2014 NWRA Annual Conference
February 3–6, 2014
Tuscany Suites & Casino
Las Vegas, Nevada

NWRA Annual Conference, February 3–6, 2014

All of us with Nevada Water Resources Association would like to thank the planning committee for the time, talent and expertise you have given to the 2014 Annual Conference Week planning. Your ideas, input, and enthusiasm were most helpful and have resulted in an exciting and informative 2014 program!

Steve Weber, *Ph.D.,* **NWRA 2014 Conference Chairman,** MWH Americas Inc.
Jeffrey Johnson, NWRA 2014 Conference Co-Chairman, Southern Nevada Water Authority

Ayoub Ayoub, *Ph.D.*
Southern Nevada Water Authority

Brian Bass, *P.E.*
Legacy Team Environmental Consultants

David Berger
U.S. Geological Survey

Steve Bradhurst
Central Nevada Regional Water Authority

Robert Coache, *P.E.*
Hydrotech Consulting Services LLC

Christopher Cottingham
Cascade Geoscience

David Donovan, *M.S. R.G. C.P.G., Hydrologist II*
Southern Nevada Water Authority

Christi Emery
Nevada Division of Water Resources

Chris Facque
Farr West Engineering

Jay Fischer
Reese River Hydrologic LLC

Alex Flangas
Holland & Hart LLP

Thomas K. Gallagher, *P.E.*
Nevada Water Solutions LLC

Linda Grossman
Clark County Water Reclamation District,
Water Quality, Research & Technical Services

Catherine Hansford, *B.S., M.S.*
Hansford Economic Consulting

Michael Hardy, *P.E., PG, WRS*
Lumos & Associates Inc.

Jena Huntington
U.S. Geological Survey

Justin Huntington, *Ph.D.*
Desert Research Institute

Michael Johnson
Hydrogeologist

Thomas Maher
Southern Nevada Water Authority

Zane Marshall
Southern Nevada Water Authority

Lisa Moseley
Schroeder Law Offices PC

Hugh Ricci, *P.E.*
Ricci Engineering Ltd.

Michael Rosen, *Ph.D.*
U.S. Geological Survey

Sam Routson
Winnemucca Farms Inc.

Laurel Saito, *Ph.D., P.E.*
University of Nevada, Reno

Loretta Singletary, *Ph.D.*
University of Nevada, Reno

Dwight Smith, *P.E., PG*
Interflow Hydrology Inc.

Adam Sullivan, *P.E.*
Nevada Division of Water Resources

Tina Triplett
Nevada Water Resources Association

Darrell Tweidt
Boart Longyear

Therese Ure
Schroeder Law Offices PC

Mike Widmer
Hydro-Geo LLC

NWRA Annual Conference, February 3–6, 2014

On behalf of the many people whose efforts make possible the 2014 Nevada Water Resources Association Annual Conference, welcome to what promises to be an enlightening and engaging journey into the world of water resources.

This year marks the 70th anniversary of the moment when former Nevada State Engineer Tom Smith planted the first seeds for what has become the NWRA by convening a group to discuss groundwater management issues. From its humble beginnings, the NWRA has emerged as the premier resource for professionals in our state to become more effective stewards of Nevada's precious water supplies. From policy-makers and public administrators to resource managers and technical service providers, we all have a role to play in ensuring our state's water is developed responsibly and used for the benefits of Nevada's residents.

Many of us attend the 2014 NWRA Annual Conference to expand our base of professional knowledge and network with our colleagues in the water community. For those purposes this conference promises to be a robust and engaging experience. This year, however, we hope that you will join us in drawing back from our sometimes-myopic perspective and consider the critical role water plays in our communities and our state's economy.

Nevada's roots are in agriculture, and despite the state's population explosion during the past quarter-century, its water use still reflects that heritage. As most people know, the majority of our state's water use remains in agriculture, with municipal/industrial uses accounting for a relatively small portion of our state's water resources, and industries such as mining and electric power production drawing nominal quantities of water. At the same time, the economic data show the inverse, with the vast majority of Nevada's economic output emanating from the state's two urban centers. This contradiction has often resulted in conflicts, with urban interests questioning the viability of agricultural water consumption while ranchers question the increasing urbanization of Nevada, as well as the use of water for habitat and wildlife purposes.

These are indeed thorny issues, but we must find ways to address them if our state is to prosper in the decades to come. Before resolution must come understanding. Our hope is that the interactions of professionals, from all water-related fields, will lay the foundation for constructive discussions and a search for middle ground. We believe mutual respect — which can only come through familiarity — will help create such a foundation and are excited for the opportunity to create a venue through which such relationships can be fostered.

We encourage you to take in this week's presentations and discussions with an open mind, and an eye toward the future.

Respectfully,

Steve Weber and Jeff Johnson
Conference Chairs

Welcome to Southern Nevada and the 2014 NWRA Annual Conference! The Nevada Water Resources Association's mission is to provide education, training and networking opportunities for those interested in understanding, developing, conserving and protecting Nevada's water resources.

For 150 years, Nevada's economy has best been described by economic booms and busts. From mining to gaming and tourism to construction and agriculture, our economy relies heavily on consumption. While Nevada strives to achieve economic diversification and climb out of the Great Recession, the one constant that has influenced our economy more than any other factor is WATER. As the driest state in the nation, our challenges are enormous, and the professionals attending this conference play a major role in the management of our most precious resource. As Governor Sandoval reminded us at our 2012 NWRA Annual Conference, "Economic development and the future quality of life are as closely linked to water resources management as to any other that confront us."

This year's conference focuses on the role of water in our economy. Once again, the Planning Committee has assembled an excellent collection of workshops, tours, panel discussions and technical presentations. The NWRA Board of Directors would like to thank the Planning Committee for all the hard work put into planning for this conference. We especially want to thank our Executive Director, Tina Triplett, and her amazing staff for their tireless efforts and meticulous planning throughout the year. We hope you enjoy the 2014 NWRA Annual Conference Week, and hope to see you again at one of our many events throughout the great state of Nevada.

Jay Dixon
NWRA President

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Our company is the product of three key lineages of engineering firms with long and successful histories.

James M. Montgomery Consulting Engineers (JMM) was formed in 1945 in southern California and recognized for its excellence and specialization in water and wastewater engineering. In the early 1990s, JMM merged with an English firm, Watson Hawksley Ltd. of High Wycombe, England, which originated in London in the 1850s. This created a company of global scope known as Montgomery Watson.

In 2001, Montgomery Watson merged with Harza Engineering, a Chicago-based energy, water and infrastructure company. The merger brought together two companies with long histories of excellence; similar corporate cultures that honored individual expertise and encouraged teamwork, innovation and initiative; and a common view of the industry's future. The name was changed to Montgomery Watson Harza and ultimately shortened to MWH.

Today, we continue to be dedicated to innovation and committed to mastering and applying emerging technologies to create client-focused results. We have engaged in the engineering, construction, financing and management of some of the world's largest and most technically significant wet infrastructure projects in the world.

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Dedicated to our clients and our employees, National's mission is to align safety, experience, industry-best equipment and service to provide dependable, professional drilling services.

Colonel William Boyce Thompson founded the Newmont Company in 1916 as a holding company for private acquisitions in oil and gas, mining and minerals enterprises. Thompson named the company "Newmont" because, as one biographer described it, "he grew up in Montana and made his money in New York."

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Demonstrating leadership in safety, stewardship of the environment and social responsibility as one of our guiding values, Newmont was included in the esteemed Dow Jones Sustainability World Index (DJSI) for the third consecutive year, and listed on both the DJSI North America and the DJSI World in 2008. The DJSI independently evaluates companies' long-term economic, environmental and social performance, publicly identifying the top 10 percent of performers in areas of sustainability.

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Activities & Schedule

NWRA Annual Conference, February 3–6, 2014

Monday, February 3, 2014

7:00 a.m. – 5:00 p.m.	**Event Activity Registration**
8:00 a.m. – 4:00 p.m.	**Water Rights in Nevada Seminar**
8:00 a.m. – 5:00 p.m.	**Nevada Well Construction Regulations Workshop**
10:00 a.m. – 4:00 p.m.	**NWRA Annual Conference Poster Presentation and Exhibitor Set-Up**
1:30 p.m. – 4:30 p.m.	**Tour of the Venetian**
4:00 p.m. – 7:00 p.m.	**NWRA Annual Conference Exhibit Area Open**
6:30 p.m. – 8:00 p.m.	**Board of Directors Business Meeting**

Tuesday, February 4, 2014

7:00 a.m. – 10:00 a.m.	**Event Activity Registration**
8:00 a.m. – 2:00 p.m.	**NWRA Annual Conference Poster Presentation and Exhibitor Set-Up**
8:00 a.m. – 3:30 p.m.	**Advanced Water Rights in Nevada Seminar**
9:00 a.m. – 3:30 p.m.	**NWRA Annual Conference Tour**
10:00 a.m. – 6:00 p.m.	**NWRA Annual Conference Registration**
12:00 p.m. – 6:00 p.m.	**NWRA Annual Conference Exhibit Area Open**
1:30 p.m. – 7:00 p.m.	**Water Resources Colloquium**

1:30 p.m. – 3:00 p.m.	U.S. Geological Survey Overview of the National Water Information Systems (NWIS)
4:00 p.m. – 5:15 p.m.	Networking Social, Exhibit and Poster Presentation Area
5:15 p.m. – 5:45 p.m.	Legislative Updates with Jason King, P.E., Nevada State Engineer

Water Resources Colloquium (continued)

5:45 p.m. – 7:00 p.m.

Perspectives on 3M Plans Discussion
Water-resources development in arid regions often must prevent or mitigate negative impacts. Challenges arise because impacts are variably defined, difficult to quantify, and may take decades to manifest or to remediate. This discussion presents various perspectives on plans designed to monitor, manage and mitigate hydrologic and biologic resources potentially affected by water development.

Moderator: **David Berger,** *U.S. Geological Survey*

- **Richard Felling,** *Chief Hydrologist, Nevada Division of Water Resources,* "Monitoring Programs of the State Engineer's Office"
- **Stephen Palmer,** *Attorney, Officer of the Solicitor, Department of Interior,* "What is the Interest of Federal Agencies in Monitoring Water Resources Development?"
- **Pat Rogers,** *Vice President, Environmental & Permitting, General Moly Inc.,* "Mt. Hope Mine 3M Plan"
- **Gregory James,** *Special Counsel to the Board of Supervisors, Inyo County, California,* "Groundwater and Surface Water Monitoring and Management in the Owens Valley, California"

Wednesday, February 5, 2014

7:00 a.m. – 4:00 p.m. **NWRA Annual Conference Registration**

7:00 a.m. – 8:30 a.m. **Continental Breakfast,** Exhibit and Poster Presentation Area

8:00 a.m. – 8:05 a.m. **Opening Remarks, Steve Weber,** *2014 Conference Chairman*

8:05 a.m. – 8:45 a.m. **Opening Keynote Presentation**
Steve Hill, *Executive Director of the Nevada Governor's Office of Economic Development*

8:45 a.m. - 10:15 a.m. **Panel: Water and Agriculture in Nevada**
This panel focuses on agricultural issues in the Walker River Basin, including economic consequences and benefits in the State of Nevada. The National Fish & Wildlife Foundation is actively involved in the Walker River Basin to address environmental issues in the Walker River and Walker Lake. Alternative

crop type and efficiency will be addressed, as well as water banking as a method to sustain water resources. The agricultural industry in the State of Nevada is sizeable and provides numerous job opportunities, and agriculture producers are constantly updating practices and methods to maintain their business and way of life.

