National Water Resources Monitoring and Outlook Webpage
(07/20/2015)

Background

Water supply forecasts and information have been generated and provided to interested customers by River Forecast Centers (RFCs) as well as other water management agencies for many decades. Traditionally, these forecasts and supportive information have been issued on a periodic basis (e.g. monthly) and only during specific seasons (e.g. winter and spring). In most cases, these forecasts were coordinated with one or more agencies to ensure consistency and consider alternate views and information.

The strength of NOAA's Hydrology Program resides in its ability to operate real-time hydrologic modeling systems that incorporate hydrometeorological data and the latest short, medium, and long-range weather and climate forecasts. Operating in an ensemble mode, RFCs are able to provide key water resources information in a probabilistic format that informs and supports effective management decisions across the country.

The vision for the National Water Resources Outlook and Monitoring Webpage (NWRMO) is to provide a comprehensive view of the water resources picture that reflects information, data, and forecasts that are updated on a daily basis, every day of the year. This is a major paradigm shift from the environment where water supply forecasts are issued on a monthly basis during a specific season of interest. While the units are the same, these forecasts are fundamentally different that those previously generated and issued. Another paradigm shift comes when the notion of a seasonal volume forecast (typically related to snowmelt) is expanded to a water year forecast or any other period of the year that may be of interest to water resource managers. This dramatically increases the number of locations where meaningful water resources information can be support by operational RFC hydrologic modeling and forecasts.

A key dimension of this "comprehensive" view is consistency across the nation. Currently, RFCs involved in water resources forecasting have a variety of graphical and tabular display formats. While all are useful, they make it difficult for users who are interested in area that cross RFC boundaries or individuals who are interested in getting a very high level view of how water availability may be varying across the country. The vision of the NWRMO is to provide a consistent interface that will meet local, regional, and national interests.

While implementation efforts are beginning in the West, an explicit design feature of the NWRMO is extensibility and expandability across the entire U.S. Indeed, while some of the features will take time to implement nationwide, many can be implemented right away.

Framework

The NWRO is a very data heavy application interface. RFCs will be providing large datasets on a daily basis that will require statistical analysis and storage for analysis on demand by interface users.

Graphics (maps and plots) will be generated on the fly, specified through the selection of available user options. Moc-ups of all maps, plots, and tables will be provided by the Project Management (PM) team.

Web Interface Concept

Upon arrival, the user will be presented with a map of the U.S. that shows the percent of average water year volume expected for all supported forecast locations. Locations are to be depicted as color-coded dots referenced in a legend. The map interface will be ESRI to improve navigation familiarity, and conform to NWS standards. The primary variable on the map will be:

1. Streamflow volume

Options along the side of the map will allow the user to display other supportive information including:

2. Reservoir status
3. Snow
4. Precipitation
5. Air Temperature
6. Soil Moisture

A description of each of these maps is provided on the following pages. In addition, several of the maps will allow the user to click on the desired location and show point specific graphics and tabular information. A description of the point specific displays and tables are also included in this document.

The interface "look and feel" should be consistent with either the NWS design or that of the National Water Center (NWC).

Navigation should be as simple and straightforward as possible where mouse clicks are minimized as possible. Access to "help" sections that will assist users in the interpretation of specific information will be integrated into the design. The content of the "help" information will be provided by the PM team.

Time Line

Initial deployment by August 1, 2016 with full implementation for CBRFC, NWRFC, and CNRFC by October 1, 2016.

Contents

1. Streamflow Volume Map

1. ESRI based
2. Points only
    a. Colored dots w/legend
    b. RFC defined and computed (website will only display composites and will not compute) composite points (e.g. Sacramento, San Joaquin, etc)
3. All forecasts from daily RFC 365-day (or more) ensemble runs
4. Options for:
    a. % average (default)
    b. % median
    c. Percentile ranking
        i. Drought monitor categories
    d. Change over time (limited)
        i. Last 1,3,7,14 days
        ii. Since first of month
        iii. Since first of WY
    e. Consider a variable that combines magnitude and variability
        i. (10%-90%)/average
5. Period selection
    a. WY (default)
    b. User selectable period*
        i. Whole months only
        ii. Any combination of past and future
        iii. Current month is combination of observed and forecast
    c. Single whole month
        i. Current month - Current month is combination of observed and forecast
        ii. Next 11 months
        iii. Past months for current water year
    d. Observed only (Oct.1 to date)
    e. Forecast residual (current date through 9/30 of current WY)
6. Date selection (default=current)
    a. Any date for which data has been developed or archived.
7. When a user clicks on a forecast location
    a. See options for point level streamflow information (PLSI)
8. Overlay options
9. Coverage of full RFC domain (e.g. including Canada, Mexico)
10. Other cool stuff – e.g. point groupings, tribes and others, etc.

*Analysis of other user selectable periods will require (significant) processing time. It is unreasonable and wasteful to analyze all possible periods, therefore RFCs will establish (and maintain) the standard processing periods for each forecast location in addition to the WY. Upon receipt of the ensemble forecasts, the system will analyze the forecasts for

each of these periods and store the information. If a user selects a period for which analysis has been performed, then the appropriately colored dots will appear on the map. For example, traditional water supply locations in the Upper Colorado may all have an April-July period identified in addition to the WY. If the user selects April-July, the dots for these locations would appear on the map.

