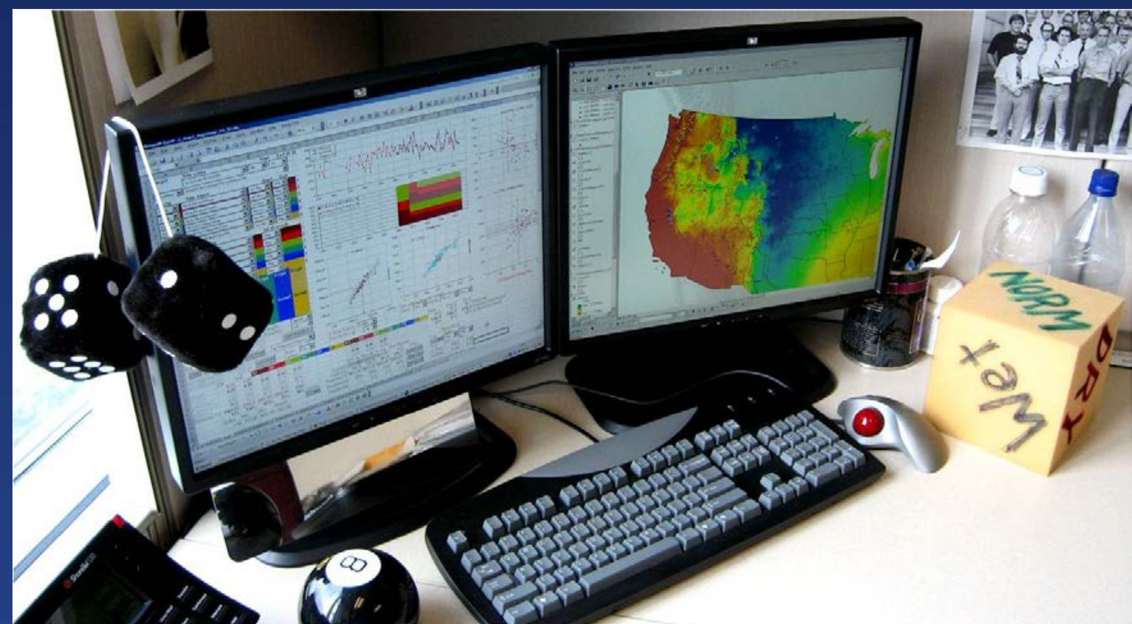
Forecast Operations

Forecast operations require a high degree of automated, real-time data collection and processing, with streamlined procedures for calculating and issuing forecasts within the first few days of the month.

Forecast Operations

Forecasting tasks include:

- Data QC and editing
- Preliminary execution of forecast models
- Review of model output
- Consultation with colleagues
- Forecast adjustments
- Final forecast issuance and preparation of reports



NRCS "enhanced" forecasting workstation

Summary

We have covered the basics of water supply forecasting in terms of how statistical forecast models are constructed, how to understand forecast accuracy/uncertainty, and how the operational workflow proceeds.

The Klamath Basin represents a few of several hundred forecast points within the NRCS forecast operations. The forecasts are fairly skillful. Of course, there are many other details and nuances, but these can be addressed during discussions.

USDA-NRCS National Water and Climate Center
http://www.wcc.nrcs.usda.gov

Thank you for your attention!

Questions?
Comments?

NWS Hydrologic Forecasting

Rob Hartman
NOAA's National Weather Service
California-Nevada River Forecast Center
Sacramento, CA

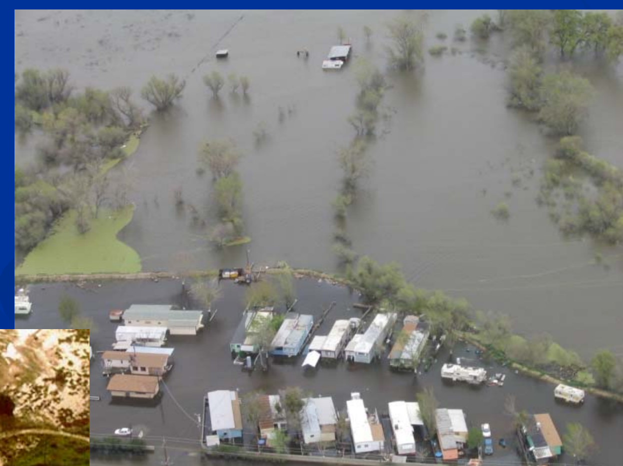
Klamath River Water Supply Workshop – December 10, 2012

Outline

- NWS Hydrologic Services
- CNRFC modeling and forecast process
  - Deterministic
  - Ensemble
- Applications in the Upper Klamath River Basin

Mission of NWS
Hydrologic Services Program

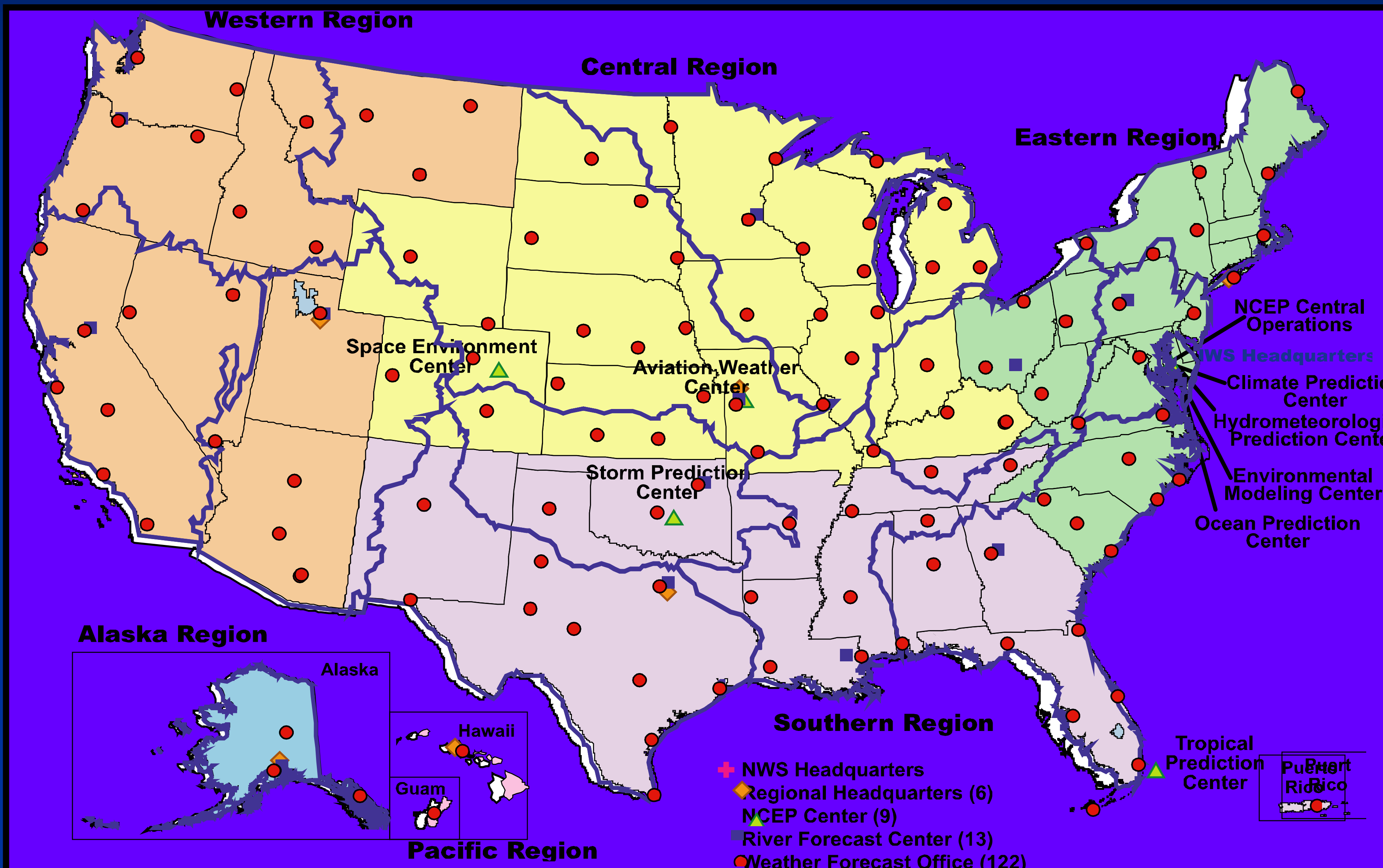
- Provide river and flood forecasts and warnings for the protection of lives and property



Mission of NWS
Hydrologic Services Program

- Provide basic hydrologic forecast information for the nation’s environmental and economic well being

NWS Structure: Five Regions
122 WFO's 13 River Forecast Centers (RFC's)



CNRFC Staffing

NWS/CNRFC

- Hydrologist in Charge
- Development and Operations Hydrologist (DOH)
- Service Coordination Hydrologist (SCH)

- 3 Senior Hydrologists
- 2 Hydrologists
- 2 Senior HAS Forecasters
- 2 HAS Forecasters

- Information Tech. Officer
- Administrative Assistant

California DWR/DFM

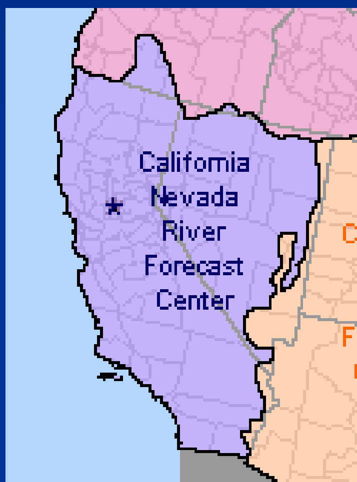
- Hydrology Branch Chief
- 7 Engineers/Forecasters

CNRFC Program Areas

- Flash Flood Support
- Dam Break Support
- Flood Forecasting
- Snowmelt Forecasting
- Water Supply Forecasting

CNRFC Customers

RFC

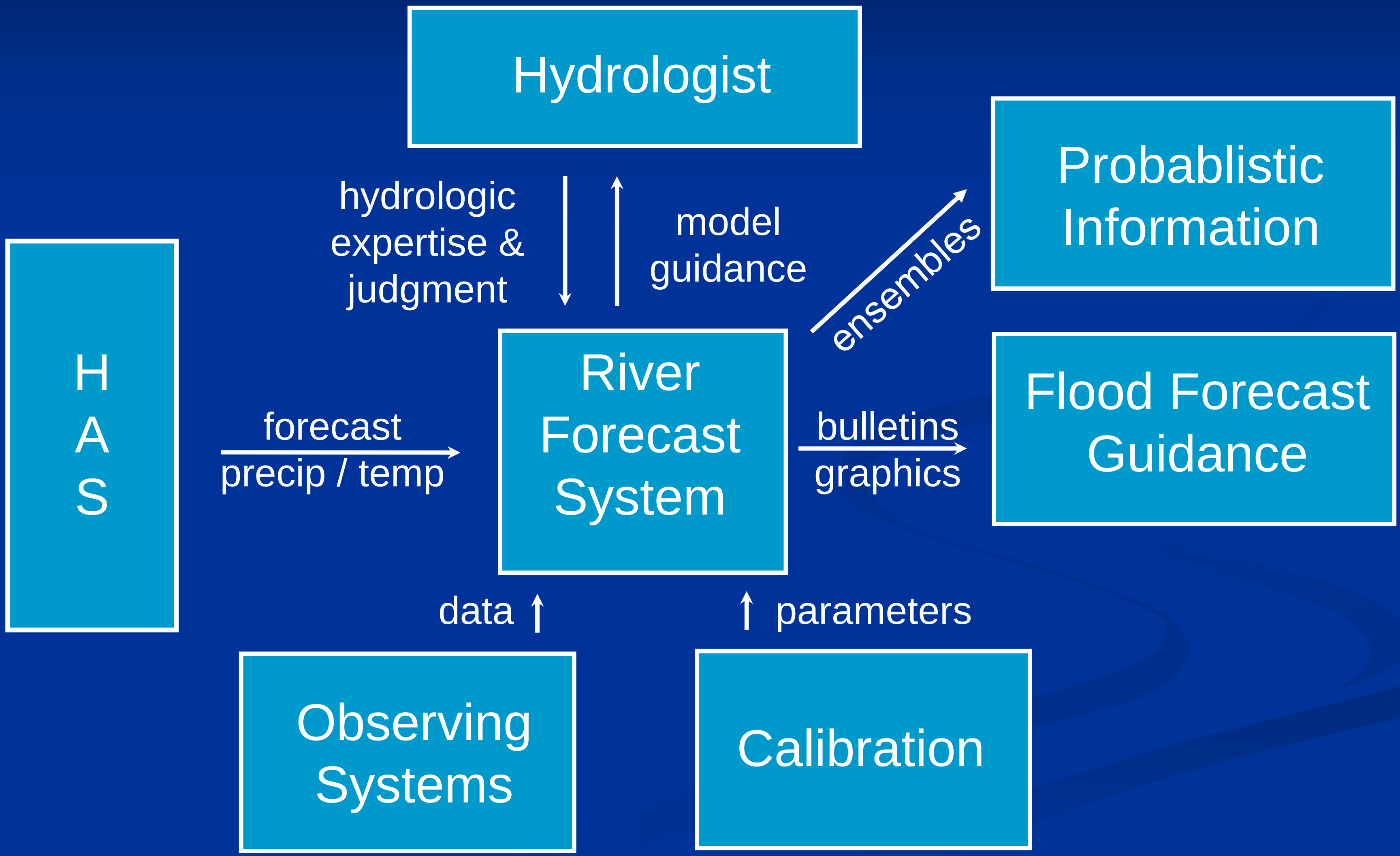


WFOs

Public Warning

Water and Flood Management Agencies, Utilities

Operational River Forecasting
(Hydrology)



Deterministic Streamflow Prediction

HAS Unit Forecasts

→

Mean Areal Time Series

Precipitation
Temperature

→

CHPS Hydrologic Models

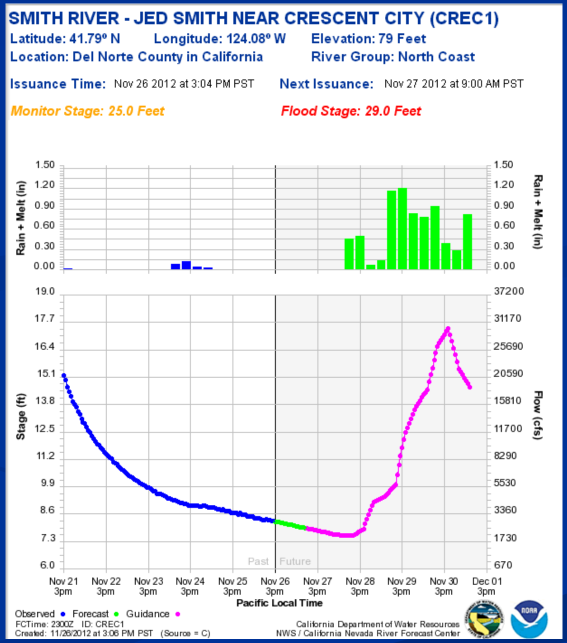
↕

Daily RFC Operations
- Data Ingest
- Data QC
- Model Updating

↕

Current Conditions
- Soil
- Snow water
- Reservoir Levels
- Streamflow

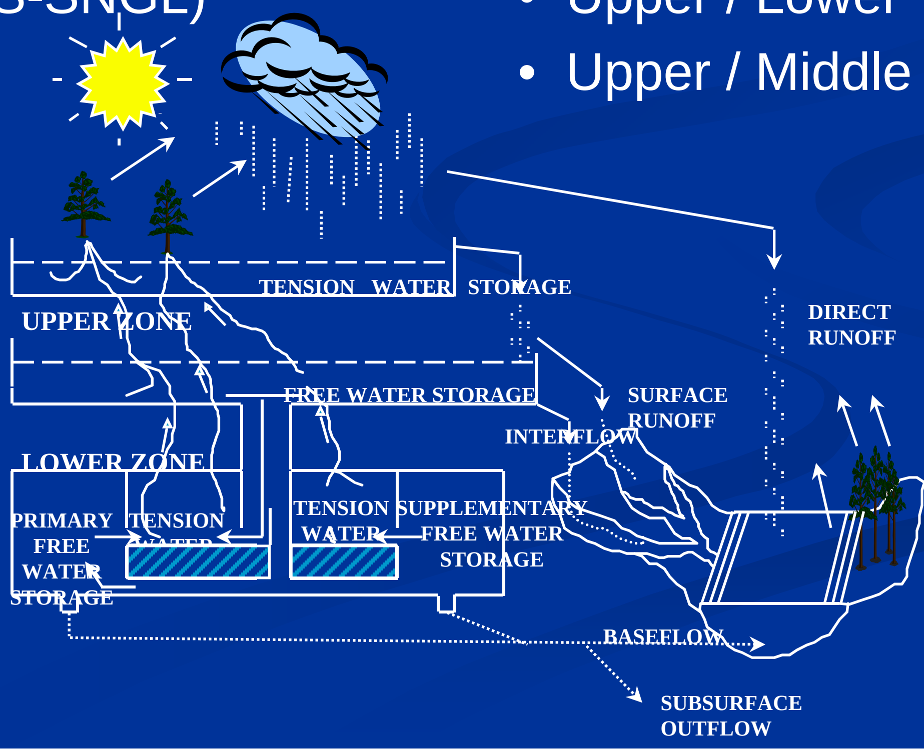
→



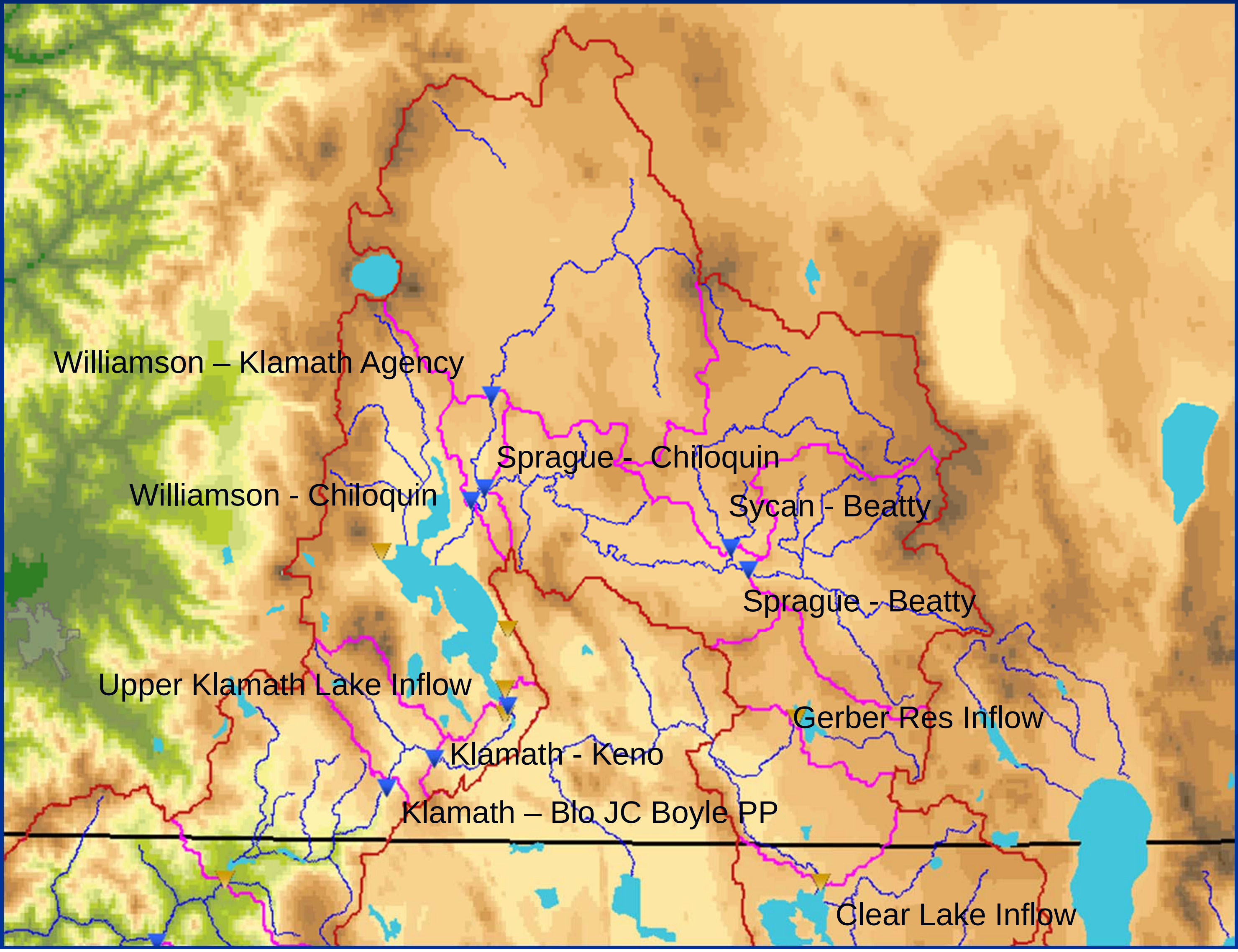
Community Hydrologic Prediction System (CHPS) Hydrologic Models

- Rain-Snow Elevation
- Snow-17
- Soil Model (SAC-SMA)
- Unit Hydrograph
- Reservoir Models (RES-SNGL)
- River Routing Models
- Arithmetic Transforms

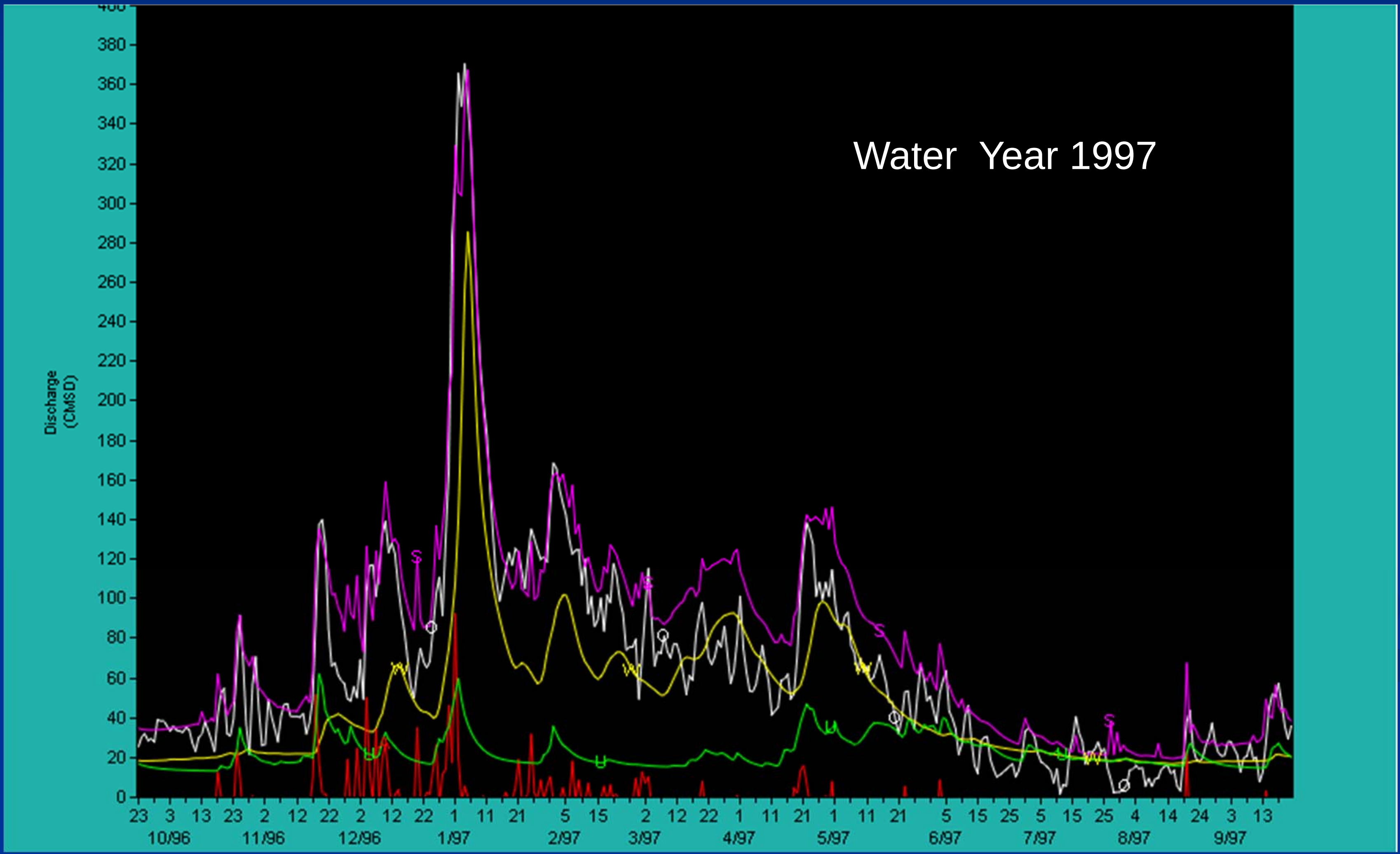
- 6-hr Time Steps
- Lumped (not distributed)
- Mountainous basins
  - Subdivided into
    - Upper / Lower
    - Upper / Middle / Lower



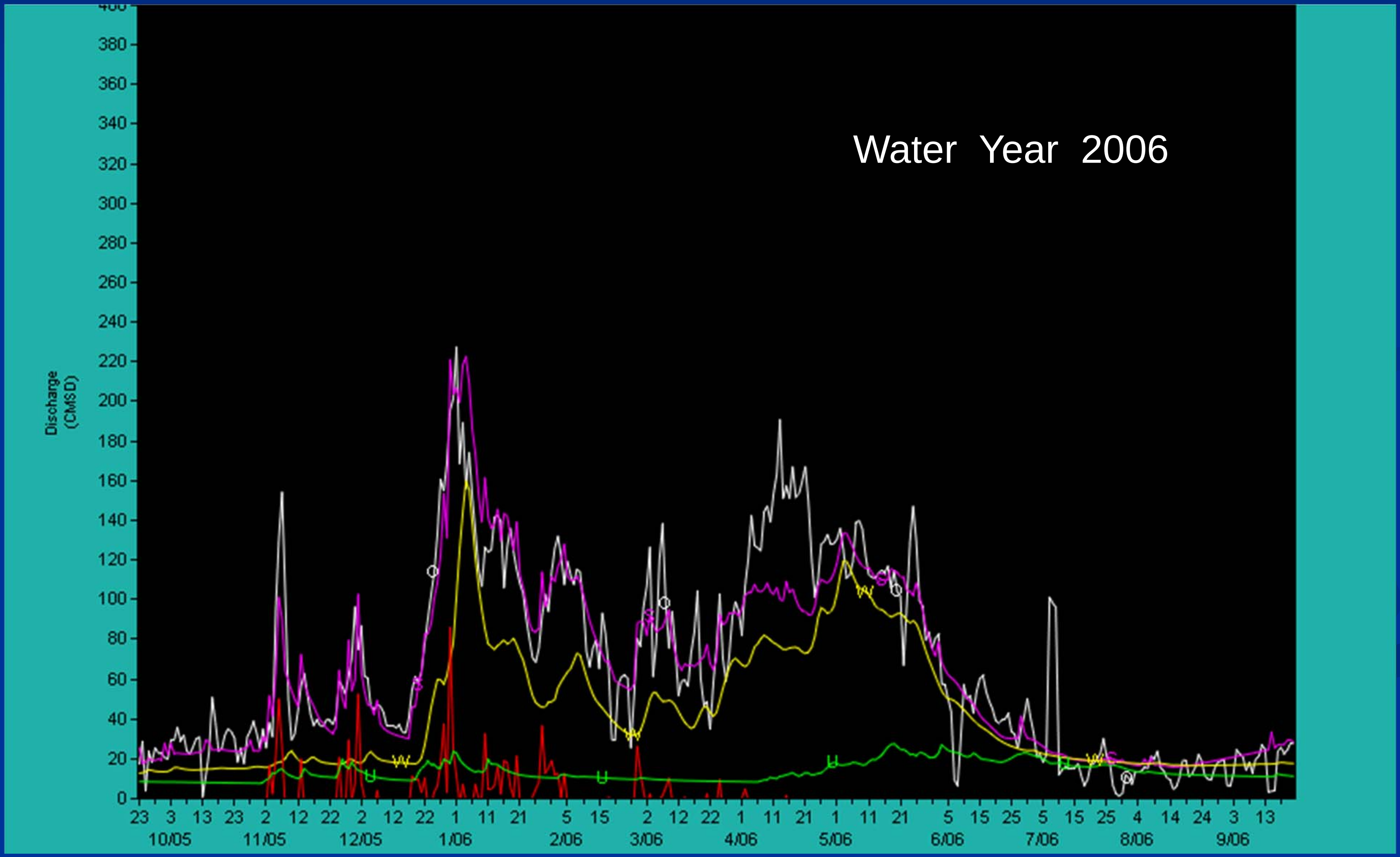
Upper Klamath Forecast Locations



Upper Klamath Lake Inflow Calibration (1991-2010)



