Forecast Challenges for the Colorado Basin River Forecast Center

John Lhotak, Development and Operations Hydrologist
Improving Sub-Seasonal to Seasonal (S2S) Workshop
May 16th, 2018
National Weather Service River Forecast Centers

- Provide streamflow forecasts for the next few hours to seasons
- 10 day forecasts for flood warnings, recreational use, etc..
- Develop probabilistic forecast of volume of water expected during the snow melt season for reservoir operations and planning - Water Supply Forecasts
# Streamflow forecasts - Routine & Flood

## River Point Condition
- **W** - Waterfall
- **G** - Gas filled
- **B** - Bankfull
- **S** - Flood stage
- **T** - Trend (<3 days)

## River Point Types
- **D** - Data
- **F** - Forecast
- **R** - Reservoir

### NWS ID: River Point Location

<table>
<thead>
<tr>
<th>NWS ID</th>
<th>River</th>
<th>Location</th>
<th>Forecast Condition</th>
<th>Point Type</th>
<th>Observed Date (Day, Time)</th>
<th>Latest Flow</th>
<th>Latest Stage</th>
<th>Flood Stage</th>
<th>Bankfull Stage</th>
<th>HMC</th>
<th>State</th>
<th>HSA</th>
<th>Elevation</th>
<th>Forecast Group</th>
<th>Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LA-Bx 2</td>
<td>Green</td>
<td>1</td>
<td>18, 12:00</td>
<td>8476</td>
<td>7.8</td>
<td>9</td>
<td>8</td>
<td>14040101</td>
<td>WY</td>
<td>RW</td>
<td>6520</td>
<td>GREEEN</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>MA-Bx 3</td>
<td>Acroc</td>
<td>1</td>
<td>18, 07:00</td>
<td>0</td>
<td>0.4</td>
<td>0</td>
<td>10</td>
<td>15060106</td>
<td>AZ</td>
<td>PSR</td>
<td>1230</td>
<td>AGUAFRIA</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>MA-Bx 4</td>
<td>Acroc</td>
<td>1</td>
<td>18, 07:00</td>
<td>0</td>
<td>0.4</td>
<td>0</td>
<td>14</td>
<td>15060106</td>
<td>AZ</td>
<td>PSR</td>
<td>1225</td>
<td>AGUAFRIA</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>MA-Bx 5</td>
<td>Acroc</td>
<td>1</td>
<td>18, 07:00</td>
<td>0</td>
<td>0.3</td>
<td>0</td>
<td>15.5</td>
<td>15070102</td>
<td>AZ</td>
<td>PSR</td>
<td>1220</td>
<td>AGUAFRIA</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>MA-Bx 6</td>
<td>Agua Caliente Wash</td>
<td>1</td>
<td>18, 22:00</td>
<td>0</td>
<td>0.8</td>
<td>4</td>
<td>10</td>
<td>15050102</td>
<td>AZ</td>
<td>TWC</td>
<td>2588</td>
<td>SANCTURZ</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>MA-Bx 7</td>
<td>Agua Frias</td>
<td>1</td>
<td>18, 12:00</td>
<td>0</td>
<td>0.78</td>
<td>10</td>
<td>15.5</td>
<td>15070102</td>
<td>AZ</td>
<td>FGZ</td>
<td>4490</td>
<td>AGUAFRIA</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>MA-Bx 8</td>
<td>Agua Frias</td>
<td>1</td>
<td>18, 11:00</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>15.1</td>
<td>15070102</td>
<td>AZ</td>
<td>FGZ</td>
<td>3434</td>
<td>AGUAFRIA</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>MA-Bx 9</td>
<td>Agua Frias</td>
<td>1</td>
<td>18, 11:00</td>
<td>0</td>
<td>2.5</td>
<td>16</td>
<td>15</td>
<td>15070102</td>
<td>AZ</td>
<td>PSR</td>
<td>1800</td>
<td>AGUAFRIA</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>MA-Bx 10</td>
<td>Agua Frias</td>
<td>1</td>
<td>18, 07:00</td>
<td>0</td>
<td>1.3</td>
<td>8</td>
<td>15</td>
<td>15070102</td>
<td>AZ</td>
<td>PSR</td>
<td>970</td>
<td>AGUAFRIA</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>MA-Bx 11</td>
<td>Agua Frias</td>
<td>1</td>
<td>18, 07:00</td>
<td>0</td>
<td>1.8</td>
<td>14</td>
<td>15</td>
<td>15070102</td>
<td>AZ</td>
<td>PSR</td>
<td>1115</td>
<td>AGUAFRIA</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>MA-Bx 12</td>
<td>Abar Wash</td>
<td>1</td>