Moderator: **Jay Dixon,** P.E., *Kinross-Round Mountain Gold Corporation*

- **Joy Morris,** *Walker Basin Restoration Program, Manager, National Fish & Wildlife Foundation,* "Walker Basin Restoration Program"
- **Jay Davison,** *Specialist-Alternative Crops & Forage, University of Nevada, Reno, Cooperative Extension, Churchill County,* "Alternative Crops for Nevada"
- **Loretta Singletary,** Ph.D., *Professor & Interdisciplinary Outreach Liaison, University of Nevada, Reno,* "Water Banking: Farmer Willingness to Participate"
- **Paul Mathews,** *Vice President, Nevada Farm Bureau,* "Perspectives From Local Agriculture Producers in the Walker River Basin Area"

10:15 a.m. – 10:30 a.m. **Break,** Exhibit and Poster Presentation Area

10:30 a.m. – 12:00 p.m. **Panel: Water and Tourism**

Tourism is the State's iconic industry that is recognized worldwide and is the major economic engine with accommodations and food service employment alone accounting for 25 percent of Nevada employment. As a key industry in southern Nevada, it employs state of the art technology to minimize water use and maintain the illusion of an oasis in the desert. The industry utilizes just 8% of municipal water used in southern Nevada, yet generates more economic output than any other industry without considering indirect benefits. The panel will discuss the industries perception of this vital resource and what tourism means to Nevada.

Moderator: **Steve Weber,** Ph.D., *MWH Americas Inc.*

- **Terry Jicinsky,** *Senior Vice President of Operations, Las Vegas Convention & Visitors Authority*
- **Jessica Rosman,** *Director of Supplier Diversity & Sustainability, Caesars Entertainment Corporation*
- **Brian McAnallen,** *Vice President of Government Affairs, Las Vegas Chamber of Commerce*
- **Robert Lang,** Ph.D., *UNLV Director, Brookings Mountain West, Professor of Urban Affairs*

12:00 p.m. – 1:30 p.m. **Luncheon with 2014 Lifetime Achievement and Scholarship Awards**

1:45 p.m. – 3:15 p.m. **Technical Session A: Water Supply**

Moderator: **Tom Maher,** *Southern Nevada Water Authority*

- **Catherine Hansford,** B.S., M.S., *Hansford Economic Consulting,* "The Cost of Rectifying Over-Appropriation of Groundwater in Diamond Valley"
- **Nathan Harper,** *Las Vegas Valley Water District,* "Deep History: The History and Prehistory of Water in the Las Vegas Valley"
- **Stephen Maples,** *U.S. Geological Survey,* "Assessing Capture from the Truckee River by Pumping Wells with a Predictive Drawdown Model — Tracy Segment Hydrographic Area, NV"

- **James Prieur,** *Southern Nevada Water Authority,* "Las Vegas Valley Artificial Recharge Program: 25 Years as a Water Resource Management Tool"

1:45 p.m. – 3:15 p.m. **Concurrent Technical Session B: Adapting to Climate Change**

Moderator: **Paul Williams,** PG, P.H., *SRK Consulting (U.S.) Inc.*

- **Keely Brooks,** *Southern Nevada Water Authority,* "Climate Impacts, Risks and Vulnerabilities: Implications of an Uncertain Climate Future for the Southern Nevada Water Authority"
- **Derek Kauneckis,** Ph.D., *University of Nevada, Reno, Department of Political Science,* "Developing a Method for Measuring the Climate Resilience of Water Policy Subsystems"
- **Al Preston,** Ph.D., P.E., *Flow Science Incorporated,* "Climate Change and Decreasing Levels in Lake Mead: Modeling Changes in Thermal Structure and Water Quality"
- **Todd Tietjen,** Ph.D., *Southern Nevada Water Authority, Regional Water Quality,* "Climate Change Modeling of Lake Mead: Extrapolating Model Results to Biological Change"

3:15 p.m. – 3:45 p.m. **Networking Break,** Exhibit and Poster Presentation Area

3:45 p.m. – 5:15 p.m. **Panel: Economic Perspective on Water Resources and Energy**

Discussion of the role of the economics of water resources within the context of the profitability of geothermal and other renewable energy development in Nevada, and related natural resources. Perspectives will be given on Regulations, Competing Local Water Uses, Cooperation and Stewardship.

Moderator: **Thomas Piechota,** Ph.D., P.E., *University of Nevada, Las Vegas*

- **James E. Faulds,** Ph.D., *Director/State Geologist/Professor, Nevada Bureau of Mines & Geology, University of Nevada, Reno,* "Why is Nevada in Hot Water: New Approaches to Understanding and Harnessing Nevada's Vast Geothermal Resources"
- **Brenda Shank,** *Director, Renewable Energy Strategy & Development, NV Energy,* "Renewable Energy in Nevada"
- **Randal Peterson,** *Manager, Corporate Permitting Group, Ormat Energy Systems,* "Geothermal Energy's Role in Nevada's Water Future"
- **Andrew Wang,** *Director of Development, SolarReserve LLC,* "Crescent Dunes Solar Energy Project — An Update"

5:15 p.m. – 6:30 p.m. **Artificial Recharge Reception and Student Poster Competition**

Thursday, February 6, 2014

7:00 a.m. – 12:00 p.m. **NWRA Annual Conference Registration**

7:00 a.m. – 8:30 a.m. **Continental Breakfast,** Exhibit and Poster Presentation Area

8:00 a.m. – 9:00 a.m. **Technical Session C: Water Quality**

Moderator: **Michael Rosen,** Ph.D., *U.S. Geological Survey*

- **Angela Paul,** *U.S. Geological Survey, Nevada Water Science Center,* "Estimated Arsenic Concentrations in Basin-Fill Aquifers of the Southwest, United States"

- **Michael Rosen,** Ph.D., *U.S. Geological Survey,* "Mixing of Deep Geothermal and Shallow Alluvial Groundwater in Dixie Valley, Nevada"
- **Zachary Walter,** *Farr West Engineering,* "NDEP-BWPC Groundwater Nitrate Assessment Study"

8:00 a.m. – 9:00 a.m. **Concurrent Technical Session D: Innovations**

Moderator: **Chris Cottingham,** *Cascade Geoscience*

- **Keith Halford,** *U.S. Geological Survey,* "Improving Groundwater Models with Transmissivity Observations"
- **Justin Huntington,** Ph.D., *Desert Research Institute* and *University of Nevada, Reno,* "Cloud Computing of Landsat Imagery and Gridded Weather Data for Evaluating Groundwater Dependent Ecosystems in Nevada"
- **Marjorie Sant,** *Fairfield & Woods PC,* "Nevada's Evolving Public Trust"

9:00 a.m. – 9:15 a.m. **Transition Break**

9:15 a.m. – 10:45 a.m. **Panel: Economic Development and Urban Water Supplies**

This panel discusses the linkages between economic development and water use in urban areas. Specifically the panel addresses securing the water resources necessary to support urban economic development, land use and water resource use relationship, the costs to secure additional water resources, and the costs to ensure environmental stewardship of our water resources before and after its use in urban areas. This discussion will demonstrate the inter-relationships of land use, water use, the environment and economic vitality for the communities that water nourishes.

Moderator: **Catherine Hansford,** B.S, M.S., *Hansford Economic Consulting*

- **Eric Dickenson,** Ph.D., *Southern Nevada Water Authority,* "The Costs of Providing Clean Water to Support Urban Economic Activities"
- **Jim Smitherman,** *Program Manager, Northern Nevada Water Planning Commission,* "Planning for Future Water Uses and Supporting Infrastructure"
- **John Hester,** AICP, *Planning Director, Tahoe Regional Planning Agency,* "It's All Linked! Land Use, Water, the Economy and the Environment"
- **Zane Marshall,** *Director of Water & Environmental Resources Department, Southern Nevada Water Authority,* "Managing Water Resources for a Metropolitan Area in the Desert Southwest"

10:45 a.m. – 11:00 a.m. **Break,** Exhibit and Poster Presentation Area

11:00 a.m. – 12:15 p.m. **Technical Session E: Science Impacts to Policy**

Moderator: **Michael Hardy,** P.E., PG, WRS, *Lumos & Associates Inc.*

- **Jeff Johnson,** *Southern Nevada Water Authority,* "Observations from the Carbonate Aquifer Testing Conducted in Compliance with State Engineer Order 1169, Coyote Springs Valley and Muddy River Springs Area, Clark and Lincoln Counties, Nevada"
- **Tim Mayer,** Ph.D., *U.S. Fish & Wildlife Service,* "Interpreting Impacts to Spring Discharge During the Order 1169 Pumping Test"

- **Richard Felling,** *Nevada Division of Water Resources,* "Groundwater Availability in the Lower White River Flow System"
- **David Syzdek,** *Southern Nevada Water Authority,* "Recovering the Moapa Dace in the Upper Muddy River Within the Warm Springs Natural Area, Moapa, Nevada"

11:00 a.m. – 12:15 p.m. **Concurrent Technical Session F: Efficiency and Optimization**

Moderator: **Ayoub Ayoub,** Ph.D., *Southern Nevada Water Authority*

- **John Enloe,** P.E., *Stantec,* "More Crop per Drop — Benefits of the South San Joaquin Irrigation District's Pilot Pressure Irrigation Project"
- **George McMahon,** Ph.D., P.E., D.WRE, *ARCADIS, U.S., Inc.,* "Water-Energy Nexus: Economic Evaluation of Hydropower"
- **Stephen Rogers,** C.W.P., *ARCADIS, U.S., Inc.*, "San Luis Project: Water Treatment Process Optimization"
- **Kimberly Rollins,** Ph.D., *University of Nevada, Reno, Department of Economics,* "Evaluation of Controllable and Uncontrollable Drivers on Residential Water Demand: An Application to the Las Vegas Area"

12:15 p.m. – 1:30 p.m. **Luncheon, Student Poster Awards and Elections**
Jay Dixon, *NWRA President*

1:40 p.m. – 2:00 p.m. **Video Presentation**
Congressman Mark Amodei, *Representing the 2nd District of Nevada*

2:00 p.m. – 3:30 p.m. **Panel: Perspectives on Water Resources and Mining**

This panel discusses the role water plays in the development of mines and related natural resource industries — specifically how the costs and benefits leads to innovation and stewardship.

