Outline

- Address barriers to forecast use
- Approach: Problem-oriented or user-driven studies
- Insights from social sciences
- Interactions with Reservoir Managers in the Upper Colorado River Basin
- “User study approach” for identifying needs for climate services

Blue Mesa Reservoir, Colorado
Barriers to Forecast Use: from Pulwarty & Redmond, ‘97

- Potential users often fail to understand what a climate forecast is, what is being forecast, or how to use it.
- Desired information is not available or the timing of the forecast is not appropriate to users needs.
- Non weather/climate factors are deemed to be more important than available climate information.
- Other constraints prevent a flexible response to using climate information.
Social Science Insights

- Three insights from the literature
- “Critical water problems approach” determines potential users’ focus of attention and what non-climate factors are most important to them
- Institutional dynamics: cycle of conservation, crisis, release, and reorganization phases
  - “constraints” weaken during these times of crisis, create opportunities in which groups may be more willing to try something new
- Technology Transfer
  - for any new technology there are early adopters, there is partial incorporation by some users, and diffusion as others see success
### Approach to Critical Water Problems

- Survey current water problems
- Survey current plans and policies for dealing with these problems
- Identify water problems and plans likely to be sensitive to climate variability and/or change
- Refine spatial and temporal scales of user studies and overall assessment focus
- Evaluate the actual and potential effects of climate variability and/or change on selected problems and plans
- Refine spatial and temporal scales of user studies and overall assessment focus
- Evaluate alternative plans and assess including the use of additional or new climate information
- Draw practical conclusion including how and when additional or new climate information might be used

Survey Critical Water Problems
Based on interviews and policy studies and statements of management agencies

- USBR Strategic Plan, 1997; Operating plans
- Restoring the West’s Waters: opportunities for the USBR, for restoring a functional level of ecosystem integrity
- Western Water Policy Review Advisory Commission Report: Colorado River Basin Study
- “Current issues” list of the Colorado Water Conservation Board includes ecosystem and salinity (water quality) issues, but not climate
- “Policy issues” list of the Colorado River Water Conservation District also does not include climate variability or change
Critical water problems in western Colorado

**Ecosystems**
- Federal reserved rights for the Black Canyon of the Gunnison
- **Upper Colorado Recovery Implementation Program for Endangered Fish**
- Other instream flow requirements

**Salinity/Water quality**
- Salinity Control Act implementation and mitigation of water quality problems from agricultural return flows

**Equity**
- Indian Water Rights, reserved when reservations were established
- Livelihoods and cultures of ranching and farming on the west slope

**Competition among uses**
- Transmountain water diversions
- Agriculture vs. urban uses
- Recreation and amenity instream uses vs. consumptive uses, including rafting industry, hiking and hunting tourism
Policies that might incorporate climate information

Implementation of all of these policies is potentially vulnerable to water shortages

- Salinity Control Act implementation
- Water Conservation Plans (USBR & Colorado Water Conservation Board)
- Upper Colorado Recovery Implementation Plan for endangered fish – includes critical river reaches and flows
- Quantification of Federal Reserved Water Rights for national parks and wilderness areas
- Long-term water planning (the thirsty front range vs. the developing west slope)
- Water quality regulations, state & federal (Clean Water Act)

(Taylor Park Reservoir, Upper Gunnison Basin)
Three insights from the literature

“Critical water problems approach” determines potential users’ focus of attention and what non-climate factors are most important to them.

Institutional dynamics: cycle of conservation, crisis, release, and reorganization phases.

“constraints” weaken during these times of crisis, create opportunities in which groups may be more willing to try something new.

Technology Transfer

for any new technology there are early adopters, there is partial incorporation by some users, and diffusion as others see success.
Insights from institutional dynamics

- Reservoir management in the Upper Colorado is in one of these “release & reorganization” phases, responding to the “crisis” of pressure to expand the purposes for which they provide water.

- Case study focuses on this opportunity, with reservoir managers and their key stakeholders as potential early adopters of this technology.
Interactions with Reservoir Managers in the Upper Colorado River Basin

User group is the reservoir managers in the Colorado headwaters and Gunnison basins who operate reservoirs originally built to provide reliable irrigation supply, hydropower, and recreation.

Grand Valley Irrigation ditch, near diversion from the Colorado River, Grand Junction
Problem and User: Reservoir Management

- An emerging, climate-sensitive issue is how to provide spring peak flows and late summer minimum in stream flows to support the recovery of endangered fish.
- This changing policy environment is forcing a “release” of past constraints on reservoir management, and a “reorganization” phase that is in progress.

- **Opportunity:** Reservoir managers are seeking new tools to help in a more complicated job, and thus open to using climate information; other types of new tools are also being tried.