Upper Klamath Lake Inflow Calibration (1991-2010)



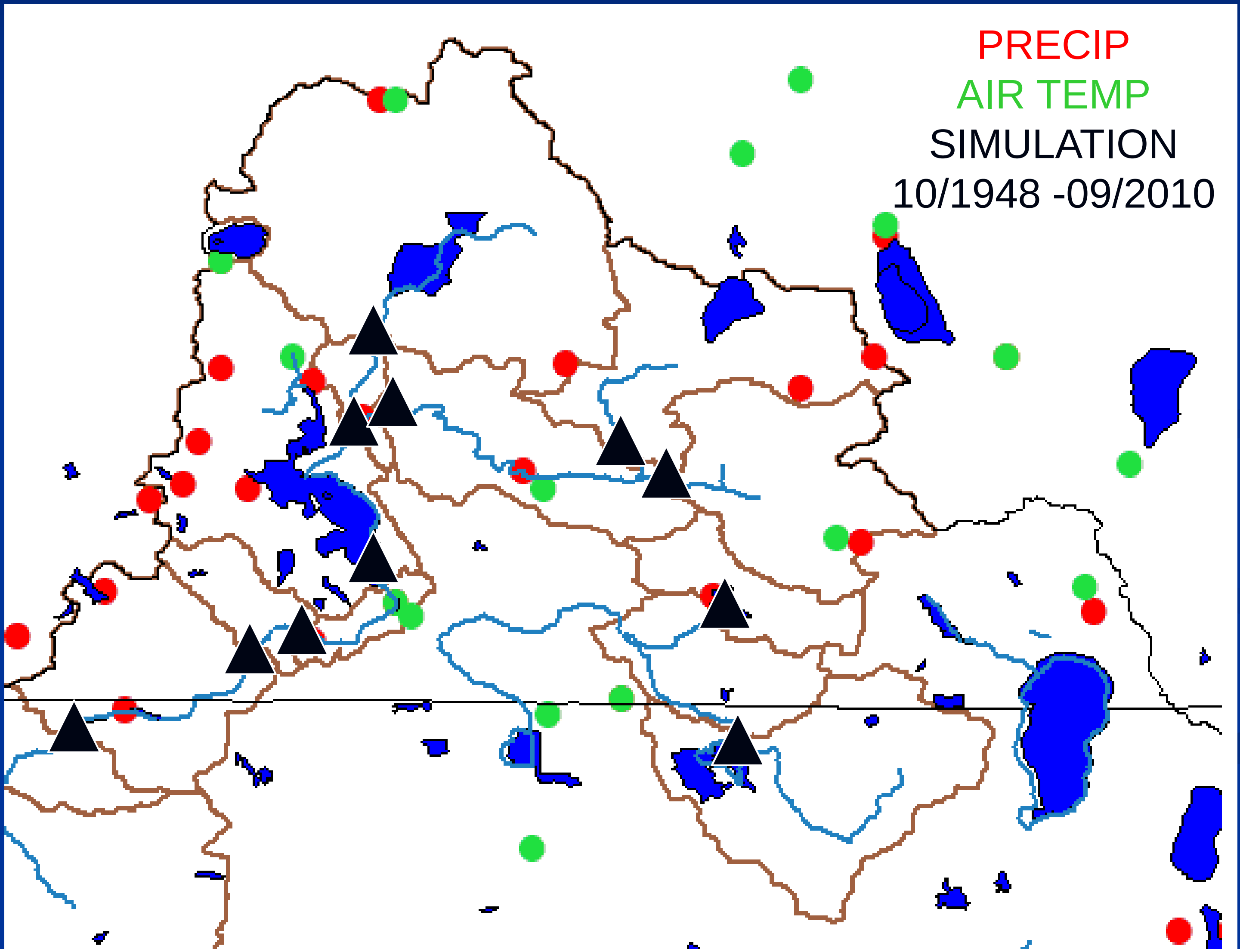
Upper Klamath Lake Inflow Calibration (1991-2010)

MULTIYEAR STATISTICAL SUMMARY

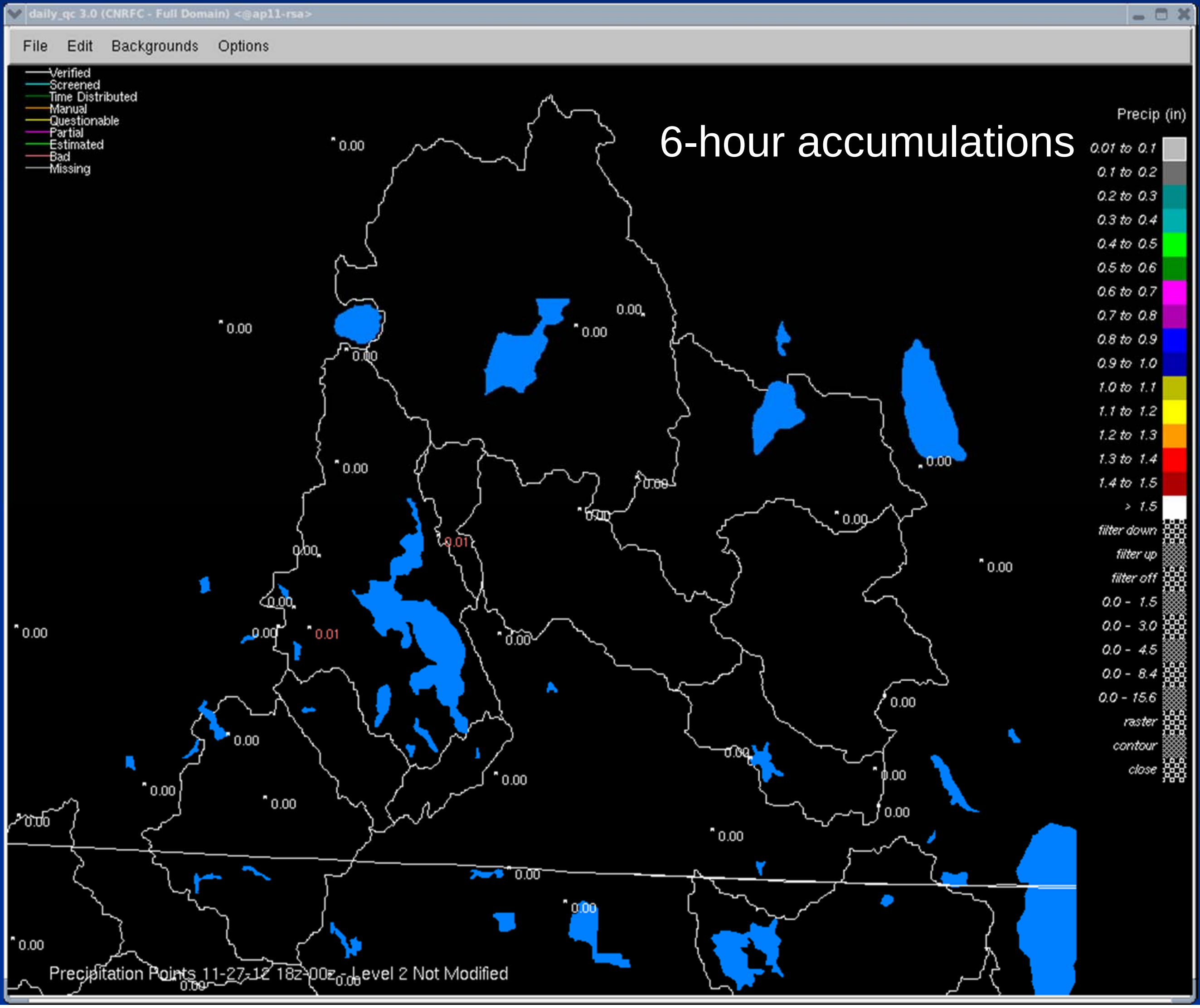
UP KLAM LAKE AREA (SQ KM) = 2030.00 WATER YEARS 1991 TO 2010

MONTHLY	SIMULATED MEAN (CMSD)	OBSERVED MEAN (CMSD)	PERCENT BIAS	MONTHLY BIAS (SIM-OBS) (MM)	MAXIMUM ERROR (SIM-OBS) (CMSD)	PERCENT AVERAGE ABSOLUTE ERROR	PERCENT DAILY RMS ERROR	MAX MONTHLY VOLUME ERROR (MM)	PERCENT AVG ABS MONTHLY VOL ERROR	PERCENT MONTHLY VOL RMS ERROR
OCTOBER	32.294	31.769	1.65	0.693	-66.863	27.94	37.71	11.508	11.07	13.65
NOVEMBER	45.678	43.728	4.46	2.489	101.564	28.76	38.48	20.938	13.30	16.53
DECEMBER	55.505	54.703	1.47	1.058	-68.334	22.63	31.93	31.126	12.75	16.63
JANUARY	69.788	66.833	4.42	3.899	81.594	17.39	24.95	34.823	11.67	15.53
FEBRUARY	67.453	64.579	4.45	3.425	-100.250	20.77	29.50	-34.527	12.95	16.61
MARCH	77.870	71.618	8.73	8.249	91.081	24.72	32.54	40.056	16.42	20.31
APRIL	75.254	70.459	6.81	6.122	-90.466	24.88	32.19	-45.457	19.24	23.76
MAY	63.814	61.846	3.18	2.598	-79.304	20.85	28.07	31.419	11.12	14.61
JUNE	31.311	30.634	2.21	0.864	-60.596	30.58	40.95	18.189	15.57	20.15
JULY	14.424	13.171	9.51	1.652	-77.370	55.20	81.16	16.824	30.97	38.55
AUGUST	12.868	11.712	9.86	1.524	29.947	53.37	69.12	-10.652	28.80	35.30
SEPTEMBER	21.225	20.157	5.30	1.363	29.410	32.67	42.00	8.274	14.50	17.14
YEAR AVG	47.333	45.143	4.85	33.937	101.564	25.20	35.84	-45.457	14.73	20.61

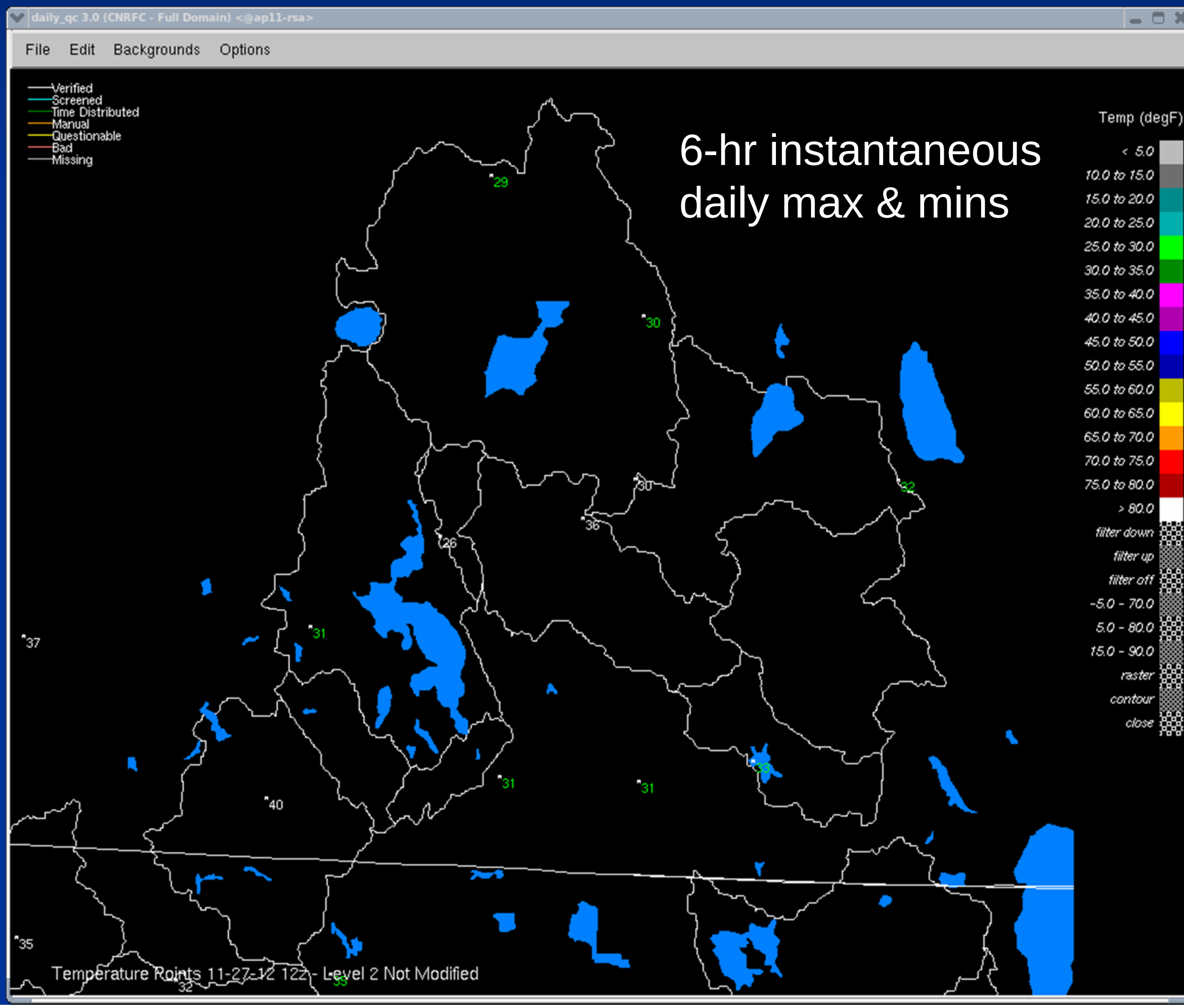
Calibration
Precipitation & Temperature Stations



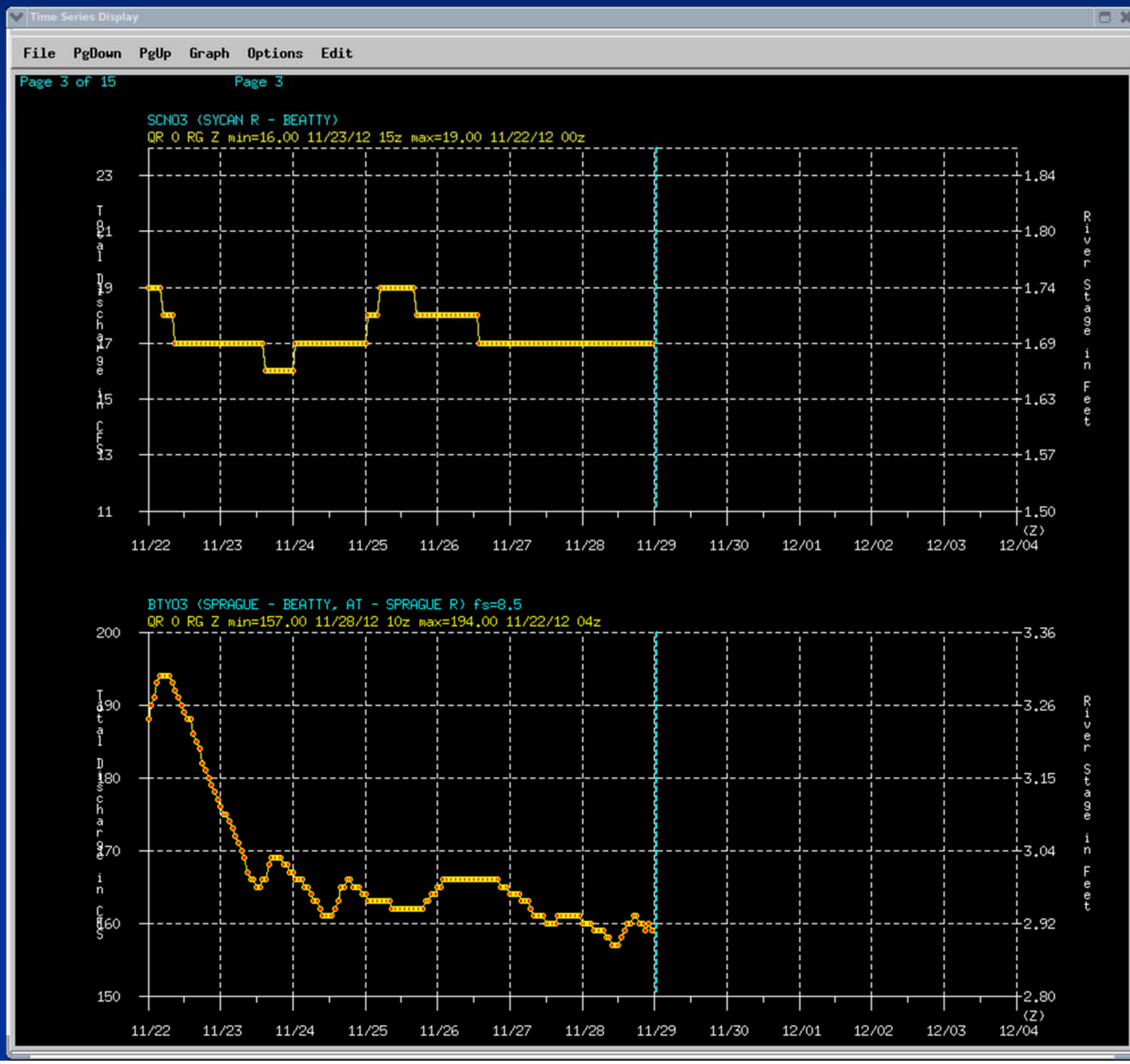
Operational
Precipitation Quality Control



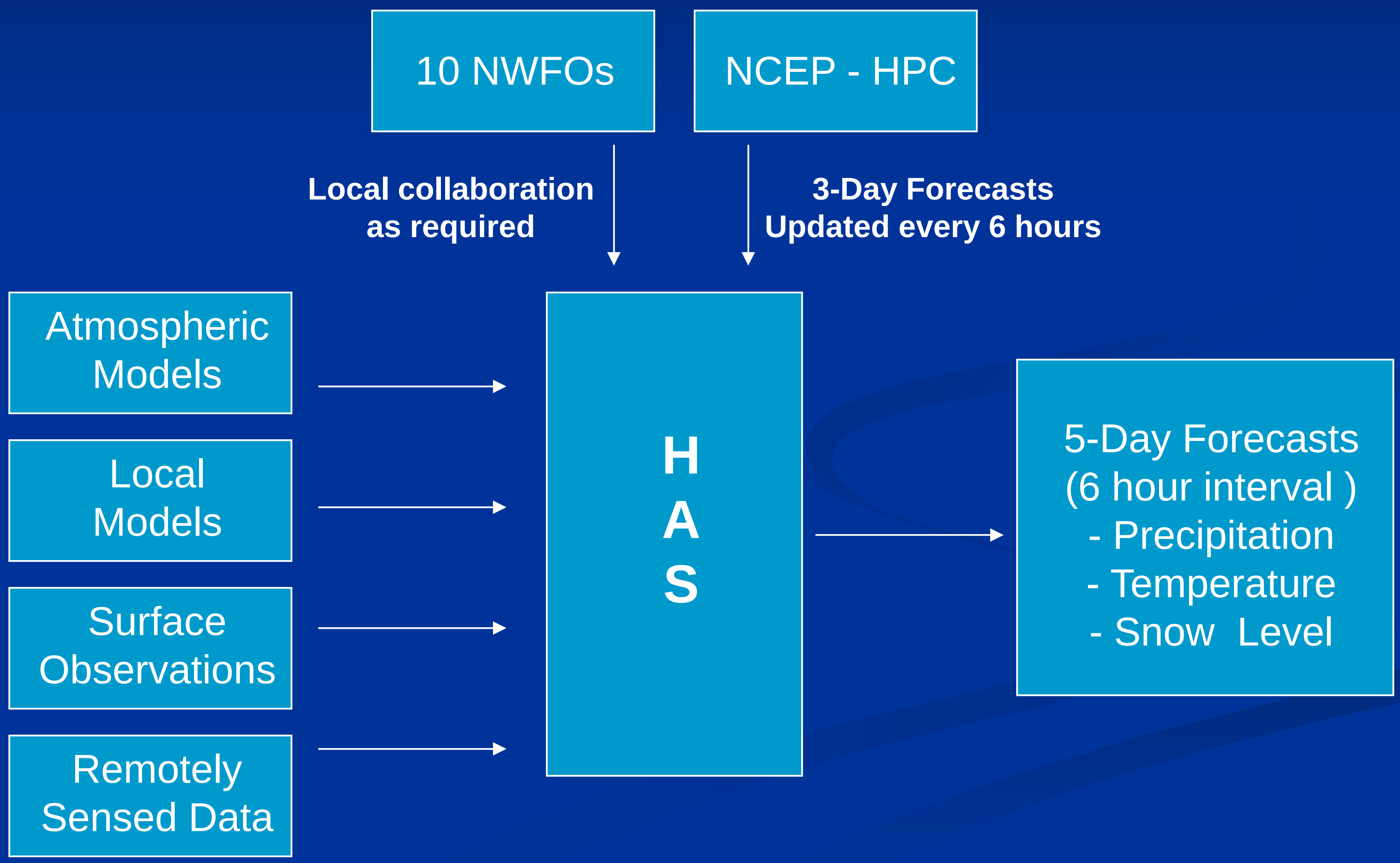
Operational
Surface Air Temperature Quality Control



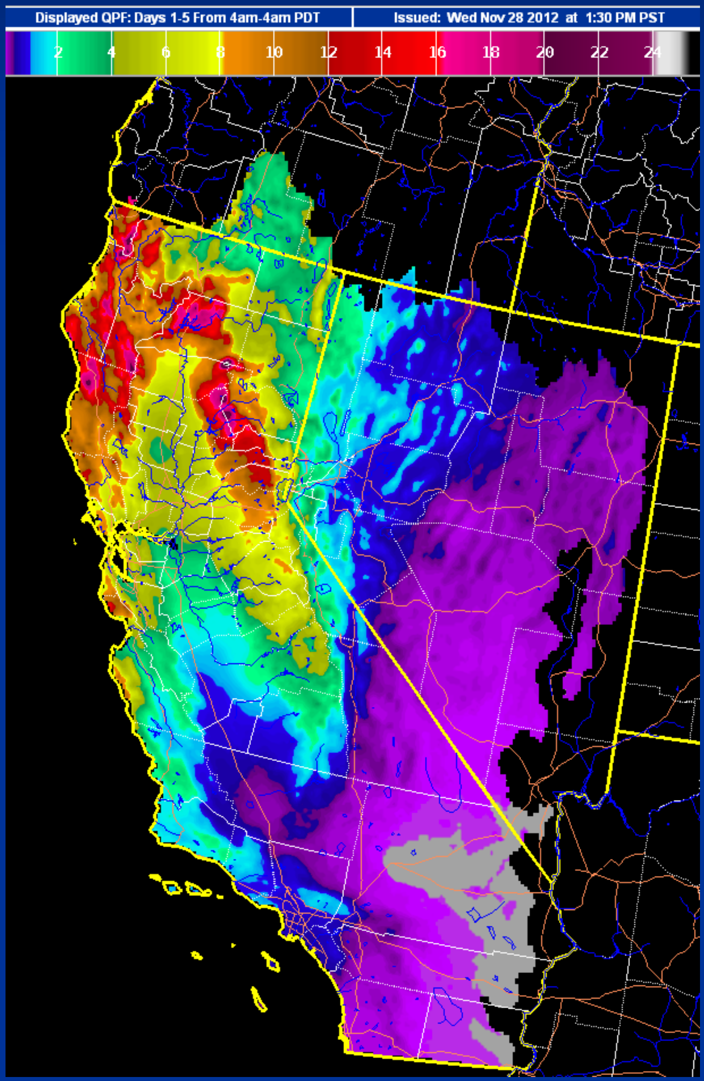
Operational Streamflow Data Quality Control



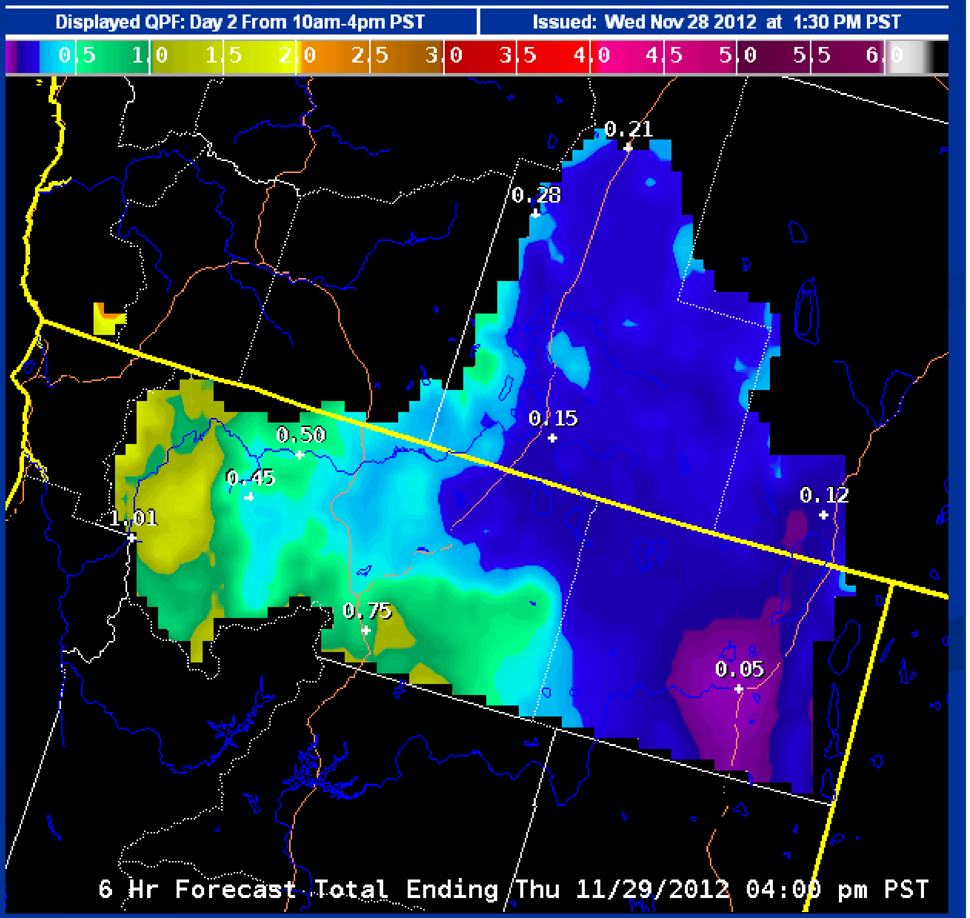
Operational HAS Function
(Meteorology)