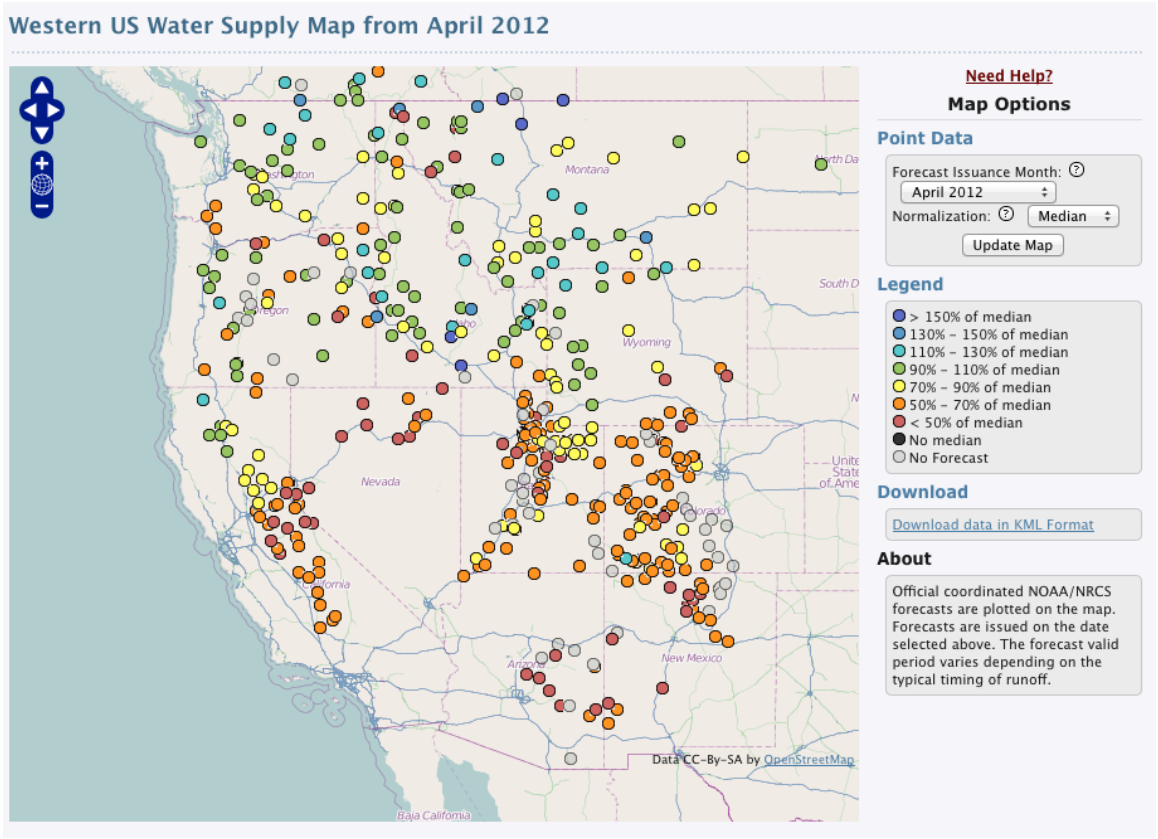

Figure 1: Example of streamflow volume forecast map. Note the options for forecast issuance date and for normalization.

2. Reservoir Storage Maps

Standard Map

1. ESRI based
2. Points based
3. Daily storage (KAF)
4. Display options
    a. % of average (for identified date)
    b. % of capacity
5. RFCs select reservoirs to be included
    a. Can include both forecast and non-forecast projects
    b. May need to "turn off" individual reservoirs due to customer sensitivity.
6. Link to inflow forecasts if available
7. When user clicks on a point:
    a. Tea Cup diagram
    b. WY storage to date plot
        i. Including historical context (max, min, median, etc)

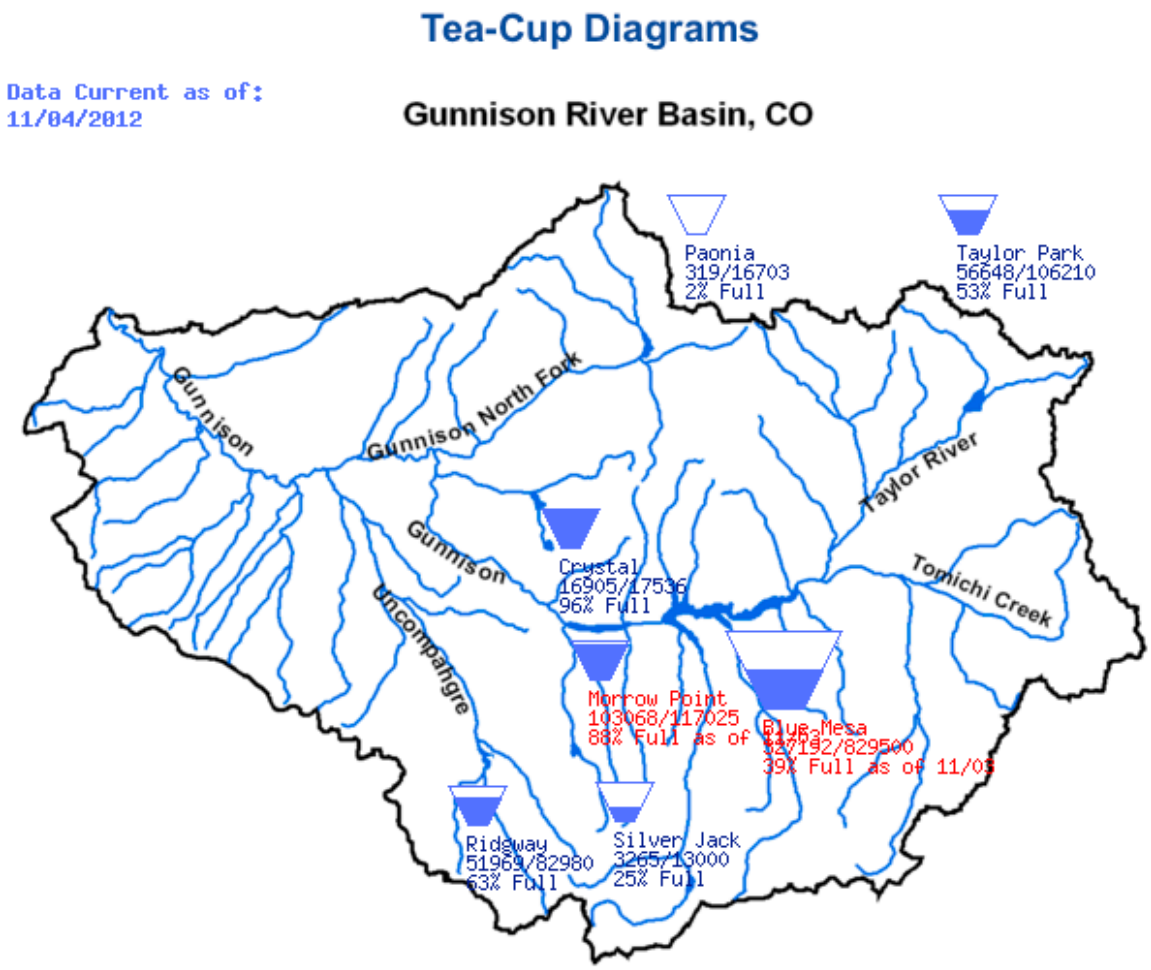

Figure 2: Tea Cup diagram example

<u>Aggregated Storage Map</u>

1. ESRI
2. Solid, color-coded areas
3. Aggregation basis
    a. States
    b. 2 to 4 digit HUCs (less important than a)
    c. Other basin delineations defined by sophisticated users (less important than a)
    d. User selected reservoirs (less important than a)
4. Reservoirs within aggregated areas pooled (summed)
5. Display options
    a. % of average (for identified date)
    b. % of capacity
6. RFCs select reservoirs to be included
    a. Can be both forecast and non-forecast projects

    b. May include reservoir excluded from individual display
7. When user clicks on an aggregated area:
    a. Tea Cup diagram
    b. WY to date plot