Moderator: **David Donovan,** M.S. R.G. C.P.G., *Hydrologist II, Southern Nevada Water Authority*

- **Paul Pettit,** *Senior Environmental Manager, Carlin Operations, Newmont Mining Corporation,* "Water Management on the Carlin Trend: Mining, Agriculture and Ecosystem Enhancement"
- **Jay Dixon,** P.E., *Senior Hydrologist, Round Mountain Gold Corporation,* "100 Years of Ranching, Politics and Mining in Big Smoky Valley — A Hydrologist's Perspective"
- **Melissa Jennings,** *Geologist & Environmental Engineer, Rockwood Lithium Inc.*, "A Comparison of the Salar de Atacama and Clayton Valley Lithium Ore Deposits: Groundwater Mining in Some of the Driest Places on Earth"
- **Johnny Zhan,** Ph.D., *Regional Manager, Hydrology, Barrick Gold Corporation,* "Groundwater Model — An Essential Tool for Mining Operations"

3:30 p.m. – 3:45 p.m. **Closing Remarks, Board Election Results and Adjourn**
Jeff Johnson, *2014 Conference Chairman*

4:30 p.m. – 6:30 p.m. **NWRA Board of Directors Meeting**

Technical Sessions Index

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Technical Session A: **Water Supply**

Concurrent Technical Session B: **Adapting to Climate Change**

Technical Session C: **Water Quality**

Concurrent Technical Session D: **Innovations**

Technical Session E: **Science Impacts to Policy**

Concurrent Technical Session F: **Efficiency and Optimization**

The Cost of Rectifying Over-Appropriation of Groundwater in Diamond Valley

Catherine R. Hansford, B.S, M.S
Principal
Hansford Economic Consulting
P.O. Box 10384
Truckee, CA 96162
catherine@hansfordecon.com
530-412-3676

In March 2013 the Eureka County Board of Commissioners approved a contract with HEC to conduct a financial feasibility analysis of creation of a Diamond Valley General Improvement District (GID) to create a locally-owned water management program to retire water rights with the goal of enhancing the sustainability of hydrographic Basin 153's over-appropriated groundwater resources. HEC presented the results of the analysis in June 2013.

The analysis found that the cost to form and operate a Diamond Valley GID to retire water rights is high. Water rights retirement and/or set aside water management strategies would benefit those farmers compensated for loss of their water rights. In addition, the strategies would benefit the aquifer and remaining irrigating farmers by stabilizing water levels such that farming can continue in perpetuity; however, a water retirement program in the valley would not benefit other residents of the County unless the land that is stripped of its water rights is put to other high-value economic use.

Financial feasibility of a GID to retire water rights in Diamond Valley is subject to acceptability of the timeframe to complete the program, assured funding commitments to the program, the prices paid to farmers to purchase their water rights and the farmers' willingness to participate in the program. This presentation discusses groundwater management in Diamond Valley, the methodology to perform the financial analysis and implications of results of the analysis.

Deep History: The History and Prehistory of Water in the Las Vegas Valley

Nathan Harper
Springs Preserve Archaeologist
Las Vegas Valley Water District
333 South Valley View
Las Vegas, NV 89107
nathan.harper@springspreserve.org
702-822-7732

Water resources in North America's driest desert region are scant. Even so, the Las Vegas Valley has transformed into a world-renowned community due to the availability of groundwater and surface water supplies. Once serving as a watering hole for explorers, the community now serves approximately 2 million residents and some 40 million visitors annually. This presentation focuses on the history of the Las Vegas Valley and the key role that water played in the City's development.

The earliest evidence of human activity in Southern Nevada is found near springs or along water courses. Even before the arrival of people to North America, mammoth, bison and dire wolves stalked the area of Tule Springs. We have found the houses of Ancestral Puebloan farmers near the banks of the Las Vegas Creek and John C. Fremont's expedition camped at the Big Springs, current site of the Springs Preserve.

What steps were taken to build this community from a sleepy watering hole on the Salt Lake Route to the thriving city you see today? The Las Vegas Land and Water Company was the first supplier of water to the local townsfolk from the Las Vegas Springs. As the town grew and demand increase the railroad addressed many improvements to the water supply. With the building of Boulder Dam and the later Southern Nevada Water System (SNWS), water shortage issues that had plagued the early town were alleviated. Learn more about how water has shaped the Las Vegas community residents and visitors experience today.

Assessing Capture from the Truckee River by Pumping Wells with a Predictive Drawdown Model — Tracy Segment Hydrographic Area, NV

Stephen R. Maples
Hydrologist
U.S. Geological Survey
2730 North Deer Run Road
Carson City, NV 89701
smaples@usgs.gov
775-887-7624

Keith J. Halford, U.S. Geological Survey

Surface water resources from the Truckee River within the Tracy Segment Hydrographic Area (HA) are fully allocated, supplying the Reno-Sparks and Fernley metropolitan areas, Pyramid Lake Paiute Tribe andNewlands Irrigation Project. The Nevada State Engineer has recently increased the perennial yield for groundwater in the Tracy Segment HA nearly two-fold. Land-use changes and increasing water-supply requirements have prompted concern with the availability and allocation of these water resources. The proximity of current and proposed groundwater pumping to the Truckee River suggests the possibility of river-water capture, confounding prudent water-resource allocation efforts. The objectives of this study are to assess the magnitude and timing of Truckee-River-water capture by nearby pumping wells within the Tracy Segment HA

Published estimates for transmissivity from aquifer tests were refined using a steady-state, three-dimensional, MODFLOW model of the basin-fill and bedrock aquifers, calibrated to measured water levels and estimated boundary conditions. The potential effects of pumping were then estimated with a separate, predictive, direct-drawdown model, utilizing refined values for transmissivity and published values for specific yield. The Truckee River was simulated as no-drawdown boundary while estimating magnitude and timing of river-water capture. Preliminary results show that drawdown propagation is attenuated by the Truckee River, and that the magnitude and timing of river-water capture correlates with pumping-well proximity to the river.

Las Vegas Valley Artificial Recharge Program: 25 Years as a Water Resource Management Tool

James Prieur
Senior Hydrologist
Southern Nevada Water Authority
100 City Parkway, Suite 700
Las Vegas, NV 89106
James.prieur@snwa.com
702-862-7437

An artificial recharge program was initiated in 1989 as a water resource management tool to provide a reserve storage bank and stabilize Las Vegas principal aquifer groundwater levels. Las Vegas Valley Water District and Southern Nevada Water Authority (SNWA) work together to manage program permits, operations and monitoring. Nevada Division of Water Resources and Department of Environmental Protection provide regulatory oversight of the program. Since inception over 365,000 acre-feet (af) of treated Colorado River Water has been recharged through 73 permitted dedicated recharge wells and dual use recharge/production wells during the off-peak season. In-lieu recharge credits are also provided for well production below annual groundwater rights. Currently, approximately 362,000 af of net recoverable AR storage is banked. An extensive monitoring network is used by SNWA to monitor hydrologic conditions in the valley. Historic hydrographs from various areas in the valley show the influence of the AR program over time including recovery of static groundwater levels of over 100 feet in the west central portion of the valley. Historic and current hydrologic conditions of the valley and AR program updates are presented.

Climate Impacts, Risks and Vulnerabilities: Implications of an Uncertain Climate Future for the Southern Nevada Water Authority

Keely Brooks
Climate Change Policy Analyst
Southern Nevada Water Authority
100 City Parkway, Suite 700
Las Vegas, NV 89106
keely.brooks@snwa.com
702-822-3349

Richard Holmes, Southern Nevada Water Authority
Jeff Johnson, Southern Nevada Water Authority

The Southern Nevada Water Authority (SNWA) recently completed a qualitative assessment of potential climate change impacts to critical infrastructure, water supply, water quality and natural resources. Using a traditional approach to risk assessment, where the measure of risk is equal to the likelihood of a threat occurring combined with the consequences if it were to occur, the assessment revealed that a hot and dry future climate scenario poses the greatest risk to SNWA water resources, with conditions becoming more dire in the 2035 and 2060 time period. The study found that SNWA is at the greatest risk from reduced Colorado River supplies, impacts to SNWA intakes in Lake Mead from low lake levels, rising costs to address diminished water quality at treatment facilities andchallenges related to accelerated disinfection byproduct formation in the distribution system. The study, which relied on information from existing literature and expert opinion to evaluate risk, will form the Base Case or "no adaptation" case. In the next phase of the study, SNWA will compare how application of different adaptation strategies will reduce risks to resources, facilities andoperations and make SNWA more resilient to a wide range of possible climate futures.

Developing a Method for Measuring the Climate Resilience of Water Policy Subsystems

Derek Kauneckis, Ph.D.
Associate Professor
Department of Political Science
University of Nevada, Reno
1664 North Virginia Street
Reno, NV 89557
kauneck@unr.edu
775-682-7765

Juhi Huda, M.A., University of Nevada, Reno

Model projections for the western United States suggest dramatic changes to the hydro-climatic conditions in the region in the near future. As policy makers begin to focus on climate change adaptation one of the continuing challenges is in understanding whether the decision making structures created to manage water resources over the past century will be flexible and responsive enough to adequately respond to, and anticipate, the potential negative impacts of climate change. This presentation will present a methodology developed to assist in assessing vulnerabilities within a policy subsystem. While the method has been developed to be generalizable to any socio-ecological system, its utility is illustrated through an empirical application to the Las Vegas and Reno-Sparks urban water systems. The presentation begins with a discussion of resilience theory, how the theory has been applied to understanding policy systems and policy change, highlights the methodology used in the comparative study of the Las Vegas and Reno-Sparks urban water systems, the resulting comparative metric andhow the method suggest can be used to suggest remedies to increase system resilience. It concludes with remaining theoretical and methodological challenges.

Research was conducted with support from the National Science Foundation – Nevada Infrastructure for Climate Change Science, Education and Outreach, #0814372.

Climate Change and Decreasing Levels in Lake Mead: Modeling Changes in Thermal Structure and Water Quality

Al Preston, Ph.D., P.E.
Project Engineer
Flow Science Incorporated
723 East Green Street
Pasadena, CA 91101
al@flowscience.com
626-304-1134

Todd Tietjen, Ph.D., Southern Nevada Water Authority
Peggy Roefer, Southern Nevada Water Authority
E. John List, Ph.D., P.E., Flow Science Incorporated

Climate change models indicate higher probability for longer periods of low water levels in Lake Mead. A 2012 report (USGS Circular 1381) identified a research need to evaluate the effects of climate change, including potential impacts of lower inflows and lower water levels, on the water quality in Lake Mead. With funding from a Reclamation WaterSMART grant we used the three-dimensional Estuary, Lake and Computer Ocean Model (ELCOM) in conjunction with the Computational Aquatic Ecosystem DYnamic Model (CAEDYM) to predict water quality changes in Lake Mead due to variable inflows from the Colorado River and lower water volumes in the lake. Simulation parameters included temperature, salinity, total organic carbon, nutrients, chlorophyll (algae), dissolved oxygen, pH andsuspended-solids. Simulations predict that decreasing lake levels will lead to changes in the thermal structure of Lake Mead once the Hoover Dam upper outlets are inoperable, and that these changes will also affect the water quality in the epilimnion of Boulder Basin. Additionally, the predicted changes in chlorophyll concentrations due to different inflow rates and lake volumes may be larger than those induced by predicted future temperature change. Given that recent 24-month flow projections by Reclamation indicate low inflow conditions and continuing decreasing lake levels, these findings may have near-term implications for conditions in the lake.