CNRFC HAS Unit
Quantitative Precipitation Forecast

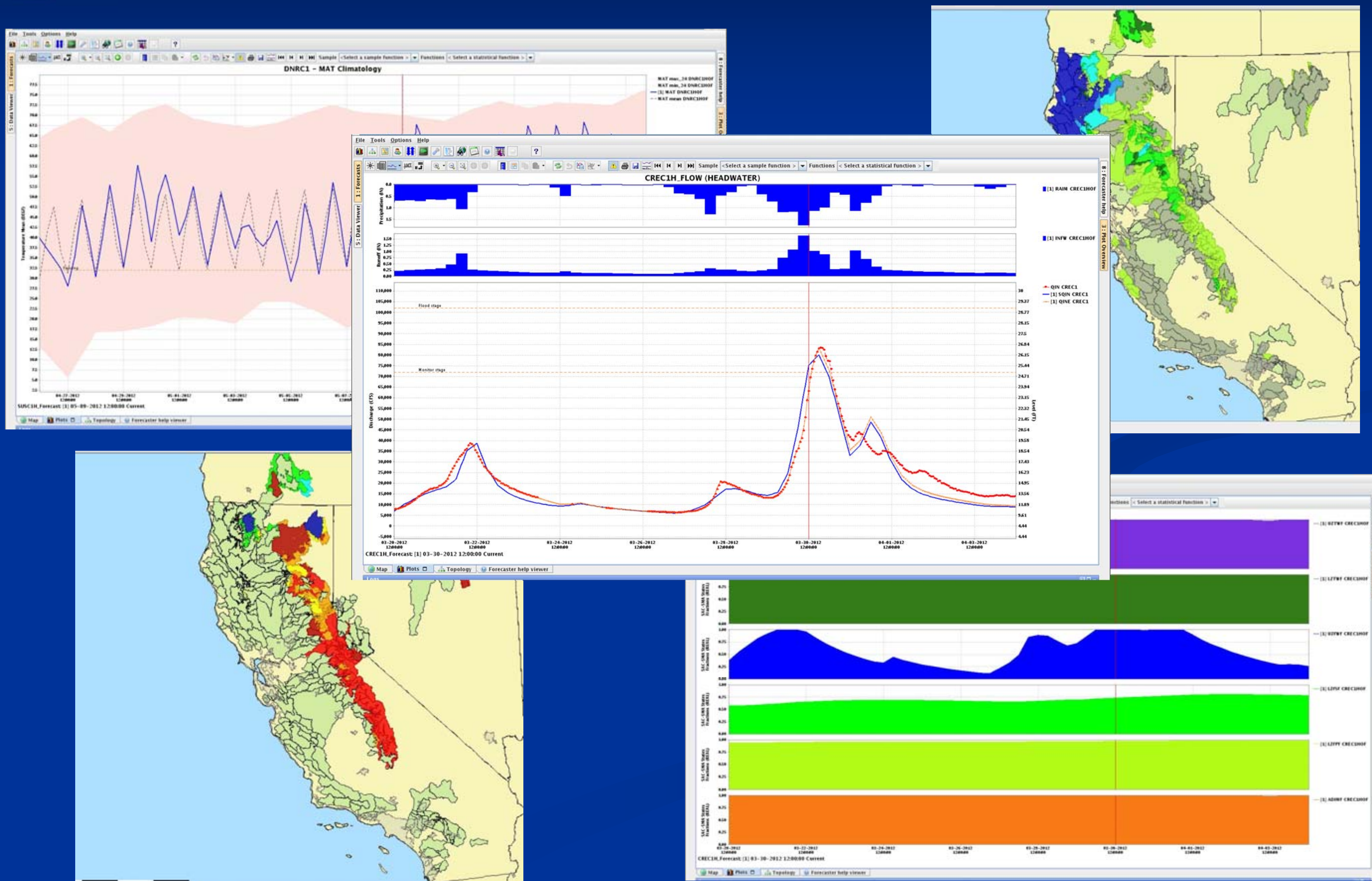


Time Step: 6 hrs
Duration: 5 days



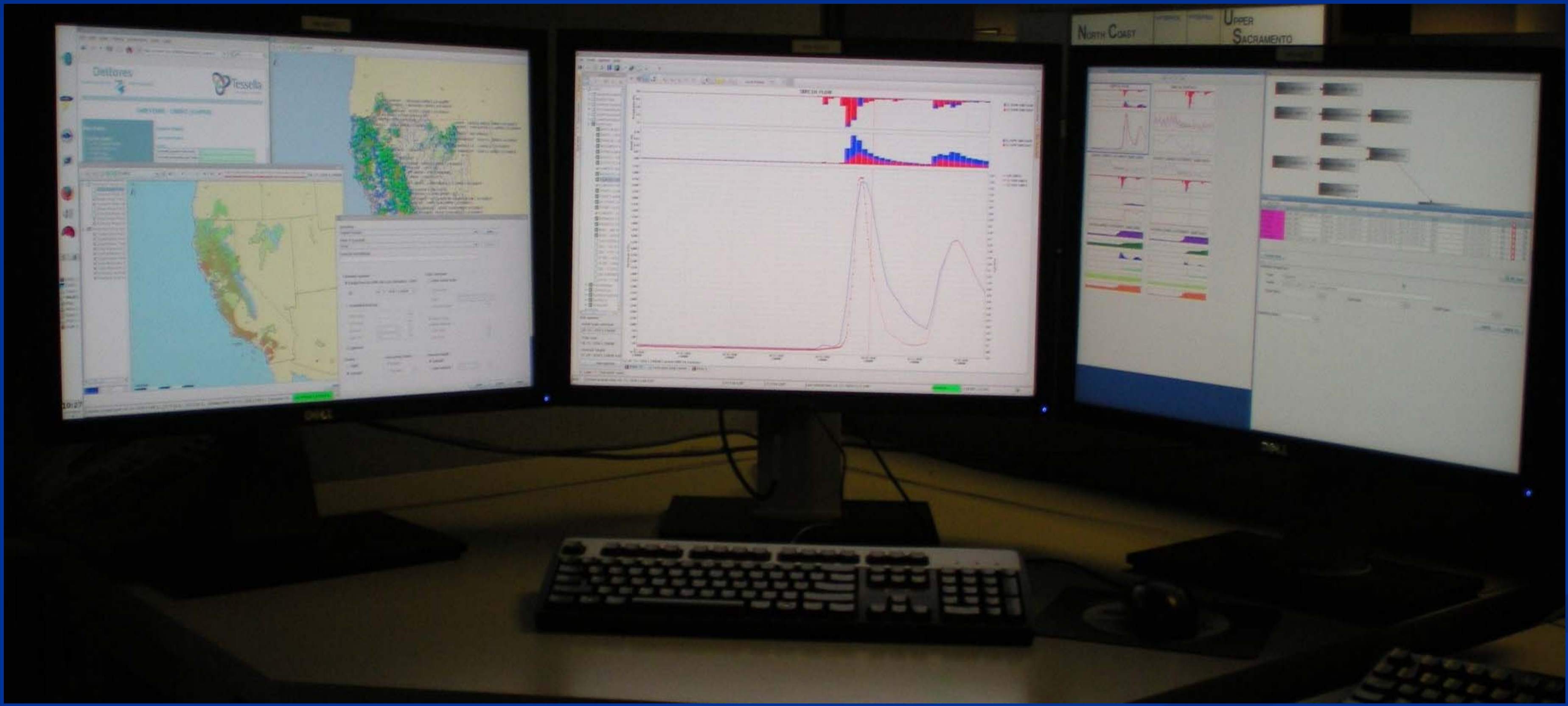
River Forecast System

Community Hydrologic Prediction System (CHPS)



River Forecast System

Community Hydrologic Prediction System (CHPS)



Available CNRFC Forecasts

Short Range … … … … Medium Range… … … … … Long Range
0-5 days **6-14 days** **> 14 days**

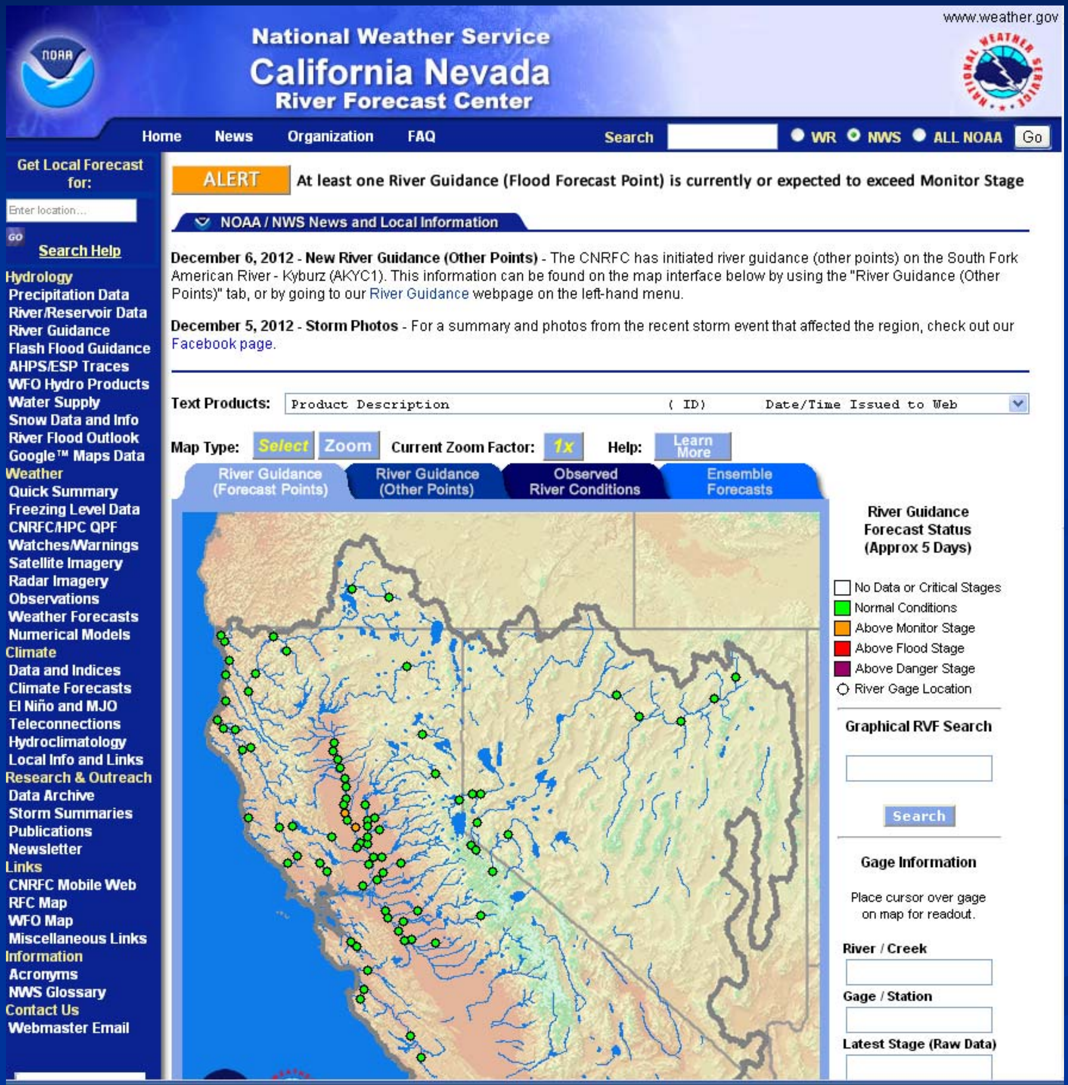
Driven by weather forecasts & scheduled reservoir releases

Driven by a combo of weather forecasts & climatology

Driven by climatology

Forecast	Duration	Season	Frequency	Probabilities
Flood / Routine	5 Days	Year-round	Daily +	No
Ensemble Streamflow Prediction	User selectable to ~1 year	Year-round	Daily	Yes

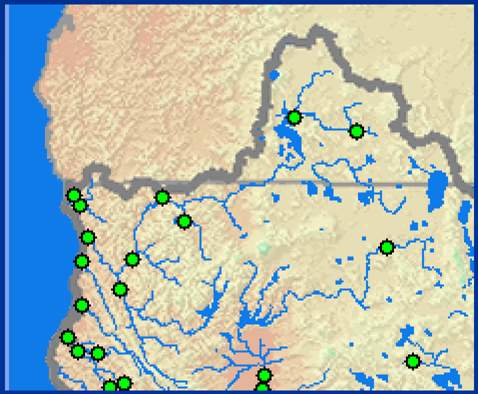
CNRFC Website



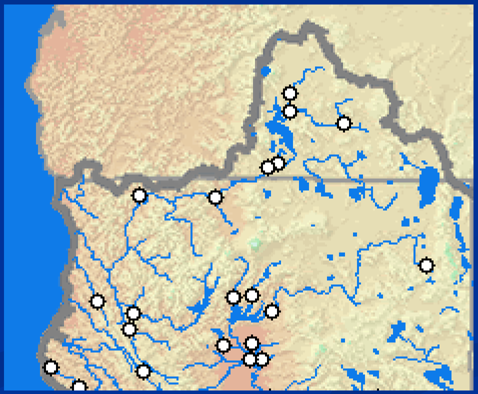
(www.cnrfc.noaa.gov)

Klamath River Forecasts

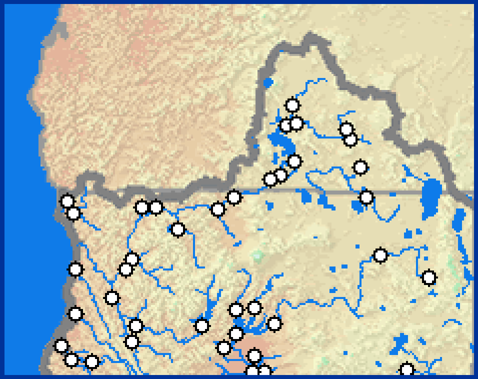
Flood Locations



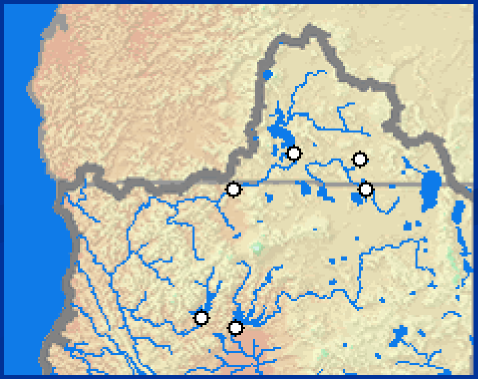
Non-Flood Locations



Ensemble Locations



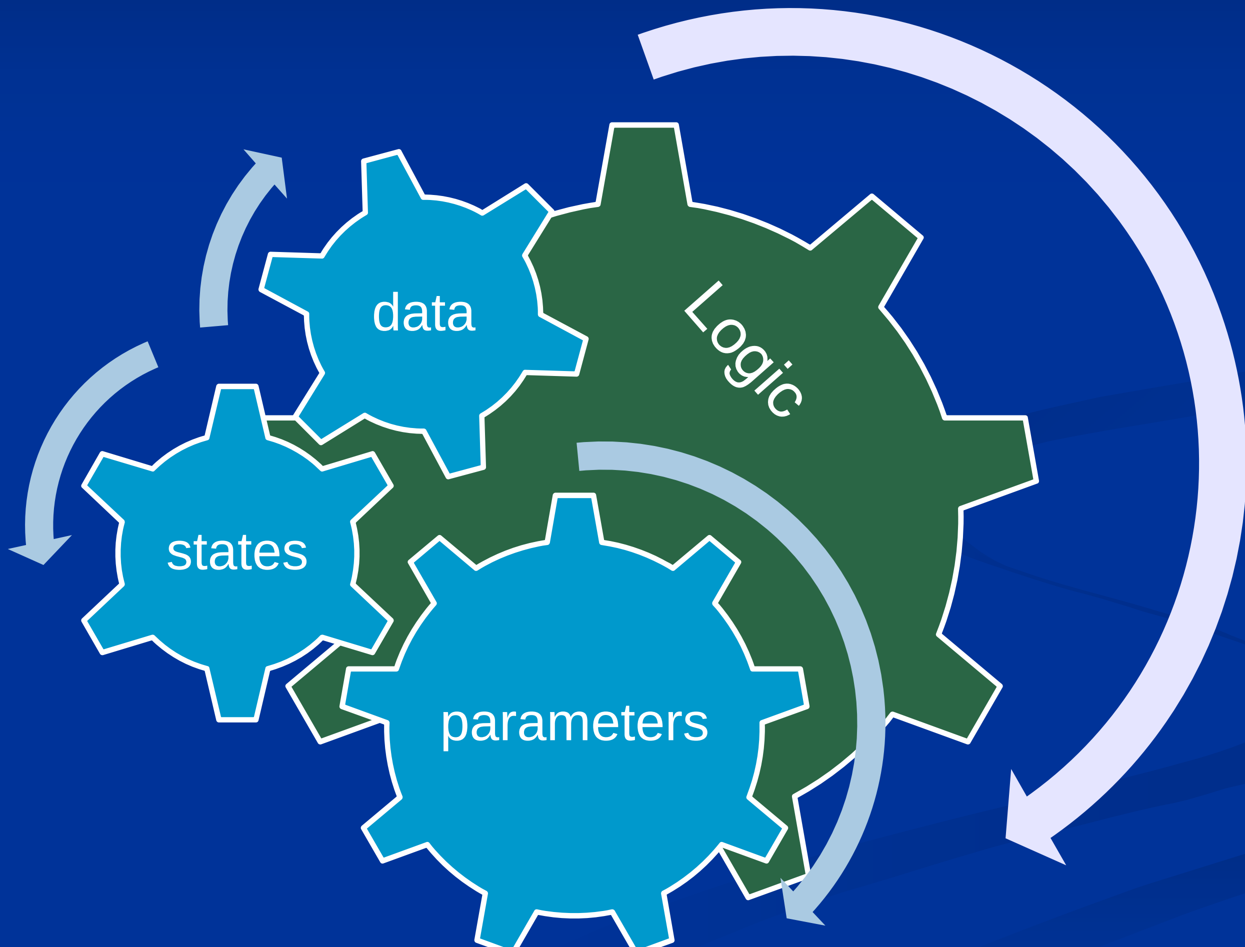
Reservoir Inflows



How Do Ensembles Work?

A three member "ensemble"

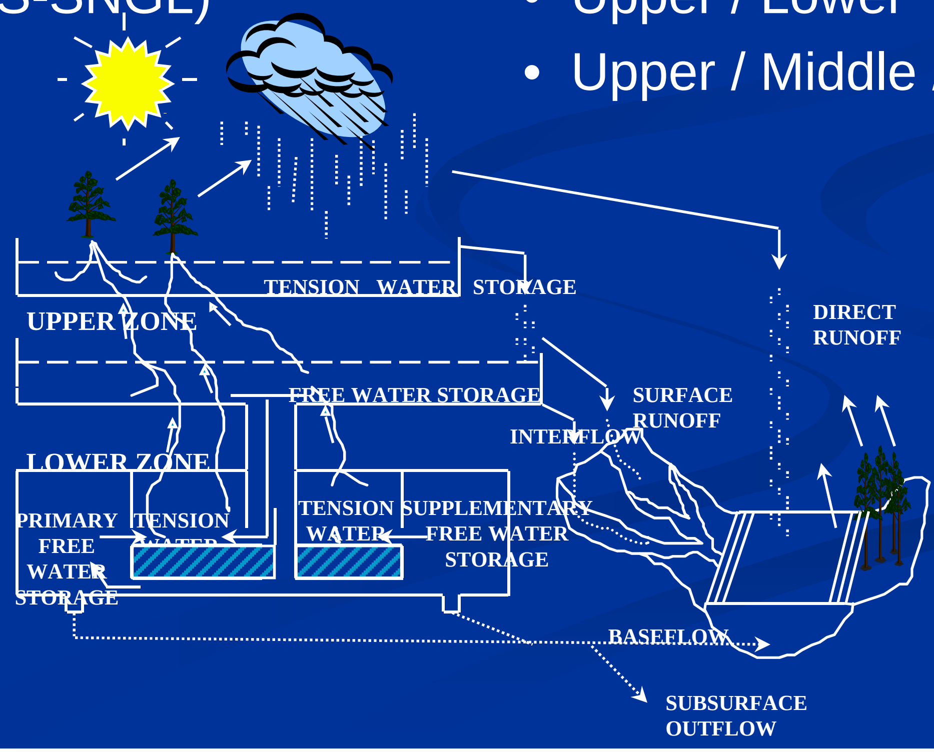
Model Components



Community Hydrologic Prediction System (CHPS) Hydrologic Models

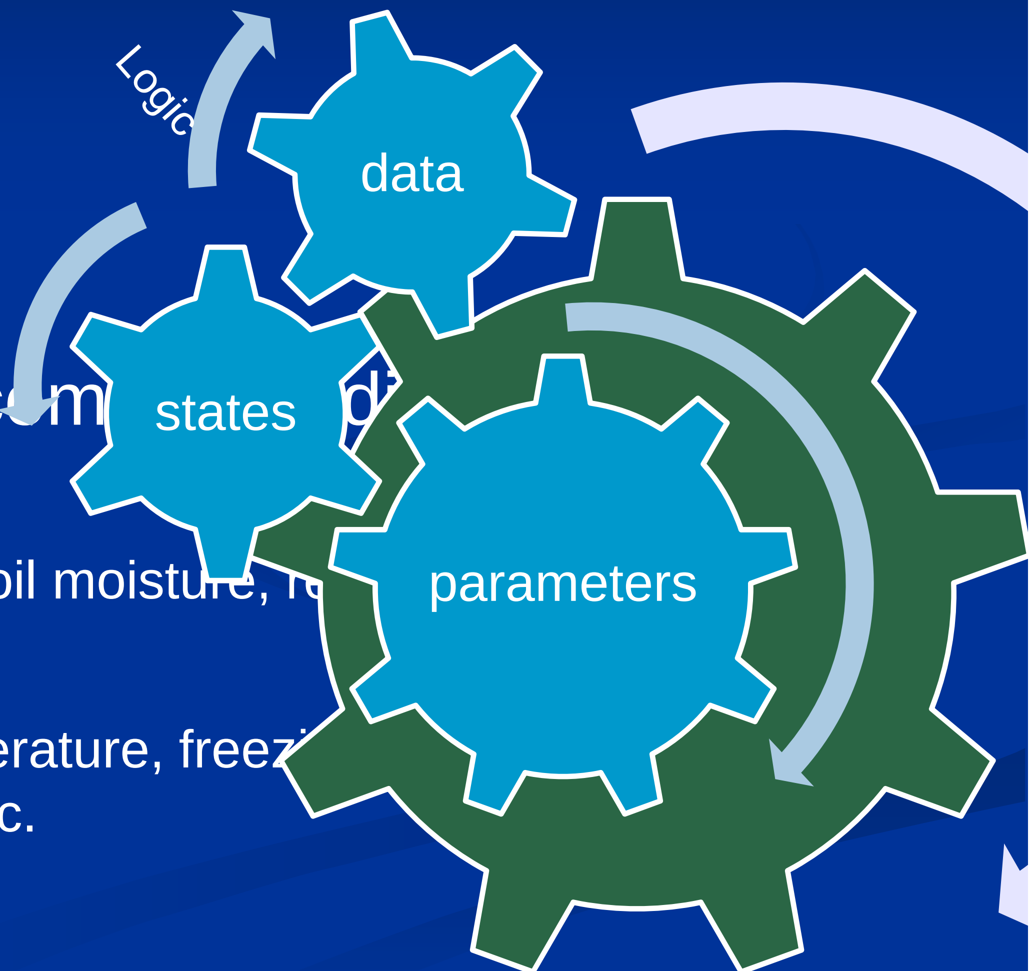
- Rain-Snow Elevation
- Snow-17
- Soil Model (SAC-SMA)
- Unit Hydrograph
- Reservoir Models (RES-SNGL)
- River Routing Models
- Arithmetic Transforms

- 6-hr Time Steps
- Lumped (not distributed)
- Mountainous basins
  - Subdivided into
    - Upper / Lower
    - Upper / Middle / Lower

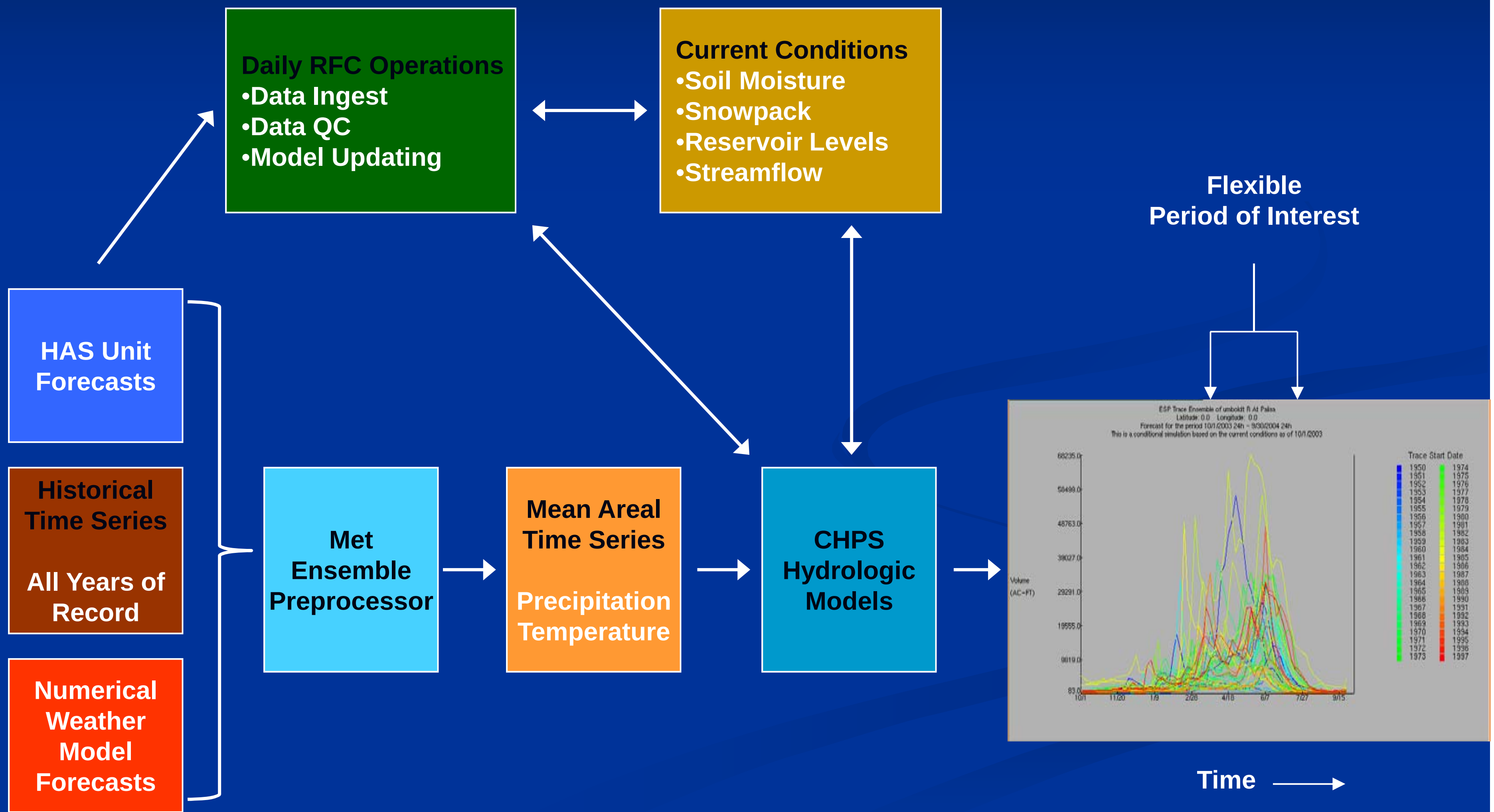


Model Results

- “Result differences” c m di
  - Model States
    - Current snow water, soil moisture, r
  - Input Data
    - Precipitation, air temperature, freezi reservoir regulation, etc.



