A LOOK BACK AT CO-PRODUCTION

The Joint Front Range CC Vulnerability Study

Laurna Kaatz, Climate Adaptation Program Director, Denver Water
## Participants

<table>
<thead>
<tr>
<th>Water Interests</th>
<th>Support Agencies</th>
<th>Additional Interest</th>
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<tbody>
<tr>
<td>Aurora Water</td>
<td>Water Research Foundation</td>
<td>Cheyenne Board of Public Utilities, WY</td>
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<tr>
<td>City of Boulder</td>
<td>Western Water Assessment</td>
<td>City of Longmont</td>
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<tr>
<td>Colorado Springs Utilities</td>
<td>Riverside Technology, inc.</td>
<td>City of Westminster</td>
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<tr>
<td>Denver Water</td>
<td>NCAR</td>
<td>Others Welcome</td>
</tr>
<tr>
<td>City of Fort Collins</td>
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<tr>
<td>Northern Water</td>
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<tr>
<td>Colorado Water Conservation Board</td>
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JFRCCVS

- Classic top down
- CMIP3, BCSD, “delta” approach
- 2040 and 2070 versus 1950-1999
- 4 Static T and P offsets and 10 GCM based T/P deltas
- 2 hydrology models: WEAP, Sac/SMA
- Lots of data, lots of meetings, lots of education
Educational Sessions

- **2007**
  - WEAP 101, Sac/SMA 101 – David Yates, Riverside

- **2008**
  - Methodology Overview and Kick-off meeting – Laurna Kaatz
  - Global Climate Modeling 101 – Joe Barsugli
  - Long Term Precipitation Trends – Nolan Doesken
  - Temperature Trends and Water Management – Klaus Wolter
  - Riverside’s C2D2S2 climate interface with NOAA - Riverside

- **2009**
  - The complexity of the Climate System and Human Roles – Roger Pielke Sr.
  - The impacts of climate change on snowpack in the Colorado headwaters – David Yates
  - The Colorado River Water Availability Study – Ben Harding
  - Statistical Downscaling 101 – Levi Brekke
  - Adapting to Climate Change – Jess Lowrey
  - Incorporating Climate Uncertainty into Planning – Jennifer Daw
Benefits of a Regional Approach

• **Scale:** Projections are coarse and cover watersheds
• **Communication:** Cohesively communicate with customers and the media
• **Safety:** Provided political coverage
• **Coordination:** Coordinate with other investigations and participants
• **Collaboration:** Continue collaboration on education and other investigations
• **Resources:** Pool finances, staff, and expert resources
• **Attention:** Everyone wanted to work with us
Science will solve this problem

Climate Model Projections for Northcentral Colorado

Precipitation Change (%)

Temperature Change (Fahrenheit)

Science can only take us so far.
Traditional Predict then Plan

Present  Future

2002: Unprecedented Simultaneous Natural Disasters

Precipitation Change (%) vs. Temperature Change (Fahrenheit)

2002: Unprecedented Simultaneous Natural Disasters
5° F Warming Means

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Reduced Supply</td>
<td>22%</td>
</tr>
<tr>
<td>Increased Demand</td>
<td>7%</td>
</tr>
<tr>
<td>Additional precipitation needed to offset warming</td>
<td>10%</td>
</tr>
</tbody>
</table>

- New planning techniques - multiple futures
- Understanding - uncertainty and science for applications
- Adaptive planning - identifying and preserving options
- Mainstreaming new culture into organization-wide decisions

The Cone of Uncertainty

Near-term

Today

Decision Points
Important outcomes

• Informed DWs philosophy on climate adaptation and planning
• Informed DWs work with WUCA
• Climate change in CO report
• CRWAS I, II – State climate modeling of CO river
• State bringing climate change and scenario planning into supply and demand analysis – SWSI
• FRCCG – quarterly meetings still!
• Endless collaborations with NCAR, WWA, RTi
CO-PRODUCTION TO INFORM DROUGHT ADAPTATION

The Shoshone Relaxation Agreement

David Yates – NCAR, RAL Hydrometeorology Applications Program
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Laurna Kaatz – Denver Water, Climate Scientist
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Rob Wilby, Loughborough University
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Denver Water’s Supply & Use

So roughly 30%-40% of Denver’s supply from West Slope
Prior Appropriation water law
1st in time = 1st in right
Shoshone Hydroelectric Plant – Senior Water Rights:
1250 CFS (1902);
158 CFS (1929)
(Xcel Energy)

Commands the entire flow of the Colorado River at that point for much of the year.

Supplies about 0.25% of Xcel’s energy.
Not Quite so Simple.. The Green Mountain Protocool (28 pgs. of legalize)
Water Planning Need: Ability to model interactions across physical and management systems
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative change</td>
<td>Fewer cold winters reduce mortality amongst infecting beetle populations. Warmer, prolonged dry conditions stress forests increasing their susceptibility to insect attack. 5% of forest dies above reservoirs GranbyGrand, and Green Mountain permanently replaced by low scrub.</td>
<td>P-20% T+2°C</td>
</tr>
<tr>
<td>Dust on snow</td>
<td>Modest warming and drying increases the annual likelihood of dust on snow events by 10%. No other effects.</td>
<td>P-10% T+1°C</td>
</tr>
<tr>
<td>Mild Warming</td>
<td>Seasonal precipitation totals are unchanged but temperatures are warmer across all seasons.</td>
<td>P-0% T+2°C</td>
</tr>
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Drought mitigation measure - Shoshone Call Relaxation Agreement (SCRA)

**Key features**

- Reduces the Call from 1408 to 704 cfs March 14 to May 20 during drought years (defined as forecast July 1 storage ≤ 80% and April-July flow forecast ≤ 85%)

- Colorado River Cooperative Agreement allows call relaxation to begin Nov 11 (severe drought & lawn water ban)

- Purpose is to increase Upper Basin Storage

Shoshone Senior Rights:
- 1250 CFS (1902);
- 158 CFS (1929) (Xcel Energy)

40% Wolford (1995);
Williams Fork (1959)

Grand River Ditch; Adams Tunnel

Grn Mtn (1935)
First Fill Right

Moffat Tunnel (1921)

Dillon (1946) ‘Paper fill’ out of priority

Continental Divide

Colorado River

Blue River

Granby
Modeled flows:

Blue River above Dillon Reservoir (top)

Colorado River at Shoshone (bottom)

Scenarios:

CNTL = current climate

PM0T2WM (Mild Warming) = No precipitation change & 2°C warming.

PM10T1DS (Dust on snow) = decline in snow albedo caused by more frequent dust on snow events, coupled with 10% less precip. with 1°C warming.

PM20T2VC (Vegetative change) = Altered vegetation and runoff rates, coupled with 20% less precipitation & 2°C warming.
Under the warmer and drier scenarios Denver begins storing water earlier, but average annual diversions are reduced by 3%, 4%, and 13% for the \textit{PM0T2WM}, \textit{PM10T1DS}, and \textit{PM20T2VC} scenarios, respectively.

Denver's storage softens the impact of declining stream flow except in the second severe drought year in the warmest and driest scenario.
Bottom line:

The benefit from the Relaxation Agreement is quite small -- increasing Denver’s drought-year water supply by < 1% on avg.

Inset: thick gray-line = weekly mean flows for all years of CNTL scenario; thin black line = flows during the 3 CNTL scenario relaxation years; warming scenarios have greater frequency of relaxation years but shorter periods before benefit of relaxation disappears.
END -- THANKS

Source: Fire Mountain Canal and Reservoir Company