Does Water Flow Downhill or Towards Money? Lessons from the Western Water Assessment

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Western Water Assessment
http://sciencepolicy.colorado/wwa
Downhill or Towards Money?

Colorado River Return Reconnaissance Study

Prepared for:
State of Colorado
Colorado Department of Natural Resources
Colorado Water Conservation Board

Prepared by:
BOYLE ASSESSMENTS CORPORATION

In Association with:
BBC Research & Consulting
ERO Resources Corporation
Hoevey Economics
URS Corporation
Water Consult:
November 14, 2003

Western Water Assessment

Colorado
University of Colorado at Boulder
Overview of Talk

Stresses on Colorado Water Supply
Basic Colorado Water Facts and a New Water Supply Era
The NOAA RISA Program
WWA in General and in Specifics
  Experimental Forecasts
  Streamflow Reconstructions
Future Work Foci
Stress: Population Growth

Colorado Population in Millions

Colorado is gaining 1m new residents every 10 years!

Source: Colorado State Demographer
Stress: Palmer Drought Index - % of area in severe drought

Western U.S. 1895-2004

1930s “Dust bowl”
Colorado River Compact Signed
2002
Stress: 50-Year Climate Trends

Slight Wet Trend Matches El Nino Cycle

Western U.S. Mostly Warmer and Wetter Since 1950

Temperature

-2.5 -2.0 -1.5 -1.0 -0.5 -0.3 0 0.3 0.5 1.0 1.5 2.0 2.5 °C

OBS Trend 1950–2003

Winter
- Colorado
+1° to +2° C
Warmer 0 to +1° C

Summer

Precipitation

- Colorado
0% to +5%

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“Water 2025” - Future Supply Crises

Potential Water Supply Crises by 2025

Note: There is an underlying assumption of a statistically stationary climate.

Source: United States Bureau of Reclamation
Basic Facts: Municipal vs. Agricultural Water Use in Colorado

**Table ES-1 Municipal & Industrial Gross Water Demand in 2000 and 2030**

<table>
<thead>
<tr>
<th>Basin</th>
<th>Estimated Water Demand in 2000 (AF)</th>
<th>Projected Water Demand with Level 1 Conservation in 2030 (AF)</th>
<th>Increase in Water Demand (AF)</th>
<th>Increase in Water Demand (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>256,900</td>
<td>354,900</td>
<td>98,000</td>
<td>38%</td>
</tr>
<tr>
<td>Colorado</td>
<td>74,100</td>
<td>136,000</td>
<td>61,900</td>
<td>84%</td>
</tr>
<tr>
<td>Dolores/San Juan/San Miguel</td>
<td>23,600</td>
<td>42,400</td>
<td>18,800</td>
<td>80%</td>
</tr>
<tr>
<td>Gunnison</td>
<td>20,600</td>
<td>35,500</td>
<td>14,900</td>
<td>72%</td>
</tr>
<tr>
<td>North Platte</td>
<td>500</td>
<td>600</td>
<td>100</td>
<td>20%</td>
</tr>
<tr>
<td>Rio Grande</td>
<td>17,400</td>
<td>21,700</td>
<td>4,300</td>
<td>25%</td>
</tr>
<tr>
<td>South Platte</td>
<td>772,400</td>
<td>1,182,100</td>
<td>409,700</td>
<td>53%</td>
</tr>
<tr>
<td>Yampa/White/Green</td>
<td>29,400</td>
<td>51,700</td>
<td>22,300</td>
<td>76%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,194,900</strong></td>
<td><strong>1,824,900</strong></td>
<td><strong>630,000</strong></td>
<td><strong>53%</strong></td>
</tr>
</tbody>
</table>

M&I = 1.2 maf/year 2000, 1.8 maf/year 2030

**Table ES-2 Irrigated Acres by Basin**

<table>
<thead>
<tr>
<th>Basin</th>
<th>Estimated Irrigated Acres</th>
<th>Average Total Diversions (AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>538,100</td>
<td>1,759,900</td>
</tr>
<tr>
<td>Colorado</td>
<td>237,700</td>
<td>1,986,900</td>
</tr>
<tr>
<td>Dolores/San Juan</td>
<td>255,000</td>
<td>902,200</td>
</tr>
<tr>
<td>Gunnison</td>
<td>263,500</td>
<td>1,736,100</td>
</tr>
<tr>
<td>North Platte</td>
<td>115,700</td>
<td>396,900</td>
</tr>
<tr>
<td>Rio Grande</td>
<td>632,700</td>
<td>1,619,000</td>
</tr>
<tr>
<td>South Platte</td>
<td>1,003,500</td>
<td>2,545,500</td>
</tr>
<tr>
<td>Yampa/White/Green</td>
<td>118,400</td>
<td>652,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3,164,600</strong></td>
<td><strong>11,605,000</strong></td>
</tr>
</tbody>
</table>