Colorado Pike Minnow
Methodology

- Critical water problems analysis
- Identification of key decision makers and the major participants in their decisions
- Participant-observer at user meetings resulting in two-way learning by both CDC and user groups
- Analyses of records of past decision processes
- Interviews with reservoir managers, river forecasters, and organizations affected by USBR management
- Decision calendar used as a *framework* for organizing the information needs
Interactions with users

- Informational workshops at CDC with USBR managers, springs of 1997, 1998, 1999
- Co-sponsored and organized interactive “Workshop on Climate Variability, Reservoir Management, and Endangered Fish” with Denver Water and the Colorado River Water Conservation District, fall 1999
- WWA researchers have been invited participants at water managers’ coordination meetings. A climate outlook discussion was the special topic at their Fall 2000 meeting.
Spring Peak Flow Scenarios

- Threshold for habitat building flows ~12.7 CFS

Graph showing flow scenarios:
- Natural Average (pre 1950)
- Impounded Average (post 1950)
- Single Subthreshold Peak
- Double Subthreshold Peaks
- Practically No Peak
- Habitat Threshold
Their Challenge ⇒ Our Problem Orientation

Reservoir Hydrograph (volume in acre-feet)

- late summer
- Feb. 1 early flow forecasts
- April 1 start of fill target
- late May to mid June Peak Augmentation Period
- early July fill date

- reservoir capacity
- spill and flood
- miss filling to capacity

bypass flow
The NOAA long lead precipitation and temperature forecasts can be incorporated into a fall forecast of winter snowpack accumulation and with implications for subsequent April-June runoff.

An improved understanding of ENSO influences on seasonal evolution of snowpack that can lead to more accurately planned “start of fill” target.

By late Spring, the NOAA long lead precipitation and temperature forecasts can be incorporated into summer season forecast irrigation demands.

Throughout the Spring one to two week precipitation and temperature forecasts can be used to provide improved estimates of volume and timing of spring peak flows needed to augment peak flows for habitat restoration as well as to enhance flood mitigation operations.

Throughout the Summer one to two week precipitation and temperature forecasts can improve both hydropower generation, irrigation scheduling, and low flow mitigation.
Reservoir Management Decision Calendar

- **Water Year Planning**: Next Water Year Planning
- **Provide for late Summer/early Fall irrigation while maintaining target flows**
- **Next water year runoff unknown, reserve water until February snowpack observations**
- **Winter season precipitation forecast for Fall release decisions**
- **Winter releases based on January/February snowpack observations**
- **Winter/Spring forecast for Winter release decisions**
- **Legend:**
  - Planning Process
  - Operational issues
  - Potential use of forecasts
- **Peak Flow Augmentation - fill curve**
- **Summer season forecast for Peak Augmentation planning**
- **Week 2 forecasts for Peak Augmentation**
- **Peak Flow Augmentation releases**
- **Plan releases for Summer irrigation & hydropower**
- **Week 2 forecasts for Summer irrigation & hydropower release decisions**
- **Provide for Summer irrigation & hydropower needs while maintaining target flows**

Ray et al. (2001)
WWA climate and hydrologic research influenced by these findings
Experimental Climate Divisions for improved monitoring of the seasonal evolution of precipitation across Colorado

- Hydroclimatic divisions based on recurrent monthly to seasonal precipitation anomalies during the last two decades (multivariate regionalization).

- These divisions explain more than half the average local precipitation variance at individual stations (symbols $\geq 50\%$ filled)
Experimental monitoring products developed to meet identified user needs for basin-scale climate and hydrology information (internet-based)

Yampa River near Maybell, Colorado
Water year 2001

Snow Water Equivalent at Rabbit Ears SNOTEL site

Observed and long-term climatological runoff and snowpack [S. Jain]

Observed daily temperatures (red) bars, 7 (green) and 10 (blue) day MRF forecasts, and long-term climatology (gray line/open circles) [G. Bates]
Insights from User Studies in the Upper Colorado Basin

- **Problem-oriented** versus sector-oriented
- **Environmental or society-relevant problems** which are affected by climate *and* which climate might be useable in addressing
- Develop an *understanding of the decision process* around these problems important to this user group.
- The **annual cycle of user decisions** can be used to organize potential uses of climate information and identify what climate information might be useful.
- **Forecast Skill** – these users have more realistic expectations, interested in what’s available vs. 90% accuracy (e.g., *Dave Brandon, CBRFC, recently requested guidance on climate and weather patterns up to 24 months out, to qualitatively adjust longer range runoff forecasts for the USBR*)
“User Study Approach” for identifying needs for climate services

- Assess and identify users’ critical problems which are sensitive to climate
- Identify decision makers and key participants with respect to those problems; these are the focus of the user study
- For recurring decisions, a decision calendar may help organize needs and reveal entry points for climate services
- Release/reorganization points in critical problems may be particularly good places to start – creating willing early adapters
- Ongoing two-way communication needed to develop appropriate products and facilitate tech transfer; partnerships critical to this stage of climate service development