Climate Change Modeling of Lake Mead: Extrapolating Model Results to Biological Change

Todd Tietjen, Ph.D.
Limnology Project Manager
Southern Nevada Water Authority
Regional Water Quality
P.O. Box 99954
Las Vegas, NV 89193-9954

Al Preston, Ph.D., P.E., Flow Science Incorporated

The Southern Nevada Water Authority and Flow Science Incorporated have undertaken modeling of Lake Mead under a range of climate change scenarios using funds from the USBR WaterSMART program. A primary conclusion regarding changes in the biology of the lake was that under warming conditions, the algae, expressed as the pigment chlorophyll a, will peak earlier in the year before decreasing to below detection limits as the temperature increases. This outcome is likely produced by a limitation of the calibration of the model based on current conditions and a failure to incorporate algal species more tolerant of the conditions generated by climate change. In an effort to address this shortcoming, we have identified and ranked candidate algae that might be expected to become dominant under these scenarios. There is the possibility that warmer conditions will result in an increase in cyanobacterial species that are more likely to produce toxins or compounds that result in taste and odor issues. Even with the colonization of these warm temperature tolerant species, the maintenance of low phosphorus concentrations will continue to limit algal growth and peak chlorophyll concentrations. The results of this analysis can be incorporated into future modeling of Lake Mead water quality under a range of warming scenarios.

Technical Session C: Water Quality

Estimated Arsenic Concentrations in Basin-Fill Aquifers of the Southwest, United States

Angela Paul
Water Quality Specialist
United States Geological Survey
Nevada Water Science Center
2730 North Deer Run Road
Carson City, NV 89701
appaul@usgs.gov
775-887-7697

David Anning, U.S. Geological Survey, Arizona Water Science Center
Tim McKinney, U.S. Geological Survey, Utah Water Science Center
Jena Huntington, U.S. Geological Survey, Nevada Water Science Center
Laura Bexfield, U.S. Geological Survey, New Mexico Water Science Center
Susan Thiros, U.S. Geological Survey, Utah Water Science Center

The lowering of the drinking-water standard for arsenic by the United States Environmental Protection Agency in 2001from 50 to 10 µg/L stimulated a renewed interest in the distribution of arsenic concentrations in groundwater throughout the United States. A random forest statistical-based model was used to characterize the regional distribution of arsenic concentrations in basin-fill aquifers of the southwestern United States. The modeled study area covered 190,612 square miles, incorporated 39 natural and 14 human-related factors, and was calibrated using measured arsenic concentrations from 4,162 wells. Estimated arsenic concentrations were extrapolated in areas with limited or non-existent data.

The most important factors influencing arsenic concentrations in groundwater included geology, position along the groundwater flow path, natural recharge rates andgroundwater discharge processes. Estimated arsenic concentrations were higher in basins where basin-fill sediments were derived from volcanic and crystalline bedrock and lower in basin-fill sediments predominately derived from carbonate and clastic sedimentary bedrock. Arsenic concentrations increased in groundwater from basin margins to topographically low areas within a basin, indicating the importance of geochemical reactions that enrich arsenic along a flow path.

Model results indicate about 43 percent of the study area likely contain groundwater with arsenic concentrations exceeding 10 µg/L. Most of the area with high estimated arsenic concentrations occurs in Arizona, California andNevada. Basin-fill aquifers in the southwestern United States are particularly susceptible to arsenic enrichment due to the presence of naturally occurring arsenic in the geologic units, climate, prevalence of topographically closed basins andfavorable geochemical conditions.

Mixing of Deep Geothermal and Shallow Alluvial Groundwater in Dixie Valley, Nevada

Michael R. Rosen, Ph.D.
Water Quality Specialist
U.S. Geological Survey
2730 North Deer Run Road
Carson City, NV 89701
mrosen@usgs.gov
775-887-5614

Jena Huntington, U.S. Geological Survey
C. Amanda Garcia, U.S. Geological Survey

Dixie Valley, in north-central Nevada, is a hydrologically-closed groundwater flow system that terminates in the Humboldt Salt Marsh, a moist playa. The basin is a fault-bounded graben structure bordered with steep mountains to the east and west. Fresh groundwater occurs in the alluvial aquifer system around the margins of the basin and becomes hypersaline towards the playa center. Since 1988, a 62 megawatt double-flash geothermal power plant has operated northwest of the playa. Due to reduced pressure from pumping of the geothermal water, cold alluvial groundwater has been used to maintain pressure heads within the geothermal field. Currently, alluvial groundwater is being considered for drinking water export; however, several studies conducted in the 1990's indicate that there is the potential for interaction between the geothermal and alluvial aquifer systems. Therefore, understanding the degree of mixing between geothermal and alluvial aquifer systems is necessary to evaluate the potential groundwater resource. Geothermal and alluvial aquifer chemical compositions and chemical evolution were evaluated using data from geothermal wells, alluvial wells, springs andstreams. Geothermal indicators such as elevated temperature, lithium, boron, chloride andsilica indicate that mixing occurs in many wells tapping the alluvial aquifer, particularly in the south and west sides of the basin. Geothermal waters have high lithium and boron concentrations and low magnesium, whereas alluvial aquifer water derived from volcanic rocks in the basin have high magnesium and low lithium concentrations. The hypersaline playa water has low lithium concentrations, probably due to exchange with smectite clays in the basin center. Silica concentrations in alluvial groundwater is typically greater than 30 mg/L, which is often indicative of a geothermal source; however, silica might also be derived from weathering of volcanic tuffs and diatomite that occur in the basin. Mixing ratios of end member geothermal and alluvial aquifer water indicate that approximately 15 percent of the elemental concentrations found in the alluvial groundwater might be derived from geothermal water.

NDEP-BWPC Groundwater Nitrate Assessment Study

Zachary Walter
Hydrogeologist
Farr West Engineering
5442 Longley Lane
Reno, NV 89511
Zachary@farrwestengineering.com
775-853-7251

Matt Forrest, GISP, Farr West Engineering
Hannah Koepnick, E.I., Bureau of Water Pollution Control
My-Linh Nguyen, Ph.D., P.E., BWPC,
Nevada Department of Environmental Protection

Nitrate contamination of drinking water supply aquifers is a prevalent problem throughout Nevada; however, scattered data sources and outdated information make it difficult to characterize the extent and severity of the contamination. The goal of this study was to create a single data source for groundwater nitrate concentrations throughout the state and a GIS mapping tool for spatial analysis and visualization of nitrate contamination.

The project consisted of assembling available nitrate concentrations that include site spatial information from multiple sources that span approximately 40 years into one database. An ArcGIS tool was then constructed that analyzes the compiled data to create an output raster grid that represents theoretical nitrate concentrations in a user-designed study area. The tool is designed to easily allow the user the ability to define the date range and/or data source, select representative site concentrations as an average of multiple samples or the most recent sample value, select a raster interpolation method, and create an output statistical file that represents only the sample data in the selection.

The tool interpolates nitrate concentrations to an output raster, which uses color contours to show the severity of contamination. This tool will be used by the BWPC to identify areas of concern and data gaps where additional sampling is important to define management areas and to assess constraints of discharge to groundwater permits. We will present our methodology, demonstrate the tool anddiscuss a case study where the tool was applied.

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Improving Groundwater Models with Transmissivity Observations

Keith J. Halford
Hydrologist
U.S. Geological Survey
2730 North Deer Run Road
Carson City, NV 89701
khalford@usgs.gov
775-887-7614

Simulated transmissivities are constrained poorly by assigning permissible ranges of hydraulic conductivities to hydrogeologic units in groundwater-flow models. These often-times wide ranges are derived from interpretations of many aquifer tests that are binned by hydrogeologic unit. Uncertainty is added to ranges of hydraulic-conductivity estimates from aquifer tests where contributing thicknesses from field estimates and in the numerical model differ. Wide ranges and discordant thicknesses result in simulated transmissivities that frequently are orders of magnitude greater than aquifer-test results particularly when transmissivity are less than 1,000 ft^2/d.

Transmissivity observations from individual aquifer tests constrain model calibration better than hydraulic-conductivity ranges assigned to hydrogeologic units because simulated transmissivity and aquifer-test results are compared directly. Transmissivity comparisons require that simulated thicknesses and simulated hydraulic conductivities for the volume investigated by the aquifer test be extracted from a model and integrated into a simulated transmissivity. Transmissivity observations have been ignored primarily because sampling simulated transmissivities from complex models is mechanically painful.

A suite of programs called T-COMP has been developed to sample simulated transmissivities easily from MODFLOW models. Transmissivities of model cells are sampled within the volume affected by an aquifer test as defined by a well-specific radial flow model. Sampled transmissivities of model cells are averaged within a layer and summed between layers. This computationally intensive process occurs in separate programs that are executed prior to model calibration. Simulated transmissivities can be sampled quickly during calibration because model cells and their fractional contributions already have been defined.

Cloud Computing of Landsat Imagery and Gridded Weather Data for Evaluating Groundwater Dependent Ecosystems in Nevada

Justin Huntington, Ph.D.
Assistant Research Professor
Desert Research Institute and University of Nevada, Reno
2215 Raggio Parkway
Reno, NV 89512
justinh@dri.edu
775-750-4617

Charles Morton, Desert Research Institute
Ken McGwire, Desert Research Institute
Andy Joros, Desert Research Institute
Sarah Peterson, U.S. Bureau of Land Management
Noel Gorelick, Google
David Thau, Google
Rick Allen, University of Idaho

Understanding the spatial and temporal variability of groundwater dependent ecosystems in relation to climate and anthropogenic changes is key for developing monitoring strategies, evaluating the effectiveness of restoration and preservation, and identifying potential impacts from groundwater development. Many sensitive species in Nevada rely on habitat areas that are groundwater dependent, such as meadows, spring complexes andriparian corridors. Annual variations in precipitation and temperature cause significant seasonal and annual variability in vegetation vigor surrounding shallow groundwater areas. In addition, groundwater pumping and water development can cause significant declines in vegetation vigor. To better understand if vegetation changes are natural or anthropogenic, natural background variability must be well understood. In this presentation, we highlight current work using the Google Earth Engine cloud computing and environmental monitoring platform, along with the entire archive of Landsat imagery and downscaled Land Data Assimilation System (NLDAS) gridded weather data to evaluate natural background variability in vegetation vigor for selected areas in Nevada. We also give examples of where groundwater development has caused noticeable changes in vegetation conditions beyond the natural variability.