Ensemble Streamflow Prediction



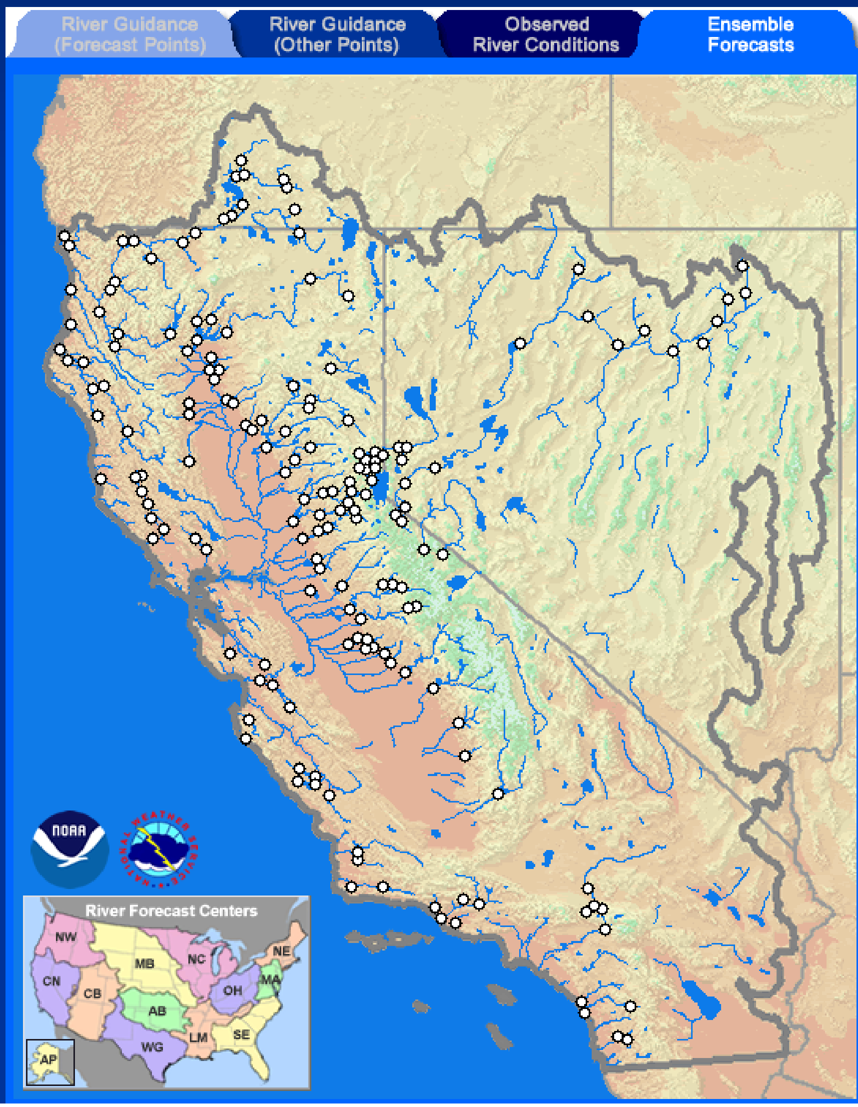
Hydrologic Ensemble Uses

- Short-range (hours to days)
  - Watch and warning program
  - Local emergency management activities
  - Reservoir and flood control system management

- Medium-range (days to weeks)
  - Reservoir management
  - Local emergency management preparedness
  - Snowmelt runoff management

- Long-range (weeks to months)
  - Water supply planning
  - Reservoir management

CNRFC Ensemble Forecasts



- Updated daily
- 150+ locations
- 365 day duration
- 8 standard graphics
- Build your own interface
- Includes 14 days of weather forecasts

Upper Klamath Lake Inflow 10-Day Traces

5-Day Peaks | 10-Day Traces | 10-Day Probability | 10-Day Accum Vol
4x5-Day Probability | Monthly Probability | Trend Plots | WY Trend Plots | Build Your Own

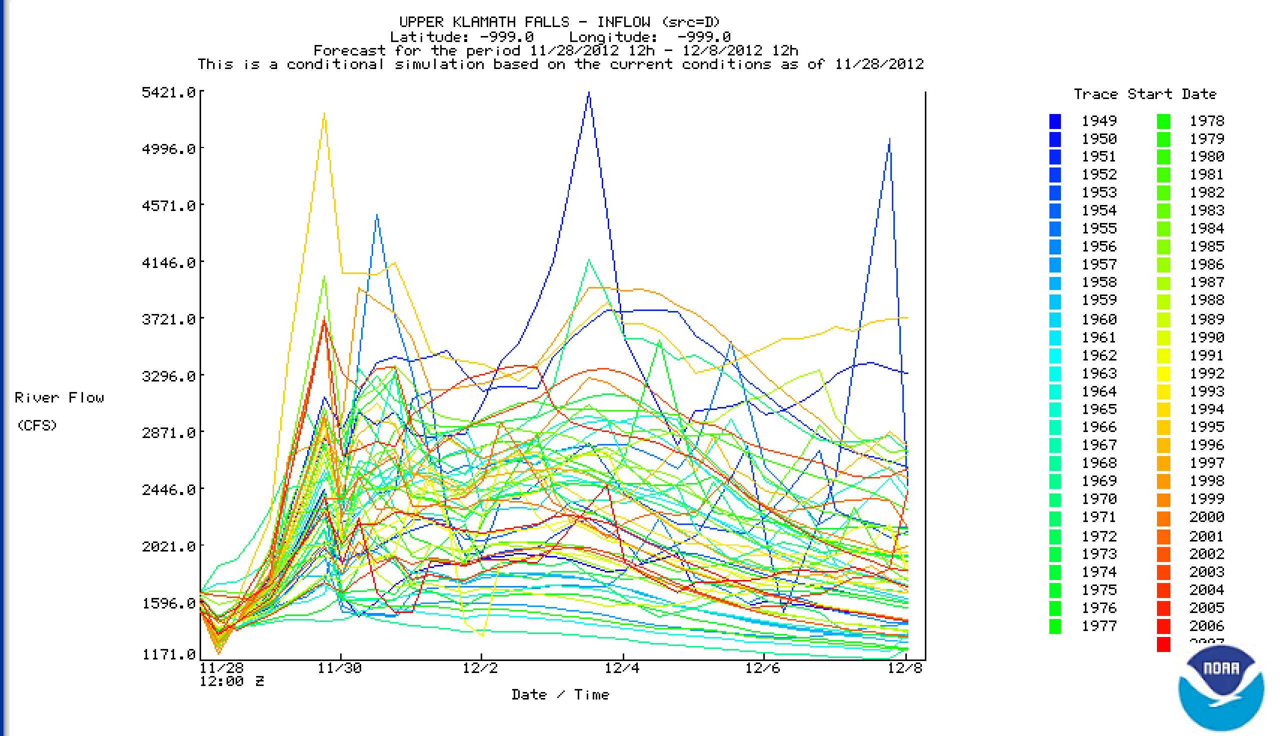
Back to Ensemble Products Map   <<< Previous Ensemble Location | Next Ensemble Location >>>

KLAMATH RIVER - UPPER KLAMATH LAKE (KLAO3)

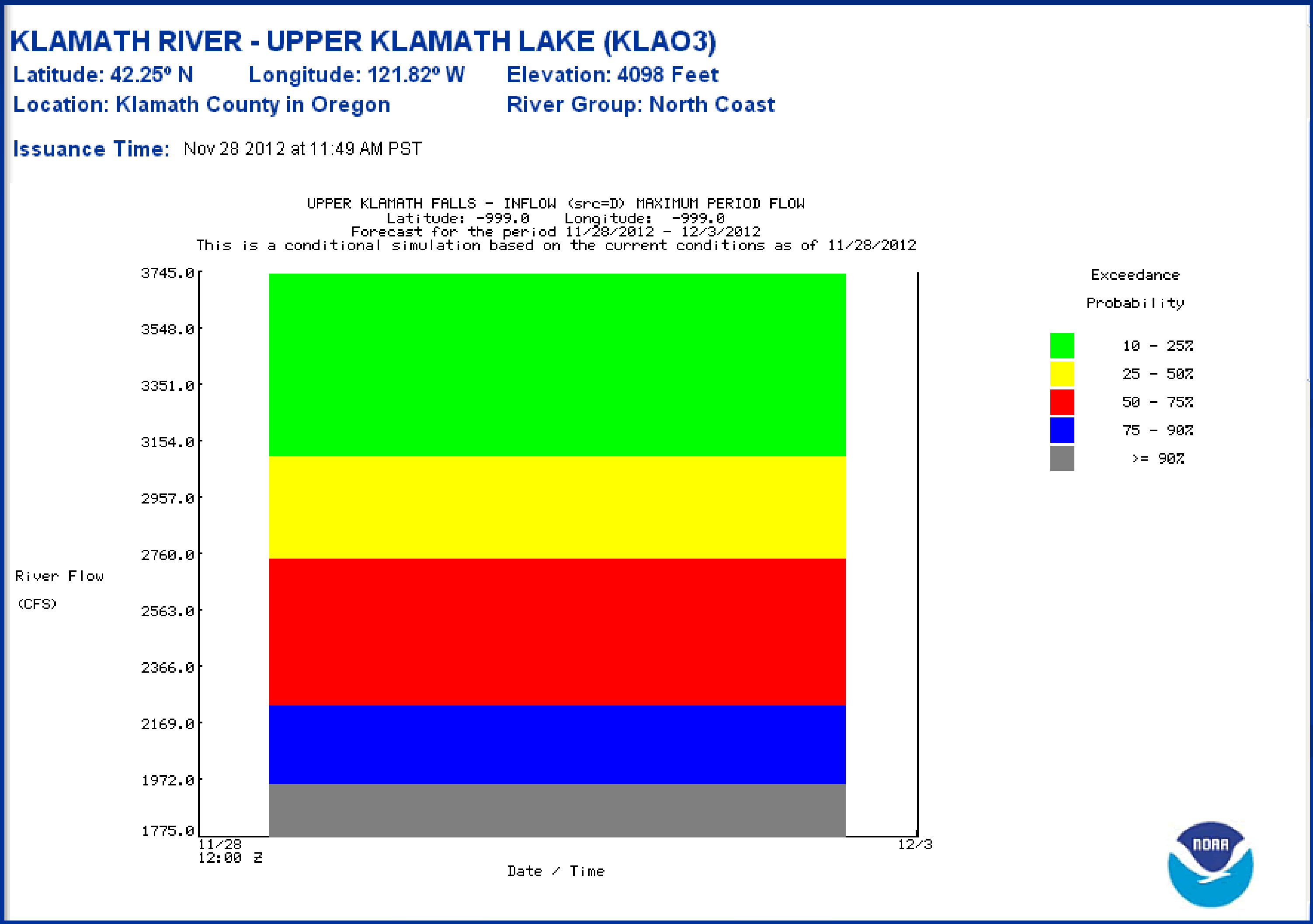
Latitude: 42.25º N   Longitude: 121.82º W   Elevation: 4098 Feet

Location: Klamath County in Oregon   River Group: North Coast

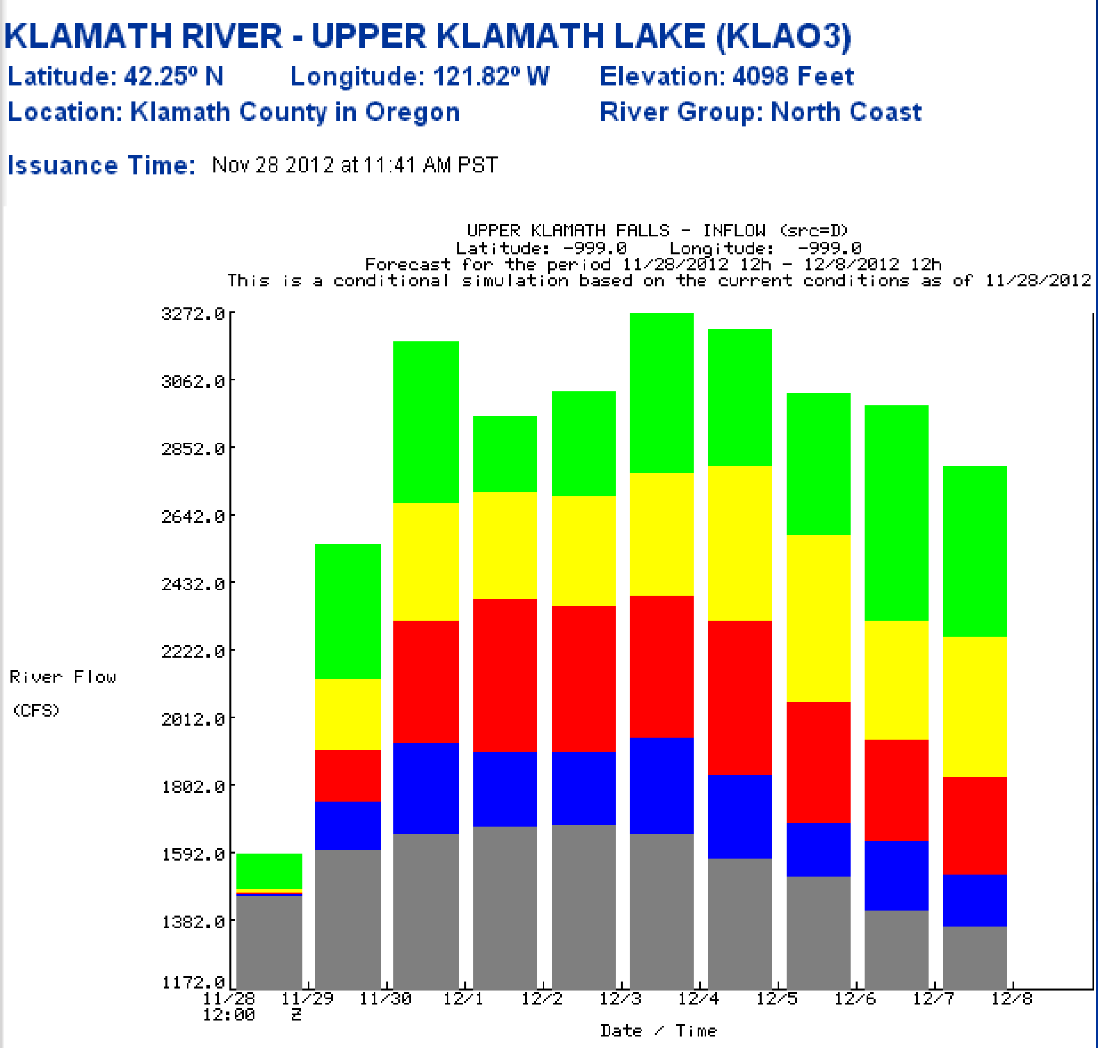
Issuance Time: Nov 28 2012 at 11:43 AM PST



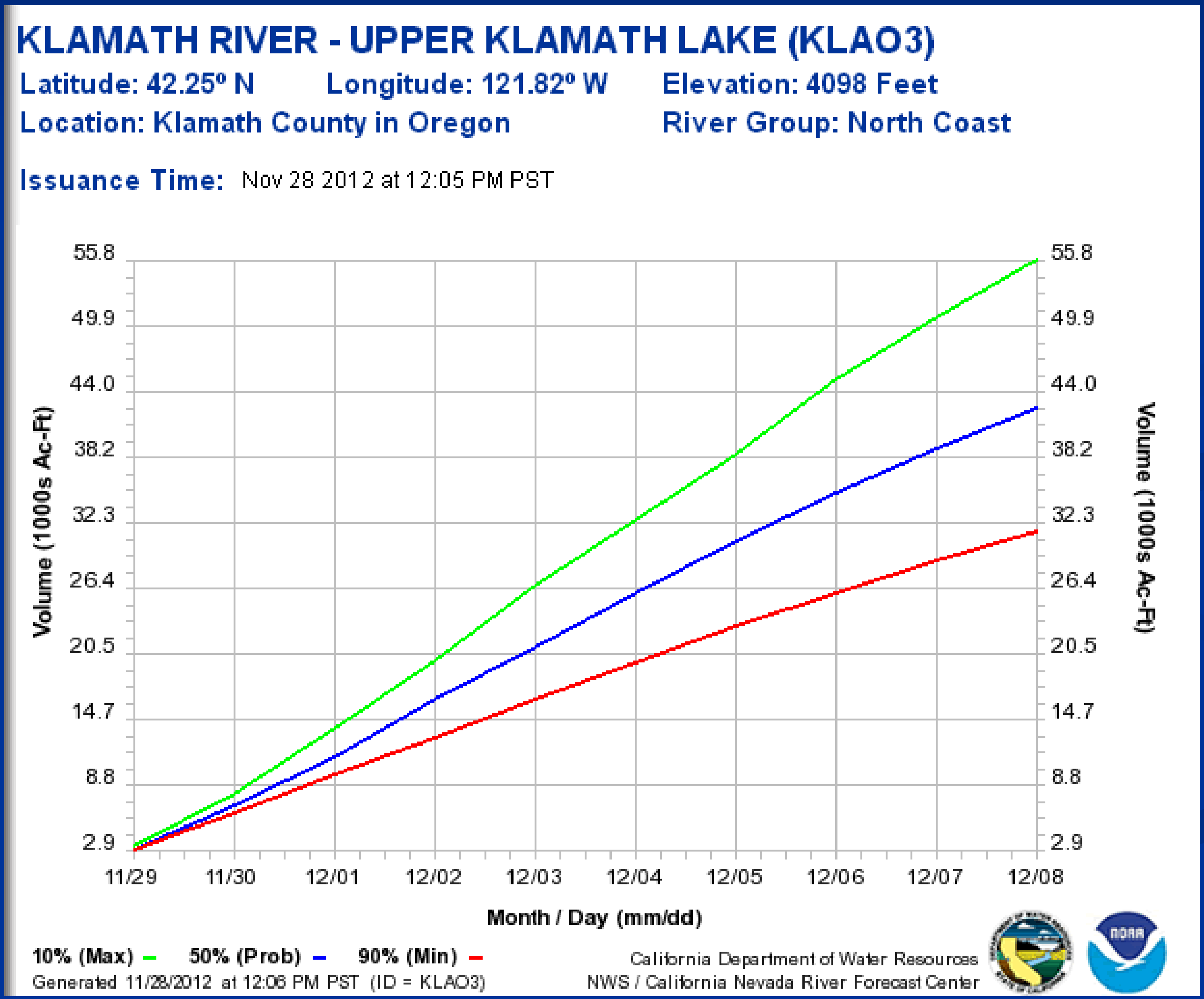
Upper Klamath Lake Inflow 5-day Peak



Upper Klamath Lake Inflow 10-Day, Daily Probabilities



Upper Klamath Lake Inflow 10-Day Accumulated Volume



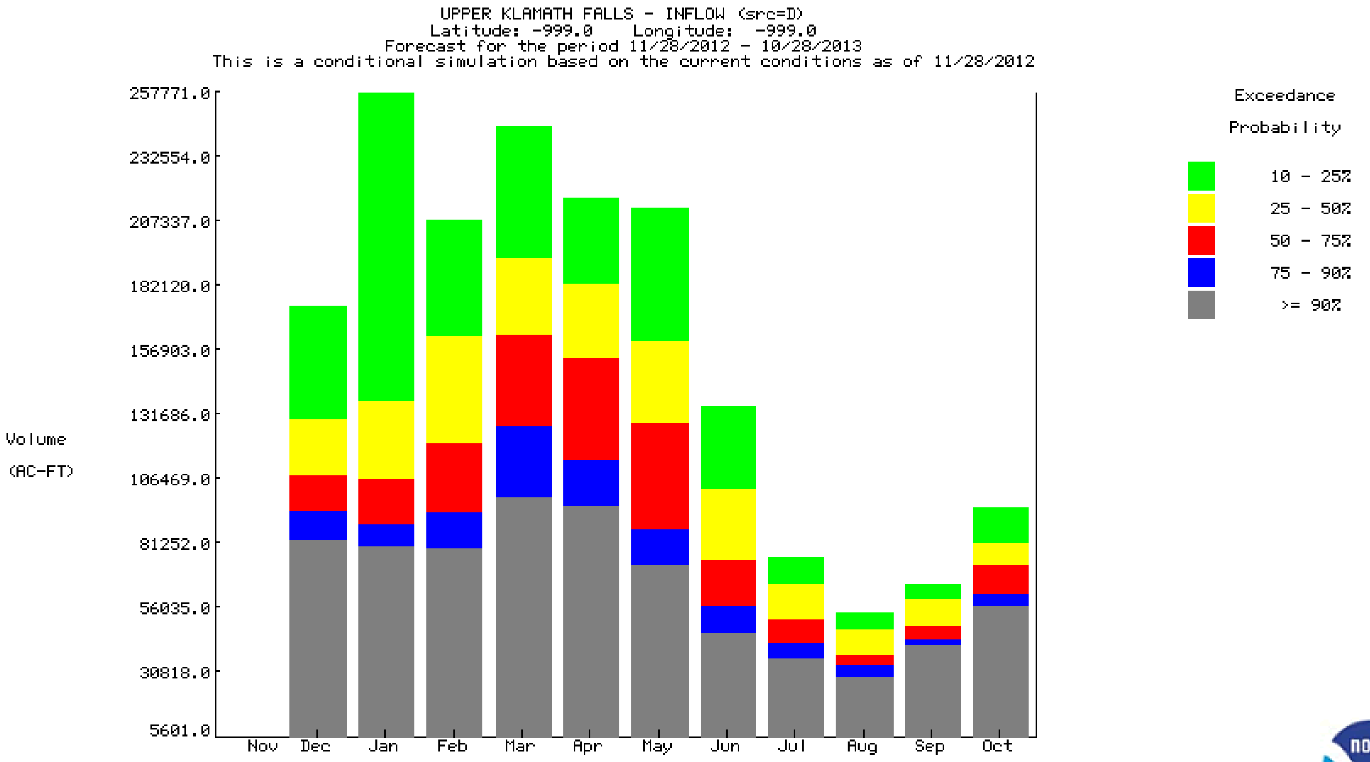
Upper Klamath Lake Inflow Monthly Volume Probabilities

KLAMATH RIVER - UPPER KLAMATH LAKE (KLAO3)

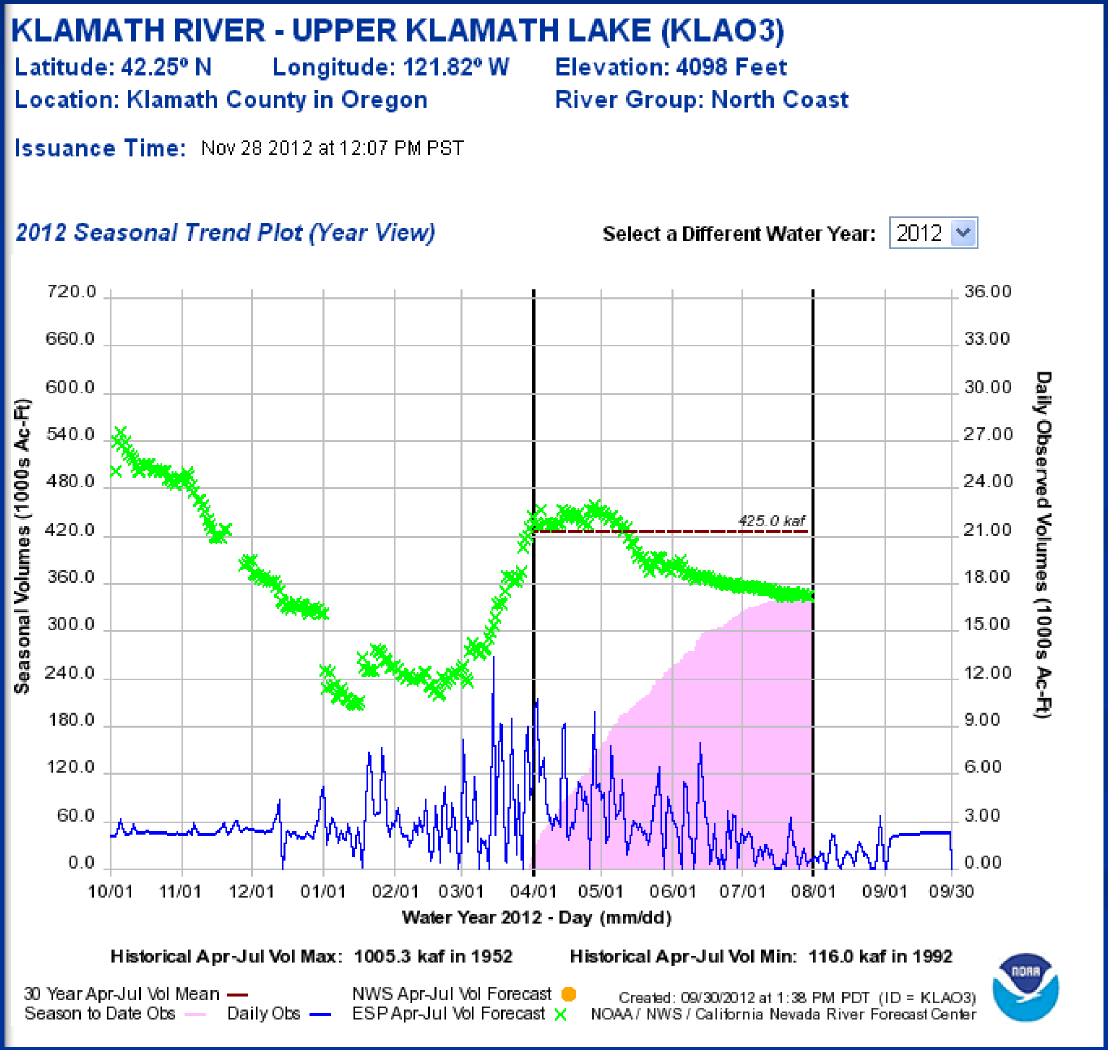
Latitude: 42.25° N **Longitude: 121.82° W** **Elevation: 4098 Feet**

Location: Klamath County in Oregon **River Group: North Coast**

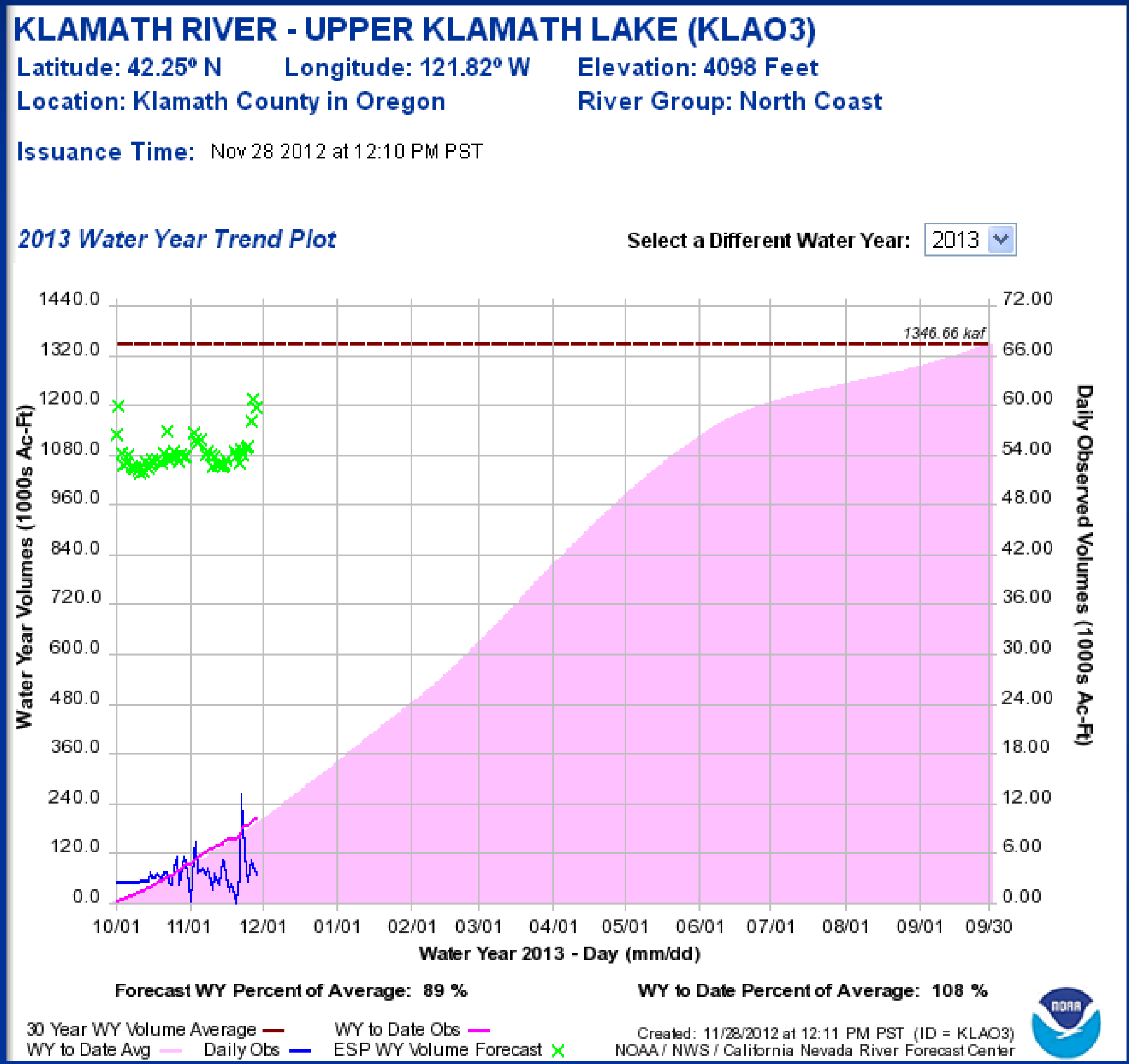
Issuance Time: Nov 28 2012 at 11:35 AM PST



Upper Klamath Lake Inflow April-July Volume Trend Plot



Upper Klamath Lake Inflow Water Year Volume Trend Plot



“Build Your Own” Ensemble Product

1 Select a Location:

KLAMATH RIVER - UPPER KLAMATH LAKE (KLAO3)

2 Select an Accumulation Type:

- Mean (selected)
- Minimum
- Maximum
- Summation

3 Select an Interval:

- Day (selected)
- Week
- Month
- Entire Period

4 Select a Distribution Type:

Empirical (selected) Wakeby

5 Select a Starting Date: Month: Nov Day: 28 Year: 2012

6 Select an Ending Date: Month: Feb Day: 28 Year: 2013

7a Select a Plot Option and Generate:

Traces (selected) Probability Expected Value Exceedance

Generate a Plot

7b Select a Table Option and Generate:

Forecast Info (selected) Quantiles Flood Quantiles

Generate a Table

Help **Making Selections and Interpreting Results** ***(Click Help Button)***

Upper Klamath Lake Inflow April-July Volume Forecasts

NATIONAL WEATHER SERVICE / CALIFORNIA-NEVADA RFC / SACRAMENTO CA
CALIFORNIA DEPARTMENT OF WATER RESOURCES / SACRAMENTO CA
335 PM PLT WED NOV 28 2012

CHPS/ESP RAW MODEL GUIDANCE
FOR OFFICIAL FORECAST... SEE WWW.CNRFC.NOAA.GOV

APRIL-JULY STREAMFLOW VOLUMES IN 1000AF (SRC=D)

		11/28	11/27	11/25	11/21	11/14
KLAO3	MAX:	614	609	560	583	558
KLAMATH	MIN:	251	243	220	215	208
UPR KLAMATH LK	PROB:	410	403	373	360	355
	OBS:	0	0	0	0	0
(AVG: 425)	%AVG:	96%	95%	88%	85%	83%
	DELTA:		2%	9%	12%	13%

(www. cnrfc.noaa.gov)

Upper Klamath Lake Inflow Water Year Volume Forecasts

NATIONAL WEATHER SERVICE / CALIFORNIA-NEVADA RFC / SACRAMENTO CA
CALIFORNIA DEPARTMENT OF WATER RESOURCES / SACRAMENTO CA
338 PM PLT WED NOV 28 2012

CHPS/ESP RAW MODEL GUIDANCE
OCTOBER - SEPTEMBER STREAMFLOW VOLUMES IN 1000AF (SRC=D)

		11/28	11/27	11/25	11/21	11/14
KLAO3	MAX:	1657	1698	1541	1504	1538
KLAMATH	MIN:	909	893	801	769	736
UPR KLAMATH LK	PROB:	1194	1214	1099	1059	1050
	OBS:	197	193	185	156	141
(AVG: 1352)	%AVG:	88%	90%	81%	78%	78%
	DELTA:		0%	7%	10%	11%

(www. cnrfc.noaa.gov)

Summary

- CNRFC produces forecasts for Upper Klamath Basin on a daily basis (365 days / year)
  - Twice / day in winter
  - Up to four / day during flood events
  - Ensembles generated once / day
- Forecasts are generated a variety of durations
  - Short (hours to days)
  - Medium (days to weeks)
  - Long (weeks to seasons)
- Ensemble forecasts integrate the latest observations, the current watershed conditions and the short term weather forecast.
  - Expecting integration of the CFSv2 before October 2013

Questions?

