CBRFC Streamflow Forecast Products & Challenges
**CBRFC Streamflow Forecast Product Overview (Plots)**

- **10-day Streamflow Forecast**
  - Deterministic
  - 1-hr Streamflow (cfs/stage)
  - Daily
  - Regulated
  - 5-day QPF (zero for days 6-10)
  - 10-day QTF

- **Water Supply Forecast (ESP)**
  - Probabilistic
  - April - July Volume (kaf)
  - Monthly (Jan1-Jun1)
  - Unregulated
  - 5-day or Climo QPF (Climo beyond)
  - 10-day QTF (Climo beyond)

- **Peak Flow Forecast (ESP)**
  - Probabilistic
  - Peak Mean Daily Apr-Jul Streamflow (cfs)
  - 2x / Month (Mar1-May1)
  - Regulated
  - 5-day or Climo QPF (Climo beyond)
  - 10-day QTF (Climo beyond)
CBRFC Streamflow Forecast Product Overview (Maps)

10-day Streamflow Forecast
~500 river points
~90 reservoirs
~185 with Flood Thresholds

Water Supply Forecast (ESP)
~150 points
%Volume 1981-2010

Peak Flow Forecast
~60 points
%Exceeding Flood Threshold
CBRFC 10-day Streamflow Forecasting

- **Model States**
  - soil moisture
  - snow
- **Precipitation Typing**
- **Assumptions**
  - reservoir operations
  - diversions
  - unmeasured depletions
  - irrigation returns

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### Observed vs. Forecast Chart

**Observed** vs **Forecast**

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### Table: Modifiers

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<thead>
<tr>
<th>Mod type</th>
<th>Name</th>
<th>Summary</th>
<th>Locations</th>
<th>Start</th>
<th>End</th>
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</table>
- Releases are held constant at current outflow unless we’ve been notified of planned changes
- Let reservoir fill & spill? -> try to follow historical patterns and/or reach out to reservoir operators
● Unmeasured Depletions & Return Flow
  ○ Evaluated / estimated during calibration process --> apply CONS-USE model
    ■ 1981 - 2015 model calibration period
    ■ Replace CONS-USE model with observed diversion data as it becomes available
      ● Return flow uncertainty

● Measured Diversions
  ○ Provide clear picture of current conditions
  ○ How much / when will water be diverted at these locations over the next 10 days?
    ■ Diversions generally held constant at current values; exceptions:
      ● We’ve been notified of a change in the future diversion
      ● Known minimum flow requirements / max diversion capacity?
      ● Use best guess; understand uncertainty involved
        ○ Developing historical data relationships to improve estimated future diversions
Current hydrologic model states:
River / Res. Levels
Soil Moisture
Snowpack

- Start with current conditions of streamflow, soil moisture, snowpack
- Apply precipitation and temperature from each historical year used in model calibration (1981-2015)
- A forecast is generated for each of the years (1981-2015)
  - This creates 35 possible future streamflow patterns
  - Each year is given a 1/35 chance of occurring
- Near normal Feb/Mar temperatures
- APR1: Dry March; large AR precip event in April forecast for April 6-8
- MAY1: Wet April; large AR precip event in forecast for May 2-4
- JUN1: Dry May; but adding some mid/high elevation SWE in model
  - Most SNOTEL SWE = 0 -> satellite data; trust calibration
- Very dry June and July
CBRFC Water Supply Forecasting

- **Forecasting unregulated volume**
  - reservoirs and diversions do not exist; all water passed downstream
  - CONS-USE operation (for unmeasured depletions) still takes water out of system (this is part of what keeps these 'unreg' forecasts from being 'natural')

- **Verification** is a path to improvement, helps us know where to focus efforts; stats available on web page

- **Primary sources of error** in the forecast:
  - Future weather (largest uncertainty and impact) -> assume climatology beyond 5 days
    - Extreme future weather results in largest forecast errors
  - Data Issues (impact model states such as snowpack)
    - Bad data quality, non-functioning gages, network outages
    - Data availability, network density
  - Model calibration limitations
    - Quality / availability of historical data
    - Unknown / ungaged Diversions
    - Changes in the river basin
Plot Options:

- Record Year Data
- Yearly Peaks
- Flood Flow
CBRFC Peak Flow Forecasting

Peak Flow forecasts (from regulated ESP):

- **Probabilistic**: likelihood of exceeding bankfull / flood thresholds

- Accounts for reservoirs / diversions
  - reservoir releases determined using predefined 'rules' based on either time of year or elevation (allows for spill)
  - diversions: each trace uses the observed diversion from that year

- Do not provide a specific date of the peak forecast
  - provide average time period of the peak

- Instantaneous peak flow forecasts available at locations with strong daily correlation & historical data

- **Challenges**:
  - timing -> temperature -> rain on snow? -> snowpack elevation -> multiple peaks possible?
CBRFC Peak Flow Forecasting

Proposed Changes

Snowmelt Peak Forecasts

- Current suite of products
- Minimal proposed changes
  - Daily updates at a subset of points
  - Graphic changes to incorporate more frequent updates; more interactive
  - Similar to water supply evolution plots
- Peak Flow Archive updated

Flood Potential

- New product
- Provide better information and guidance for flooding potential
- Updated daily and throughout entire melt season
- May help with late season challenges associated with long lead peak flow forecasts
CBRFC Peak Flow Forecasting: Flood Potential “Mock Up”

Color Coded Flood Potential Indicator Map

Flood Potential Evolution Plot

Flood Potential Table

<table>
<thead>
<tr>
<th>Exceedance Probability</th>
<th>Stage (feet)</th>
<th>Discharge (CFS)</th>
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</thead>
<tbody>
<tr>
<td>90%</td>
<td>6.0</td>
<td>3300</td>
</tr>
<tr>
<td>75%</td>
<td>6.5</td>
<td>4000</td>
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<td>50%</td>
<td>7.5</td>
<td>6250</td>
</tr>
<tr>
<td>25%</td>
<td>8.0</td>
<td>7500</td>
</tr>
<tr>
<td>10%</td>
<td>8.5</td>
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</tr>
</tbody>
</table>

ELK RIVER NEAR MILNER
Forecast Issued: 2019-05-10
Forecast Period: May 10 to July 31
Flood Stage: 7.5'  Flood Flow: 6220 cfs

Selecting a site -> new page with more details
August to October - Verification & Model Improvements

• Verification of forecasts
  - How did we do?
  - Determine sources of error
  - Available on our website

• Model Improvements
  - Address errors identified in verification
  - Incorporate new information
  - Stakeholder requests
Historical Water Supply Verification

Historical Model Error 1981-2010

How good can you expect the forecasts to be
- Available for each month Jan - Jun
- Generally improves through the spring

Where we do better:
- Headwaters
- Primarily snow melt basins
- Little/no diversions or historical and real time diversion data available

Where we do worse:
- Lower elevations (rain or early melt)
- Downstream of diversions / irrigation when little is known and/or no data
Yearly Water Supply Verification

April 2018 forecasts were generally more accurate than historical April forecasts.

- Red: %error greater than historical
- Blue: %error less than historical
- Black: %error similar to historical

% Error Difference
- No Data
- < -45
- -45 - -35
- -35 - -25
- -25 - -15
- -15 - -5
- -5 - 5
- 5 - 15
- 15 - 25
- 25 - 35
- >35
Questions & Quick Web Tour