<td>18, 08:00</td>
<td>0</td>
<td>1.4</td>
<td>14</td>
<td>15</td>
<td>15060304</td>
<td>AZ</td>
<td>TWC</td>
<td>2975</td>
<td>SANTURZ</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>MA-Bx 13</td>
<td>American Fork</td>
<td>1</td>
<td>18, 11:00</td>
<td>49</td>
<td>6.4</td>
<td>8.2</td>
<td>16020201</td>
<td>UT</td>
<td>SLIC</td>
<td>5850</td>
<td>PROVO</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>MA-Bx 14</td>
<td>Animas</td>
<td>1</td>
<td>18, 11:00</td>
<td>851</td>
<td>5.5</td>
<td>10</td>
<td>9</td>
<td>14000104</td>
<td>NM</td>
<td>ARBQ</td>
<td>5280</td>
<td>SANJUAN</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>MA-Bx 15</td>
<td>Animas</td>
<td>1</td>
<td>18, 12:00</td>
<td>913</td>
<td>6.4</td>
<td>10.5</td>
<td>9.5</td>
<td>14000104</td>
<td>CO</td>
<td>ARBQ</td>
<td>5860</td>
<td>SANJUAN</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>MA-Bx 16</td>
<td>Animas</td>
<td>1</td>
<td>18, 12:00</td>
<td>1270</td>
<td>4.6</td>
<td>10</td>
<td>14</td>
<td>14000104</td>
<td>CO</td>
<td>GJTR</td>
<td>6437</td>
<td>SANJUAN</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>MA-Bx 17</td>
<td>Animas</td>
<td>1</td>
<td>18, 11:00</td>
<td>1250</td>
<td>3.6</td>
<td>8</td>
<td>7</td>
<td>14000104</td>
<td>CO</td>
<td>GJTR</td>
<td>6522</td>
<td>SANJUAN</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>MA-Bx 18</td>
<td>Anthracite Clk</td>
<td>1</td>
<td>18, 11:00</td>
<td>789</td>
<td>3</td>
<td>4</td>
<td>14</td>
<td>20000404</td>
<td>CO</td>
<td>GJTR</td>
<td>6280</td>
<td>GUN</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>MA-Bx 19</td>
<td>Araxia Clk</td>
<td>1</td>
<td>18, 12:00</td>
<td>2</td>
<td>0.20</td>
<td>12.8</td>
<td>10.8</td>
<td>15020203</td>
<td>AZ</td>
<td>TWC</td>
<td>2345</td>
<td>SANEDRO</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>MA-Bx 20</td>
<td>Arxivas</td>
<td>1</td>
<td>18, 12:00</td>
<td>4</td>
<td>0.30</td>
<td>12.0</td>
<td>10.8</td>
<td>15030304</td>
<td>AZ</td>
<td>TWC</td>
<td>3580</td>
<td>SANCTURZ</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>MA-Bx 21</td>
<td>Ashcroft Clk</td>
<td>1</td>
<td>18, 12:00</td>
<td>0</td>
<td>0</td>
<td>18.2</td>
<td>14000002</td>
<td>UT</td>
<td>GJTR</td>
<td>4740</td>
<td>DUCHYR</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>441</td>
<td>MA-Bx 22</td>
<td>Short Creek</td>
<td>1</td>
<td>18, 12:00</td>
<td>0</td>
<td>0</td>
<td>18.2</td>
<td>14000002</td>
<td>UT</td>
<td>GJTR</td>
<td>4740</td>
<td>DUCHYR</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>442</td>
<td>MA-Bx 23</td>
<td>Silver Clk</td>
<td>1</td>
<td>18, 12:00</td>
<td>0</td>
<td>0</td>
<td>18.2</td>
<td>14000002</td>
<td>UT</td>
<td>GJTR</td>
<td>4740</td>
<td>DUCHYR</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>443</td>
<td>MA-Bx 24</td>
<td>South Fork Clk</td>
<td>1</td>
<td>18, 11:00</td>
<td>6</td>
<td>0</td>
<td>18.2</td>
<td>14000003</td>
<td>UT</td>
<td>SLIC</td>
<td>6201</td>
<td>DUCHYR</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>444</td>
<td>MA-Bx 25</td>
<td>Upper Enterprise R</td>
<td>1</td>
<td>18, 12:00</td>
<td>0</td>
<td>0</td>
<td>18.2</td>
<td>16030006</td>
<td>UT</td>
<td>SLIC</td>
<td>5691</td>
<td>SEY_H</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>445</td>
<td>MA-Bx 26</td>
<td>Weber</td>
<td>1</td>
<td>18, 12:00</td>
<td>0</td>
<td>0</td>
<td>18.2</td>
<td>16020101</td>
<td>UT</td>
<td>SLIC</td>
<td>6037</td>
<td>WEBER</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**National Oceanic and Atmospheric Administration's National Weather Service**