**Figure ES-6**

Relative Proportions of Agricultural, M&I, and SSI Gross Water Use in 2030

Source: State Water Supply Initiative
A Changing Water Supply Paradigm

- Fewer Supply-side options – 6 maf in Storage Sites Already
- Compacts, Decrees, ESA (Platte, Rio Grande, Colorado) Limit Water Availability
- Conservation reduces buffers – ‘demand hardening’
- Water Law Constraints
- Water Quality an Increasing Concern
- Very Different Operational Needs – Ag vs. municipal
- Water is not a commodity, aspects of public good, externalities
- Environment and Recreational Water Needs – ‘beneficial use’ is changing
- Climate may not be “Stationary”
- Local Planning May no longer be enough
- New Demand-side and Supply-side Techniques…
  - Land Fallowing, Water Banks, Reverse Auctions, Reuse, Interruptible Supply Contracts, Conservation, Water Rates
- Focal Point on Colorado River Basin – from 0 to 1 maf left to develop
What is the Western Water Assessment?

Public Mission:

The mission of the Western Water Assessment is to identify and characterize regional vulnerabilities to climate variability and change, ....and, to develop information, products and processes to assist water-resource decision-makers throughout the Intermountain West.
Why Western Water Assessment?

Private Mission:

Help NOAA Consider and Implement Future “Climate Services”, an analog to the National Weather Service but Different…

Existing NOAA Climate-centered Activities…

River Forecast Centers – Volumetric Streamflow Forecasts
Climate Prediction Center – Long-lead T&P Forecasts
Climate Focal Points – NWS Regional Personnel
Climate Services Division
Western Water Assessment one of 8 Similar Regional Integrated Sciences and Assessments ("RISA") Programs.
Regional Integrated Sciences and Assessments ("RISA")
History, Goals and Objectives

• Arose from NOAA Office of Global Programs discussions ca. 1995

• Characterize the state of knowledge of climate variations and changes, and their social, economic, and ecological interactions, impacts, and projections at appropriate scales of interest within a region

• Assess regional and local resources, capacity, and decision-support dialogs needed in responding to environmental variability and change

• Identify knowledge gaps in selected critical climate-environment-society problems in a region and develop experimental decision support products and services to bridge these gaps as needed

• Carry out research focused on realizing the benefits of integrated knowledge and forecasts in different contexts and provide an informed basis for place-based decision support and services.

Source: Pulwarty, NOAA OGP
Who is WWA?  
(A Cast of Thousands...)

Principal Investigators: Susan Avery, Randy Dole

University of Colorado Scientists
Snow and Hydrology – Martyn Clark, Balaji Rajagopalan
Water Quality – Jim Saunders
Economics – Chuck Howe, Chris Goemans

NOAA-CIRES Climate Diagnostics Center Scientists
Policy – Andrea Ray, Roger Pulwarty, Jessica Lowrey
Climatologists – Klaus Wolter
Snow Scientists – Shaleen Jain, Jessica Lundquist
Paleoclimatologists – Connie Woodhouse, Robin Webb, Jeff Lukas

Colorado State University Scientists
John MacKenzie, Reagan Waskom, Dan Smith, John Wilkin-Wells
### Evaluation Matrix 1 for WWA Activities

<table>
<thead>
<tr>
<th>RISA Ends</th>
<th>Assessments</th>
<th>Information, Products &amp; Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Links to Decision Makers</td>
<td></td>
<td></td>
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<tr>
<td>Links to NOAA Operations</td>
<td></td>
<td></td>
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<tr>
<td>Integrated Research</td>
<td></td>
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<tr>
<td>Synthesis Research</td>
<td></td>
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<tr>
<td>Self Evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training New Leaders</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Evaluation Matrix 2 for WWA Activities

