

Water Resources Center, Desert Research Institute
Annual Technical Report
FY 2003

Introduction

Research Program

Long-Range Water Supply Forecasting for Nevada and the Colorado River Basin

Basic Information

Title:	Long-Range Water Supply Forecasting for Nevada and the Colorado River Basin
Project Number:	2002NV9B
Start Date:	3/1/2002
End Date:	2/28/2004
Funding Source:	104B
Congressional District:	Nevada 01
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Water Supply, Surface Water
Descriptors:	
Principal Investigators:	Thomas C. Piechota

Publication

1. Piechota, T.C., Hildalgo, H., Timilsena, J., and G. Tootle. Western U.S. drought: How bad is it? submitted for publication in the American Geophysical Union EOS Transactions.
2. Tootle, G.A., and T.C. Piechota, 2004a. Identification of Climate Teleconnections and Forecasting of the Upper Truckee River. Tentatively accepted for publication in the Journal of Nevada Water Resources Association.
3. Lakshmi, V., T. Piechota, U. Narayan, and C. Tang, 2004. Soil Moisture as an Indicator of Weather Extremes. Geophysical Research Letters, 31.
4. Tootle, G., and T. Piechota, 2004b. Forecasting of Lower Colorado River Basin Streamflow using Pacific Ocean Sea Surface Temperatures and ENSO. Proceedings of the Arid Lands Symposium, June 26 - July 1, 2004, Salt Lake City, Utah, American Society of Civil Engineers, Washington D.C.
5. Tootle, G.A., and T.C. Piechota, 2004c. Climate Variability, Water Supply, and Drought in Upper Colorado River Basin. Accepted for publication in Climate Variability, Climate Change and Water Resources Management, ASCE Technical Committee Report.
6. Tootle, G., and T. Piechota, 2003. Drought and the 2002-2003 El Niño in the Southwest U.S., 2003. Proceedings of the World Water & Environmental Resources Congress 2003, June 22-26, 2003, Philadelphia, Pennsylvania, American Society of Civil Engineers, Washington D.C.

Problem and research objectives:

A sufficient water supply in the southwest U.S. is a concern for planners and managers of water systems. The southwest has a limited supply of water and in many cases the demand exceeds the supply. In Nevada, 70% of the total water supply comes from surface water. The surface water generally comes from rivers that are snow-melt driven and experience the highest flow values in the spring and summer time. In Southern Nevada, surface water comes from the Colorado River allotment of 300,000 acre-ft per year. It is estimated that the full Colorado River allotment will be used by the year 2007. In Northern Nevada, the Walker, Carson, Truckee, and Humboldt Rivers are the main source of surface water.

The ongoing research seeks to provide information for better management of water resource systems at the beginning of the water year (October, November, December). This was accomplished by evaluating the influence of large-scale atmospheric and oceanic processes on streamflow variability. An improved long-range water supply forecasts is the major contribution of this work. **Thus, the overall goal of the research was to develop an improved long-range streamflow forecast for major rivers supplying Nevada with surface water.**

Methodology:

To produce an improved long-range streamflow forecasts, there were two major research activities performed. First, the relationship between streamflow and various atmospheric and oceanic parameters was investigated. These parameters include those that explain the El Niño – Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO) and global sea surface temperatures (SSTs). Based on the results of the preliminary analysis, a statistical long-range streamflow forecast is developed using procedures that have been applied to Australia and the Pacific Northwest United States.