- Reservoir content normals - RFCs will provide either daily average storage or average first of month storage for all reservoirs to be included in this service. If first of month storage is provided, the system will interpolate the average storage for specific days.
- RFCs to provide meta data file(s) that describe any special conditions that may exist at a reservoir. For example, the reservoir may have a storage restriction due a seismic problem.

3. Snow Maps

Map w/ gridded information

1. SWE and satellite areal extent of snow cover (snow/no snow)
    a. Amount
    b. Percent of median, average, and percentile ranking (past and current within current WY)
    c. Change over time
        i. Days, week, month, etc.
2. SNODAS

Map with point-based information

1. Reports from daily automated stations (SWE)
    a. SNOTEL, CADWR , and Canadian data
2. Manual observations
    a. Snow course
    b. Flight lines
3. Color coded dots
    a. Based on percent of median for selected date
4. Date selectable (default = current)
5. Clicking on point
    a. Water year plot
    b. Context
        i. Median
        ii. Average
        iii. Historical max/min
        iv. % of seasonal peak
        v. Analog years
            1. Multiple
            2. User selectable

System will need to database full period of record of daily snow water observations in order to compute averages and provide analog year displays.

The NWC is currently receiving most of these data in near real time. Leverage existing data and database structures.

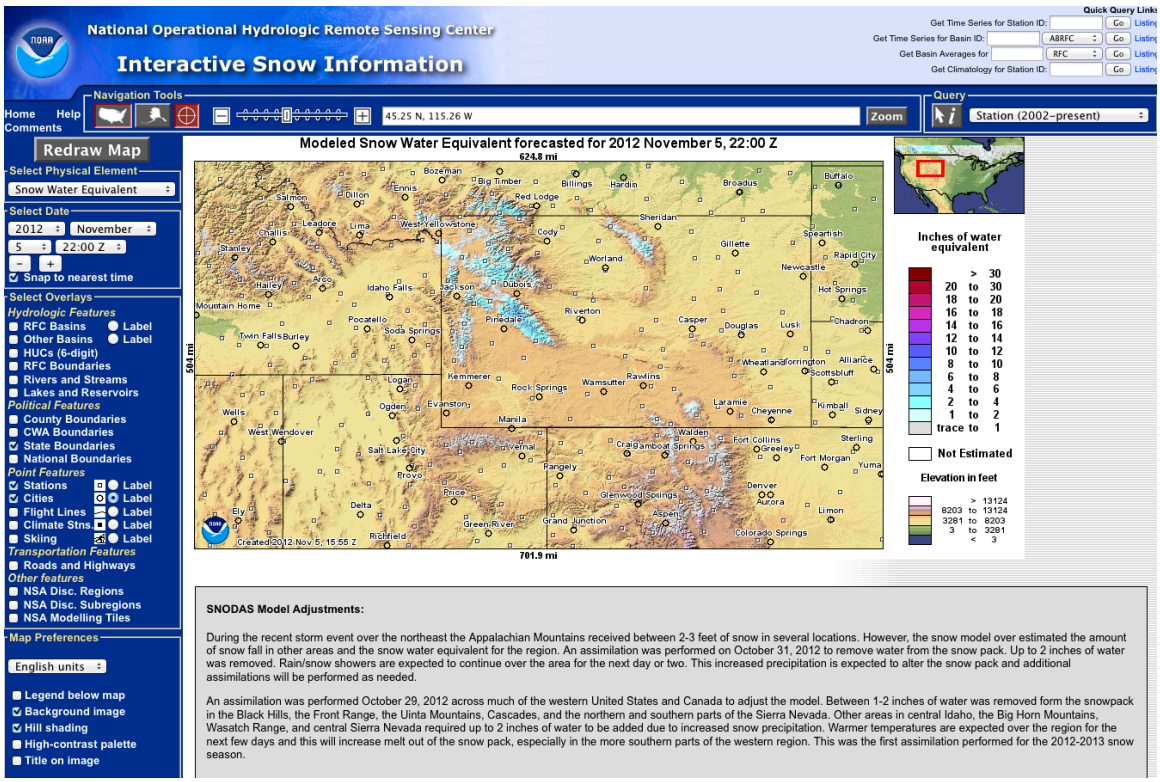

Figure 3: Current NOHRSC snow mapping website (www.nohrsc.noaa.gov)

4. Precipitation Map

1. ESRI based
2. Gridded information
    a. Ability to aggregate to watershed
3. Leverage existing data
    a. Water.weather.gov daily precip
    b. NCEI daily and monthly grids
        i. 5km grid resolution
        ii. ~3day latency
        iii. Spatially and temporally consistent
    c. Gage adjusted radar based Climate Date Record
    d. PRISM
    e. Weather Prediction Center (WPC) precipitaiton forecasts?
4. Parameters
    a. Observed precipitation (inches)
    b. Forecasted precipitation (inches)?
    c. Normal (inches)
    d. Deviation from normal (inches)
    e. Percent of normal (%)
5. Periods
    a. Past 1 to 7 days
    b. Month to date
    c. Past months
    d. WY to date
    e. WPC Forecast Periods?