<table>
<thead>
<tr>
<th>RISA Ends</th>
<th>Assessments</th>
<th>Information, Products &amp; Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal Scale</td>
<td>Paleo</td>
<td>Seasonal to Interannual</td>
</tr>
</tbody>
</table>

- **Paleo**
- **Seasonal to Interannual**
- **Decadal**
- **Global Change**
Stakeholder Research Partners

- Municipal
  - Denver Water Department – M&I
- Combined Ag and M&I
  - Northern Colorado Water Conservancy District – Ag, M&I
- Federal
  - United States Bureau of Reclamation – Ag, M&I
- Non-governmental
  - Ditch and Reservoir Company Alliance – Ag
- State Chartered Planning Entities
  - Colorado River Water Conservation District
  - Colorado Water Conservation Board
Some Current Projects...

1. South Platte Regional Assessment Tool
2. Streamflow Reconstructions using Tree-Rings**
3. Climate Services Clearinghouse
4. Improved “Week 2” Streamflow Forecasts
5. Seasonal Forecasts for Drought Task Force**
6. DARCA Use of Climate Forecasts
7. Intermountain West Climate Outlook

Predicting Climate Variability in Colorado – ENSO–Based Experimental Seasonal Forecasts

Source: Wolter Website, 2004
http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/index.html
Sample Experimental Forecast

Colorado (and Interior Southwest) forecasts

- 1. Current status of the El Niño/Southern Oscillation (ENSO) phenomenon and prospects for the next six to nine months.
- 2. Regional climate variability and El Niño composites.
- 3. Most recent Climate Prediction Center forecasts for February through June 2005.
- 5. Discussion of forecasts.
- 6. Executive summary.

**EXPERIMENTAL CDC JAN-MAR 2005 PRECIPITATION FORECAST**
(issued: January 18, 2005)

Outline for latest forecast webpage (updated on February 24th, 2005)

This webpage consists of six parts:

1. Status and Outlook for ENSO (El Niño/Southern Oscillation), the most important global climate variability factor on a time scale of months to years.

6. Executive summary (updated on January 2)

- 1. The 2004-05 El Niño event continues to limp along, with large-scale SST anomalies that barely exceed 1°C (2°F). Nevertheles, precipitation anomalies have been consistent with typical El Niño-associations (for instance, a failed summer monsoon in India in the southwestern (northwestern) U.S.).

- 6. A concise summary of the webpage.

The most recent forecasts are based on data through December 2004. This website will remain online until further notice.

Western Water Assessment
Lessons from Experimental Regional Forecasts

- CPC National Forecasts lack spatial scale needed by water managers.
- Active (email) contact provides new forecast reminder.
- Experimental Forecast has multiple sections – map, discussion, summary, skill.
- CPC “Equal Chances” forecast confusing.
- 2002 Prompted interest and attention.
Blue River at Dillon Streamflow Reconstruction

http://www.ngdc.noaa.gov/paleo/streamflow/background.html
The early 20th century wet period does not appear matched in prior centuries. However, drought similar to the 1950s drought have occurred.
Many Events Like 2002, at least 10 in 550 Years.

Source: Woodhouse, 2003
Blue River Flow - Years Categorized by Percentile

Number of Very Low Flow Years Per Century

Source: Woodhouse, 2003
Lessons from Streamflow Reconstructions

• Take advantage of event-related windows of opportunity. Tree-ring data could answer the question that gage data could not: how rare was this event?

• Collaborative work with decision makers is essential. Sustained communication allowed us to explore the development of reconstructions and analyses useful for planning and management.

• Be open willing to address user-based questions. Updating tree-ring collections from 1999 to 2002 or ensemble reconstructions would not have been undertaken otherwise.

• Do not wait to develop collaborative partnerships with decision makers until there is an impeding crisis and they are too busy to figure out how new climate information might be of use.
Future Work Foci

Continued Product Development
Paleo, Seasonal, Streamflows, Others

Continued Assessments
SPRAT, Demand, Others

New Initiatives
Global Change Work with Local Provider
Colorado River Compact
NOAA Climate Services Feedback
Lake Powell: Current vs. 1995 Severe Sustained Drought Study

Lake Powell Contents
SSD Drought vs. Current Conditions

Source: Harding