Principal findings and significance:

The two year research project resulted in several noteworthy publications and presentations. Following is a summary from the significant publications for the Truckee River and the Colorado River Basin. The Tootle and Piechota (2004a) study provided several noteworthy results for long lead-time forecasting of the Truckee River. Persistence (high flows following high flows and low flows following low flows) was only useful for short lead times of streamflow forecasting. For instance, the October – December streamflow from the previous year was useful for providing a forecast of Spring-Summer runoff in the following year. Climate indices such as SOI, PDO, and PNA show little correlation and predictability for spring-summer streamflow. Since PDO and PNA have 20 to 30 year oscillations, short lead-times (3 to 9 months) may not be appropriate. The lack of a significant ENSO signal was also noted when Pacific Ocean SSTs were evaluated. Since the climate indices had weak relationships with streamflow, a long lead-time forecast for all years is unavailable based on the low skill scores. However, the model displayed moderate predictability for drought years. Linear correlations of drought year AMJJ(0) streamflow to previous year seasonal AMJ(-1) and JAS(-1) SSTs provided encouraging results. Numerous regions of significant correlation were identified in and around Australia and the southern Pacific Ocean. Additionally, these regions are positively correlated which shows that lower sea surface temperatures results in lower streamflow. Future research may be able to utilize this data for forecasting.

The Tootle and Piechota (2004c) study evaluated the influence of climate indices and Pacific Ocean SSTs on streamflow in the Colorado River Basin. Similar to the results for the Truckee River, the

best predictors are not in the region of ENSO activity. The research results suggest that SSTs in the northern Pacific (adjacent to the western United States) influence the hydrology of the Upper Colorado River Basin. The ability to provide a six-month lead time, summer [JAS(-1)] SSTs as a predictor of spring-summer [AMJJAS(0)] streamflow, could be beneficial to water resource planners since this would correspond with the beginning of the water year. For drought years, four of the five rivers forecasted resulted in positive skill scores. These forecasts are slightly better than Climatology and could be used to make preliminary decisions on the coming year streamflow. The model does not have a strong bias toward higher or lower streamflow; however, there is a tendency for improved skill when predicting extreme droughts.

Lastly, the Piechota et al., (2004) study evaluated historical streamflow records and tree ring data for the Upper Colorado River Basin to place the current southwest drought in a historical context. The past four years of drought and the forecast for 2004 make the current (1999 to 2004) drought in the southwestern U.S. the worst drought since streamflow has been recorded (1923 – present) for portions of the Upper Colorado River Basin. For the Colorado River (near Cisco, UT), the cumulative streamflow deficit (departure from long term mean) for the current drought is almost 11 cubic kilometers (km³), or, approximately two years of average streamflow. Although the current drought is the most significant, based on streamflow records, is it the worst, ever? Tree ring data from the basin indicate that even more severe droughts have occurred in the past and the current drought is the seventh worst in an approximately 500 year record. The largest drought in the tree ring data occurred at the end of the 16th century and lasted for at least 20 years.

Information Transfer Activities

Conference Presentations:

- Tootle, G., and T.C. Piechota, 2003. Identification of Pacific Ocean Sea Surface Temperature Teleconnections with Western United States Streamflow. Presented at the *American Geophysical Union (AGU) Fall Meeting*, December 8-12, 2003, San Francisco, California.
- Tootle, G., and T.C. Piechota, 2003. Drought and the 2002-2003 El Niño in the Southwest U.S., 2003. Presented at the *World Water & Environmental Resources Congress 2003*, June 22-26, 2003, Philadelphia, PA.
- Decker, R., T. Piechota, C. Ester, C. Collum, 2003. Growth and Drought in the Colorado Basin. Presented at the NAU 2003 Southwest Drought Summit, May 12-13, 2003, Flagstaff, Arizona (INVITED)
- Piechota, T.C., and G. Tootle, 2003. Climate Teleconnections for Improved Streamflow Forecasting in the Colorado River Basin. Presented at the *Nevada Water Resources Association Annual Conference*, February 26-28, 2003, Sparks, Nevada.
- Piechota, T.C., 2002. Climate Variability and Water Supply of the Colorado River Basin. Presented at the *2002 Conference on Water Resources Planning and Management, Symposium on Managing Extremes: Floods and Droughts*, May 19 – 22, 2002, Roanoke, Virginia.