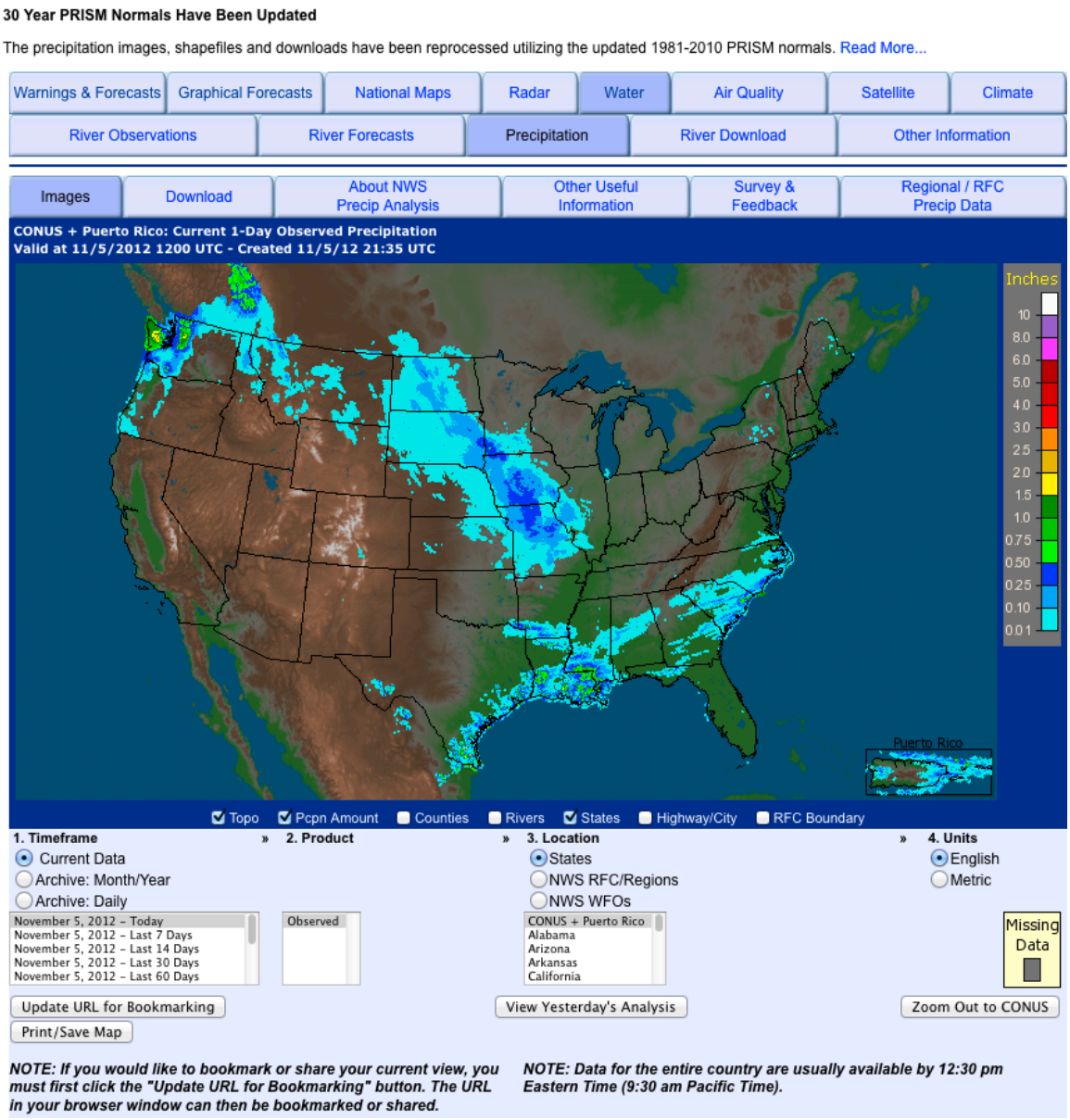

Figure 4: Current daily precip page (water.weather.gov/precip)

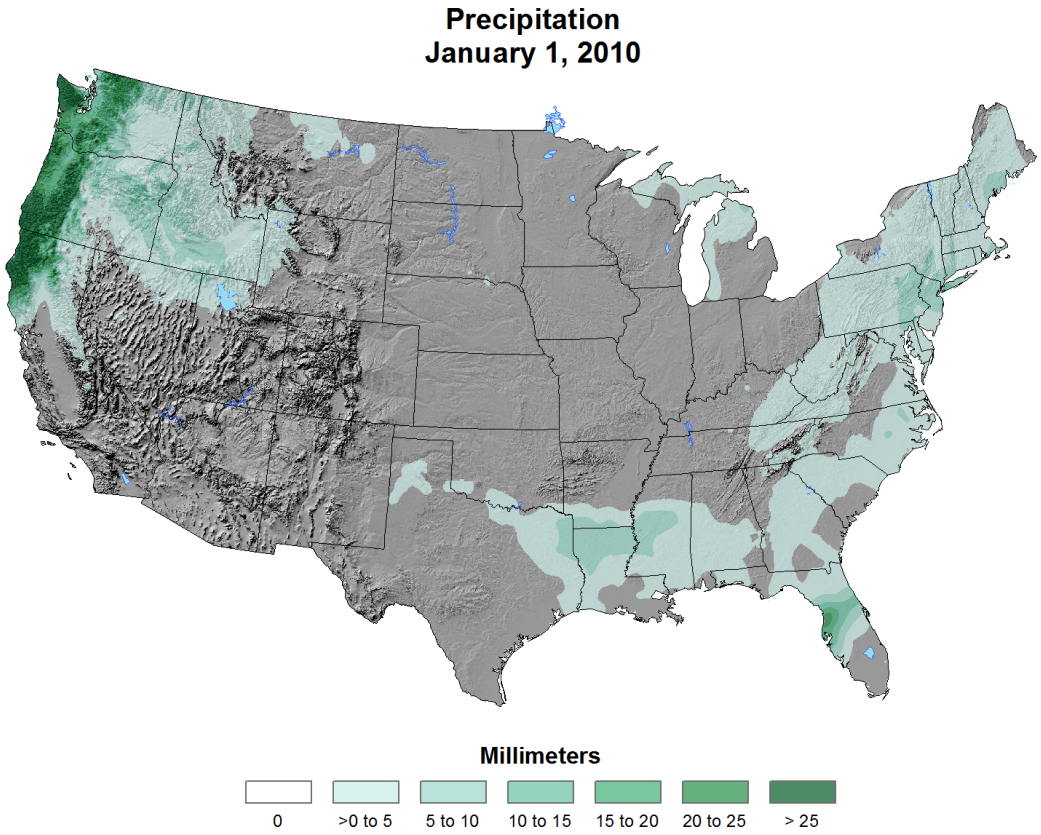

Figure 5: Example of NCEI daily precipitation grid.