Nevada's Evolving Public Trust

Marjorie Sant
Of Counsel
Fairfield & Woods P.C.
1700 Lincoln, Suite 2400
Denver, CO 80203
msant@fwlaw.com
303-894-4488

Over four decades after Joseph Sax's introduction of the public trust doctrine in 1970 and nearly three decades after the California Superior Court's decision in the Mono Lake case, Nat'l Audubon Soc'y v. Sup. Ct., 658 P.2d 709 (Cal. 1983), that the doctrine applies to water rights, the Nevada Supreme Court expressly adopted of the public trust doctrine in Lawrence v. Clark County, 254 P.3d 606 (Nev. 2011). The Lawrence decision holds the doctrine applies to prevent the state from disposing of land formerly submerged under a navigable waterway when the transfer is not in the public interest. Just as the doctrine evolved in California, it is likely the Lawrence decision portends the application of the public trust to water rights in Nevada.

The Lawrence decision relies on Justice Rose's concurring opinion in Mineral County v. State, 20 P.3d 800 (Nev. 2001), invoking the Mono Lake case to implore the court to apply the public trust doctrine to rights to use surface and ground water. The 2013 legislative session saw the introduction of Assembly Bill 396 in direct response to Lawrence, attempting to clearly establish the public's rights to access navigable waterways. Although AB 396 was unsuccessful, together with the Lawrence court's reliance on Justice Rose's concurring opinion, it demonstrates a progression toward full application of the public trust to water rights. Nevada will face increasing challenges to balance the public trust and environmental interests with private water rights, necessary to the region's varied economies.

Observations from the Carbonate Aquifer Testing Conducted in Compliance with State Engineer Order 1169, Coyote Springs Valley and Muddy River Springs Area, Clark and Lincoln Counties, Nevada

Jeff Johnson
Water Management & Planning Manager
Southern Nevada Water Authority
100 North City Parkway, Suite 700
Las Vegas, NV 89106
jeff.johnson@snwa.com
702-862-3748

Douglas Switzer, Southern Nevada Water Authority
Sean Collier, Southern Nevada Water Authority

In December 2012, the Southern Nevada Water Authority (SNWA) and others completed a 2year pumping test of the regional carbonate aquifer in Coyote Spring Valley, which was required by Nevada State Engineer Order 1169. The test was designed to evaluate the availability of unappropriated groundwater in Coyote Spring Valley through the development of existing water rights in Coyote Spring Valley in conjunction with extensive surface- and groundwater monitoring. Development of existing water rights are subject to monitoring plans, permit conditions andspecific criteria developed in concert with the U.S. Fish & Wildlife Service to ensure protection of Muddy River springs instream flows and Moapa dace habitat. Preparations to undertake the test were extensive, involving installation of monitor wells and surface water gages and construction of a water conveyance pipeline and arsenic removal system. Pumping for Order 1169 was initiated in November 2010.

The magnitude and extent of drawdown produced by pumping at MX-5 was minor, producing generally less than 3 feet at most observation wells. Regional trends in groundwater levels were driven by both groundwater pumping from Coyote Spring Valley, Garnet and Hidden Valleys, and the Upper Muddy River Springs, combined with changes in hydrologic conditions preceding and during the test. Pumping of existing groundwater rights did not result in unreasonable lowering of the groundwater table, and when pumping was reduced groundwater levels recovered. Future groundwater production by SNWA will continue to be carefully monitored in accordance with permit conditions and stipulated agreements.

Interpreting Impacts to Spring Discharge During the Order 1169 Pumping Test

Tim Mayer, Ph.D.
Supervisory Hydrologist
U.S. Fish & Wildlife Service
911 North East 11th Avenue
Portland, OR 97232
tim_mayer@fws.gov
503-231-2395

Gary Karst, Hydrologist, National Park Service

This presentation interprets the impacts to spring discharge at the Muddy River Springs Area (MRSA) from groundwater pumping of the carbonate rock aquifer in Coyote Spring Valley during the Order 1169 pumping test. We hypothesize that changes in spring discharge will be proportional to the changes in hydraulic head differential at each individual spring, meaning the higher elevation springs, with the smallest hydraulic head, will be the most sensitive to the observed drawdown. To validate this hypothesis, we evaluated relationships between carbonate water levels and discharge at four spring monitoring sites and four streamflow monitoring sites, located at or downstream of the outlets of springs in the MRSA.

Results from the study indicate that the system responded to pumping impacts and drawdown as hypothesized. Predicted declines in springflow, based on changes in head differential, were similar to the observed declines in flow at each spring, and were proportional to the estimated reduction in hydraulic head differential at each spring. Streamflow monitoring sites were more variable because they are affected by other factors.

Only one-third of the existing permitted rights in Coyote Spring Valley were pumped during the pumping test, with most of the groundwater pumped being captured from storage rather than spring discharge. The total sum of the reductions in spring discharge during the test was 0.77 cfs or about 1250 acre-feet, equal to about 13% of the total Well MX-5 pumping during the test. If carbonate pumping continues or increases, we expect the capture of springflow and ET to increase substantially.

Groundwater Availability in the Lower White River Flow System

Richard Felling
Chief Hydrologist
Nevada Division of Water Resources
901 South Stewart Street, Suite 2002
Carson City, NV 89702
rfelling@water.nv.gov
775-684-2866

The State Engineer recently released rulings on applications for groundwater in several hydrographic basins of the lower White River Flow System, including Coyote Spring Valley, the Muddy River Springs Area, Hidden Valley, Garnet Valley, California Wash, the Black Mountains Area and Lower Moapa Valley. Existing groundwater rights in these basins total almost 50,000 acre-feet. The Muddy River, a fully-appropriated stream, has an annual flow of 25,000 acre-feet, down from 35,000 acre-feet when it was first measured. Pending applications for groundwater totaled in excess of 350,000 acre-feet. The Order 1169 pumping test and monitoring program resulted in a significant addition to our understanding of the hydrogeology and water budgets of the region. This presentation will discuss results of the pumping test, water available for appropriation in the region andthese recent rulings from the perspective of the State Engineer's office.

Recovering the Moapa Dace in the Upper Muddy River Within the Warm Springs Natural Area, Moapa, Nevada

David J. Syzdek
Environmental Biologist II
Southern Nevada Water Authority
100 City Parkway, Suite 700
Las Vegas, NV 89106
david.syzdek@snwa.com
702-691-5208

The Warm Springs area near Moapa, Nevada is a regional spring complex that is the headwaters of the Muddy River. These thermal springs and associated streams are habitat for an endemic suite of thermophilic aquatic species that includes the federally endangered Moapa dace (Moapa coriacea). The Southern Nevada Water Authority (SNWA), U.S. Fish & Wildlife Service (USFWS), Moapa Valley Water District, Coyote Springs Investments andthe Moapa Band of Paiutes signed a Memorandum of Agreement (MOA) in 2006 which establishes a plan for management and mitigation of groundwater development in Coyote Springs Valley and California Wash while simultaneously working to protect and recover the Moapa dace. The MOA signatories, along with other stakeholders (including the U.S. Geological Survey (USGS), Nevada Department of Wildlife (NDOW), the Bureau of Land Management and The Nature Conservancy), are conducting conservation actions such as the construction of fish barriers, reduction in or removal of non-native and invasive species, riparian and aquatic habitat restoration, and development of an ecological model for the Moapa dace. In September 2007, SNWA purchased the 1,220-acre Warm Springs Natural Area to protect the headwaters of the Muddy River and to enhance habitat of the Moapa dace.

In 2008, Moapa dace numbers suddenly declined to a record low of 459 individuals. Working with the USFWS, NDOW andthe USGS, SNWA is conducting stream restoration work and intensive habitat improvements to reverse the population's decline. Following the February 2008 nadir, dace numbers have been steadily increasing despite a wildfire in 2010 that burned over 600 acres of woodland near many of the streams that contain dace. Moapa dace numbers are currently at a 19-year high, and future efforts are anticipated to further improve dace habitat, improve stream connectivity and monitor for invasive species.

More Crop per Drop — Benefits of the South San Joaquin Irrigation District's Pilot Pressure Irrigation Project

John Enloe, P.E.
Principal, Water
Stantec
6995 Sierra Center Parkway, Suite 200
Reno, NV 89511
John.enloe@stantec.com
775-398-1284

The SSJID board partnered with Stantec Consulting in developing an irrigation program that could improve delivery efficiency and service. A portion of one of the District's nine divisions — 3,800 acres in Division 9 — was chosen as the site for building, testing and optimizing a pilot pressure irrigation project. The vision for the system included the following fundamental capabilities:

- Pressurization – pumping water from a 56-acre-foot pond to individual farms through 19 miles of pressurized pipeline

- Calculated use – letting farmers choose the time, volume andflow rate of deliveries

- Automated/mobile access – developing a web-based tool that allows farmers to schedule deliveries from a computer, smart phone or iPad based on current and past weather forecasts, previous water usage and historical evapotranspiration rates, and orchard moisture sensors.

This presentation will focus on the realized benefits for the SSJID and the Division 9 farmers including but not limited to: improved service to crops, volumetric billing compliance, improved irrigation flexibility (duration, frequency, flow rate), water conservation, reduction in farmer energy costs, reduced groundwater pumping, improved air quality, improved yields, reduction in labor inputs, automatic delivery information for billing, increased pumping efficiency, increased District enrollment, protection of water rights, improved flood delivery service and efficiency, intelligent irrigation scheduling, and improved management of flows through a regulating reservoir.

Water-Energy Nexus: Economic Evaluation of Hydropower

George F. McMahon, Ph.D., P.E., D.WRE
Vice President
ARCADIS, U.S., Inc.
2410 Paces Ferry Road, Suite 400
Atlanta, GA 30339
george.mcmahon@arcadis-us.com
770-431-8666

Multipurpose reservoirs serve a variety of competing and complimentary demands on water and storage, hydropower among them. Sustainable and adaptive management of water resources infrastructure requires accurate valuation of water in alternative uses to (1) reflect evolving social and environmental concerns, (2) inform reservoir operation, and (3) evaluate alternative asset management strategies.

This paper introduces basic concepts of economic evaluation of hydropower resources relative to alternative power resources displaced (thermal and renewable) and electric system load. This is accomplished by (1) description of hydroelectric plant types and components, (2) characterization of power demand, marketing and distribution within the United States, and (3) overview of procedures and criteria applicable to feasibility studies of federal and private hydropower development.

Also discussed is hydropower resource assessment in the contexts of integrated water resource management and opportunity costs of resource use, i.e. value of water and reservoir storage in alternative uses. A case study in application of sound planning principles to hydropower resource analysis of federal hydropower systems is presented, illustrating the effects of changing social preferences and market deregulation on economic viability of the power purpose. The paper concludes that realistic determination of hydropower benefits is essential to planning of new hydropower projects or capacity additions to existing projects, and that timely re-evaluation of operational priorities of existing projects is essential to ensuring most beneficial and sustainable uses of multipurpose reservoirs.