**Colorado Basin River Forecast Center**

Salt Lake City, Utah
Streamflow forecasts - Hydrographs

**GREEN - LA BARGE, NR (LABW4)**

- **Info:** Station, Rating Table, Critical Stages, Yearly Peaks, Daily Stats, Recent Verification, Seasonal Verification, USGS data

- **Observed**
- **Forecast (05/15 15:00)**
- **Outlook (increasing uncertainty)**
- **Bankfull 8.00**
- **Flood 9.0**

- **Historical Exceedance Probability (USGS):** 90-70% 75-50% 50-25% 25-10%

- **Observations:** QF611420, Simulated QH61222, Forecasted QH61222 F (USGS 1500)

- **Hydrograph Options:**
  - Critical Stages
  - Yearly Peaks
  - Historical Flow
  - Peak Flood Probability

- **Graphs:**
  - Precipitation
  - Temperature
  - Snowfall
  - Soil Moisture
  - Hydrograph

- **Tabular Data:**
  - Precipitation
  - Temperature
  - Snowfall
  - Soil Moisture

- **Hourly Forecast Flow CSV**
- **Daily Average Forecast Flow CSV**

---

National Oceanic and Atmospheric Administration’s National Weather Service

Salt Lake City, Utah
Water Supply Forecasts
CBRFC Role in Colorado River Management

- CBRFC’s water supply forecasts drive Reclamation’s operational planning model (24-Month Study)
  - Determine operations of Lakes Powell and Mead
  - Determine shortage declarations
  - Direct impact to State, municipal, agricultural, water and energy managers and Mexico
Providing Decision Support Services

- **Resource Management**
  - Adaptive Management Program (Peak Flow Forecasts)
  - Day to day decisions, especially during times of active weather

- **Technical Support and Communication**
  - Meeting participation
  - Custom products and outreach
Developing a model

Each river point in the model is called a segment.

There are 188 river segments and 44 reservoir segments above Lake Powell.

There are 585 segments in the CBRFC area.
Data and creating a forecast
What Affects Forecast Quality - Data

- Undetected errors in historical/current observations
- Data density/Gage network distribution
  - SNOTEL Network
    - Since it became available, has improved accuracy of forecasts
    - In some areas the gage density is better
- Unmeasured Depletions
- Forecasted Weather Conditions
What Affects Forecast Quality - Model

- The model itself
  - Calibration Error (bias)
  - Initial Conditions - Seasonal volumes are controlled by SWE and soil moisture
    - Do we have SWE right?
    - Mischaracterizing rain vs. snow events
    - Missed precipitation event
    - Do we have the soil moisture right?
    - Have we captured baseflow conditions accurately?
    - Has a storm event impacted soil state conditions?
What Affects Forecast Quality - Weather Forecast

- Uncertainty in short term weather
  - Precipitation
    - accuracy
    - distribution in space & time
  - Spring temperatures affect melt/runoff pattern
  - Extreme weather events
What Affects Forecast Quality - Seasonal Forecast

- **January 1st Forecast** -
  - What we know:
    - ~40% of snowpack accumulation
  - What we DON’T know:
    - Jan-May weather (4 months)
    - ~60% of snowpack accumulation

- **April 1st Forecast**
  - What we KNOW:
    - ~96% of snowpack accumulation
    - Dec-March weather
  - What we DON’T know:
    - April-May weather (2 months)
    - Snowmelt pattern
Seasonal Forecast - Using CFSv2
Seasonal Forecast - CFSv2 Temperature MAX Skill

Green: Warren Bridge  Elk: Milner  East: Almont  Animas: Durango

Lower

Mid

Upper

Scale
Seasonal Forecast - CFSv2 Precipitation Skill
Adding Seasonal Forecast Thoughts

- Little, if any, skill added with GEFS/CFS forecast
  - not unexpected given not much skill in CFSv2
  - need to develop better CFSv2 forecast smoothing
- How does CFS forecast fair when looking at ENSO signal?
  - limited sample size so it will be difficult to draw any conclusions from
- In general more skillful S2S forecasts are needed to fully utilize in HEFS framework for water supply forecasting.
Questions?

John Lhotak 801-524-5130 ext 323  john.lhotak@noaa.gov

www.cbrfc.noaa.gov