5. Air Temperature Map

1. ESRI based
2. Gridded information
3. Leverage existing data
    a. NCEI daily and monthly grids
        i. 5km grid resolution
        ii. ~3day latency
        iii. Spatially and temporally consistent
    b. Temperature forecasts?
4. Parameters
    a. Maximum and minimum air temperature
        i. Observed
        ii. Normal
        iii. Deviation from normal
        iv. Forecasted temperatures?
5. Periods
    a. Past 1 to 7 days
    b. Month to date
    c. Past months
    d. Temperature forecasts?

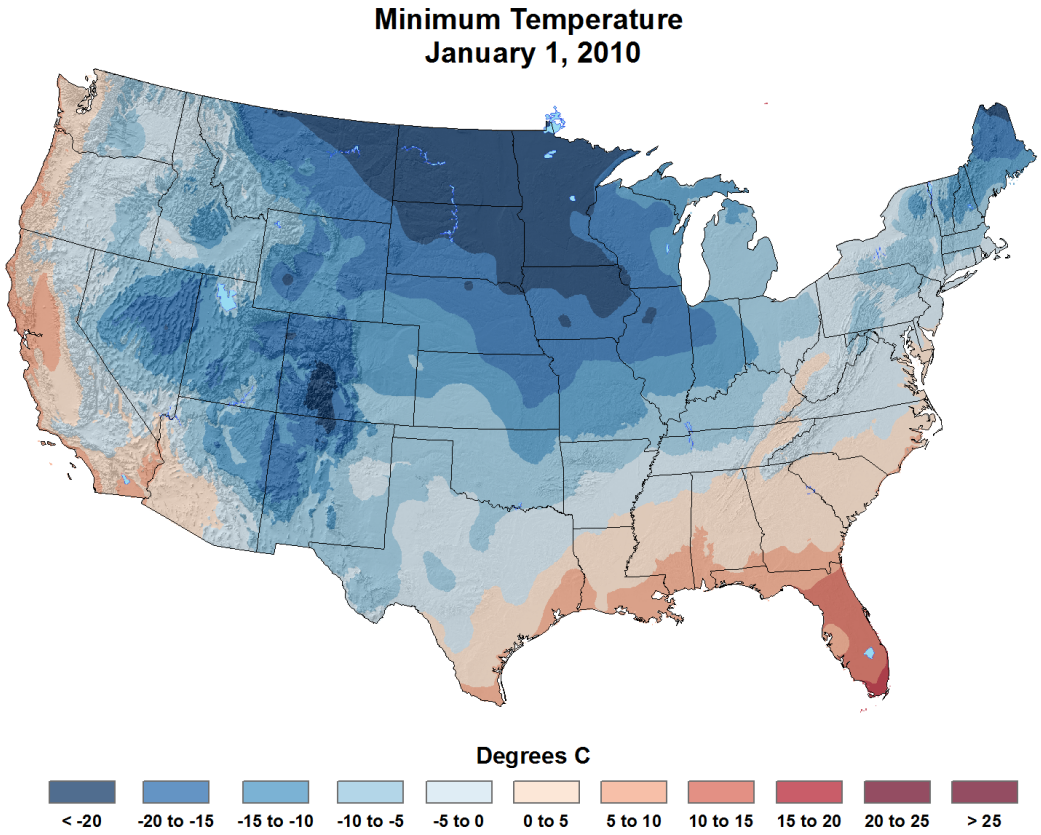

Figure 6: Example of NCEI daily minimum temperature grid.

6. Soil Moisture Maps

Map w/ gridded information

1. Data from WRF-Hydro model at NWC
2. Soil moisture
    a. Percent of average (what is average?)
    b. Percentiles?
    c. Change over time
        i. Days, week, month, etc.

Future Enhancement

Map with point-based information

1. Reports from daily automated stations (SM)
    a. Will need to establish data pathway for these data
    b. Coordinate through RFCs.
2. Color coded dots
    a. Based on percent of average for selected date
3. Date selectable (default = current)
4. Clicking on point
    a. Water year plot
    b. Context
        i. Average (if available)

7. Point Level Streamflow Information

Water Year Plot

1. Covers full water year (October 1 through September 30)
    a. Labeled x-axis
2. Primary display elements are forecast WY streamflow volume for each day starting on October 1.
    a. Combination of observed and forecast after October 1.
3. Primary display element (forecast volume) options
    a. Box and whiskers
    b. 10%, 30%, 50%, 70%, and 90%,exceedance probability volumes
    c. Max/Min
4. Secondary display element options
    a. Daily observed volume to date
    b. Accumulated observed volume to date
5. Context options
    a. Average WY volume
    b. Median WY volume
    c. Max and Min WY volume
6. Date
    a. User selectable
    b. Default is current day.
7. Small table at the bottom provides the key data for the date selected
    a. WY forecast (10%, 30%, 50%, 70%, and 90%,exceedance probability volumes)
    b. Max/Min
    c. Observed to date