Technical Session F:
Efficiency & Optimization

San Luis Project: Water Treatment Process Optimization

Stephen E. Rogers, C.W.P
Senior Water Resources Engineer
ARCADIS, U.S., Inc.
1687 Cole Boulevard
Lakewood, CO 80401-3190
Stephen.Rogers@arcadis-US.com
720-519-5117

Jason Kerstiens, P.E., ARCADIS, U.S., Inc.
William Lyle, Newmont Mining Corporation

The San Luis Project in Colorado involves the reclamation of a gold mine that closed in the 1990s. As groundwater filled the backfilled excavations, seeps into the Rito Seco were observed. These were deemed to be unpermitted discharges to surface water by the Colorado Department of Public Health and Environment. A series of interceptor and extraction wells were installed to halt the movement of the presumed groundwater plume. Groundwater captured by these wells is treated in the Rito Seco Water Treatment Plant (WTP). The original WTP included two chemical precipitation processes and reverse osmosis (RO) to remove dissolved constituents from the groundwater, most notably manganese, sulfate andfluoride.

Within the first six months of operation, the original RO membranes fouled with gypsum (calcium sulfate). Also, the facility never achieved its design capacity of 350 gpm. Initial operations were plagued by changing water quality as a consequence of the concentrate recirculation, excessively high chloride concentrations anddeclining recovery as recirculating salts accumulated in the system.

The treatment process at Rito Seco was redesigned to a single pass lime/ soda ash chemical precipitation process followed by RO. As a result, the WTP throughput was increased to ~600 gpm and overall efficiency to 94 percent. This allowed the WTP to operate intermittently, reducing operating personnel, power requirements andimproved efficiency in chemical usage. This paper describes the process changes implemented to improve plant performance. An example of the successful operations is the service life of the RO membranes: now thirteen years in service.

Evaluation of Controllable and Uncontrollable Drivers on Residential Water Demand: An Application to the Las Vegas Area

Kimberly Rollins, Ph.D.
Associate Professor
Department of Economics
University of Nevada, Reno
Mail Stop 204
Reno, NV 89557
krollins@unr.edu
775-784-1677

Elena Tchigriaeva, University of Nevada, Reno
Corey Lott, University of California, Santa Barbara

We develop a random effects econometric model of urban residential water demand using a five-year panel of monthly water-use for individual households. The model incorporates demand drivers that are uncontrollable by water users and utilities (precipitation, temperature, economic trends andhousehold characteristics) and drivers that are controllable (turf, trees, xeriscaping, price structure, conservation incentives). The model exploits variation across household characteristics, weather variables andeconomic trends to analyze the impact of these drivers on residential water use. We use a unique disaggregated dataset developed for the Las Vegas area, consisting of 3,671,983 observations for over 62,237 households with uninterrupted water history from 2007 to 2011. The data were obtained from five national and regional agencies and represent about 40% of single family households in the Las Vegas metropolitan area. Results are significantly robust andconform with empirical knowledge of weather and surface influences on outdoor water consumption. Coefficients and elasticities are similar to other published studies (our temperature coefficient of 0.0094 is close to 0.01 estimated for Phoenix, Arizona). Potential water savings are calculated and compared with previous calculations based on biophysical characteristics and relationships for the region, but which could not account for consumers' behavioral responses. The two approaches predict similar water savings for tree covers, which are less affected by conservation programs; but different savings for changes in turf, which are potentially affected by a wider range of consumer behavioral responses in water use.

Poster Presenters

Improvement of Hydrologic Reconstructions Using Oceanic-Atmospheric Climate Variables

Saria Bukhary
Graduate Student
University of Nevada, Las Vegas
Department of Civil & Environmental Engineering
4505 South Maryland Parkway
Las Vegas, NV 89119
bukhary2@unlv.nevada.edu
702-774-1416

Ajay Kalra, Ph.D., Desert Research Institute
Sajjad Ahmad, Ph.D., University of Nevada

Southwest U.S. has a history of recurring hydrologic droughts. These droughts coupled with increasing population and changing climate has stressed available water resources within the region. Particularly its longest river, Rio Grande, which caters to the need of millions along its 1900 mile stretch, has been seriously affected. The available regional streamflow records are relatively short and do not provide sufficient information on severity and duration of past droughts. An alternative to increase the length of data is using Tree-ring chronology, which is used conventionally to reconstruct streamflow. Inclusion of oceanic-atmospheric climate variables of Sea Surface Temperatures (SST) and climate Indices: Pacific Decadal Oscillation (PDO) and Southern Oscillation Index (SOI) can potentially improve the conventional methodology. The current study focuses on improving reconstructions by utilizing climate information. Stepwise linear regression technique is used to find the best combination out of the three pools of predictor variables. This approach is tested on six unimpaired streamflow gages in the Rio Grande River Basin (RGB). Reconstructions are performed from 1856 to 2002 with an overlap period of 54-years i.e. 1949-2002. Results show improvement in the streamflow reconstruction by including Oceanic-Atmospheric Climate variables compared to only Tree-ring chronologies. Also the inclusion of SST in reconstructions brings higher degree of hydrological variability in the results than those using Tree-rings and Climate Indices. RGB streamflow reconstructions can effectively be used to better understand historic climate variability of the region. This modeling technique is applicable to other river basins in the Western United States.

Modeling Study of the Rainfall-Runoff Processes and Scaling Effect in Complex Arid Environments

Li Chen
Associate Research Professor
Desert Research Institute
755 East Flamingo Road
Las Vegas, NV 89119
lchen@dri.edu
702-862-5349

Shai Sela, Ben Gurion University, Israel
Tal Svoray, Ben Gurion University, Israel
Shmuel Assouline, Agriculture Research Organization, Israel
Xiaobing Chen, Hohai University, China

Rainfall-runoff processes in arid environments can be affected by many landscape features such as topography, vegetation patches and soil surface sealing. To examine complex interactions among the multiple factors and their impact on the entire system, we developed a modeling approach coupling a two-dimensional surface runoff routing model with a two-layer infiltration model, as well as elaborated numerical treatment, to study the rainfall-runoff processes under real environmental conditions. The combination of the two models made the approach applicable to heterogeneous surfaces with spatially varying soil and landscape properties. Results show that, in such a system, soil surface sealing and vegetation are the major controlling factors for the runoff volume in plot-scale rainfall-runoff processes, while the topography affects the runoff pattern and water resources distribution. Through this mechanism, vegetation patches can receive much more water than the precipitation provides. On the other hand, the rainfall-runoff dynamics may change across spatial scales. To examine the scale effect, the combined modeling approach is applied to various scales. Upscaling approaches are used to reduce the model spatial resolution hence the overall computation demand while preserves the model accuracy, which allows an analysis with realistic modeling costs. Artificial plots are created to link the scales between the field experimental plot and the hillslope such that multiscale results are obtained. Results quantitatively verify the scale effect that reduces the runoff at larger spatial scales, which may be attributed to the runoff-infiltration interaction in this landscape.

Long-Term Effects of Rotenone on Aquatic Invertebrates in the Muddy River Within the Warm Springs Natural Area, Moapa, Nevada

Jason R. Eckberg
Southern Nevada Water Authority
100 City Parkway, Suite 700
Las Vegas, NV 89106
jason.eckberg@snwa.com
702-822-3389

The Warm Springs Natural Area (WSNA) was acquired by the Southern Nevada Water Authority (SNWA) in 2007 to protect the headwaters of the Muddy River and enhance the habitat of the endangered Moapa dace (Moapa coriacea). SNWA is also working to protect several endemic and rare non-endemic invertebrates in this area. In October 2010, the Nevada Department of Wildlife in cooperation with the U.S. Fish & Wildlife Service and SNWA conducted two rotenone treatments to eradicate non-native, invasive fish species along the upper Muddy River to assist in Moapa dace recovery. Rotenone is a commonly used piscicide in fisheries management but may inadvertently impact non-targeted aquatic invertebrates.

Benthic macroinvertebrates were sampled along the mainstem and tributaries of the Muddy River prior to rotenone treatments as well as two days following treatments and monthly thereafter for one year. Invertebrates were sampled using a 30cm2 Surber bottom sampler. Samples were collected from three riffles within the treatment reach: upper, middle andlower, plus a reference site from a non-treated tributary. Six samples were collected per site. Richness and abundance were compared between pre and post treatments, as well as treated versus untreated reaches. Specific attention was given to nine sensitive species described in the WSNA Stewardship Plan: western naucorid (Ambrysus mormon); Warm Springs crawling water beetle (Haliplus eremicus); Moapa naucorid (Limnocoris moapensis); Moapa riffle beetle (Microcylloepus moapus); Pahranagat naucorid (Pelocoris biimpressus) Moapa pebblesnail (Pyrgulopsis avernalis); Moapa Valley pyrg (Pyrgulopsis carinifera); Moapa Warm Springs riffle beetle (Stenelmis moapa); and Grated tryonia (Tryonia clathrata).

Removal Efficiency of Nitrogen by *Chlamydomonas reinhardtii* Under Three Kinds of Inorganic Nitrogen Treatments in a Water-Sediment System

Jiangang Han, Ph.D.
Associate Professor
Nanjing Forestry University
College of Forest Resources & Environment
Nanjing 210037, P. R. China
hanjiangang76@126.com
702-728-6454

Lanhai li, Ph.D., Nanjing Forestry University
Sajjad Ahmad, Ph.D., University of Nevada, Las Vegas

Chlamydomonas reinhardtii, a typical eukaryotic green alga, is very efficient in removing nitrogen (N) from waters. However, little information is available on physiological antagonism of NH4+-N on NO3−-N assimilation by the alga in a water-sediment system.

The aim of this study is to examine whether the antagonism of NH4+-N would decrease or delay the removal of NO3−-N by *C. reinhardtii. C. reinhardtii* was thus incubated in a water-sediment ecosystem, adding three kinds of inorganic N in water, 20 mg/l NO3−-N (TNO3-–N), 20 mg/l NH4+-N (TNH4+–N) and10 mg/l NO3−-N + 10 mg/l NH4+-N (TNO3-–N + NH4+–N), respectively. Concentrations of Chlorophyll a (Chl.a), NO3−-N, NO2−-N and NH4+-N in waters and sediments were measured with time during 21 days incubation.

NO3−-N in waters was found to be intermittently consumed with time in contrast to a rapid and continuous consumption of NH4+-N when supplying the two N substrates at equal concentrations (TNO3-–N + NH4+–N), implying physiological antagonism of NH4+-N on NO3−-N assimilation by C. reinhardtii. It was observed that NH4+-N concentrations in waters for 3 treatments was decreased to a range of 0.4–0.7 mg/l while NO3−-N was reduced to a much lower concentrations of 0.1–0.2 mg/l in the late stage of incubation ($P<0.01$).

This showed that *C. reinhardtii* had much higher removal efficacy to NO3−-N than NH4+-N in the water-sediment ecosystem. Our results suggested that utilization of NO3−-N by *C. reinhardtii* is not decreased and delayed in spite of the antagonism.

Acknowledgements This research was funded by the national Natural Science Foundation of China (40901112, 40905070 and 41375149).

