

# Water Resources Center, Desert Research Institute

## Annual Technical Report

### FY 1998

## Introduction

## Research Program

### Basic Project Information

<b>Basic Project Information</b>	
<b>Category</b>	<b>Data</b>
<b>Title</b>	Paleohydrological and Hydroclimatological Analysis of the Magnitude and Frequency of Large Floods in the Verde River Basin, Central Arizona
<b>Project Number</b>	C-01
<b>Start Date</b>	09/01/1996
<b>End Date</b>	08/31/1998
<b>Research Category</b>	Climate and Hydrologic Processes
<b>Focus Category #1</b>	Floods
<b>Focus Category #2</b>	Hydrology
<b>Focus Category #3</b>	Climatological Processes
<b>Lead Institution</b>	Desert Research Institute

### Principal Investigators

<b>Principal Investigators</b>			
<b>Name</b>	<b>Title During Project Period</b>	<b>Affiliated Organization</b>	<b>Order</b>
Kyle P. House	Assistant Professor	Desert Research Institute	01
Victor R. Baker	Professor	University of Arizona	02
Stephen G. Wells	Professor	Desert Research Institute	03

## **Problem and Research Objectives**

Spatial and temporal variations in the magnitude and frequency of large floods in the southwestern United States are strongly influenced by hydroclimatic variability. Large floods in most large river basins in the region result almost exclusively from regional-scale extratropical and/or tropical weather systems. The spatial and temporal distribution of these storm types are strongly influenced by persistent, anomalous patterns in hemispheric to global-scale atmospheric and oceanic circulation. Short- and long-term variability in flood frequency in this region are thus good indicators of variability in the larger-scale climatic phenomena over similar time scales. Flood runoff processes from flood-producing storms in individual basins in semi-arid and arid portions of the western U.S. can also vary significantly over space and time. This is often the case for large river basins that integrate areas of strikingly diverse physiography ranging from extensive, high elevation forested areas to rugged, low elevation desert areas. The resulting complex characteristics of individual flood events coupled with the variability in their occurrence induced by larger-scale hydroclimatic controls present unique challenges to water resource management and flood control practices in the region. The relatively short lengths of stream gage records in the southwest preclude attempts to evaluate effects of these hydrologic and climatic phenomena on flood magnitude and frequency over time scales greater than about 100 years. A comprehensive study of the paleoflood hydrology and flood hydroclimatology of an individual, regionally significant river basin would constitute a valuable contribution towards greater understanding of the implications of hydrologic and hydroclimatic variability for water resources management and flood control in the western U.S.

We are studying the influence of hydroclimatic variability on flood magnitude and frequency in the Verde River basin of central Arizona (total area approx. 15,000 km<sup>2</sup>) over a period of time extending beyond the historical record by 100s to 1000s of years using techniques of paleoflood hydrology and flood hydroclimatology. The Verde River is chosen as an excellent representative for large basins throughout the southwestern U.S. because its flood regime is sensitive to hydroclimatic variability, it has an extensive gage network with fairly long records, it has several excellent sites for paleoflood studies, and it was affected by extreme floods in 1993 for which a wealth of hydrological and meteorological data exist. The largest floods on the Verde River have occurred as a result of anomalous winter atmospheric circulation patterns, but dissipating tropical storms have resulted in large floods on many of its tributaries. Flood runoff in the basin during individual events can be highly variable in space and time such that similar hydroclimatic circumstances can result in floods of significantly different magnitudes. We will examine links between hydroclimatic phenomena and the gaged and historical record of large floods on the mainstem of the Verde River and its gaged tributaries.

## **Methodology**

### **Principal Findings and Significance**

Data collection and most of the analyses for the Verde River paleoflood project are complete. Various reports were prepared to coincide with the 2<sup>nd</sup> International Paleoflood Conference and Field Trip (September 26-October 1, 1999) which highlighted this research.

The most significant findings from the project include:

- The identification, excavation, and detailed analysis of 4 high-quality paleoflood study sites at strategic locations within the basin. Each site is within close proximity to a USGS stream gaging

station to aid in hydraulic modeling and flood frequency modeling. In total, we have acquired radiometric dates on 31 samples of organic detritus collected from within and between flood deposits at each site. This has resulted in the compilation of the most comprehensive paleoflood chronology that exists in the region.