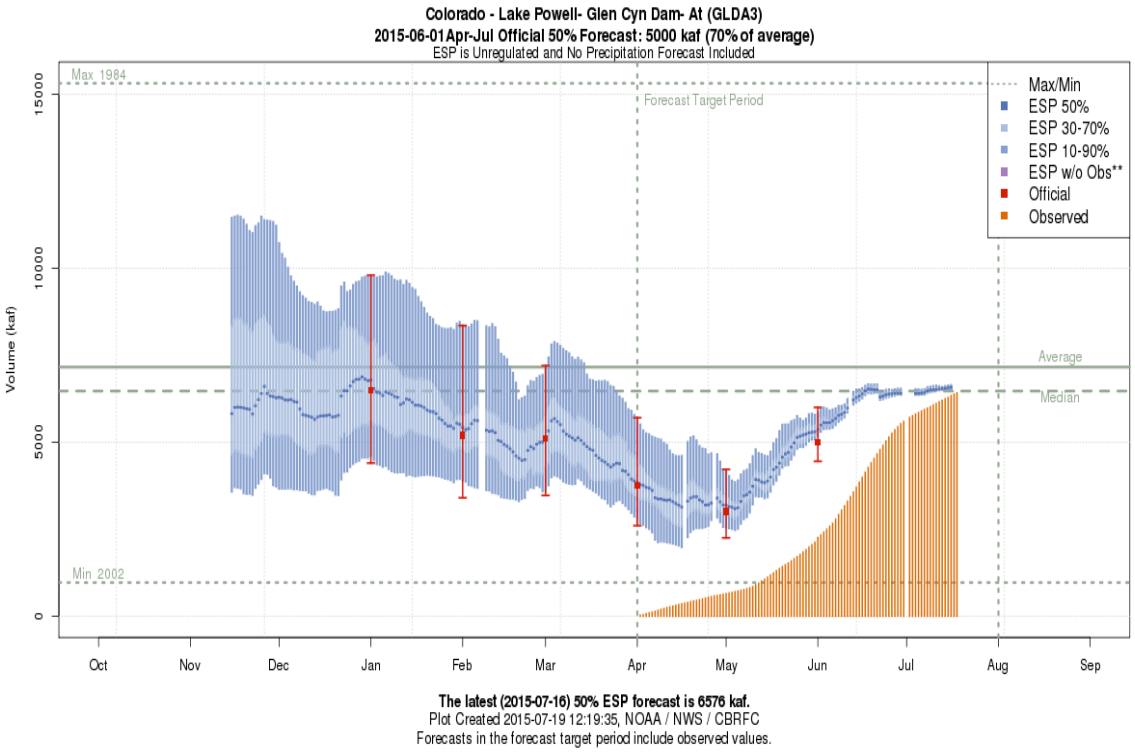

Figure 7: Example of CBRFC water supply evolution plot showing daily forecast exceedance probabilities (blue), accumulated daily volume (orange), and official forecasts (red) over a water year (www.cbrfc.noaa.gov).

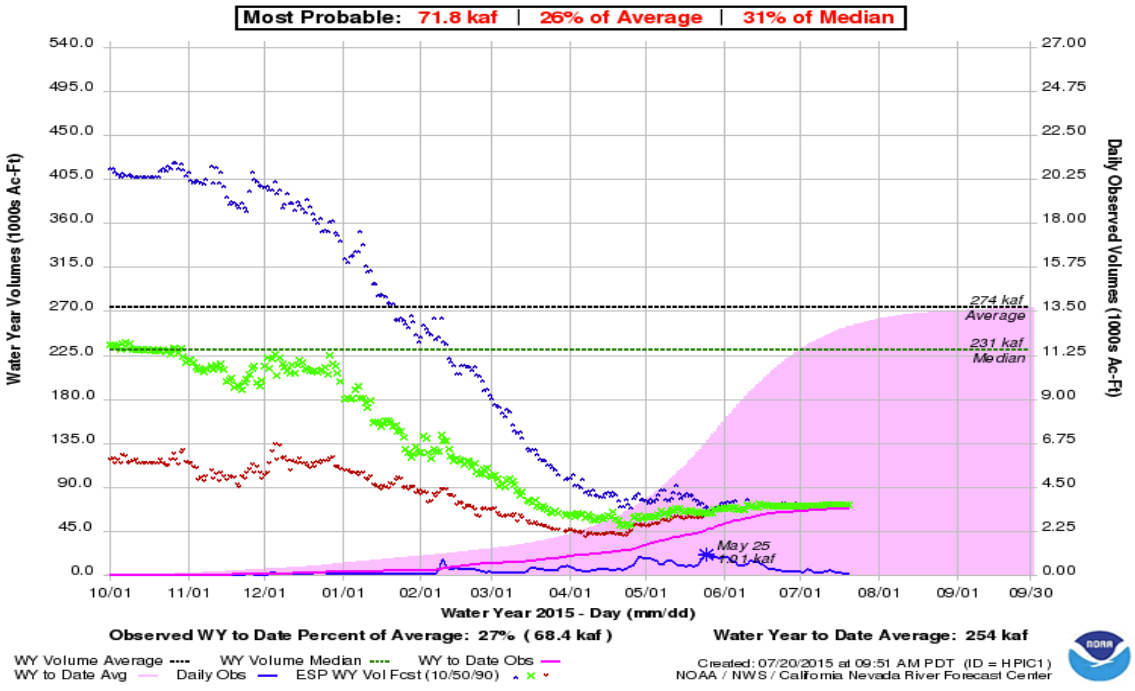

Figure 8: Example of CNRFC water supply evolution plot showing 10% (blue), 50% (green) and 90% (red) daily forecast exceedance probabilities, accumulated daily

volume (pink), daily flow observations (blue), and WY to date average (pink) over a water year (www.cnrfc.noaa.gov).