Trace Metal Mobilization at Abandoned Mining Sites Due to Redevelopment Activities in Hyperarid Climates

Douglas B. Sims, Ph.D.
Instructor of Environmental Science
College of Southern Nevada
Department of Physical Sciences
Cheyenne Campus, SE1, Room 1064H
3200 East Cheyenne Boulevard
North Las Vegas, NV 89030
Douglas.sims@csn.edu
702-651-4840

John E. Keller, Ph.D., College of Southern Nevada

Reclamation of abandoned mine sites in arid regions has been a focus of development in recent years, in part, to rising land costs. These sites are redeveloped into parks, golf courses andresidential communities. This study was a laboratory experiment using three columns that were monitored for 393 days to evaluate trace metal and metalloid availability in soil-water solution containing commercially available fertilizers. Sediment from Three Kids Mine was utilized in this study as it is well documented to contain high levels of trace metals and metalloids. This experiment simulated agricultural activities over time to assess whether fertilizers would mobilize trapped contaminates. Results indicate that irrigation followed by fertilizers can provide favorable conditions for lead, manganese, zinc, aluminum, barium, copper and arsenic to become mobile, though on a limited basis. Results showed an increase in lead, manganese, zinc, aluminum, barium, copper and arsenic within the first 30 days with a decrease at 90 days. Data further indicated manganese, lead and zinc increased at 273 days from application of fertilizer fortified waters. This study shows there is a potential for mobilized trace metals and metalloids to enter the wider environment, including water sources, after development activities are finished, even in an arid environment.

Distributed Temperature Sensing Downhole Profiling

Matt Vitale, PG
Hydrologist
Meridian Geoscience LLC
10580 North McCarran Boulevard, Suite 115-415
Reno, NV 89503
mvitale@meridiangeoscience.com
775-901-6265

Distributed temperature sensing (DTS) measures temperature along a fiber optic cable (fiber). A laser light source excites silica glass fiber particles that form backscattered light in the Raman band where temperature is directly proportional to the ratio of stokes to anti-stokes frequencies. Continuous temperature measurements along the fiber are typically obtained at two, one, or even sub-meter spatial scales with generally 0.1 degree Celsius or better resolution, which is dependent primarily on the DTS used and secondarily on the fiber configuration and system calibration.

There are numerous practical uses with DTS that include communications and data transfer, pipeline leak detection, security applications, fire detection, and waste pile monitoring, as some examples. DTS is used for fluids applications such as hydrostratigraphic characterization in hard and soft rock, fracture flow, geothermal and oil and gas well optimization and reservoir monitoring, and stream dynamics focusing on ground and surface water exchange. The focus herein is on downhole temperature profiling.

DTS equipment costs and end-use have evolved such that quality data collection for practical planning and operational purposes is feasible, for both instrument operation and data post-processing and management. Obtaining DTS data, however, does require a substantial amount of initial effort as compared to courser temperature resolution and less technologically advanced alternatives.

Student Poster Presenters

NWRA Annual Conference, February 3–6, 2014

Understanding the Spatiotemporal Behavior of Floods in an Urban Catchment

Sayed Joinal Hossain Abedin
Graduate Student
University of Nevada, Las Vegas
4248 Claymont Street
Las Vegas, NV 89119
hossain2@unlv.nevada.edu
702-577-8731

Haroon Stephen, University of Nevada, Las Vegas

Understanding the progression of flood inundation and predicting its spatiotemporal behavior is important for planning mitigation strategies. Geographic Information System (GIS) has gained much interest to model urban floods. In this paper, we devise a GIS-based approach to map spatiotemporal behavior of urban floods by producing a time series of inundation. Gridded Soil Conservation Service (SCS) Curve Number method is used to estimate surface runoff and flow time is used to develop a translation hydrograph at the catchment outlet i.e. a drainage inlet. The stage-discharge relation of the drainage inlet is used to partition the translation hydrograph into overflow volume and pass through discharge. This provides the onset and progression of overflow volume, which is converted into a time series of inundation depth and spatial extent of flood using stage-volume relation of the watershed. The method is calibrated by comparing inundation depths and extents to ground observations of flood line and photographic evidence. Finally, the time variation of inundation depth and extent is visualized in GIS to understand the flood behavior. This approach is tested with a known flood event that occurred in a parking lot of University of Nevada-Las Vegas on September 11, 2012. The estimated peak flood depth is found consistent with the maximum observed flood depth (2.33 ft.) near the inlet. Depths at other points and inundation extents are found compatible with the observed data. This approach can be used to provide insight into spatial propagation and recession of floods in any urban catchment.

Rewetting of Artificially Desiccated Soils: Effects of Gravity on Vapor Phase Diffusion

Taylor Ball, B.S.
MS Geoscience
University of Nevada, Las Vegas
4505 South Maryland Parkway
Las Vegas, NV 89154
ballt1@unlv.nevada.edu
951-235-0027

Michael Nicholl, University of Nevada, Las Vegas

Soil desiccation has been proposed as an economical means to limit the downward flow of contaminants in thick vadose zones. This alternative involves pumping dry air through multiple wells to evaporate fluids in the vadose zone, thus causing the soil to become desiccated. When water is removed from the soil, future migration of dissolved contaminants is prevented as they solidify and stabilize, thus reducing the potential for groundwater contamination. A primary concern pertaining to soil desiccation relates to the potential for the desiccated soil to rewet after the air pumping has ceased, which could result in remobilization of the contaminants. One of the least understood mechanisms pertaining to the rewetting of desiccated soils is vapor phase diffusion. Water vapor diffuses into the pore space of a desiccated soil due to concentration gradients. This may result in the adsorption of water onto dry soil particles. The effect of gravity on less dense humid air could cause convective flow. Lab experiments will be performed on artificial soils to consider both upwards and downwards diffusion of humid air into the soil. Gravity is expected to enhance vapor migration for the first case, and work against it for the second.

Analyzing Differences in Crop ET During Wet and Dry Years in the Walker Basin Using Remotely Sensed Data

Matthew Bromley
Desert Research Institute
Division of Earth & Ecosystem Sciences
2215 Raggio Parkway
Reno, NV 89512
matthew.bromley@dri.edu
775-673-7683

Charles Morton, M.S., Desert Research Institute
Justin Huntington, Ph.D., Desert Research Institute
Tim Minor, M.S., Desert Research Institute
Thomas Albright, Ph.D., University of Nevada, Reno

Terminal lakes are important hydrologic, ecological andeconomic resources in highly water-limited environments. Walker Lake is a terminal lake in western Nevada in the Great Basin Desert. In order to estimate the amount of water that can potentially be made available for Walker Lake; it is necessary to characterize historical water use from agriculture within the Walker River Basin. The amount of water that enters the basin is variable depending on the timing and quantity of precipitation, available surface water runoff, and atmospheric water demand.

In this presentation we compare estimated evapotranspiration (ET) and consumptive use (i.e. ET - effective PPT) to fluctuations in the water supply and atmospheric water demand. We use the METRIC remote sensing model with Landsat satellite imagery and local weather station data to estimate ET, atmospheric water demand andprecipitation. Multiple years were selected for analysis, in order to represent conditions of above average precipitation and below average precipitation. Initial results suggest that the relationships between ET, surface water runoff, precipitation, atmospheric water demand are different among the different valleys in the Walker Basin due to differences in depth to groundwater, irrigation method andthe seniority of water rights held.

Improvement of Hydrologic Reconstructions Using Oceanic-Atmospheric Climate Variables

Saria Bukhary
Graduate Student
University of Nevada, Las Vegas
Department of Civil & Environmental Engineering
4505 South Maryland Parkway
Las Vegas, NV 89119
bukhary2@unlv.nevada.edu
702-774-1416

Sajjad Ahmad, Ph.D., University of Nevada, Las Vegas
Parker Hill, University of Nevada, Las Vegas
Ajay Kalra, Ph.D., Desert Research Institute, Las Vegas

Southwest U.S. has a history of recurring hydrologic droughts. These droughts coupled with increasing population and changing climate has stressed available water resources within the region. Particularly its longest river, Rio Grande, which caters to the need of millions along its 1900 mile stretch, has been seriously affected. The available regional streamflow records are relatively short and do not provide sufficient information on severity and duration of past droughts. An alternative to increase the length of data is using Tree-ring chronology, which is used conventionally to reconstruct streamflow. Inclusion of oceanic-atmospheric climate variables of Sea Surface Temperatures (SST) and climate Indices: Pacific Decadal Oscillation (PDO) and Southern Oscillation Index (SOI) can potentially improve the conventional methodology. The current study focuses on improving reconstructions by utilizing climate information. Stepwise linear regression technique is used to find the best combination out of the three pools of predictor variables. This approach is tested on six unimpaired streamflow gages in the Rio Grande River Basin (RGB). Reconstructions are performed from 1856 to 2002 with an overlap period of 54-years i.e. 1949-2002. Results show improvement in the streamflow reconstruction by including Oceanic-Atmospheric Climate variables compared to only Tree-ring chronologies. Also the inclusion of SST in reconstructions brings higher degree of hydrological variability in the results than those using Tree-rings and Climate Indices. RGB streamflow reconstructions can effectively be used to better understand historic climate variability of the region. This modeling technique is applicable to other river basins in the Western United States.

Planning and Managing Water Resources Allocations in Shanshan County, China: A Dynamic Modeling Approach

Chao Chen
Graduate Student
University of Nevada, Las Vegas
Department of Civil & Environmental Engineering
4505 South Maryland Parkway
Las Vegas, NV 89154
Chenc6@unlv.nevada.edu
702-358-1694

Zhixia Xu, Ph.D., China Institute of Water Resources & Hydropower Research, Beijing, China
Ajay Kalra, Ph.D., Desert Research Institute
Sajjad Ahmad, Ph.D., University of Nevada

Water scarcity and population growth combined with uneven distribution of water resources has caused severe challenges of water management across the semi-arid northwest China. The necessity of a change in the allocation of the available water resources by improving the user efficiency to meet the short-term and long-term goals of social and economic development has grown. The current study proposes a System Dynamics (SD) approach to simulate the water resource allocation in the Shanshan County located in northwest China. Water supply in the region comes both from surface and ground water sources and major water demands include agricultural, industrial and drinking use. Monthly supply and demand data were collected for 53 years (1956-2008). Future supply and demand were estimated up to year 2030. The model was calibrated using the historical water supply and demand data. The reservoir operation was introduced based on water-limit level which is governed by the priority of water use. Three scenarios were generated depending on the water demand by reducing irrigation area and water use efficiency in agriculture. The results indicated that the best possible scenario required for improving the economic and environmental water demand is to ecologically meet the reliability of water users. The model also highlighted that the overexploitation of groundwater resources is expected to reduce to a normal level by 2030. The SD modeling approach was able to capture the interactions among different water users and may assist water managers in efficiently managing the water resources within the region.