Topic 3: Understanding Forecast Uncertainty and Error and Risk Management Decisions

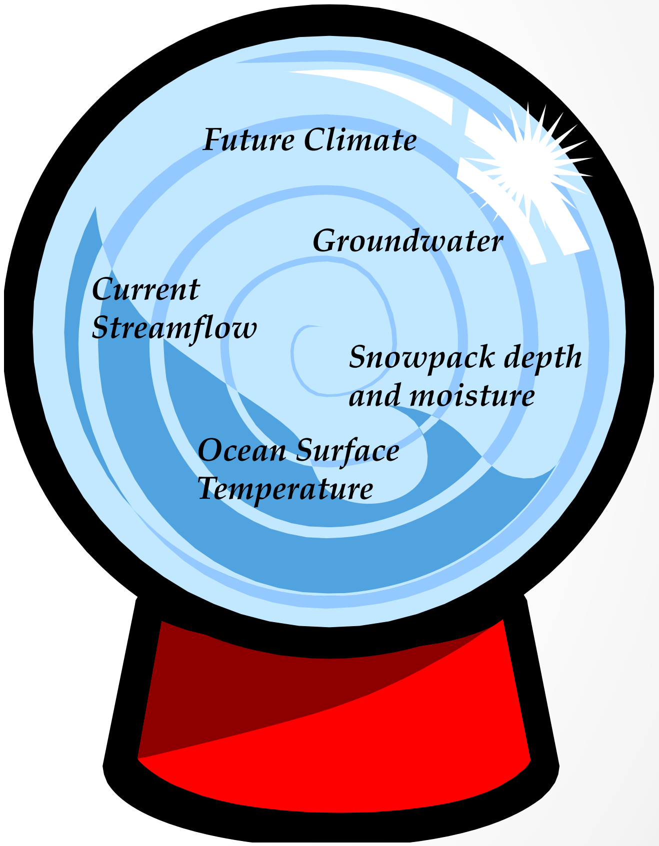
Mark Deutschman
Houston Engineering, Inc.
Minneapolis, MN

Pressures for "Improved" Water Supply Forecasting

- 2001 water shortage
- March 2010 Biop for the Klamath Project
- Project operation by Reclamation
- Farmer's need for water
- Fish need for water
- Everyone's need for water
- Drought plan
- KBRA limitations on diversion
- Adjudication?

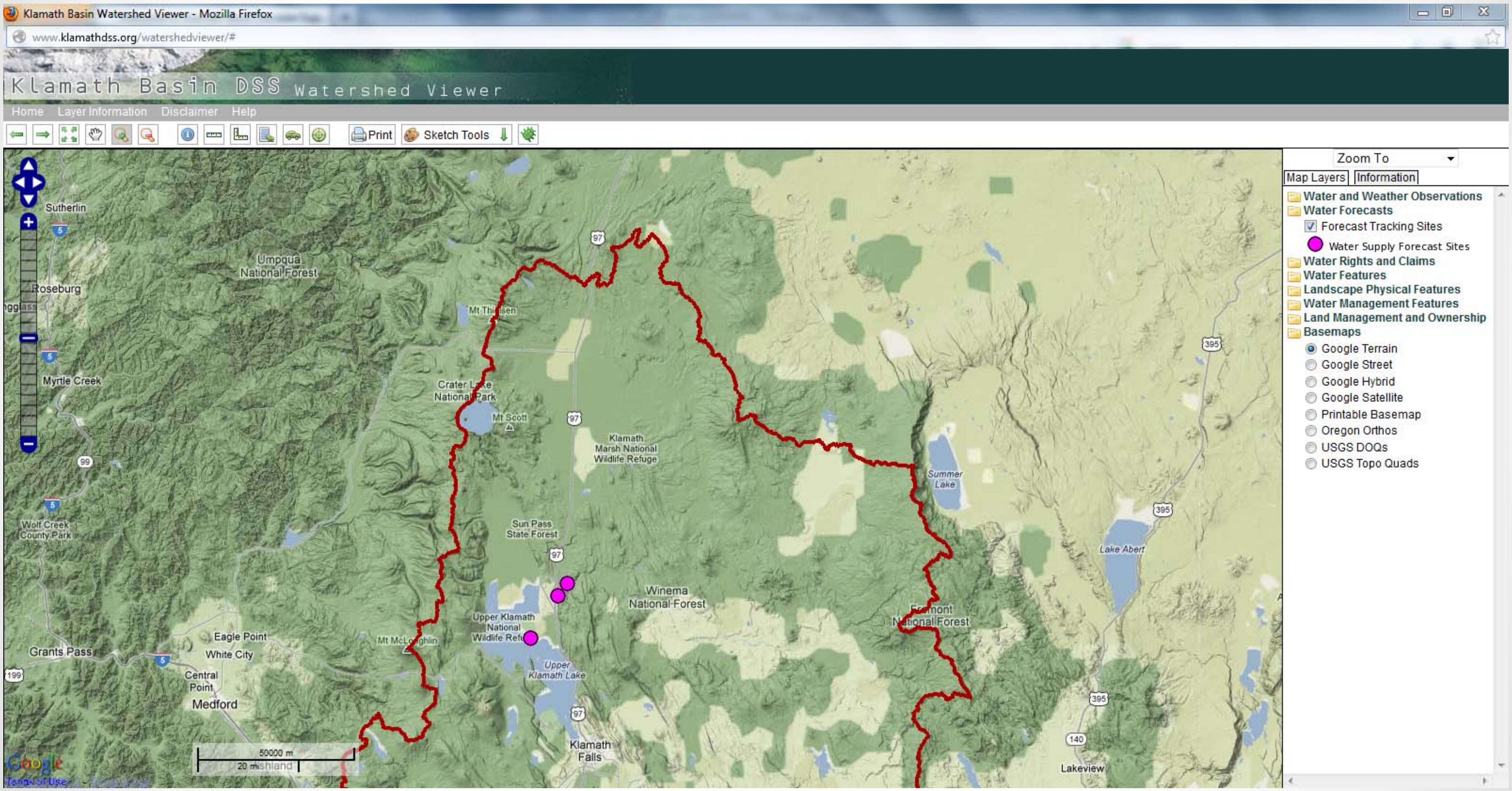
Improved Forecasts

- More forecast locations (spatial resolution)?
- Additional time periods (daily, weekly, monthly, and seasonal – temporal resolution)?
- More accurate?



Forecast Crystal Ball

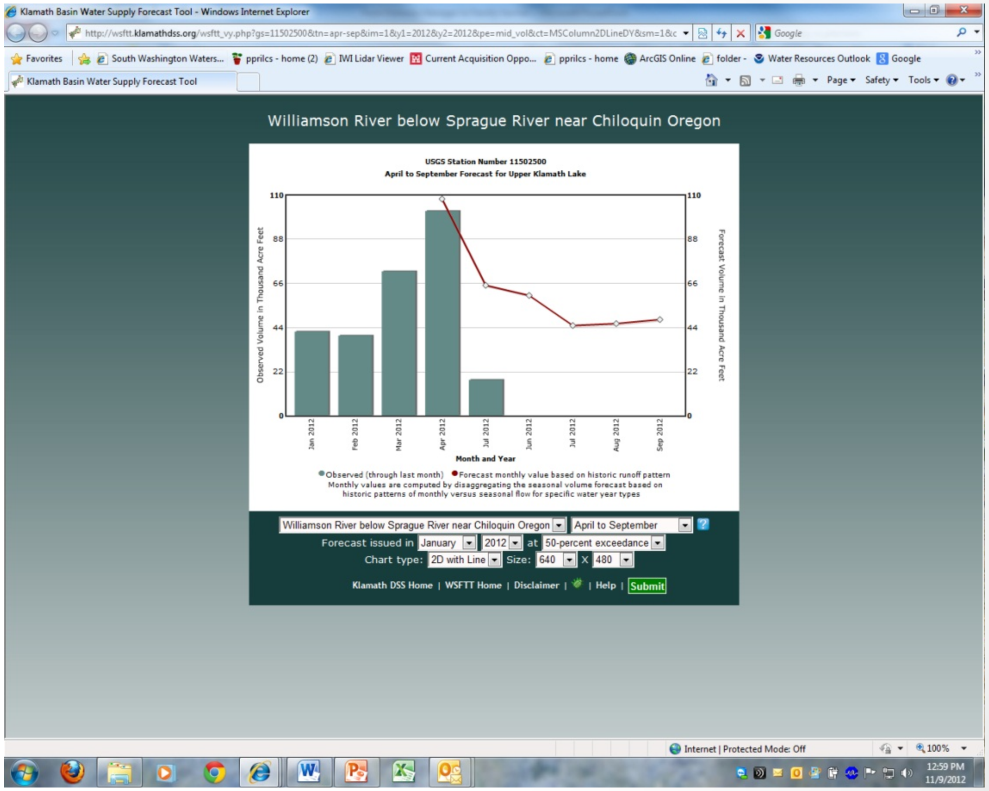
Forecast Locations

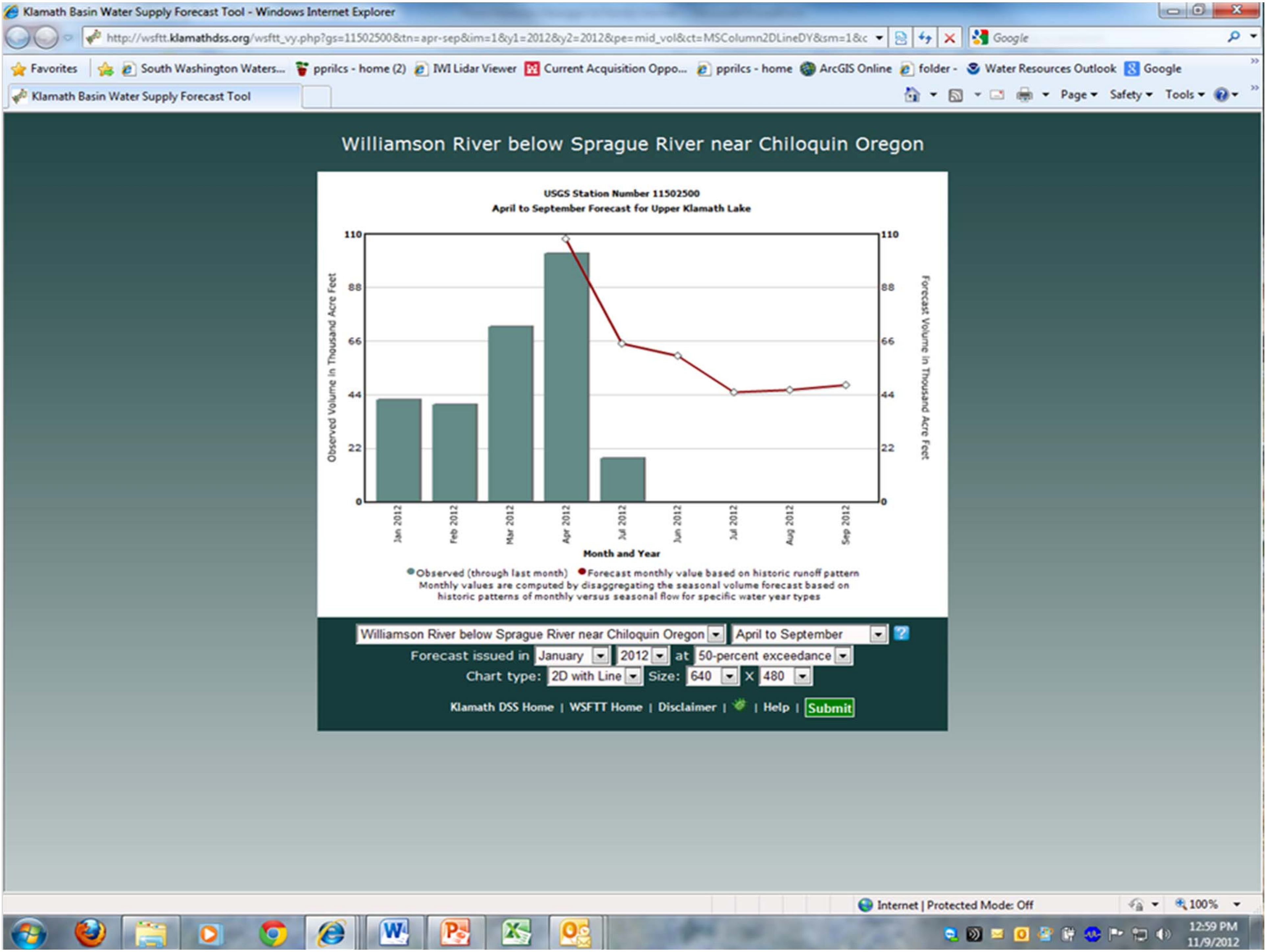


- Do the locations correspond with the locations of the resource issues?

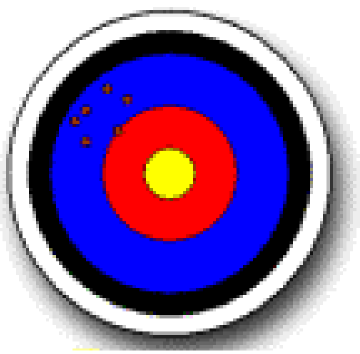
Forecast Temporal Scale

- Currently seasonal
- Ideally correspond to the time (temporal) scale of the resource issue / decision
- Need for additional time scales
  - o Daily
  - o Weekly
  - o Monthly

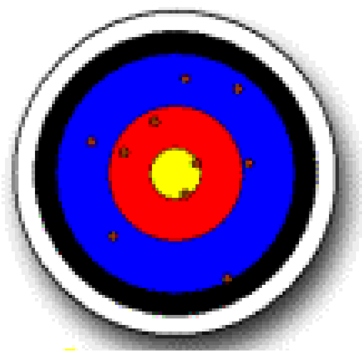



Klamath Basin Water Supply Forecast Tool - Windows Internet Explorer
http://wsftt.klamathdss.org/wsftt_vy.php?gs=11502500&tn=apr-sep&im=1&y1=2012&y2=2012&pe=mid_vol&ct=MSColumn2DLineDY&sm=1&c
Favorites
South Washington Waters...
pprilcs - home (2)
IWI Lidar Viewer
Current Acquisition Oppo...
pprilcs - home
ArcGIS Online
folder -
Water Resources Outlook
Google
Klamath Basin Water Supply Forecast Tool
Page
Safety
Tools
Williamson River below Sprague River near Chiloquin Oregon
USGS Station Number 11502500
April to September Forecast for Upper Klamath Lake
Observed Volume in Thousand Acre Feet
Forecast Volume in Thousand Acre Feet
110
88
66
44
22
0
Jan 2012
Feb 2012
Mar 2012
Apr 2012
Jul 2012
Jun 2012
Jul 2012
Aug 2012
Sep 2012
Month and Year
Observed (through last month)
Forecast monthly value based on historic runoff pattern
Monthly values are computed by disaggregating the seasonal volume forecast based on
historic patterns of monthly versus seasonal flow for specific water year types
Williamson River below Sprague River near Chiloquin Oregon
April to September
Forecast issued in
January
2012
at
50-percent exceedance
Chart type:
2D with Line
Size:
640
X
480
Klamath DSS Home | WSFTT Home | Disclaimer | | Help | Submit
Internet | Protected Mode: Off
100%
12:59 PM
11/9/2012

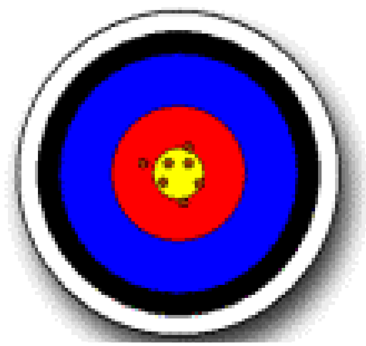
Forecast Accuracy, Bias & Precision



POOR ACCURACY
BIASED
PRECISE



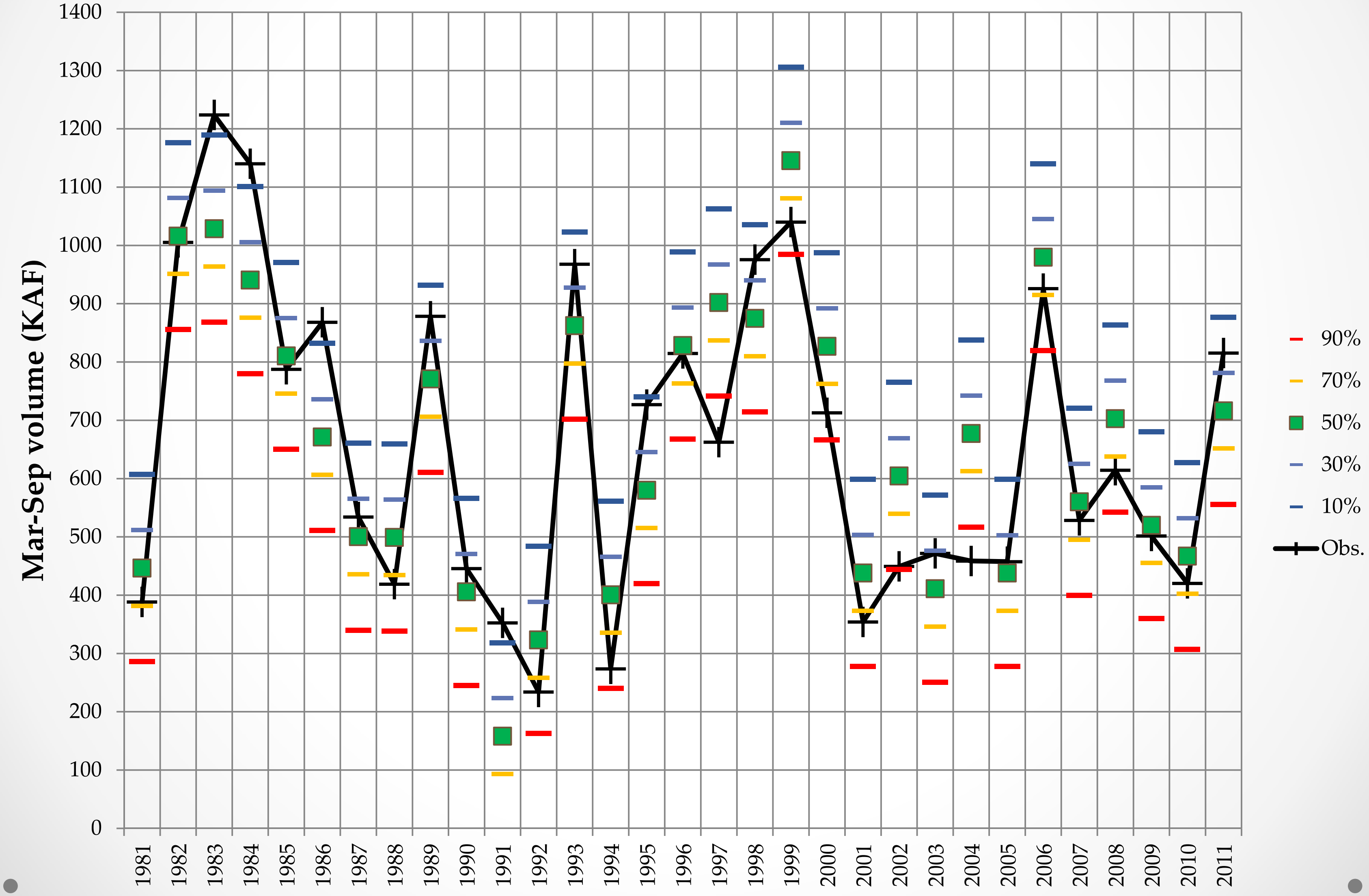
ACCURATE
NOT BIASED
NOT PRECISE



ACCURATE
UNBIASED
PRECISE

Accuracy – how close to bulls eye (gaged volume)
Bias – average distance of points from bulls eye
Precision – spread in points around average

Upper Klamath Lake Observed Flows and 1 March Reconstructed Forecasts, Mar-Sep Volume, 1981-2011



Forecast Accuracy

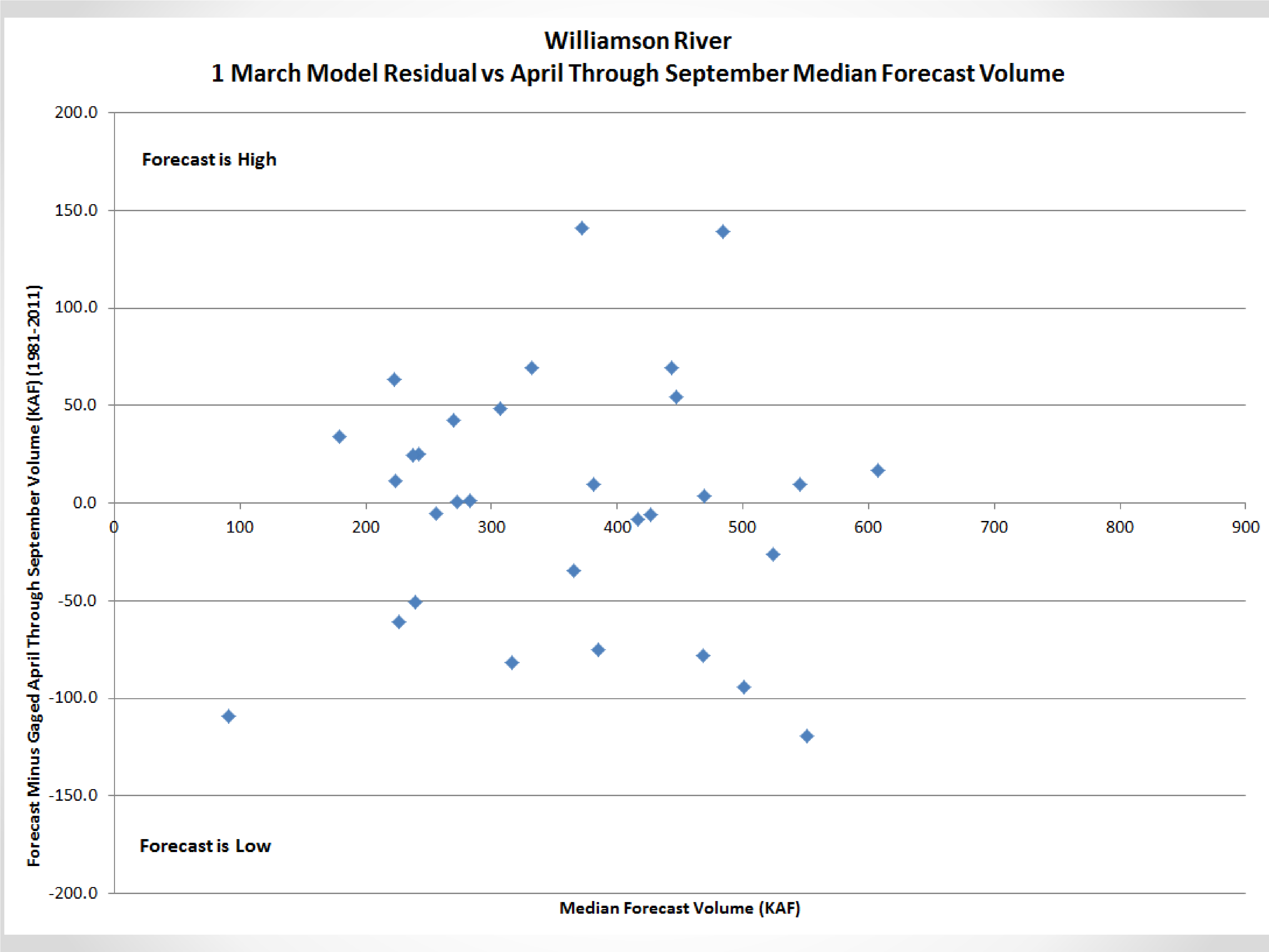
Forecast Accuracy
Based On 1981 - 2011 Reconstructed Forecast
April - September Seasonal Volumes

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

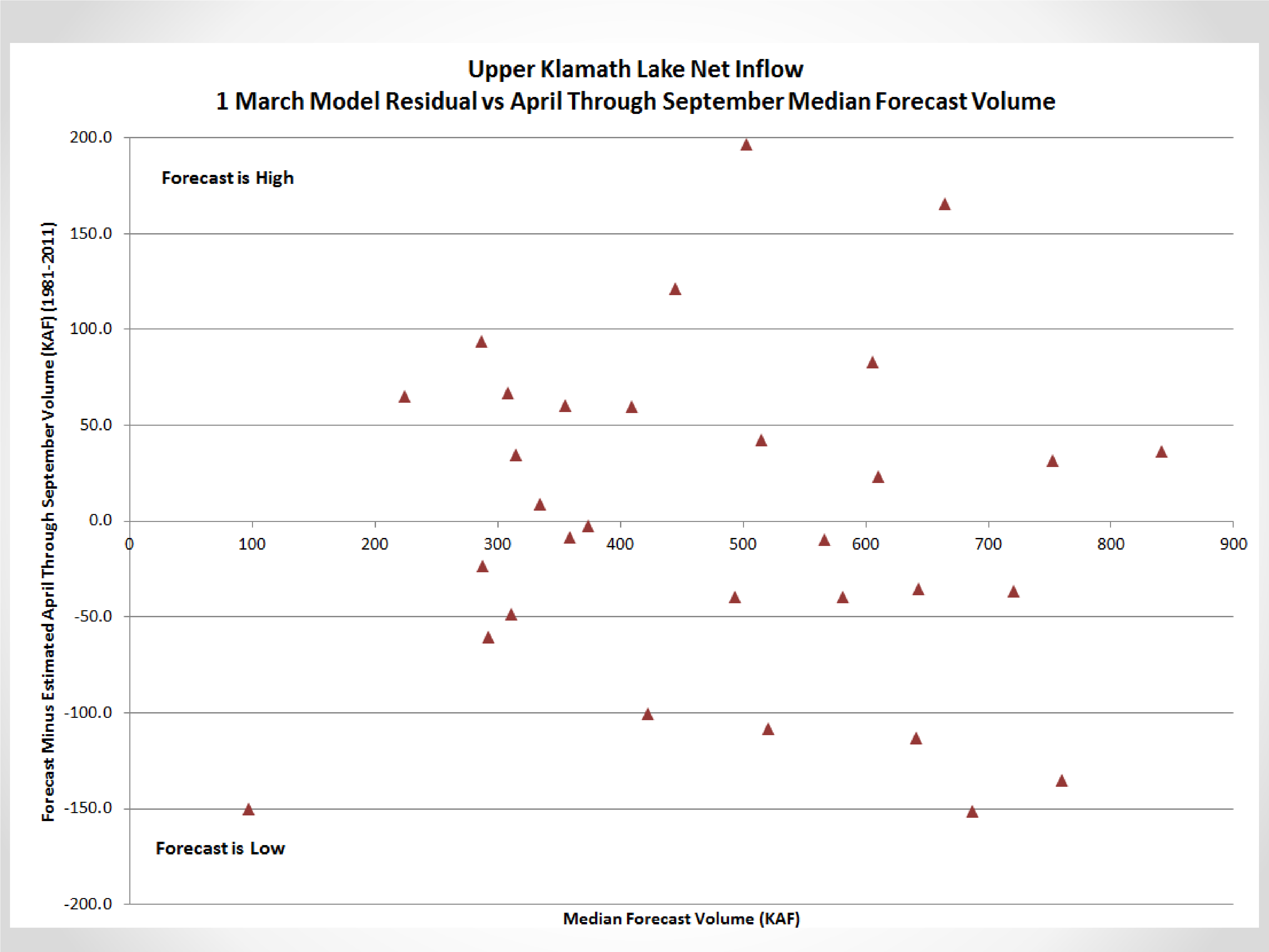
	70% Forecast					
	Williamson River			UKL Net Inflow*		
Forecast Date	**Jacknife Standard Error (KAF)**	**Mean Absolute Error (KAF)**	**Mean Percent Difference**	**Jacknife Standard Error (KAF)**	**Mean Absolute Error (KAF)**	**Mean Percent Difference**
1 January Forecast	---	80.5	22.0%	136.2	114.7	24.2%
1 February Forecast	---	61.6	17.3%	103.8	85.7	18.4%
1 March Forecast	---	34.5	16.1%	88.8	77.8	17.7%
1 April Forecast	---	35.8	11.2%	63.2	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.