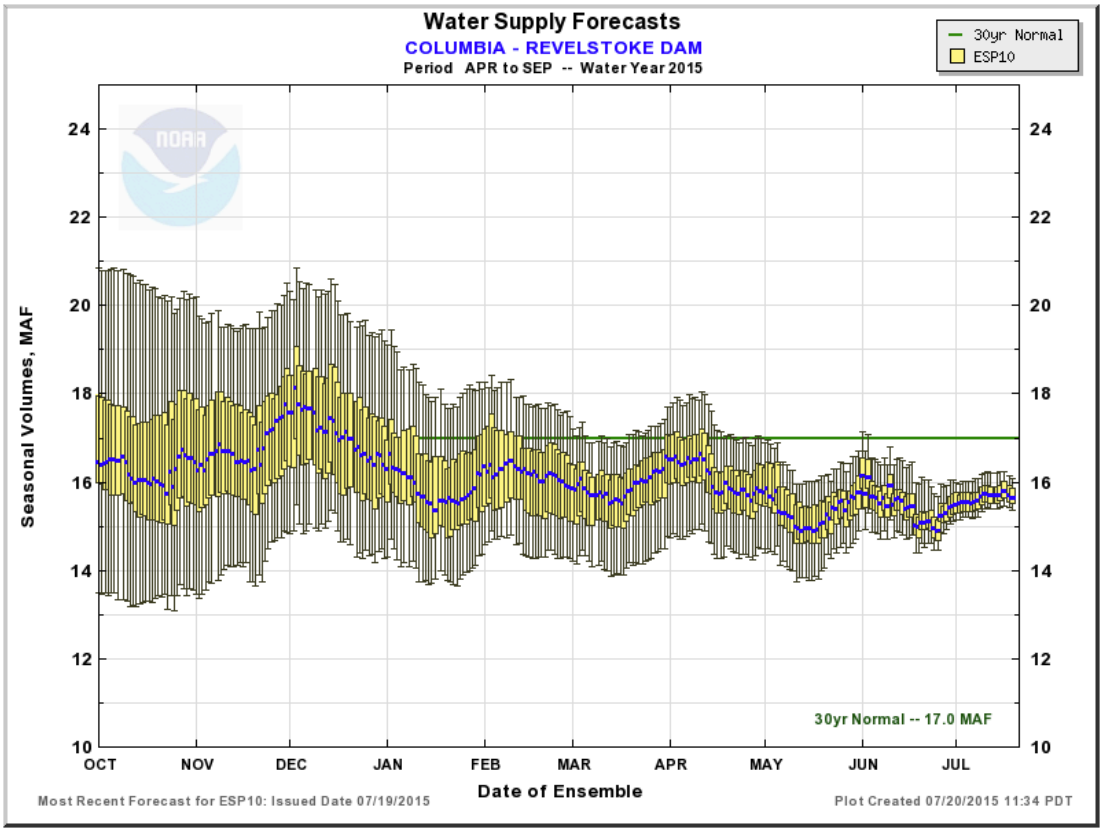

Figure 9: Example of NWRFC water supply evolution plot showing daily forecast exceedance probabilities (90%, 70%, 50%, 30%, 10%) and maximum and minimum over a water year (nwrfc.noaa.gov).

User Selectable Plot

1. Similar to WY plot except the user can select any start date and end date
    a. Start date >= beginning of current water year
    b. End date <= 365 days into the future
    c. Start date < End date
    d. Can include observed period
        i. Or even all observed
2. Primary display elements are forecast period streamflow volume for each day starting on October 1.
    a. Combination of observed and forecast if Start date is > current date.
3. Primary display element (forecast volume) options
    a. Box and whiskers
    b. 10%, 30%, 50%, 70%, or 90% exceedance probability volume
    c. Max/Min

4. Secondary display element options
    a. Daily observed volume to date if Start date is in the past.
    b. Accumulated observed volume to date if Start date is in the past.
5. Context options
    a. Average period volume
    b. Median period volume
    c. Max and Min period volume
6. Date
    a. User selectable
    b. Default is current day.
7. Small table at the bottom provides the key data for the date selected
    a. Period forecast (90%, 70%, 50%, 30%, 10% exceedance probabilities)
    b. Observed to date

Use of this option for periods not pre-selected for analysis by the supporting RFC will require substantial analysis and the results may take several minutes to generate from resident forecast information. The user will be advised that they are requesting a non-standard period and asked if they wish to proceed with the understanding this request will take time to process. A record on non-standard period requests will be kept per forecast location in order to more efficiently manage the list of pre-selected periods managed by the supporting RFC. Data from non-standard period user requests will be stored in the system for 24 hours.

Monthly Plot

1. Standard x-y plot
    a. X-axis is time in months beginning with Oct 1 of current WY and extending to the last full month 365 days in the future.
    b. Y-axis is monthly volume
2. Data plotted as box and whiskers
3. Context options
    a. Average (default)
    b. Median
    c. Selected (analog) years
        i. Single or multiple

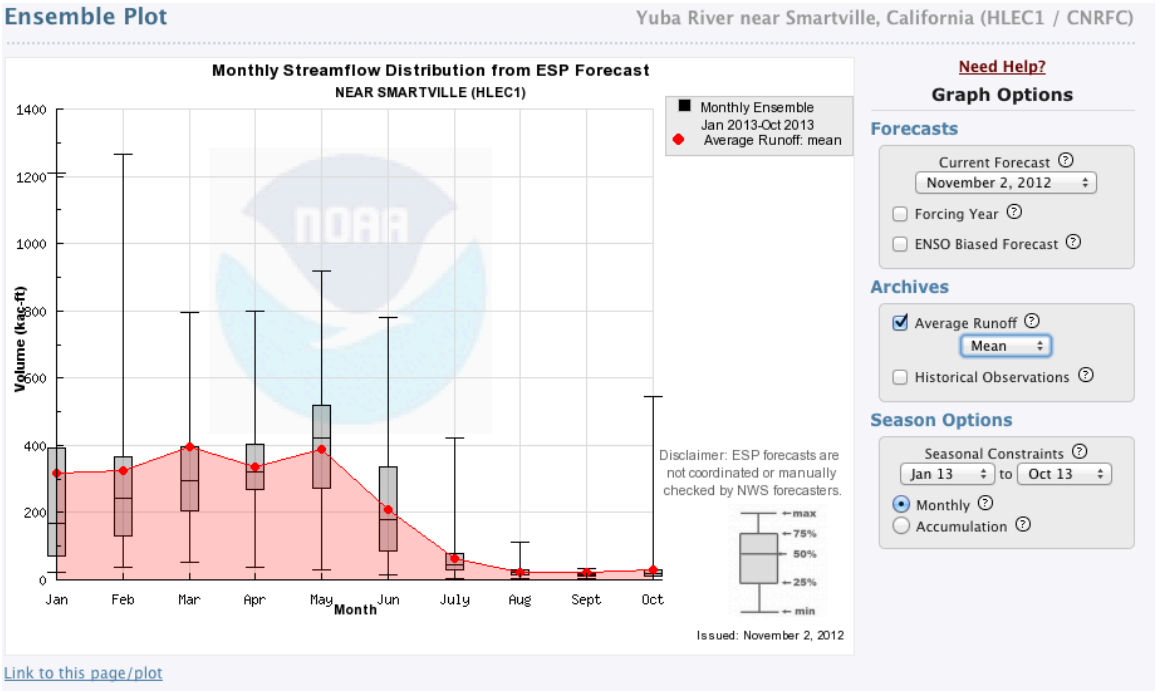

Figure 10: Example of monthly plot showing average runoff.