A Study of Ancient Trees Rooted 120 Feet Below the Surface Level of Fallen Leaf Lake

Basic Information

Title:	A Study of Ancient Trees Rooted 120 Feet Below the Surface Level of Fallen Leaf Lake
Project Number:	2003NV39B
Start Date:	3/1/2003
End Date:	2/28/2004
Funding Source:	104B
Congressional District:	02
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Drought, Management and Planning
Descriptors:	submerged rooted trees
Principal Investigators:	John A. Kleppe

Publication

1. Kleppe, J.A., W.J. Norris (2004), A Study of Ancient Trees Rooted 120 Feet Below the Surface Level of Fallen Leaf Lake, presented at the 2nd Biennial Conference on Tahoe Environmental Concerns, May.

Problem and research objectives:

Large trees have been discovered rooted at a depth of 120 feet in Fallen Leaf Lake. It is important to determine whether or not they grew there or were transported from another location.

Methodology:

A sample of one of the trees that died simultaneously was recovered and a tree ring study initiated. The samples included the entire root ball and several “rounds” of 4 inch thickness representing cross sections of the tree for the first 20 feet in height.

Principal findings and significance:

The raised tree samples indicated that the tree was a yellow pine that died in AD 1215 \pm 40 years. There were counted 220 rings indicating that the tree was over 200 years old at the time it died. The tree was totally “water logged” and still had sap coming out of the root ball and other parts of the tree. Additional sampling is required to confirm the date of death and to match tree ring samples with other trees determined to be from this same period of time.

Information Transfer Activities

Several invited presentations were made to scientific as well as local interest groups.

- 2/3/03 – Invited presentation to DRI and local developers in Squaw Valley, about research results from studying the ancient trees rooted in Fallen Leaf Lake.
- 2/3/04 – “The Submerged Trees of Fallon Leaf Lake,” presented to Science, Technology, Engineering and Mathematics Class, University of Nevada, Reno.
- 5/03/04 – “Research at Fallen Leaf Lake,” presentation to Lake Tahoe Issues and Agencies Course, Tahoe Community College.
- 5/19/04 – “A Study of Ancient Trees Rooted 120 Feet Below the Surface Level of Fallen Leaf Lake,” 2nd Biennial Conferences on Tahoe Environmental Concerns, North Shore Lake Tahoe.





Quantifying Potential Economic Impacts of Water Quality Modeling Uncertainty for the Lower Truckee River, Nevada

Basic Information

Title:	Quantifying Potential Economic Impacts of Water Quality Modeling Uncertainty for the Lower Truckee River, Nevada
Project Number:	2003NV41B
Start Date:	3/1/2003
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	02
Research Category:	Water Quality
Focus Category:	Water Quality, Economics, Models
Descriptors:	water quality simulation, TMDL's, economic analysis
Principal Investigators:	Alan McKay

Publication

1. McKay, W. A., J.J. Warwick, S. Kish, C. Fritsen, and J. Bartlett, 2003. Modeling linkages between groundwater, surface water and periphyton-driven oxygen dynamics in the lower Truckee River, Nevada Fall Meeting of the American Geophysical Union, San Francisco, California, December 8-12.

Problem and Research Objectives:

Tens of millions of dollars are spent annually to treat municipal and industrial (M&I) wastewater within the Truckee River Basin. In the Nevada portion of the watershed, the Cities of Reno and Sparks, in conjunction with their partner Washoe County, jointly operate the Truckee Meadows Wastewater Reclamation Facility (TMWRF). In order to achieve water quality objectives, particularly as they relate to Total Maximum Daily Loads (TMDLs), TMWRF operators are faced with additional infrastructure improvements and/or non-structural watershed improvements (i.e., river restoration) that will cost additional millions of dollars. In addition to the considerable resources expended on wastewater treatment, the Cities, County and State support extensive water quality monitoring activities within the river basin. Currently, there is only a cursory understanding of the relationship between water quality benefits associated with incremental infrastructure improvements (and associated costs) and the information gained from ongoing water quality monitoring (and the costs associated with those activities). The proposed project will help address these issues.