Williamson River
1 March Model Residual vs April Through September Median Forecast Volume
Forecast is High
Forecast is Low
200.0
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
-200.0
0
100
200
300
400
500
600
700
800
900
Forecast Minus Gaged April Through September Volume (KAF) (1981-2011)
Median Forecast Volume (KAF)


Upper Klamath Lake Net Inflow
1 March Model Residual vs April Through September Median Forecast Volume
Forecast is High
Forecast is Low
Forecast Minus Estimated April Through September Volume (KAF) (1981-2011)
Median Forecast Volume (KAF)
200.0
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
-200.0
0
100
200
300
400
500
600
700
800
900

Analyse-it v2.24

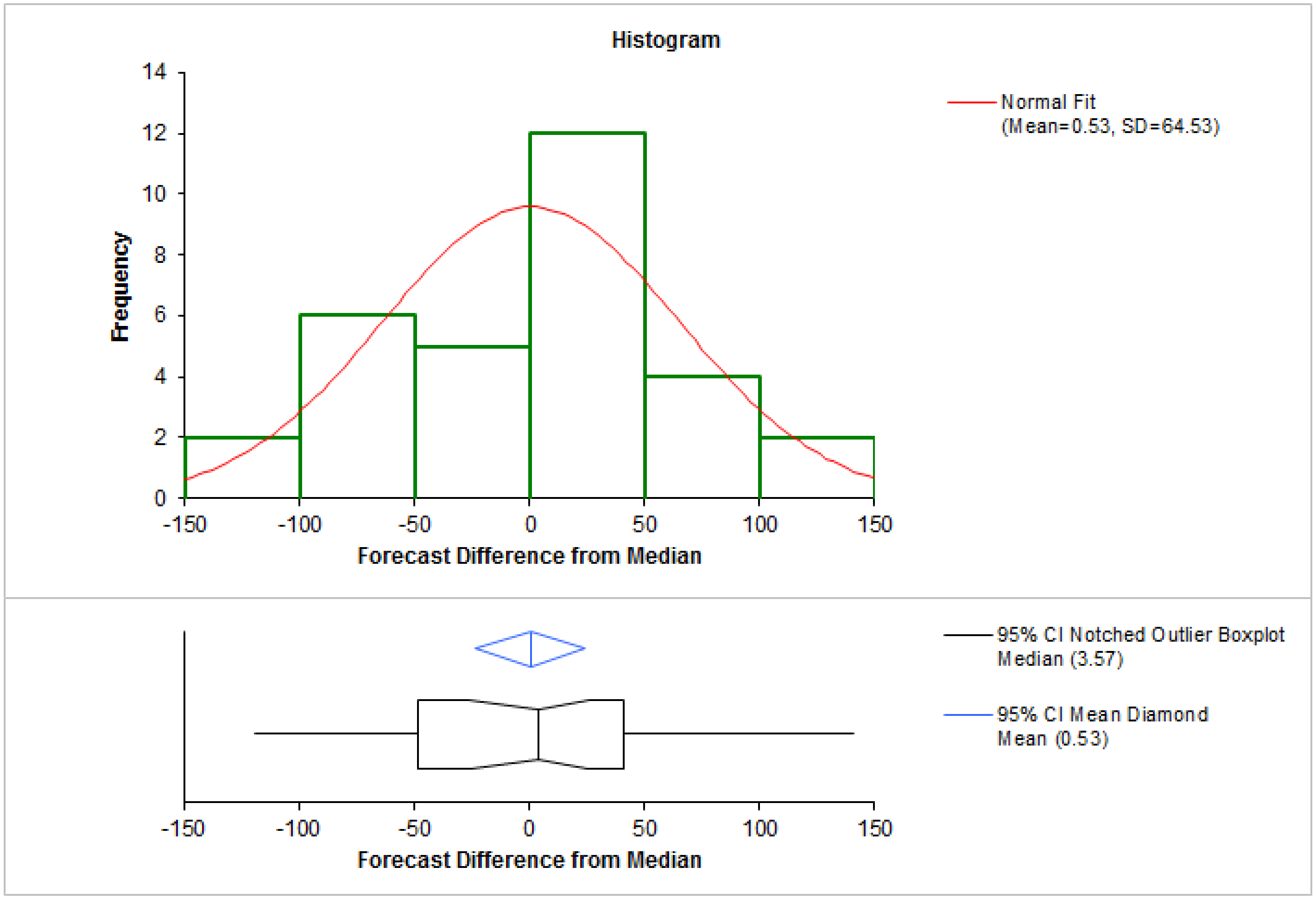
Test: **Describe - Summary**

Forecast Difference from Median

Performed by: Mark Deutschman

Date: 12 November 2012

Williamson River, 1 March Median Forecast for April – September Volume



Analyse-it v2.24

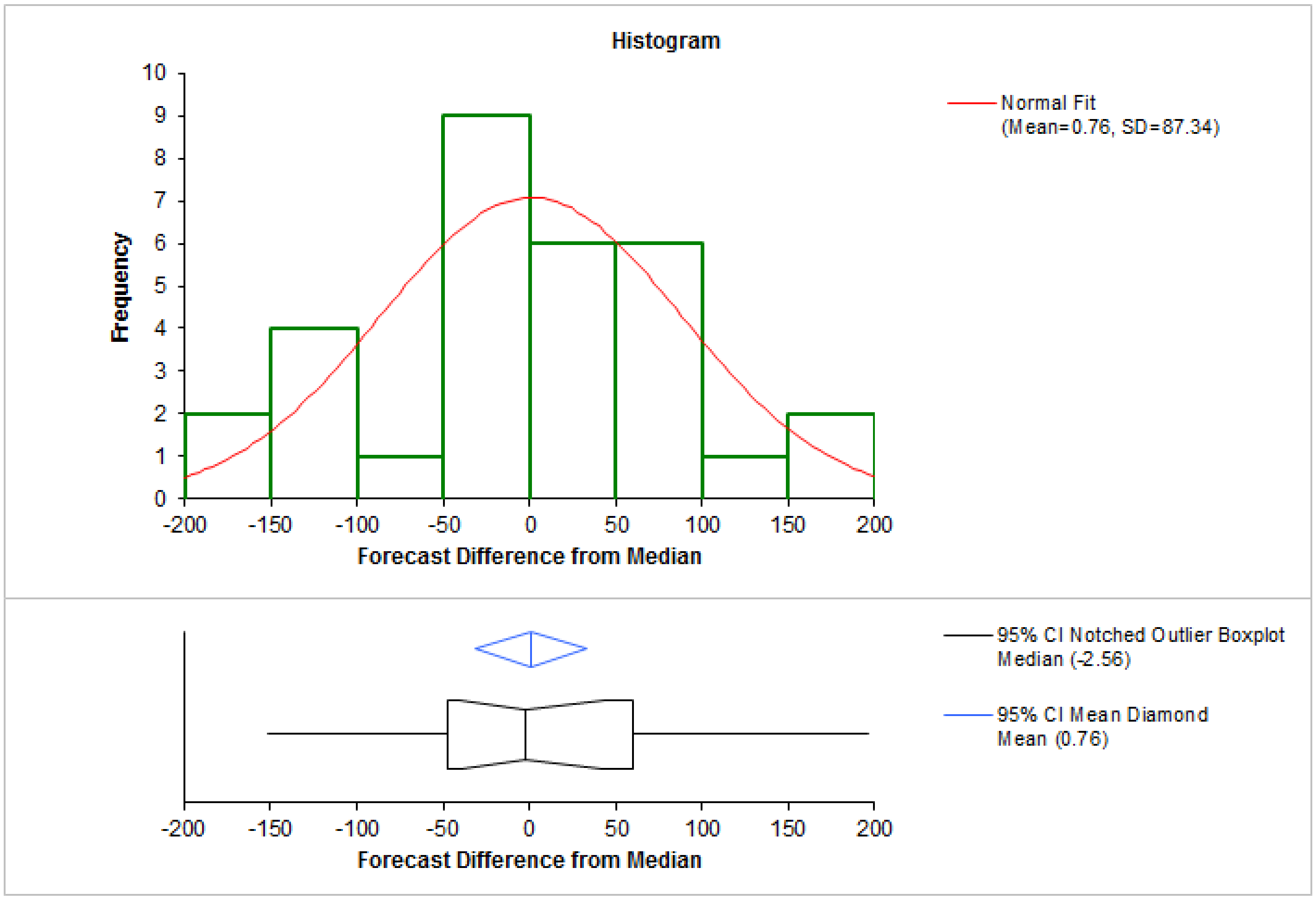
Test: **Describe - Summary**

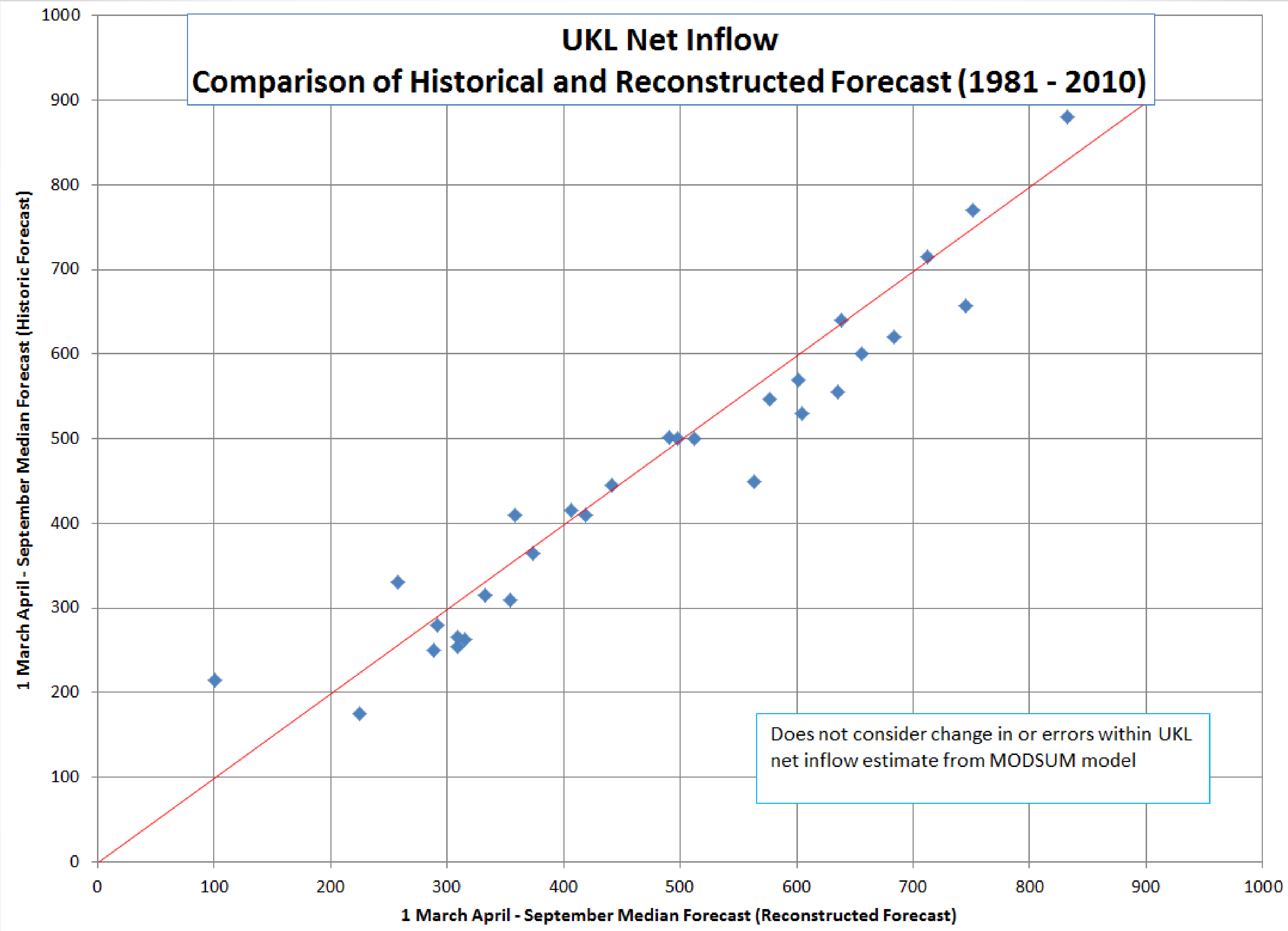
UKL Forecast Difference from Median

Performed by: Mark Deutschman

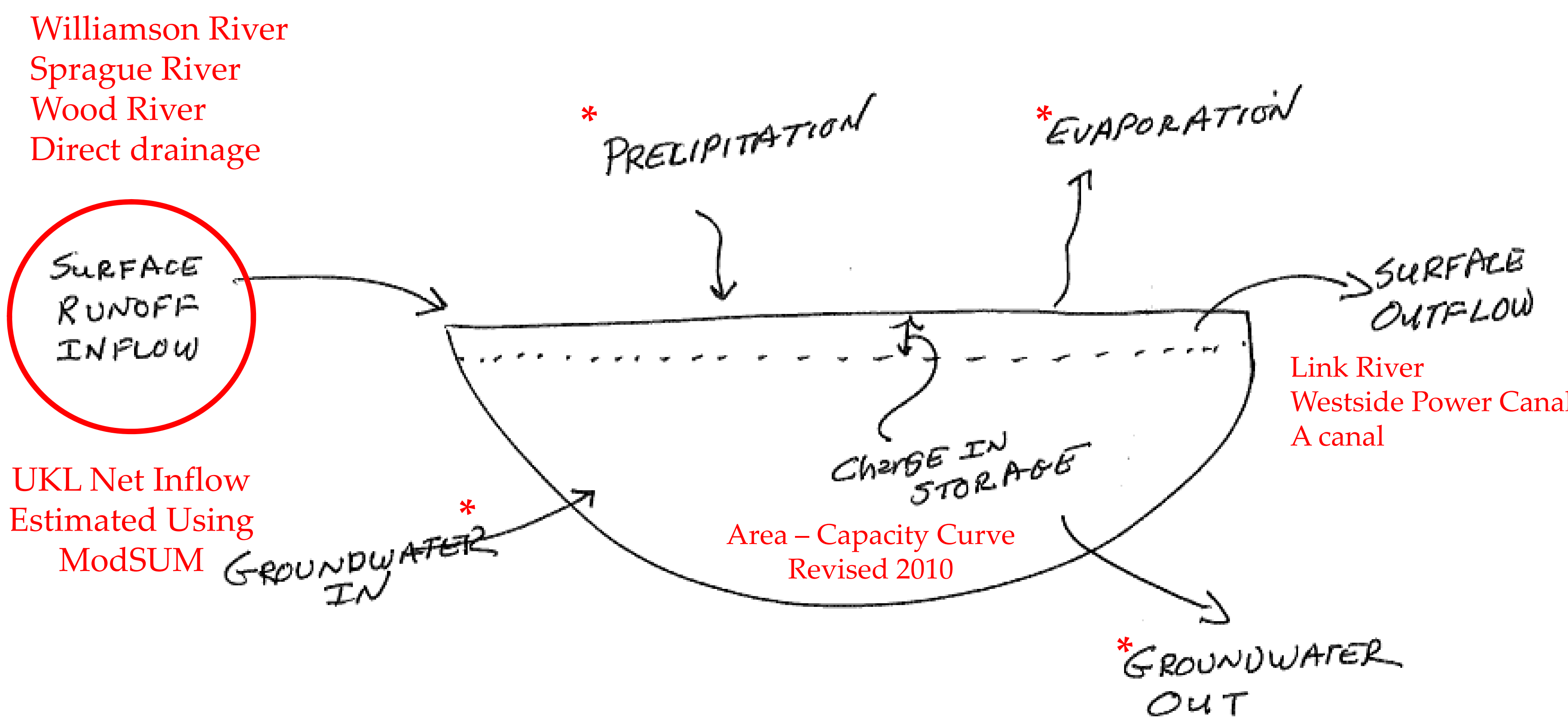
Date: 12 November 2012

UKL Net Inflow, 1 March Median Forecast for April – September Volume




UKL Net Inflow
Comparison of Historical and Reconstructed Forecast (1981 - 2010)
Does not consider change in or errors within UKL net inflow estimate from MODSUM model
1 March April - September Median Forecast (Historic Forecast)
1 March April - September Median Forecast (Reconstructed Forecast)
0
100
200
300
400
500
600
700
800
900
1000

Upper Klamath Lake Water Budget



- No term present in ModSUM model.
- Error not independently estimated/
- Assumes groundwater in – groundwater out = 0
- Precipitation and evaporation not directly measured.
- Have been changes in estimation of westside power canal discharges.

UKL Water Budget

Table 3. The 1950–2005 Annual Average Water Balance Components of UKL Expressed in Volume and Depth Over the Mean Lake Surface Area[a]

	Volume[b] ($m^3 \times 10^9$)	Percent of Total Water Sources and Losses
Sources		
Williamson River	1.01 (3381)	50.25 (49)
Wood River[c]	0.28 (947)	13.93 (16)
Over-lake precipitation[d]	0.14 (460)	6.97 (7)
Groundwater, springs and seeps	0.33[e] (1105)	16.42 (14)[f]
Other[g]	0.25 (836)	12.44 (14)
Total Inputs	2.01 (6729)	100
Losses		
Link plus A-Canal	1.64 (5472)	80.79 (78)
Open-water evaporation	0.32 (1075)	15.76 (20)
Wetland evapotranspiration	0.07 (235)	3.45 (–)
Total Losses	2.03 (6782)	100
Change in Storage	0.00	–
Residual	–0.02 (53)	

[a]Parenthetical values are those of *Hubbard* [1970].
[b]Volume is given in equivalent depth mm.
[c]Reconstructed by regression.
[d]PRISM data for Klamath Lake grid point.
[e]From *Perry et al.* [2004].
[f]*Hubbard* [1970] water balance residual.
[g]Other is irrigation returns and ungauged streams.

Hostetler, S. W. (2009), Use of models and observations to assess trends in the 1950–2005 water balance and climate of Upper Klamath Lake, Oregon, Water Resour. Res., 45, W12409, doi:10.1029/2008WR007295.

Errors are Part of Water Budget

WATER RESOURCES BULLETIN
VOL. 17, NO. 1 AMERICAN WATER RESOURCES ASSOCIATION FEBRUARY 1981

UNCERTAINTIES IN ESTIMATING THE WATER BALANCE OF LAKES[1]

Thomas C. Winter[1]

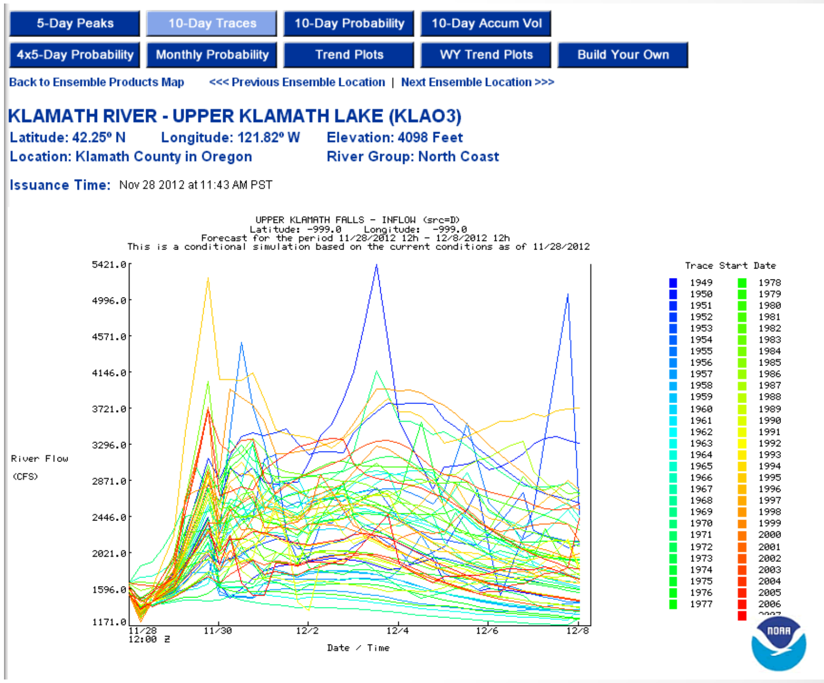
When comparing the water supply forecast results to the "measured" forecast results to Upper Klamath Lake Net Inflow remember UKL net inflow is an estimate from the ModSUM model with its own error. Some of this error is managed by the NRCS within their forecast methods.

Summary

- Forecasts are unbiased and accurate
- Accuracy increases as more is known (1 January vs 1 April)
- 75% of the time the 1 March UKL Median Forecast is ± 50 KAF
- Mean absolute error 1 March UKL Net Inflow Median Forecast ~ 47 KAF
- Forecast accuracy "as good" (better) than typical lake water budget
- Series of changes have affected forecast
  - Reconstruction raised forecasts when > 650 KAF
  - Changes to ModSUM model also affect forecast
- Historical median forecast "good" below 650 KAF
- ~ 40 KAF less volume on average for 70% versus median forecast (1 March)
- UKL net inflow is from water budget (not know)
- Model calibration "addresses" water budget errors

Managing Forecast Uncertainty

- Supplement forecast with climate and resource information
  - Climate data (e.g., precipitation depths)
  - Resource information (flow in the river, reservoir water level)
- Place forecast into historical context (what it was it like last time)- use your experience
- Use higher exceedence forecast value(s) (e.g., 70% vs median) when decision has more risk
- Contingency plan tied for exceedance value

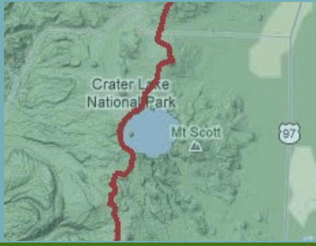


Improving the Forecast?

- Is there need for additional forecast time scales
- Should the locations of forecast and resource issue be aligned
- Do the decisions need to be tied to specific forecast time scales and locations
- Should additional climate and resource data (e.g., reservoir levels) be used to supplement the forecasts
- Are enhanced methods for estimating water budget terms in ModSUM model needed

Discussion

Appendix D



Stakeholder Questionnaire, Presentations, and Survey Monkey Results

List of Questions
Presentations from Water Supply Forecast Users

1. What decisions do you make which rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? Examples might include planting a specific crop, operating the Klamath Project, watering up soils early, opening a head gate on a canal).

2. When (what time or times) in the year do you make these decisions (e.g., what month or months after the start of the year) and how soon is it before the implications of those decisions are realized)? An example might be that I consult the forecast in February and my crops are planted in May.

3. How often do you make or revisit this / these decision and rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? For example, do you need the information every day, a couple of times a month, once a month, etc.?

4. Across what geographic scale do the decisions apply? Examples might include only on a particular field or farm, within a part of the County, within all of a single or multiple Counties, to an entire irrigation District, within multiple subwatersheds, within the entire Klamath Basin).

5. Can you describe how you make decisions about the quality of the water supply forecast (i.e., how good it is, how much you trust the forecast)? For example, how do you understand or evaluate the uncertainty of the forecast (as represented by the five exceedance probability values)?

6. What alternative decisions / actions do you make IF ANY when the water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS) OR other sources of information show there is a shortage of water (e.g., you might plant an alternative crop, decide not to plant, plan for more use of ground water).

7. What are the implications of (a "right" and "wrong") your decision? If you make a decision based on a certain value of the forecast, and if the water supply turns out to be lower or higher than this, do you have a backup plan or some planned adaptations?

8. What is/are the sources / sources of the water supply forecast information? (e.g., do you obtain your information from the print media, news media, extension service, internet, coffee shop, irrigation district meetings, agency briefings).

9. If you obtain your water supply forecast information from the internet can you provide some of the URLs/links?

10. Do you rely on other climate data (e.g., precipitation amounts, snow pack amounts) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate data?

11. Do you rely on other resource data (e.g., flows in the river, amount of water in a reservoir) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate data?