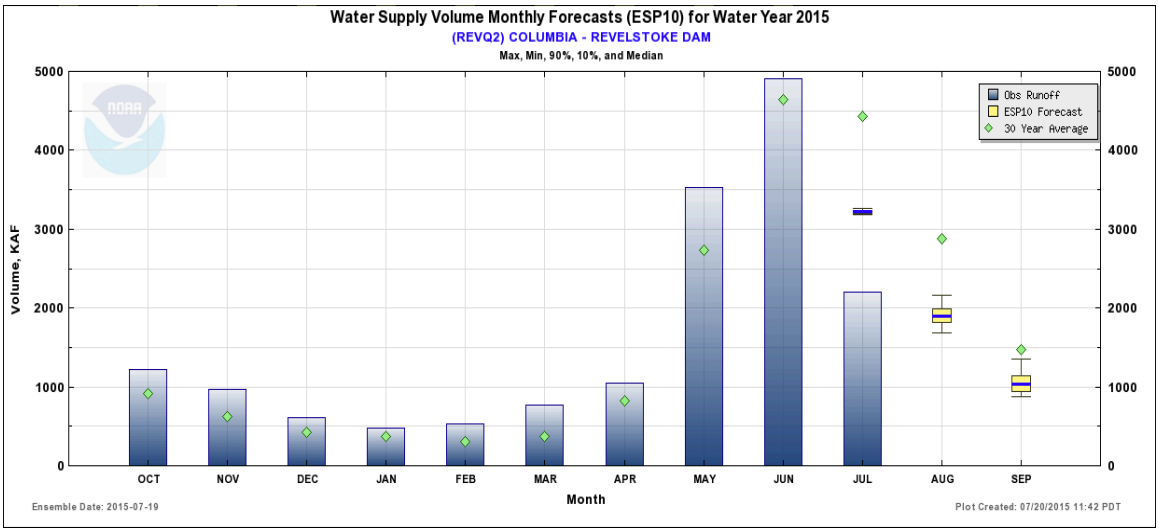

Figure 11: Example of monthly volume forecasts, monthly observed volumes, and average monthly volume over a water year (nwrfc.noaa.gov).

Forecast Ranking

1. Table that compares current forecast with those of the past
    a. Rank
    b. Year
    c. Volume
    d. Percent of Normal

e. Exceedance probability
f. Other attributes (precipitation, ENSO, snow, other contextual info)?

2. Ranking graphic
3. User selectable period
    a. Default is WY
    b. Standard periods
    c. Monthly

Forecast Ranking Table — Yuba River near Smartville, California (HLEC1 / CNRFC)

Flow Forecast in context with similar Historic Years (Apr – Jul, 1900 – 2012) [Apr-July] [Change Period]

Need Help?

Rank	Year	Flow (kaf)	Percent Mean
1	1952	2,424.09	116.5
2	1995	2,174.03	104.5
3	1983	2,131.61	102.5
4	1938	2,075.20	99.8
5	1922	2,044.30	98.3
6	1906	2,032.90	97.7
7	2011	2,017.03	97.0
8	1911	1,963.50	94.4
9	1907	1,953.90	93.9
10	1982	1,926.84	92.6
11	1958	1,913.70	92.0
12	2006	1,840.12	88.5
13	1998	1,815.75	87.3
14	1967	1,735.80	83.5
15	1969	1,721.00	82.7
16	1904	1,708.40	82.1
17	1915	1,652.10	79.4
18	1942	1,623.60	78.1
19	1916	1,573.50	75.6
20	1927	1,559.20	75.0
21	1914	1,553.70	74.7
22	1935	1,547.20	74.4
23	1917	1,532.20	73.7
24	1909	1,480.80	71.2
25	1996	1,457.09	70.1
26	2005	1,445.43	69.5
27	1941	1,434.55	69.0
28	1963	1,426.08	68.6
29	1975	1,412.45	67.9
30	1948	1,406.07	67.6
31	1993	1,391.72	66.9
32	1974	1,385.50	66.6
33	1971	1,380.00	66.3
34	1902	1,364.20	65.6
35	1901	1,346.50	64.7

Figure 12: Example ranking table

8. Meta / Background Data (provided by RFCs)

1. Streamflow Forecast Points
    a. Location (lat/lng)
    b. Upstream /Downstream connectivity?
    c. Responsible RFC/Contact Information
    d. Standard analysis period(s)
        i. Default is WY
        ii. Whole months
        iii. As many as required by customers (e.g. Apr-Jul, Jan-Sept, etc.)
    e. Observed data attribution
        i. Estimated, observed, simulated, etc.
        ii. Historical and real-time observations (unreg/adjusted)
        iii. Daily and monthly time step
        iv. Natural flow adjustments
    f. Ensemble attribution
        i. forcing type
        ii. post-processing type
        iii. special notes or considerations
    g. Daily/Monthly historical time series data
        i. Available period of record
        ii. Simulated
        iii. "observed"

2. Reservoirs
    a. Links to operator website
    b. Location (lat/lng)
    c. Monthly 1st of month storage averages (KAF)
    d. Capacity (KAF)
    e. Confidentiality information
    f. Daily/monthly historical storage data (KAF)
        i. As available

9. RFC Forecasts and Information Provided Daily, 365 days/year

1. Ensemble forecasts for each identified location.
    a. 365 day minimum duration.
    b. Minimum of 25 ensemble members
    c. 12Z time basis
    d. Reflect unregulated (natural) streamflow
2. "observed" daily volume for the same locations as (1).
    a. 24 hrs ending at 12Z
    b. Can be computed or simulated
    c. Provided daily
    d. Provisions for providing revised values back to the beginning of the water year.
3. "observed" reservoir storage
    a. Daily (local midnight or 12Z)
    b. Provisions for providing revised values back to the beginning of the water year.
4. Precipitation and Temperature Grids?

10. Verification Information

In the initial implementation, the verification information will be quite limited. Once hindcasts are developed under the Hydrologic Ensemble Forecast Service (HEFS), the verification information will expand dramatically.

Website design is to allow for ready inclusion of verification information generated through HEFS and other existing data and methodologies.

1. Water year forecast plots that show individual daily forecasts with developing observations will provide anecdotal validation. Plots will be archived as each year is completed.
    a. Allowance for RFCs to provide archived forecast data in order to generate additional historical WY plots.
2. Monthly plots
    a. From archive of available forecast information.
    b. Similar to monthly plot for individual point.

11. Climate Forecasts

Climate forecasts (CFSv2) will be made available both in their native resolutions as well as at the watershed scale. Initially climate forecasts will be clipped to watersheds of interest together with verification information (linking to the temperature and precipitation data).

1. Map
    a. Current forecasts
    b. Past climate forecasts
    c. Ability to select watersheds
2. Time series
    a. Precipitation and Temperature at the watershed scale
        i. Observed
        ii. Forecast
3. Verification
4. Forecast discussion

12. Global Attributes

1. Permalink capabilities
2. Mobile device usability
3. Capability to view past map based information
    a. Date selectable (within current WY)
4. Links back to original data/product provider