- The oldest basal dates from the stratigraphy at the two sites in the upper basin are approximately 3000 yr BP. The site in the middle basin has a basal date of only 1200 yr BP. At the downstream most site, the oldest Holocene date is 2000 years; but here we have a stratigraphic from the latest Pleistocene that is overtopped by at least two late Holocene flood deposits. This gap in the record spans approximately 8000 years. The elevation of the uppermost Pleistocene deposit represents a threshold flood stage that has been exceeded only twice during the Holocene.
- Several of the dates indicate that some floods most likely occurred in intervals of the late Holocene that have been previously described as "non-flood intervals" from the basis of preexisting regional paleoflood records.
- Evaluations of soil development, sedimentology, and stratigraphy of flood deposits have suggested that acquiring accurate and complete counts of paleofloods is extremely difficult even under the best conditions of deposit preservation. This problem becomes more pronounced with the ages of the deposits. However, the presence of buried soils in the stratigraphic sections provides a baseline of flood non-exceedence in time and space thereby negating the need for an absolute count of flood deposits. This fact is being exploited in the flood frequency analysis currently underway.

Site	Record Length (yr)	# of Floods	1993 Qpk	#> 1993 Qpk
Bear Siding	>3000	~11	~35,000*	at least 4
Duff Canyon	>3000	~9	53,200	at least 3
Chasm Creek	1300	>3	119,000	at least 1
Sheep Bridge	>10,000	~28	145,000	at least 2
*Minimum estimate				

## Two-Dimensional Flow Modeling

We have worked in conjunction with the USBR Paleohydrology Research group to collect high-resolution GPS survey data for 2-dimensional modeling through the reach including the Sheep Bridge site. The accumulation of flood slackwater sediment is associated with a complex hydraulic situation that is best resolved using a 2-D modeling approach. This component of the project is an important advance in paleohydrological investigation and will be a principal topic of discussion on the field trip associated with the 2<sup>nd</sup> International Paleoflood Conference.

## Paleoflood Frequency Analysis

The flood-frequency implications of the paleoflood records are being evaluated for use in the U.S. Bureau of Reclamation's flood frequency modeling program FLDFRQ3. This particular program is a very powerful tool for maximizing the value of paleoflood data in the improvement of flood frequency estimates. Various flood frequency analysis scenarios with data from each of the paleoflood study sites combined with systematic data from the proximate gaging stations. The analysis will be performed in cooperation with the paleoflood research group at the USBR.

## **Descriptors**

floods, paleohydrology, hydroclimatology, flood frequency

## **Articles in Refereed Scientific Journals**

House, P.K., and K.K. Hirschboeck, 1997, Hydroclimatological and paleohydrological context of extreme winter flooding in Arizona, 1993: in Larson, R.A., and Slosson, J.E., editors., *Reviews in Engineering Geology*, vol. 11, *Storm-Induced Geologic Hazards: Case Histories from the 1992-1993 Winter in Southern California and Arizona*, p. 1-24.

## **Book Chapters**

## **Dissertations**

House, P.K., 1996, Ph.D. Dissertation: Reports on Applied Paleoflood Hydrological Investigations in Western and Central Arizona. Department of Geosciences, University of Arizona, Tucson, Arizona, 356 p.

## **Water Resources Research Institute Reports**

## **Conference Proceedings**

House, P.K., 1999, A multiscaled approach to evaluating the paleoflood hydrology and hydroclimatology of the Verde River basin, Arizona. *In* Abstracts of the International Conference on Drainage Basin Dynamics and Morphology, Hebrew University, Jerusalem, Israel.

House, P.K., J.E. Klawon and P.A. Pearthree, 1998, A multiscaled evaluation of the paleoflood hydrology and flood hydroclimatology of the Verde River basin, Arizona. Presented at the Geological Society of America, Rocky Mountain Section Meeting, Flagstaff, Arizona.

House, P.K., 1999, Lessons Learned from Paleoflood Stratigraphy in the Verde River basin, Arizona. Invited abstract for presentation at the International Conference on Drainage Basin Dynamics and Morphology, Hebrew University, Jerusalem, Israel.

House, P.K., Levish, D.R., and Ostenaar, D.A., 1999, Paleoflood Hydrology Tomorrow -- New Challenges and Directions for the 21st Century. Invited abstract for presentation at the 15th Biennial Meeting of the International Union for Quaternary Research, Durban, South Africa.

House, P.K., editor, 1999, Abstracts for oral presentations and posters, The Second International Paleoflood Conference, Prescott, Arizona, September 27-29, 1999. 44 p.