November 5, 2012

RECLAMATION
Managing Water in the West

Klamath Project

Forecasting Flows and Lake Elevations

by Dave Felstul, KBAO, dfelstul@usbr.gov

U.S. Department of the Interior
Bureau of Reclamation

Objectives

1. Forecast Upper Klamath Lake elevations in future months
2. Forecast agricultural demands
3. Assess UKL, Gerber, Clear Lake adequacy to meet project needs
4. Assess probability of meeting regulatory requirements

RECLAMATION

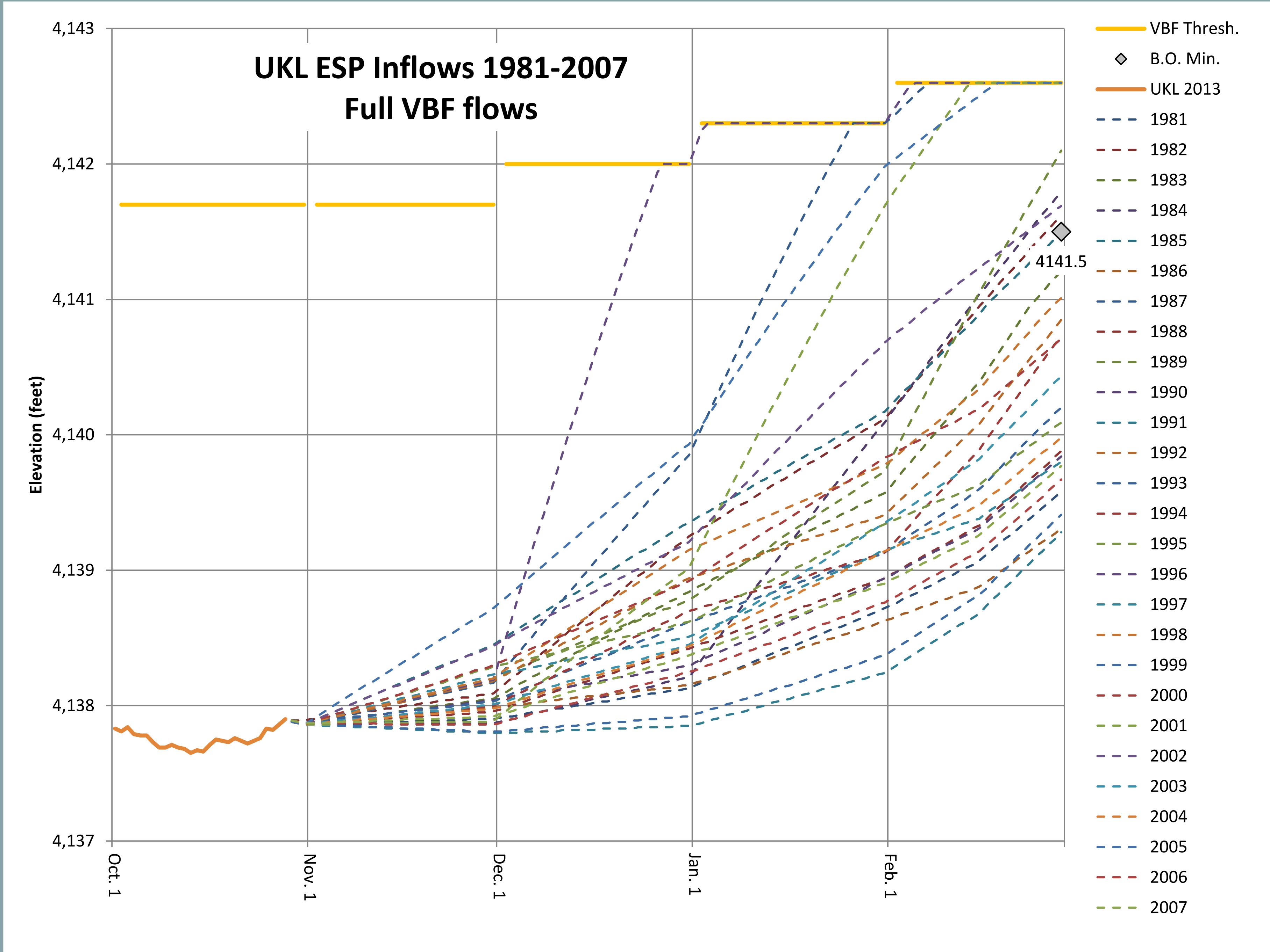
1. Forecast Upper Klamath Lake elevations in future months

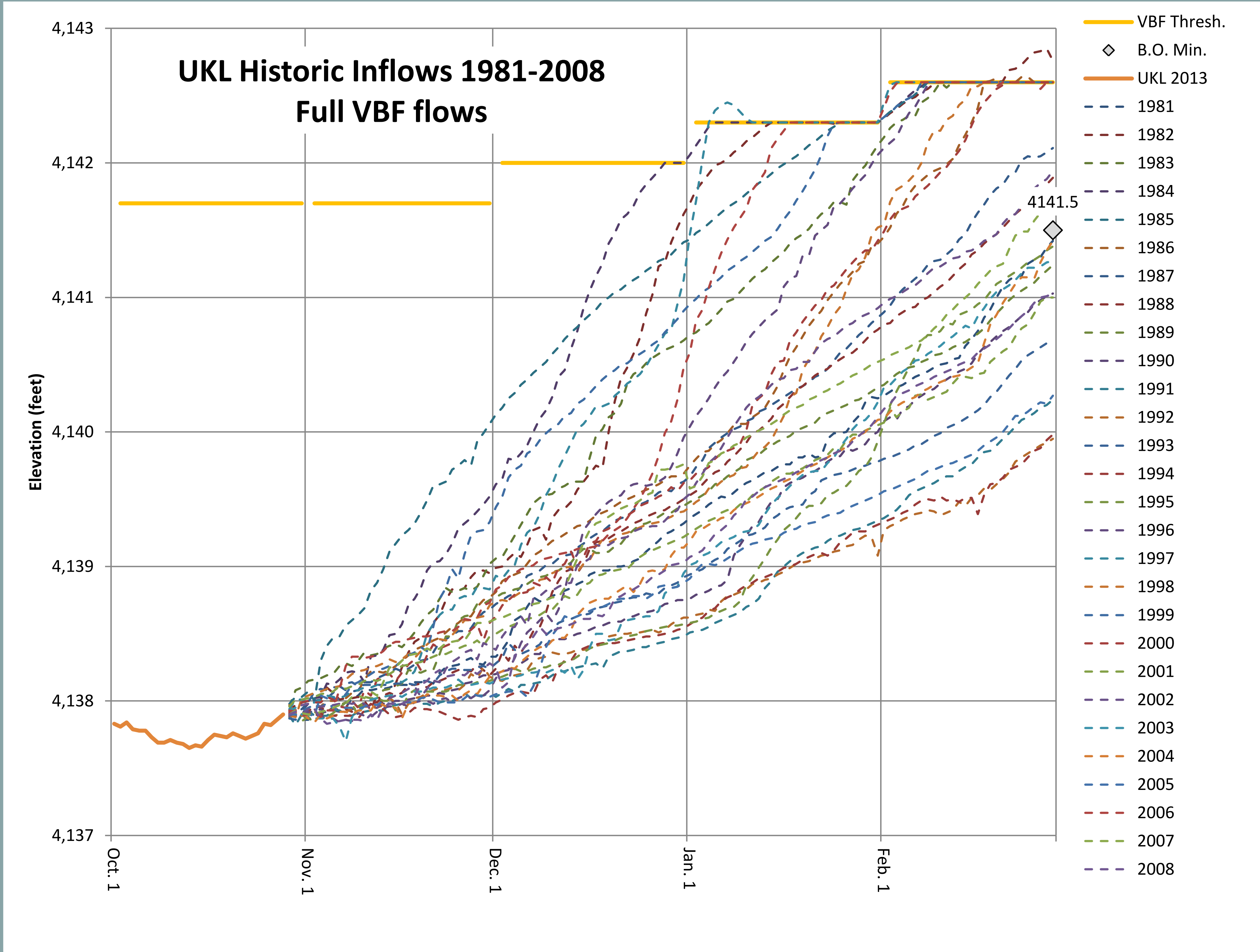
- Starting lake elevation
- Average monthly precipitation Oct-Mar
- Ag demands
- Flows at LRDC, Klamath Straits Drain, Lake Ewauna & Iron Gate gains/losses
- Iron Gate base flow
- Inflow volume

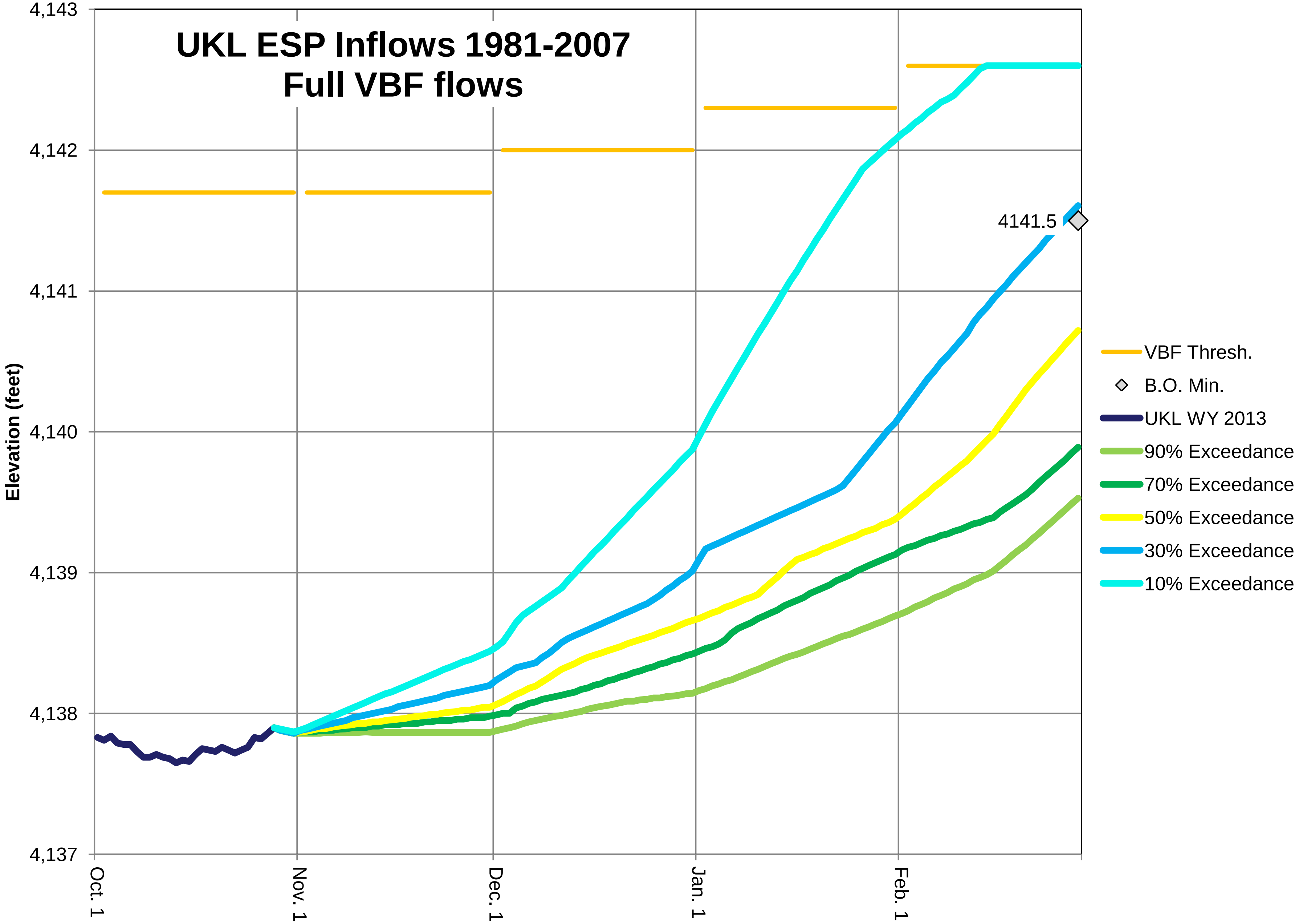
RECLAMATION

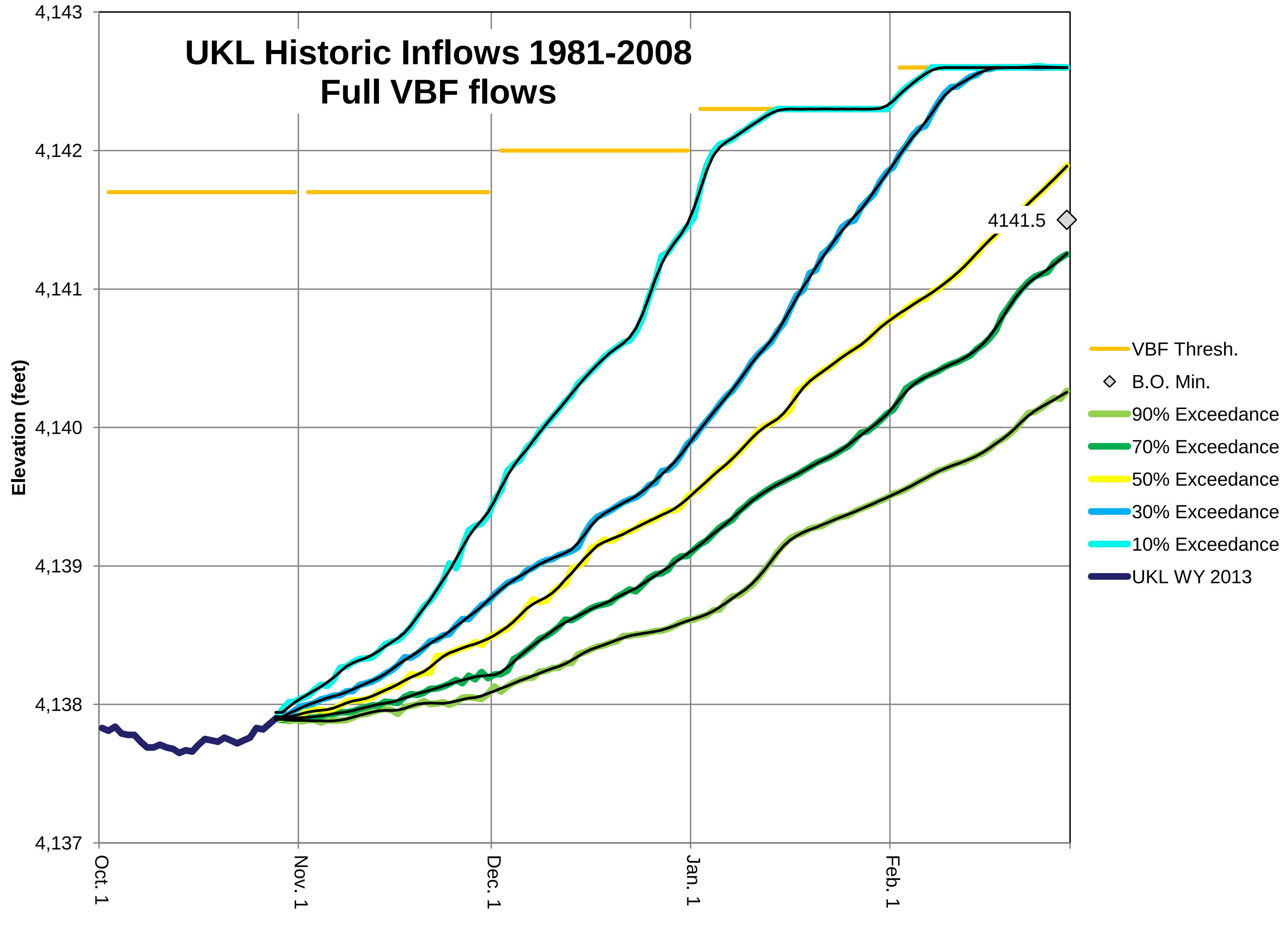
Inflow volume

- Ensemble Streamflow Predictions (ESP) traces
- Historical


UKL ESP Inflows 1981-2007
Full VBF flows
Elevation (feet)
4,143
4,142
4,141
4,140
4,139
4,138
4,137
Oct. 1
Nov. 1
Dec. 1
Jan. 1
Feb. 1
4141.5
VBF Thresh.
B.O. Min.
UKL 2013
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007


UKL Historic Inflows 1981-2008
Full VBF flows
Elevation (feet)
4,143
4,142
4,141
4,140
4,139
4,138
4,137
Oct. 1
Nov. 1
Dec. 1
Jan. 1
Feb. 1
4141.5
VBF Thresh.
B.O. Min.
UKL 2013
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008

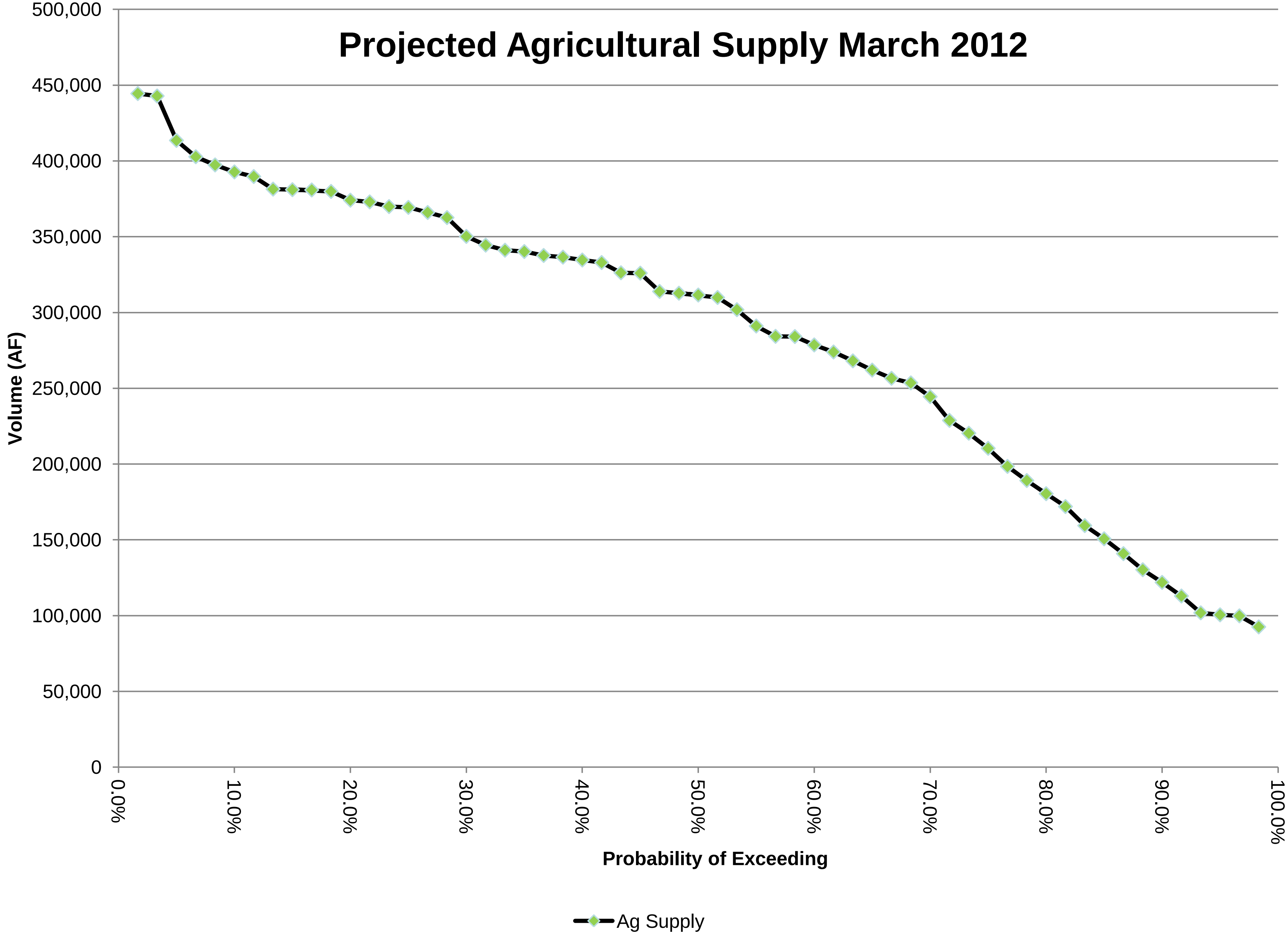

UKL ESP Inflows 1981-2007
Full VBF flows
Elevation (feet)
4,143
4,142
4,141
4,140
4,139
4,138
4,137
4141.5
Oct. 1
Nov. 1
Dec. 1
Jan. 1
Feb. 1
VBF Thresh.
B.O. Min.
UKL WY 2013
90% Exceedance
70% Exceedance
50% Exceedance
30% Exceedance
10% Exceedance


UKL Historic Inflows 1981-2008
Full VBF flows
Elevation (feet)
4,143
4,142
4,141
4,140
4,139
4,138
4,137
Oct. 1
Nov. 1
Dec. 1
Jan. 1
Feb. 1
4141.5
VBF Thresh.
B.O. Min.
90% Exceedance
70% Exceedance
50% Exceedance
30% Exceedance
10% Exceedance
UKL WY 2013

2. Forecast Agricultural Supply

- **UKL starting storage**
- **UKL inflow**
- **UKL end of September storage**
- **Project needs**
- **Other needs, Iron Gate, Refuge, flow augmentation**

RECLAMATION


Projected Agricultural Supply March 2012
Volume (AF)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
0.0%
10.0%
20.0%
30.0%
40.0%
50.0%
60.0%
70.0%
80.0%
90.0%
100.0%
Probability of Exceeding
Ag Supply

3. Assess UKL, Gerber, Clear Lake adequacy to meet project needs

- Reservoir starting storage
- Reservoir inflow
- Project needs
- Other needs: Iron Gate flows, Refuge, flow variability releases

RECLAMATION

Clear Lake 2012 Operational Forecast Model
April 1, 2012

Time Period	Forecasted Inflow (50% exceedance), Acre-Feet	Irrigation Releases, Acre-Feet	Losses					Total Outflow, Acre-Feet	Storage, Acre-Feet	Elevation, Feet
			Submerged/ Surface Area, Acres	Seepage, Feet per Acre	Total Seepage, Acre-Feet	Evap, Feet per Acre	Total Evap, Acre-Feet			
									124,310	4,525.92
Apr 1-15	10,738	417	19,000	0.05	950	0.18	3,325	4,692	130,356	4,526.23
Apr 16-30	10,738	417	19,180	0.05	959	0.18	3,357	4,733	136,362	4,526.54
May 1-15	3,360	2,578	19,360	0.05	968	0.21	4,066	7,612	132,111	4,526.32
May 16-31	3,360	2,578	19,240	0.05	962	0.21	4,040	7,580	127,890	4,526.10
Jun 1-15	1,442	3,416	19,120	0.05	956	0.26	4,876	9,248	120,084	4,525.69
Jun 16-30	1,442	3,416	18,730	0.05	937	0.26	4,776	9,129	112,397	4,525.28
Jul 1-31	721	8,203	18,370	0.05	919	0.72	13,226	22,348	90,771	4,524.06
Aug 1-31	464	7,784	17,110	0.05	856	0.64	10,950	19,590	71,644	4,522.88
Sep 1-30	775	5,211	15,580	0.05	779	0.47	7,323	13,313	59,107	4,522.05

Clear Lake Biological Opinion Minimum Elevation	4,520.60	Feet
Resulting Biological Opinion Minimum Storage	41,150	Acre-Feet
Forecasted Water Available for Delivery	51,977	Acre-Feet
Clear Lake Operational Minimum Elevation	4,522.00	Feet
Resulting Operational Minimum Storage	58,280	Acre-Feet
Forecasted Water Available for Delivery	34,847	Acre-Feet

Forecasted Inflow (70% exceedance), Acre-Feet	Irrigation Releases, Acre-Feet	Losses					Total Outflow, Acre-Feet	Storage, Acre-Feet	Elevation, Feet
		Submerged/ Surface Area, Acres	Seepage, Feet per Acre	Total Seepage, Acre-Feet	Evap, Feet per Acre	Total Evap, Acre-Feet			
								124,310	4,525.92
7,364	417	19,000	0.05	950	0.18	3,325	4,692	126,982	4,526.06
7,364	417	19,060	0.05	953	0.18	3,336	4,706	129,640	4,526.19
2,304	2,578	19,120	0.05	956	0.21	4,015	7,549	124,394	4,525.92
2,304	2,578	19,000	0.05	950	0.21	3,990	7,518	119,180	4,525.64
989	3,416	18,730	0.05	937	0.26	4,776	9,129	111,040	4,525.20
989	3,416	18,370	0.05	919	0.26	4,684	9,019	103,010	4,524.76
989	8,203	17,880	0.05	894	0.72	12,874	21,971	82,028	4,523.53
636	7,784	16,480	0.05	824	0.64	10,547	19,155	63,509	4,522.35
1,063	5,211	14,980	0.05	749	0.47	7,041	13,001	51,571	4,521.50

Biological Opinion Minimum Elevation	4,520.60	Feet
Biological Opinion Minimum Storage	41,150	Acre-Feet
Water Available for Delivery	44,441	Acre-Feet
Operational Minimum Elevation	4,522.00	Feet
Operational Minimum Storage	58,280	Acre-Feet
Water Available for Delivery	27,311	Acre-Feet

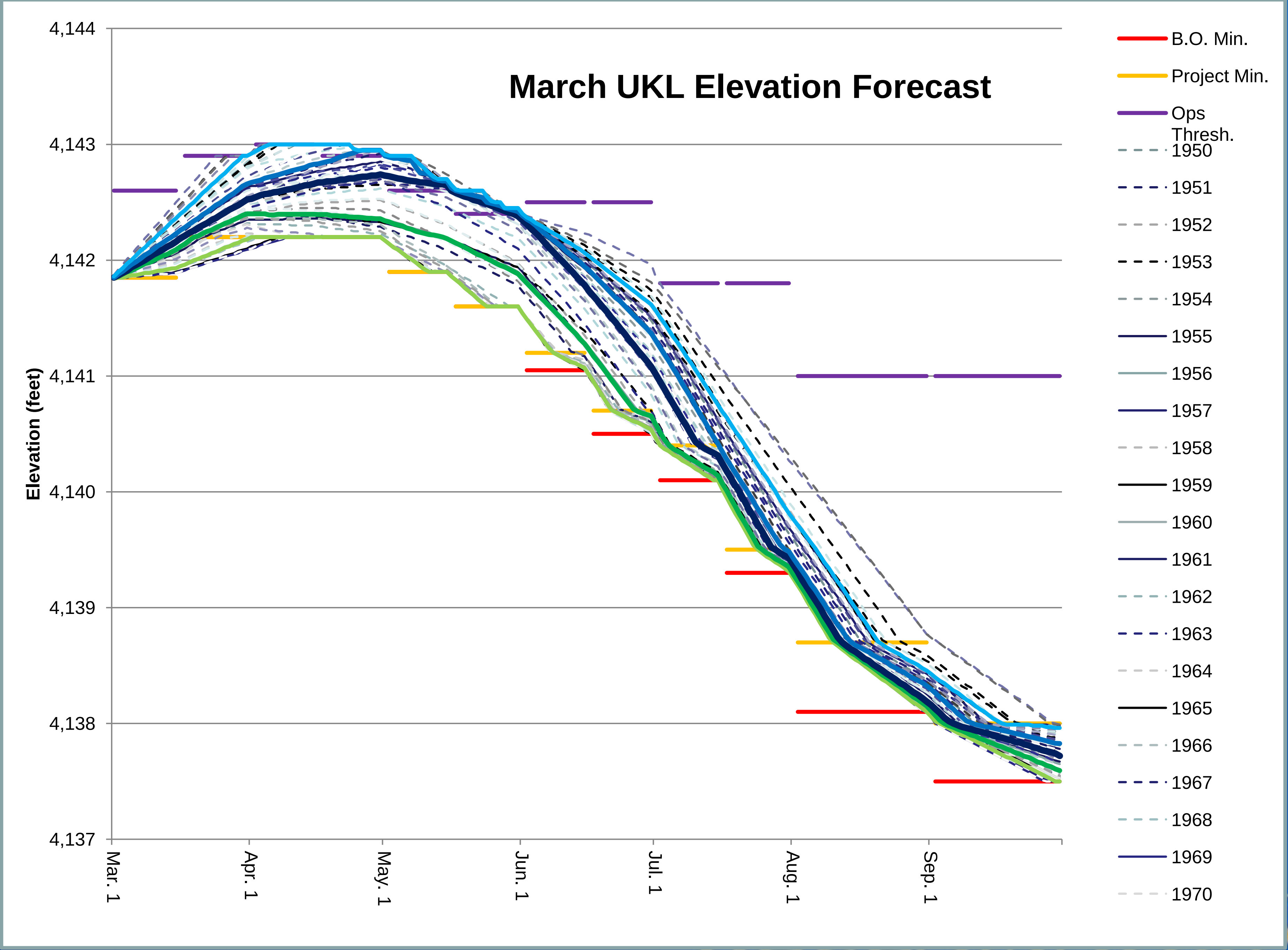
Forecasted Inflow (90% exceedance), Acre-Feet	Irrigation Releases, Acre-Feet	Losses					Total Outflow, Acre-Feet	Storage, Acre-Feet	Elevation, Feet
		Submerged/ Surface Area, Acres	Seepage, Feet per Acre	Total Seepage, Acre-Feet	Evap, Feet per Acre	Total Evap, Acre-Feet			
								124,310	4,525.92
2,761	417	19,000	0.05	950	0.18	3,325	4,692	122,379	4,525.81
2,761	417	18,910	0.05	946	0.18	3,309	4,672	120,469	4,525.71
864	2,578	18,820	0.05	941	0.21	3,952	7,471	113,862	4,525.36
864	2,578	18,460	0.05	923	0.21	3,877	7,378	107,348	4,525.00
371	3,416	18,190	0.05	910	0.26	4,638	8,964	98,755	4,524.52
371	3,416	17,660	0.05	883	0.26	4,503	8,802	90,323	4,524.03
371	8,203	17,110	0.05	856	0.72	12,319	21,378	69,316	4,522.73
238	7,784	15,460	0.05	773	0.64	9,894	18,451	51,103	4,521.47
399	5,211	12,800	0.05	640	0.47	6,016	11,867	39,635	4,520.45

Biological Opinion Minimum Elevation	4,520.60	Feet
Biological Opinion Minimum Storage	41,150	Acre-Feet
Water Available for Delivery	32,505	Acre-Feet
Operational Minimum Elevation	4,522.00	Feet
Operational Minimum Storage	58,280	Acre-Feet
Water Available for Delivery	15,375	Acre-Feet

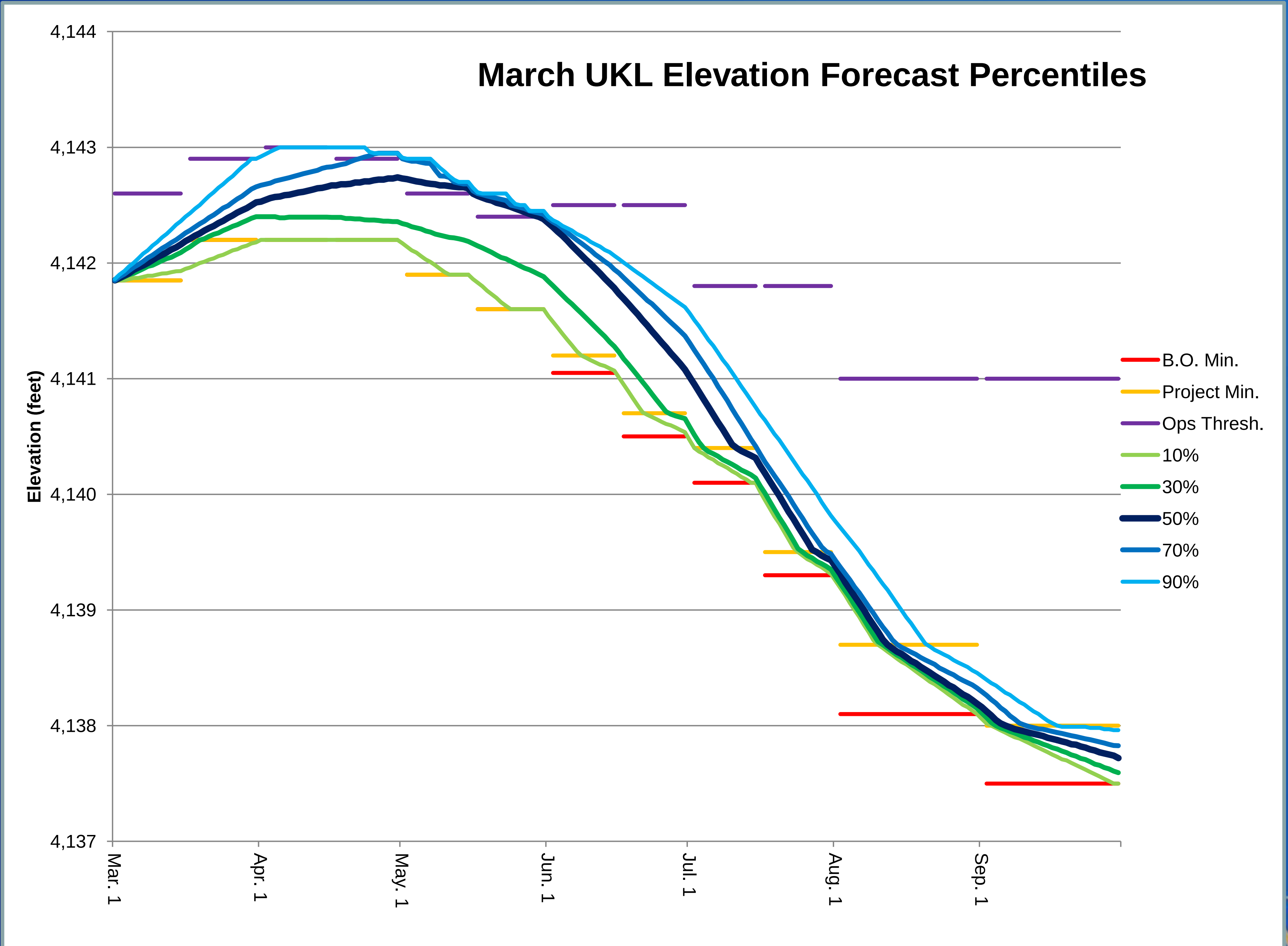
4. Assess probability of meeting regulatory requirements

- UKL elevation
- Clear Lake elevation
- Klamath River flows

RECLAMATION



March UKL Elevation Forecast
Elevation (feet)
4,144
4,143
4,142
4,141
4,140
4,139
4,138
4,137
Mar. 1
Apr. 1
May. 1
Jun. 1
Jul. 1
Aug. 1
Sep. 1
B.O. Min.
Project Min.
Ops Thresh.
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970


March UKL Elevation Forecast Percentiles
Elevation (feet)
4,144
4,143
4,142
4,141
4,140
4,139
4,138
4,137
Mar. 1
Apr. 1
May. 1
Jun. 1
Jul. 1
Aug. 1
Sep. 1
B.O. Min.
Project Min.
Ops Thresh.
10%
30%
50%
70%
90%

Objectives

1. Forecast Upper Klamath Lake elevations in future months
2. Forecast agricultural demands
3. Assess UKL, Gerber, Clear Lake adequacy to meet project needs
4. Assess probability of meeting regulatory requirements

RECLAMATION


That's all Folks!