The project scope involves defining conditions in the Lower Truckee River from the input of Truckee Meadows Water Reclamation Facility (TMWRF) effluent at the Steamboat Creek confluence downstream to Marble Bluff Dam. The specific objectives are:

- 1) Construct an economic model defining costs (including both facilities and operation) associated with various levels of potential treatment
- 2) Construct an economic model defining costs associated with potential watershed (in-stream and groundwater) monitoring programs
- 3) Translate economic models into FORTRAN code and integrate with existing water quality modeling program
- 4) Define expected values and associated uncertainties associated for non-point source loads
- 5) Define uncertainties associated with water quality modeling predictions
- 6) Develop Monte Carlo simulation shell around integrated code to predict probabilities of achieving desired in-stream water quality conditions as a function of various investment scenarios

Principal Findings & Significance (year 1):

A long-term dynamic water quality modeling program (WASP5) was modified to correctly deal with relevant data for the study site (Lower Truckee River). The model was successfully calibrated and verified using a robust dataset spanning 528 days. A planned wastewater treatment plant excursion (discharging higher than permitted nutrient levels) had significant impacts on the growth of attached algae, with concomitant increased in predicted diel dissolved oxygen swings. Retiring irrigated lands is also predicted to have a significant impact on local in-stream nutrient concentrations with associated decreases in attached algae biomass.

Information Transfer Program

Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 RCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	0	0	0	0	0
Masters	1	0	0	0	1
Ph.D.	3	0	0	0	3
Post-Doc.	0	0	0	0	0
Total	4	0	0	0	4

Notable Awards and Achievements

Publications from Prior Projects

1. 2002NV1B ("Identification of Nutrient Rich Groundwater Inflows to Lake Tahoe") - Water Resources Research Institute Reports - Taylor, Kendrick, Rick Susfalk, Margaret Shanafield, Geoff Schladow, 2003, Near Shore Clarity at Lake Tahoe: Status and Causes of Reduction, Division of Hydrologic Sciences, Publication No. 41193, 80 p.
2. 2002NV1B ("Identification of Nutrient Rich Groundwater Inflows to Lake Tahoe") - Conference Proceedings - Shanafield, Margaret, Kenrick Taylor and Rick Susfalk, 2003, Spatial and Temporal Variability of Near Shore Clarity in an Alpine Lake. AGU Fall Meeting, H12B-0985.
3. 2001NV6B ("Assessment of Ground Water Recharge in Mine-Altered Regions of Nevada ") - Conference Proceedings - Webb, Geoff, Scott Tyler, D. Van Zyl and J. Collard, 2003, Spatial variability of flow in a coarse unsaturated mining material: Results from field-scale infiltration experiments. American Geophysical Union EOS Trans. AGU, 84(46), Fall Meet. Suppl., Abstract H32A-0523,2003
4. 2001NV6B ("Assessment of Ground Water Recharge in Mine-Altered Regions of Nevada ") - Dissertations - Webb, Geoff, 2003, Spatial Variability of Flow in Coarse, Unsaturated Mining Material: Results from Field-scale Infiltration Experiments. Unpublished M.S. Thesis, Hydrogeology, University of Nevada, Reno.
5. 2001NV6B ("Assessment of Ground Water Recharge in Mine-Altered Regions of Nevada ") - Dissertations - Tarentino, Julie, 2003, Development of Electrical Resistance Tomography to Determine Infiltration Variability in Heterogeneous Mining Waste. Unpublished M.S. Thesis, Geophysics, Oklahoma State University, December 2003.
6. 2001NV4281B ("Evaluation of Ecosystem Metabolism at Selected Sites in the Lower Truckee River Basin") - Dissertations - Peterson, Sarah E., 2003, Modeling agriculturally driven nutrients in the Truckee River, Nevada. Unpublished M.S. Thesis, Hydrology, University of Nevada, Reno, 152 p.
7. 2001NV4281B ("Evaluation of Ecosystem Metabolism at Selected Sites in the Lower Truckee River Basin") - Dissertations - Robinson, Megan, 2003, The Azolla-Anabaena Symbiosis in the Lower

Truckee River, Nevada. University of Nevada Reno, Hydrologic Sciences Graduate Program, Reno Nevada. 55 p.