## **Other Publications**

House, P.K., Klawon, J.E., and Pearthree, P.A., 1999, Field Trip Guide for the Second International Paleoflood Conference, September 29-October 1, 1999, unpublished manuscript, 97 p.

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## Basic Project Information

Basic Project Information	
Category	Data
<b>Title</b>	Salinity Management in Western Wetlands:colon;colon; Effects of Irrigated Agriculture
<b>Project Number</b>	C-02
<b>Start Date</b>	09/01/1997
<b>End Date</b>	08/31/2000
<b>Research Category</b>	Biological Sciences
<b>Focus Category #1</b>	Wetlands
<b>Focus Category #2</b>	Agriculture
<b>Focus Category #3</b>	Water Quality
<b>Lead Institution</b>	Desert Research Institute

## Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Lewis W. Oring	Professor	University of Nevada, Reno	01
Kristina Hannam	Post Doctoral Student	University of Nevada, Reno	02
Susan Haig	Associate Professor	Oregon State University	03

## Problem and Research Objectives

Investigate salt tolerance of shorebirds, evaluate movements about and use of hypersaline sites by waterbirds, and develop standards for freshwater availability for waterbirds.

## Methodology

Primary laboratory methodology involves incubating wild captured eggs in carefully controlled incubators, rearing resulting chicks in controlled saline environments representing fresh, brackish, saline and hypersaline conditions, and then measuring physiological, behavioral and morphological features of chicks reared in the various environments. New work this year is exploring effects of varying salinities on stress hormones (corticosterone) and stress proteins. Primary field methodology involves noting waterbird use of differing aquatic environments relative to salinity, and comparing known-age chicks in the wild with those reared in captivity.

## Principal Findings and Significance

We have determined that two shorebird species, American Avocet (*Recurvirostra americana*) and Black-necked Stilt (*Himantopus mexicanus*) cannot tolerate hypersaline water (more than 50,000 uS). Freshwater availability is essential to life. Birds reared in environments with lower salinity grew and behaved normally. However, prior to this year we had no measures of sublethal effects of salt on physiology. This is a focus for years two and three of this grant. In this second year of the grant we have confirmed laboratory work involving rearing chicks under varying salinities. In collaboration with Drs. Albert Dufty (Boise State University) and Lee Weber (University of Nevada, Reno) we are expanding our analyses to involve stress hormones (Dufty) and stress proteins (Weber). Samples being collected in summer 1999 will be analyzed in Dufty's and Weber's laboratories in fall 1999. We have just initiated preliminary landscape level field work in the last two weeks. We are experimentally manipulating the freshwater inflow to a hypersaline playa and observing bird responses. These data will be summarized in fall 1999.

### Descriptors

Wetlands, salinity, conservation, shorebirds, water quality standards, water reuse, conflict management, resource planning, wildlife management

### Articles in Refereed Scientific Journals

Haig, S.M. and L.W. Oring, 1998, Wetland connectivity and waterbird conservation in the western Great Basin of the United States. *Wader Study Group Bull.*, 85:19-28.

Haig, S.M., D.W. Mehlman and L.W. Oring, 1998, Avian movements and Wetland connectivity in landscape conservation. *Cons. Biol.*, 12:749-758.

Warnock, N., S.M. Haig and L.W. Oring, 1998, Monitoring species richness and abundance of shorebirds in the western Great Basin. *Condor*, 100:589-600.

### Book Chapters

### Dissertations

### Water Resources Research Institute Reports

### Conference Proceedings

### Other Publications

### Basic Project Information

Basic Project Information	
Category	Data
Title	A Multi-Level Approach to Modeling Ground- and Surface Water Exchange in Agriculturally-Dominated Settings
Project Number	C-03

<b>Start Date</b>	09/01/1998
<b>End Date</b>	08/31/2001
<b>Research Category</b>	Water Quality
<b>Focus Category #1</b>	Nitrate Contamination
<b>Focus Category #2</b>	Irrigation
<b>Focus Category #3</b>	Models
<b>Lead Institution</b>	Desert Research Institute

### Principal Investigators

<b>Principal Investigators</b>			
<b>Name</b>	<b>Title During Project Period</b>	<b>Affiliated Organization</b>	<b>Order</b>
Alan McKay	Professional Staff	Desert Research Institute	01
John J. Warwick	Professor	University of Nevada, Reno	02
Michael E. Campana	Professor	University of New Mexico	03

### Problem and Research Objectives

Flood irrigation of field crops is believed to be linked to non-point source groundwater solute returns in the lower Truckee River Basin. The objectives of the research are to characterize the source of solutes to the lower Truckee River, and determine the potential benefits in converting land and water use from agriculture to urban and municipal uses. Additional objectives include characterizing the impacts of groundwater nutrient inputs on attached benthic algal communities in the river.