Default Report

Displaying **1** of **8** respondents

Response Type:
Normal Response

Collector:
Web Link
(Web Link)

Custom Value:
empty

IP Address:
216.115.9.20

Response Started:
Wednesday, November 7, 2012 8:51:38 AM

Response Modified:
Wednesday, November 7, 2012 9:55:46 AM

1. What decisions do you make which rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? Examples might include planting a specific crop, operating the Klamath Project, watering up soils early, opening a head gate on a canal).

Currently, Klamath County primarily serves as a disseminator of information (such as the DSS website). However, if the water supply forecast tools proved to be easy to access with accurate information we feel there would be a whole array of uses beneficial to County Government.

2. When (what time or times) in the year do you make these decisions (e.g., what month or months after the start of the year) and how soon is it before the implications of those decisions are realized)? An example might be that I consult the forecast in February and my crops are planted in May.

This tool could have the potential to be useful year round if it provided information related to specific weather conditions (i.e. projected flooding coupled with locations, drought planning/political measures to be initiated). These are just a couple examples, there are many more.

3. How often do you make or revisit this / these decision and rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? For example, do you need the information every day, a couple of times a month, once a month, etc.?

The necessity of this information would be based on the conditions outside.

4. Across what geographic scale do the decisions apply? Examples might include only on a particular field or farm, within a part of the County, within all of a single or multiple Counties, to an entire irrigation District, within multiple subwatersheds, within the entire Klamath Basin).

County wide.

5. Can you describe how you make decisions about the quality of the water supply forecast (i.e., how good it is, how much you trust the forecast)? For example, how do you interpret and use the uncertainty of the forecast (as represented by mulyiple exceedance probability values)?

Would like to see feedback in the form of forecast values variance from actual used for continual improvement of the forecasting model. Experience with the model would be our guide for how much trust we have in the forecast.

6. What alternative decisions / actions do you make IF ANY when the water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS) OR other sources of information show there is a shortage of water (e.g., you might plant an alternative crop, decide not to plant, plan for more use of ground water).

This is where political actions may be required; the County might be able to influence these actions prior to the actual disaster.

7. What are the implications of (a “right” and “wrong”) your decision? If you make a decision based on a certain value of the forecast and if the water supply turns out to be lower or higher than this, do you have a backup plan or some planned adaptations?

Our government entity is normally able to evolve with the changes it confronts. We generally always have plans A, B, C, etc. But, if we had the tools to make better decisions and be in a state of preparedness if necessary, that could save the county time and money and serve the public better.

8. What is/are the source / sources of the water supply forecast information (e.g., do you obtain your information from the print media, news media, extension service, internet, coffee shop, irrigation district meetings, agency briefings)?

Emergency Services NOAA Weather Services Internet

9. If you obtain your water supply forecast information from the internet can you provide some of the URLs/links?

N/A

10. Do you rely on other climate data (e.g., precipitation amounts, snow pack amounts) or resource data (flows in the river, amounts of water in a reservoir) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate or resource data?

We do watch these things mainly from the weather services available on the internet. The area TV Stations also provide snowpack information.

Displaying **2** of **8** respondents

Response Type:
Normal Response

Collector:
Web Link
(Web Link)

Custom Value:
empty

IP Address:
66.169.250.136

Response Started:
Tuesday, November 13, 2012 8:30:30 AM

Response Modified:
Tuesday, November 13, 2012 9:11:38 AM

1. What decisions do you make which rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? Examples might include planting a specific crop, operating the Klamath Project, watering up soils early, opening a head gate on a canal).

KWAPA uses the water supply forecasts to anticipate the need for supplemental water supply to the Klamath Project

2. When (what time or times) in the year do you make these decisions (e.g., what month or months after the start of the year) and how soon is it before the implications of those decisions are realized)? An example might be that I consult the forecast in February and my crops are planted in May.

Our annual cycle is November and December: policy development January: begin advertisement of program (groundwater) February: receive applications (for Groundwater pumping) and mapping, advertise land idling March: receive and map land idling bids, contract for groundwater pumping. March 15 to 31: KWAPA Board determines the extent of shortage of surface water. April: programs go into effect or are not needed The short answer: there is continuous monitoring of the water supply with particular interest in the March through May period.

3. How often do you make or revisit this / these decision and rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? For example, do you need the information every day, a couple of times a month, once a month, etc.?

We are particularly interested after each weather event what the change in the forecast has been. it would be very nice to have forecasts on this schedule January 1st February 1st March 1st March 15th April 1st April 7th April 15th April 21st May 1st May 15th June 1st

4. Across what geographic scale do the decisions apply? Examples might include only on a particular field or farm, within a part of the County, within all of a single or multiple Counties, to an entire irrigation District, within multiple subwatersheds, within the entire Klamath Basin).

entire Klamath Basin

5. Can you describe how you make decisions about the quality of the water supply forecast (i.e., how good it is, how much you trust the forecast)? For example, how do you interpret and use the uncertainty of the forecast (as represented by mulyiple exceedance probability values)?

Currently we view the forecast very cautiously. We use a lot of common sense judgment as to whether we believe what the forecast is saying. does the current forecast take into account the soil moisture content before snow pack begins to build? does the current forecast take into account the loss of moisture due the long periods of no precipitation? Does the forecast take into account the large number of groundwater irrigation wells drilled in the last 15 years, causing a decline in river inflow to UKL?

6. What alternative decisions / actions do you make IF ANY when the water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS) OR other sources of information show there is a shortage of water (e.g., you might plant an alternative crop, decide not to plant, plan for more use of ground water).

KWAPA basis the water supplementation programs on water supply forecasts. these decisions involve the expense of millions of dollars.

7. What are the implications of (a "right" and "wrong") your decision? If you make a decision based on a certain value of the forecast and if the water supply turns out to be lower or higher than this, do you have a backup plan or some planned adaptations?

the implications are huge. if the forecast predicts low flows that do not happen, then KWAPA is paying for land to be taken out of production that did not need to be idled. on the other hand, if the forecast is for more water then is received, then the KWAPA program is too small and there are lost opportunities for farming where KWAPA could have planned for.

8. What is/are the source / sources of the water supply forecast information (e.g., do you obtain your information from the print media, news media, extension service, internet, coffee shop, irrigation district meetings, agency briefings)?

Reclamation common sense

9. If you obtain your water supply forecast information from the internet can you provide some of the URLs/links?

sometimes, but mostly from Reclamation

10. Do you rely on other climate data (e.g., precipitation amounts, snow pack amounts) or resource data (flows in the river, amounts of water in a reservoir) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate or resource data?

yes, precipitation totals and snow pack

Default Report

Displaying **3** of **8** respondents

Response Type:
Normal Response

Collector:
Web Link
(Web Link)

Custom Value:
empty

IP Address:
140.214.91.105

Response Started:
Tuesday, November 13, 2012 1:10:52 PM

Response Modified:
Tuesday, November 13, 2012 1:21:27 PM

1. What decisions do you make which rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? Examples might include planting a specific crop, operating the Klamath Project, watering up soils early, opening a head gate on a canal).

Operating the Klamath Project

2. When (what time or times) in the year do you make these decisions (e.g., what month or months after the start of the year) and how soon is it before the implications of those decisions are realized)? An example might be that I consult the forecast in February and my crops are planted in May.

At start of water year, already doing limited projections of likely elevations of Upper Klamath Lake for next spring. Begin regular projections in January.

3. How often do you make or revisit this / these decision and rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? For example, do you need the information every day, a couple of times a month, once a month, etc.?

At least every other week, increasing to weekly at key points during the irrigation season.

4. Across what geographic scale do the decisions apply? Examples might include only on a particular field or farm, within a part of the County, within all of a single or multiple Counties, to an entire irrigation District, within multiple subwatersheds, within the entire Klamath Basin).

Entire Klamath Basin.

5. Can you describe how you make decisions about the quality of the water supply forecast (i.e., how good it is, how much you trust the forecast)? For example, how do you interpret and use the uncertainty of the forecast (as represented by mulyiple exceedance probability values)?

Use as long a period of historical record as possible, usually 20-40 years. Present results in terms of exceedance probabilities.

6. What alternative decisions / actions do you make IF ANY when the water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS) OR other sources of information show there is a shortage of water (e.g., you might plant an alternative crop, decide not to plant, plan for more use of ground water).

This may affect how we operate Klamath Basin project within limitations of regulatory controls.

7. What are the implications of (a “right” and “wrong”) your decision? If you make a decision based on a certain value of the forecast and if the water supply turns out to be lower or higher than this, do you have a backup plan or some planned adaptations?

Worst case is we project too much water and have to cut back deliveries later in season.

8. What is/are the source / sources of the water supply forecast information (e.g., do you obtain your information from the print media, news media, extension service, internet, coffee shop, irrigation district meetings, agency briefings)?

Rely on various Reclamation models and NWS/NRCS flow forecasts.

9. If you obtain your water supply forecast information from the internet can you provide some of the URLs/links?

http://www.usbr.gov/pn/hydromet/klamath/ http://www.wcc.nrcs.usda.gov/snotel/Oregon/oregon.html

10. Do you rely on other climate data (e.g., precipitation amounts, snow pack amounts) or resource data (flows in the river, amounts of water in a reservoir) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate or resource data?

Look at data from individual SnoTel sites and flow gages maintained by Reclamation (hydromet), USGS, OWRD, weather forecasts, and just about anything we can get our hands on.

Default Report

Displaying **4** of **8** respondents

Response Type:
Normal Response

Collector:
Web Link
(Web Link)

Custom Value:
empty

IP Address:
66.169.250.136

Response Started:
Thursday, November 15, 2012 9:49:01 AM

Response Modified:
Thursday, November 15, 2012 10:37:22 AM

1. What decisions do you make which rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? Examples might include planting a specific crop, operating the Klamath Project, watering up soils early, opening a head gate on a canal).

Forecasts are critical in determining Klamath Project water supply. This will be even more true starting next year with a new Biological Opinion for operations of the Project.

2. When (what time or times) in the year do you make these decisions (e.g., what month or months after the start of the year) and how soon is it before the implications of those decisions are realized)? An example might be that I consult the forecast in February and my crops are planted in May.

February is important as an indicator. March and April are critical in deterimining water supply availablity (allocation).

3. How often do you make or revisit this / these decision and rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? For example, do you need the information every day, a couple of times a month, once a month, etc.?

First NRCS forecasts provide an indicator. Currently revidions are made to water supply projects clear through early summer. In the future March, April and May will be critical in deterimingn water users supply allocation for the year.

4. Across what geographic scale do the decisions apply? Examples might include only on a particular field or farm, within a part of the County, within all of a single or multiple Counties, to an entire irrigation District, within multiple subwatersheds, within the entire Klamath Basin).

Entire Basin. Future Biological Opinions will use the NRCS forecasts to determine Klamath River and Klamath Reclamation Project Allocations

5. Can you describe how you make decisions about the quality of the water supply forecast (i.e., how good it is, how much you trust the forecast)? For example, how do you interpret and use the uncertainty of the forecast (as represented by mulyiple exceedance probability values)?

We focus a lot on the 70% exceedence forecast. But look at 30%, 50% and 90% also. Last year the NRCS 70% exceedence forecast over estimated inflow by about 65,000 acre-feet. This had muliple negative consequences.

6. What alternative decisions / actions do you make IF ANY when the water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS) OR other sources of information show there is a shortage of water (e.g., you might plant an alternative crop, decide not to plant, plan for more use of ground water).

Project water users must prepare. Other uses have historically been addressed first. Water bank activities increase. Arrangements for ground wate pumping are made, if possible. Coordination with the state occurs related to potential for Drought Declarations. Farmers often will secure ground outside of the Klamath Project that has a well or secure water supply.

7. What are the implications of (a “right” and “wrong”) your decision? If you make a decision based on a certain value of the forecast and if the water supply turns out to be lower or higher than this, do you have a backup plan or some planned adaptations?

Project water users try to develop contingency plans and operate conservatively. Histocially if the forecast is higher than actual, that can cause a disruption in the water supply to Project irrigators late in the season after crops are planted and maturing. This year, it resulted in more water to other uses and a lake elevation that is at an 18 year low.

8. What is/are the source / sources of the water supply forecast information (e.g., do you obtain your information from the print media, news media, extension service, internet, coffee shop, irrigation district meetings, agency briefings)?

We use the internet and also rely on information supplied by the U.S. Bureau of Reclamation. We also get a lot of informatin directly from the USGS websites.

9. If you obtain your water supply forecast information from the internet can you provide some of the URLs/links?

http://www.or.nrcs.usda.gov/snow/data/SWE_Maps&Graphs.html http://waterdata.usgs.gov/or/nwis/uv?site_no=11507500 http://waterdata.usgs.gov/nwis/uv/?site_no=11507001 http://waterdata.usgs.gov/ca/nwis/dv?referred_module=sw&format=html&period=31&site_no=11516530 http://kwua.org/

10. Do you rely on other climate data (e.g., precipitation amounts, snow pack amounts) or resource data (flows in the river, amounts of water in a reservoir) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate or resource data?

no, but we pray for snow and rain.

View Summary
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Default Report

Displaying **5** of **8** respondents

Response Type:
Normal Response

Collector:
Web Link
(Web Link)

Custom Value:
empty

IP Address:
140.211.236.138

Response Started:
Friday, November 16, 2012 11:09:07 AM

Response Modified:
Friday, November 16, 2012 11:20:51 AM

1. What decisions do you make which rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? Examples might include planting a specific crop, operating the Klamath Project, watering up soils early, opening a head gate on a canal).

The financial sector is also monitoring these sites. I.E. holding on to opporating loan packages until water issues are finalized. A producer is then limited in alternatives until operating loans are approved. The sooner a solid forcast the sooner operating loans are set. This could allow a grower to save money by pre purchasing or at the very lease not having to wait until the last minute to purchase inputs. Lots of ground in the basin is leased and competition is strong. Water allocations equate to establishment of lease agreements.

2. When (what time or times) in the year do you make these decisions (e.g., what month or months after the start of the year) and how soon is it before the implications of those decisions are realized)? An example might be that I consult the forecast in February and my crops are planted in May.

Operating Budgets are developed in January and February. Farm Plans also start at this time. Some row crops could be planted as late as May. February-April forcast are critical. Later in the year decisions regarding establishment of perennial crops will rely on water availabilty. In our rotations between annual crops and perennials it is important to understand and forcast water availability.

3. How often do you make or revisit this / these decision and rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? For example, do you need the information every day, a couple of times a month, once a month, etc.?

From January through April at least weekly to make decisions. Then monthly through the growing season. Once annual crops are planted the grower is committed. Some crops like grain peak in July. Others like row crops will need water through September/October. Lets not miss use of water for Frost Protection both early and late in the growing season.

4. Across what geographic scale do the decisions apply? Examples might include only on a particular field or farm, within a part of the County, within all of a single or multiple Counties, to an entire irrigation District, within multiple subwatersheds, within the entire Klamath Basin).

For us it would be county wide.

5. Can you describe how you make decisions about the quality of the water supply forecast (i.e., how good it is, how much you trust the forecast)? For example, how do you interpret and use the uncertainty of the forecast (as represented by mulyiple exceedance probability values)?

Put a high level of trust into the forecast as it is water delivery agents rely on. They control the valve.

6. What alternative decisions / actions do you make IF ANY when the water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS) OR other sources of information show there is a shortage of water (e.g., you might plant an alternative crop, decide not to plant, plan for more use of ground water).

Plan alternative crops. Lease ground. Lease ground with secondary water sources. Not plant. Find a second job.

7. What are the implications of (a “right” and “wrong”) your decision? If you make a decision based on a certain value of the forecast and if the water supply turns out to be lower or higher than this, do you have a backup plan or some planned adaptations?

Yes. We always have a plan B and C to fall back on.

8. What is/are the source / sources of the water supply forecast information (e.g., do you obtain your information from the print media, news media, extension service, internet, coffee shop, irrigation district meetings, agency briefings)?

All the above.

9. If you obtain your water supply forecast information from the internet can you provide some of the URLs/links?

Currnetly using KlamathDSS.org

10. Do you rely on other climate data (e.g., precipitation amounts, snow pack amounts) or resource data (flows in the river, amounts of water in a reservoir) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate or resource data?

Yes. Snow Tel sights, flow data, historical data tied to dates.

Default Report

Displaying **6** of **8** respondents

Response Type:
Normal Response

Collector:
Web Link
(Web Link)

Custom Value:
empty

IP Address:
66.190.240.116

Response Started:
Monday, November 19, 2012 3:43:45 PM

Response Modified:
Monday, November 19, 2012 4:04:32 PM

1. What decisions do you make which rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? Examples might include planting a specific crop, operating the Klamath Project, watering up soils early, opening a head gate on a canal).

Not applicable to me, directly, but many of the folks I represent rely on these forecasts indirectly as they impact the annual operations plans of the Klamath Irrigation Project.

2. When (what time or times) in the year do you make these decisions (e.g., what month or months after the start of the year) and how soon is it before the implications of those decisions are realized)? An example might be that I consult the forecast in February and my crops are planted in May.

February, especially, but than, every month during the irrigation season as projected inflows into UKL impact annual project operations.

3. How often do you make or revisit this / these decision and rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? For example, do you need the information every day, a couple of times a month, once a month, etc.?

N/A to me directly, but I think having accurate, updated information on a daily basis would provide a tremendous tool to help managers make better informed decisions.

4. Across what geographic scale do the decisions apply? Examples might include only on a particular field or farm, within a part of the County, within all of a single or multiple Counties, to an entire irrigation District, within multiple subwatersheds, within the entire Klamath Basin).

I'm most interested in the larger scale applications (Klamath Project, watershed).

5. Can you describe how you make decisions about the quality of the water supply forecast (i.e., how good it is, how much you trust the forecast)? For example, how do you interpret and use the uncertainty of the forecast (as represented by mulyiple exceedance probability values)?

I'm not really making decisions on a personal basis, but improving the forecast will have a direct positive impact on many of the people I represent.

6. What alternative decisions / actions do you make IF ANY when the water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS) OR other sources of information show there is a shortage of water (e.g., you might plant an alternative crop, decide not to plant, plan for more use of ground water).

See above.

7. What are the implications of (a “right” and “wrong”) your decision? If you make a decision based on a certain value of the forecast and if the water supply turns out to be lower or higher than this, do you have a backup plan or some planned adaptations?

See above. OPP implementation will be improved, I believe, if forecasts are the best available.

8. What is/are the source / sources of the water supply forecast information (e.g., do you obtain your information from the print media, news media, extension service, internet, coffee shop, irrigation district meetings, agency briefings)?

NRCS / BOR forecast from website.

9. If you obtain your water supply forecast information from the internet can you provide some of the URLs/links?

You have the ones I'm familiar with.

10. Do you rely on other climate data (e.g., precipitation amounts, snow pack amounts) or resource data (flows in the river, amounts of water in a reservoir) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate or resource data?

TNC actually has developed a forecast from empirical sources that is interesting. I can help dig that out for you.

Displaying **7** of **8** respondents

Response Type:
Normal Response

Collector:
Web Link
(Web Link)

Custom Value:
empty

IP Address:
164.159.60.2

Response Started:
Wednesday, November 28, 2012 1:53:32 PM

Response Modified:
Wednesday, November 28, 2012 2:08:28 PM

1. What decisions do you make which rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? Examples might include planting a specific crop, operating the Klamath Project, watering up soils early, opening a head gate on a canal).

whether to hold and recirculate existing water on refuge wetlands or drain wetlands in late spring. Predictions of adequate water means summer water supply rather than recirculation.

2. When (what time or times) in the year do you make these decisions (e.g., what month or months after the start of the year) and how soon is it before the implications of those decisions are realized)? An example might be that I consult the forecast in February and my crops are planted in May.

for refuge wetlands, the April 1 forecast is the one most relied upon. However, how this predicted water is divided up for River, Lake, and Ag and BOR projections for refuge water are considered along with the April forecast.

3. How often do you make or revisit this / these decision and rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? For example, do you need the information every day, a couple of times a month, once a month, etc.?

Once April is past, its more a matter of viewing inflows to the Lake as well as current lake elevations and projected elevations from BOR

4. Across what geographic scale do the decisions apply? Examples might include only on a particular field or farm, within a part of the County, within all of a single or multiple Counties, to an entire irrigation District, within multiple subwatersheds, within the entire Klamath Basin).

Our decisions pertain mostly to Lower Klamath NWR. In terms of scale, the biological implications span the Pacific Flyway from Siberia to Central America and most of the Intermountain West.

5. Can you describe how you make decisions about the quality of the water supply forecast (i.e., how good it is, how much you trust the forecast)? For example, how do you interpret and use the uncertainty of the forecast (as represented by mulyiple exceedance probability values)?

Past experience says indicates that the April forecast gets progressively less accurate as the season progresses. Because of this uncertainty, there is a tendency to take water now if its available and you have a place to use it rather than gamble that it will be available later. Generally, habitat and agricultural planning on refuge takes place later in the season - Mar/Apr as making decisions earlier prior to the full precipitation year, does not make sense.

6. What alternative decisions / actions do you make IF ANY when the water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS) OR other sources of information show there is a shortage of water (e.g., you might plant an alternative crop, decide not to plant, plan for more use of ground water).

1. hold and recirculate existing water as much as possible. 2. Notify the public that water shortages may hinder their recreational experience. ie if you come here what to expect. 3. In some cases, limit public use (especially hunting) if habitat areas are limited.

7. What are the implications of (a “right” and “wrong”) your decision? If you make a decision based on a certain value of the forecast and if the water supply turns out to be lower or higher than this, do you have a backup plan or some planned adaptations?

I no longer understand the meaning of "right and wrong" in the Klamath Basin - depends on your perspective and politics of the year.

8. What is/are the source / sources of the water supply forecast information (e.g., do you obtain your information from the print media, news media, extension service, internet, coffee shop, irrigation district meetings, agency briefings)?

BOR notices, NRCS via internet

9. If you obtain your water supply forecast information from the internet can you provide some of the URLs/links?

Don't have it off hand - just google my way into it.

10. Do you rely on other climate data (e.g., precipitation amounts, snow pack amounts) or resource data (flows in the river, amounts of water in a reservoir) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate or resource data?

No.

Displaying **8** of **8** respondents

Response Type:
Normal Response

Collector:
Web Link
(Web Link)

Custom Value:
empty

IP Address:
161.55.24.162

Response Started:
Thursday, November 29, 2012 11:31:56 AM

Response Modified:
Thursday, November 29, 2012 11:41:27 AM

1. What decisions do you make which rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? Examples might include planting a specific crop, operating the Klamath Project, watering up soils early, opening a head gate on a canal).

Klamath River flows measured at Iron Gate Dam USGS gage

2. When (what time or times) in the year do you make these decisions (e.g., what month or months after the start of the year) and how soon is it before the implications of those decisions are realized)? An example might be that I consult the forecast in February and my crops are planted in May.

Monthly from Mar-Sept

3. How often do you make or revisit this / these decision and rely on water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? For example, do you need the information every day, a couple of times a month, once a month, etc.?

Currently, only monthly NRCS forecasts are applicable for managment decisions. However bi-weekly or weekly would be more useful.

4. Across what geographic scale do the decisions apply? Examples might include only on a particular field or farm, within a part of the County, within all of a single or multiple Counties, to an entire irrigation District, within multiple subwatersheds, within the entire Klamath Basin).

Klamath Basin at IGD

5. Can you describe how you make decisions about the quality of the water supply forecast (i.e., how good it is, how much you trust the forecast)? For example, how do you interpret and use the uncertainty of the forecast (as represented by mulyiple exceedance probability values)?

That is a complicated answer becuase it varies for different decisions/applications. In general use 50% forecast for management decisions but always identify effects or repercussions if 95% exceedance forecast is realized.

6. What alternative decisions / actions do you make IF ANY when the water supply forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS) OR other sources of information show there is a shortage of water (e.g., you might plant an alternative crop, decide not to plant, plan for more use of ground water).

Take more conservative approach to river flows in winter to increase storage in UKL.

7. What are the implications of (a “right” and “wrong”) your decision? If you make a decision based on a certain value of the forecast and if the water supply turns out to be lower or higher than this, do you have a backup plan or some planned adaptations?

Can have drastic effects to fish health/habitat in Upper Klamath Lake and river, irrigation water supplies, NWR deliveries.

8. What is/are the source / sources of the water supply forecast information (e.g., do you obtain your information from the print media, news media, extension service, internet, coffee shop, irrigation district meetings, agency briefings)?

Internet and agency briefings.

9. If you obtain your water supply forecast information from the internet can you provide some of the URLs/links?

http://www.wcc.nrcs.usda.gov/cgibin/strm_cht.pl http://www.wcc.nrcs.usda.gov/cgibin/strm_cht_get.pl?basin=4129&month=01&year=2012&state=oregon

10. Do you rely on other climate data (e.g., precipitation amounts, snow pack amounts) or resource data (flows in the river, amounts of water in a reservoir) to supplement the water supply forecast information forecasts issued by the Natural Resources Conservation Service National Water and Climate Center and the National Weather Service (NWS)? If so, what sources of climate or resource data?

Yes, NRCS SNOTEL site data, USGS Klamath river and well gages and other tributary gages, all precipitation gages in the basin.