8. 2000NV2G ("A Multi-Level Approach to Modeling Ground- and Surface Water Exchange in Agriculturally-Dominated Settings") - Water Resources Research Institute Reports - Mihevc, Todd, Greg Pohll, Rich Niswonger, and Elizabeth Stevick, 2002, Truckee Canal Seepage Analysis in the Fernley/Wadsworth Area, Desert Research Institute, Division of Hydrologic Sciences Report No. 41176.
9. 2000NV2G ("A Multi-Level Approach to Modeling Ground- and Surface Water Exchange in Agriculturally-Dominated Settings") - Dissertations - Ralston, Jill, 2001, Influence of Irrigation of the Geochemical Evolution of Groundwater in the Fernley Aquifer System. Unpublished MS Thesis, Hydrology, University of Nevada, Reno, Nevada, 145 p.
10. 2000NV2G ("A Multi-Level Approach to Modeling Ground- and Surface Water Exchange in Agriculturally-Dominated Settings") - Dissertations - Stevick, Elizabeth, 2003, Simulation of Groundwater Resources in the Fernley and Dodge Flat Hydrographic Basins, Nevada, Unpublished M.S. Thesis, Hydrology, University of Nevada, Reno, Nevada, 92 p.
11. 2000NV2G ("A Multi-Level Approach to Modeling Ground- and Surface Water Exchange in Agriculturally-Dominated Settings") - Conference Proceedings - Ralston, Jill, James Thomas, Burkhard Bohm, and W. Alan McKay, 2001, The Influence of Irrigation Infiltration on the Evolution of Groundwater Chemistry Near Fernley, Nevada. "In" Geological Society of America Abstracts with Programs, A-110.
12. 2000NV5B ("Determination and Source Apportionment of Polycyclic Aromatic Hydrocarbons (PAHs) from Watercraft in Recreational Lakes in Northern Nevada and Eastern California") - Other Publications - Miller, Glenn C., Cynthia Hoonhout, Erica Sufka, Sandra Carroll, Veronica Edirveerasingam, Brant Allen, John Reuter, Jim Oris and Michael S. Lico, 2003, Environmental Assessment of the Impacts of Polycyclic Aromatic Hydrocarbons (PAH) in Lake Tahoe and Donner Lake. A Final Report to the California State Water Resources Control Board, 79 p.
13. 2000NV5B ("Determination and Source Apportionment of Polycyclic Aromatic Hydrocarbons (PAHs) from Watercraft in Recreational Lakes in Northern Nevada and Eastern California") - Conference Proceedings - Miller, Glenn C., Cynthia Hoonhout, Sandra Carroll and Erica Sufka, 2002, Polycyclic Aromatic Hydrocarbons (PAY): Will These Newly Discovered Compounds Limit Boating on Inland Lakes? In Proceedings of the 31st Annual Marina Recreation Association of California, 6 p.
14. 2000NV5B ("Determination and Source Apportionment of Polycyclic Aromatic Hydrocarbons (PAHs) from Watercraft in Recreational Lakes in Northern Nevada and Eastern California") - Dissertations - Sufka, Erica, 2003, Photochemical Fate of Polycyclic Aromatic Hydrocarbons Derived from Marine Engines in High Alpine Lakes. Unpublished M.S. Thesis, Environmental Sciences and Health, University of Nevada, Reno, Nevada.
15. 1999NVB-02 ("Investigation of Mercury in Water, Sediment and Aquatic Biota Tissue from Seven Tributary Streams of the East Fork of the Carson River, California") - Articles in Refereed Scientific Journals - Fischer, Peter and Mae Sexauer Gustin, 2002, Influences of Natural Sources of Mercury in Water, Sediment and Aquatic Biota in Seven Tributaries of the East Fork of the Upper Carson River, California. *Water Air Soil Pollution*, 133:283-295.