### Methodology

Field studies, including drilling and coring activities, will be integrated with numerical groundwater flow & transport and surface water quality models.

### Principal Findings and Significance

To-date, approximately 20 shallow and deep wells have been installed in the study area. These wells are providing valuable information on the nature and distribution of subsurface salts in the study area. Additionally, the wells are serving as monitoring wells for hydrologic and geochemical data collection. A computer geologic model of the study area has been completed. The numerical groundwater flow model is being developed; to-date, flow model boundaries have been assigned.

### Descriptors

surface-groundwater relationships, subsurface drainage, water quality modeling, groundwater modeling, irrigation, algae

**Articles in Refereed Scientific Journals**

**Book Chapters**

**Dissertations**

**Water Resources Research Institute Reports**

**Conference Proceedings**

**Other Publications**

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## **Information Transfer Program**

### **Objectives**

The Nevada Center's principal technology transfer program objective is to provide agencies and individuals responsible for management of Nevada's water resources with results of its research, presented in a way as to enable them to be applied in a timely manner. A related objective is to keep the citizenry of Nevada informed of the Center's program and how the program benefits them in their use of the resource. A third objective of the Center's program is to keep other water resources research personnel apprised of the work being done in Nevada, enabling them to apply the Nevada results to their own area of research.

### **Methods**

Since 1966, the Nevada Water Resources Center has maintained a strong program in information dissemination and technology transfer. Constant interchange provides ideas for improved water use and conservation and guidance as to the directions Center research activities should take. Such interchange is facilitated by numerous interviews and discussions held with water officials throughout the state on all levels - local, state, and federal - in order to promote a better relationship and understanding with the Center. The Nevada Center established a statewide advisory council in 1972 comprised of local, state and federal officials and representatives of the local citizenry to serve as an advisory group for the research and development program of the Center.

Center personnel have been actively making public presentations to professional and social groups concerning the current research of the Center and water resource problems in general. Also, staff members are involved in various professional societies, lay groups, and local committees dealing with water resources.

John R. Doherty, Science Information Officer for the Desert Research Institute, is responsible for disseminating information on the programs and accomplishments of the Institute's research faculty. This is accomplished through such techniques as periodic news releases, presentations before public groups, arranging feature articles by media personnel, production of radio presentations, production of videotaped material, and use of brochures, pamphlets and annual reports.

Another facet of the water resources program is maintaining a library of water resource publications. A list of the new acquisitions to the library is sent out monthly to the professional community throughout Nevada (agencies, consulting firms, the University, and government). Also, the Center publishes all project results in the form of

reports which are routinely provided to the libraries and other researchers, as well as being made available to the public.

During the past several years, personnel from the Center have participated in, arranged, and co-sponsored the Nevada Water Resources Association Annual Conference. These conferences involve the interaction of professionals, politicians, and the general public in discussions of water-related problems and issues. Conferences sponsored during the past two years are listed below.

October 1997: "Life in a Closed Basin" held in Elko, Nevada.

September 1998: "Water Solutions for Nevada" held in Las Vegas, Nevada

## **USGS Internship Program**

### **Student Support**

<b>Student Support</b>					
<b>Category</b>	<b>Section 104 Base Grant</b>	<b>Section 104 RCGP Award</b>	<b>NIWR-USGS Internship</b>	<b>Supplemental Awards</b>	<b>Total</b>
<b>Undergraduate</b>	N/A	6	N/A	N/A	N/A
<b>Masters</b>	N/A	2	N/A	N/A	N/A
<b>Ph.D.</b>	N/A	2	N/A	N/A	N/A
<b>Post-Doc.</b>	N/A	1	N/A	N/A	N/A
<b>Total</b>	N/A	11	N/A	N/A	N/A

## **Awards & Achievements**

### **Publications from Prior Projects**

**Articles in Refereed Scientific Journals**

**Book Chapters**

**Dissertations**

**Water Resources Research Institute Reports**

**Conference Proceedings**

**Other Publications**