Hyperspectral Remote Sensing of an Open Pit Sulfur Mine for Characterization of Temporal Sulfate Minerals Relating to Acid Mine Drainage

Gwendolyn E. Davies
Research Assistant/M.S. Student
University of Nevada, Reno
1664 North Virginia Street
Reno, NV 89557
gdavies@unr.edu
443-504-9718

Wendy Calvin, University of Nevada, Reno

The exposure of pyrite to oxygen and water in mine waste environments is known to generate acidic water and the accumulation of secondary Fe minerals, which may contaminate surface and groundwater triggering a suite of environmental quality issues. Sulfates and secondary Fe minerals associated with acid mine drainage exhibit diverse spectral properties in the optical and infrared region of the electromagnetic spectrum. The use of airborne hyperspectral imagery for assessing the occurrence and potential of acid drainage at mine sites has been well studied. Fewer studies have explored the mapping of seasonally induced ephemeral features of these minerals. Sulfates dissolve during rain events and re-precipitate when less humidity is present causing the formation of surface crusts on waste piles and in mine water treatment ponds. A better understanding of the spectral properties of changes in mineralogy related to climate fluctuations will improve the accuracy of mineralogical maps and assessment of contamination. This study will examine the ability of remotely sensed hyperspectral data to identify geochemical evolution of substances and contaminant patterns. High temporally resolved spectral data from NASA's AVIRIS instrument will be collected at the Leviathan Mine Superfund site, an inactive open pit sulfur mine now undergoing water treatment and remediation, located 24 miles southeast of Lake Tahoe in the Eastern Sierra Nevada. Airborne data and ground-based surveys coupled with surface material and pit water geochemical analyses will be used to evaluate the surfaces around treatment ponds. Data will be collected in April, May, September and October in the years 2013-2014.

Modeling Halophytic Plants in APEX for Sustainable Agriculture and Water Resources

Tanna DeRuyter, EIT
Graduate Student Researcher
Graduate Program of Hydrologic Sciences
University of Nevada, Reno
Department of Natural Resources & Environmental Science
1664 North Virginia Street, Mail Stop 186
Reno, NV 89557
tanna.deruyter@gmail.com
509-844-2947

Laurel Saito, Ph.D., P.E., Department of Natural Resources & Environmental Science at the University of Nevada, Reno
Robert Nowak, Ph.D., Department of Natural Resources & Environmental Science at the University of Nevada, Reno
Jaehak Jeong, Ph.D., P.E., Department of Biological & Agricultural Engineering at Texas A&M University
Kristina Toderich, Ph.D., International Center for Biosaline Agriculture
Colleen Rossi, Ph.D., Bureau of Land Management

Irrigated land is more than twice as productive as rainfed land and produces roughly one-third of the world's food. Nearly 20% of irrigated agriculture suffers from soil salinization, which causes reduced crop yield, especially in arid and semi-arid regions. Many farmers worldwide practice seasonal leaching to reduce soil salts, but this practice has many undesirable side-effects such as a raised groundwater table and elevated concentrations of fertilizer, pesticides andsalts in the nearby freshwater sources. Reduced crop yield is caused because most conventional crops are glycophytes and lack the genetic basis for salt tolerance. Some plants, however, are halophytes, and are "salt-loving" and can complete their life-cycle in higher saline soil or water environments as compared to glycophytes. Halophytes also may be cultivated for human consumption, livestock fodder, or biofuel and may reduce or maintain salt levels in the soil and nearby freshwater. To assess the potential of halophytes to be cultivated in salt-affected agricultural sites, the model Agricultural Policy/Environmental Extender (APEX) is being augmented to include a salinity module that is capable of tracking salinity through the soil-plant-water interface. Field sites in the Central Kyzylkum and Khorezm regions of Uzbekistan are being parameterized to test the new module. These field sites were chosen because data are being gathered on the halophytes Atriplex nitens, Climacoptera lanata andSalicornea europaea, which have been parameterized and added into the APEX model database. Field data on the soil, plants andwater being gathered in Uzbekistan are being used for model verification. This presentation will discuss the plant and site parameterizations as well as the application of the APEX model to assess the utility of halophytes for crop production on saline lands.

Examining Aridity-Induced Bias in Reference Evapotranspiration Calculations for Agriculture

Christian Dunkerly, B.S. Student
Desert Research Institute and University of Nevada, Reno
5200 Summit Ridge Drive, #1224
Reno, NV 89523
chrisdunkerly@gmail.com
702-287-1265

Austin Chapman, Undergraduate, Desert Research Institute and University of Nevada, Reno
Justin Huntington, Ph.D., Desert Research Institute and University of Nevada, Reno

Accurate reference evapotranspiration (ETr) rates are important for estimating irrigation water requirements of agricultural systems. ETr is commonly computed using the ASCE Standardized Penman-Monteith method (ASCE-PM), which estimates the ET from a well-irrigated non-stressed reference crop as a function of solar radiation, temperature, humidity andwindspeed. The ASCE-PM equation requires that the measured weather variables be representative of an agricultural environment. Unfortunately, most weather stations in Nevada that are commonly used to estimate ETr are not located in agricultural environments, but instead are commonly located in arid areas. This aridity introduces positive bias into the estimation of the irrigation water requirement, as arid conditions cause warmer air temperature, lower humidity andincreased windspeed as compared to the agricultural environment due to the lack of transpiring vegetation. Due to the limited amount of water available to Nevada's agriculture, and the value of transferring agricultural water rights for municipal uses, it is important that this bias be well understood and potentially corrected.

In this work, we evaluate aridity-induced bias in ETr by examining two weather stations located in Snake Valley, NV, one located in an agricultural environment at the Baker Ranch, and the other located in salt desert brushland less than 3 km away. The close geographical proximity of these stations to each other allows us to isolate the effects of the arid weather on ETr estimation. By comparing the differences in individual weather variables between the two stations, we are able to more accurately understand the impact of aridity-induced bias on irrigation water requirement estimates across Nevada. Initial results show that aridity can increase ETr estimates by almost 630 mm per year, which is a bias of 30% when compared to the agricultural ETr estimates.

Study of Hydrological Impacts of Constructing a Large Scale Solar Power Plant

Mohammad Masih Edalat
Graduate Student
University of Nevada, Las Vegas
4505 South Maryland Parkway
Las Vegas, NV 89154
edalat@unlv.nevada.edu
702-443-3193

Haroon Stephen, University of Nevada, Las Vegas

In recent years, many large scale solar power plants have been developed for their benefits over conventional energy sources. Solar energy has low emissions and environmental impacts. Nevertheless, solar energy plants have some impact on the environment and surface hydrology. Landscape of the area is impacted due to changes in vegetation cover, habitat connectivity and thermal characteristics. Especially, large scale plants alter the drainage characteristics of the area. Although it is a standard practice to perform drainage studies to ensure unaltered downstream flow conditions, the hydrology under and around the solar panels is altered. Such changes can impact localized natural vegetation as well as result in adverse flow conditions harmful to plant structural features. Thus, it is imperative to understand how the solar plants alter the hydrological behavior of the area.

In this research, we use geographic information systems (GIS) to map pre- and post-installation hydrological features at a large solar energy facility. Light Detection and Ranging (LiDAR) data is used to create digital elevation maps and delineate drainage features. Since LiDAR data is available for post-installation time, the pre-installation elevation is artificially created from observations of satellite imagery of the solar facility. The Soil Conservation Service (SCS) curve number method is used to estimate surface runoff and study its hydraulic behavior. Structural features of a solar facility can result in flow contraction and bed elevation which can cause choking of the flow and may result in supercritical flow regimes. These conditions can result in erosion and sediment transport harmful to solar installation as well as soil stability in the area. Simulated rainfall scenarios are used to study hydraulic behavior and map areas at risk of supercritical flow. This research is tested at three solar facilities including Nevada Solar One, Nellis Solar Power Plant andIvanpah Solar Electric Generating System. It provides a useful insight into the hydrological response of areas with solar facilities.

Fate and Transport of Disinfection By-Products in Las Vegas Valley During Aquifer Storage and Recovery

Sunny Grunloh
Masters Student
Desert Research Institute and University of Nevada, Reno
2215 Raggio Parkway
Reno, NV 89512
sgrunloh@dri.edu
775-674-7104

Clay Cooper, Ph.D., Desert Research Institute

Municipalities strive to provide a clean reliable water source. Chlorine is the most popular disinfectant. When chorine reacts with dissolved organic matter, disinfection by-products are formed. Trihalomethanes are the most common disinfection by-product. The Southern Nevada Water Authority has used an aquifer storage and recovery program where water is stored in the aquifer via an injection well for a few months and pumped out or recovered to meet consumer demands. The United States Environmental Protection Agency established a maximum contaminant level (MCL) for total trihalomethanes at 0.080 mg/L or 80 parts per billion. Long term consumption of drinking water containing total trihalomethane concentrations great than the MCL is linked to adverse human health effects, such as central nervous system problems. Several disinfection by-product studies have been conducted, but few studies involving disinfection by-product fate and transport during aquifer storage and recovery have been published. Based on preliminary data analysis, there is a strong correlation between chloride concentration and total trihalomethane concentration. Municipalities want to deliver the cleanest water possible and an in-depth knowledge of disinfection by-product, specifically trihalomethane, fate may aid in making management decisions. The objective of my study is to create a conceptual and analytical model of trihalomethane formation surrounding an aquifer storage and recovery well. The proposed computer model could be used to assess violation of public drinking water standards and point out areas more likely to contain elevated total trihalomethane concentrations.

Estimating Open Water Evaporation for Lake Mead with Remote Sensing

Ryan Liebert
Desert Research Institute
Division of Hydrologic Sciences
2215 Raggio Parkway
Reno, NV 89512
ryan.liebert@dri.edu
714-930-6414

Justin Huntington, Ph.D., Desert Research Institute, Division of Hydrologic Sciences
Charles Morton, Desert Research Institute, Division of Earth & Ecosystem Sciences

Lake Mead is one of the most important water resources in the American Southwest. The reservoir helps manage and deliver Colorado River water to Nevada, California andArizona. The Bureau of Reclamation estimates that approximately 800,000 acre-feet of the Lake Mead water is lost to evaporation annually. Open water evaporation is both a dynamic and highly variable process. For this reason it is generally difficult to quantify actual evaporative losses. For example, heat storage has been shown to impact both the timing and magnitude of evaporation. This impact can lead to overestimates of evaporation in the summer months, and underestimates in the fall and winter. An aerodynamic method for measuring Lake Mead evaporation is applied through the coupling of remotely sensed imagery and ground-based weather data. The results are estimates of actual evaporation from Lake Mead that captures spatial and temporal variation. Sensitivity analysis is performed to reveal uncertainly in remotely sensed evaporation estimates. Results are then compared with previous studies for the water body. Comparisons reveal that the method has potential for estimating evaporation from open water bodies, while also capturing spatial and temporal variability.

Role of Large-Scale Climate Patterns and Sea Surface Temperature in Influencing the Continental U.S. Streamflow

Soumya Sagarika
Graduate Student
University of Nevada, Las Vegas
Department of Civil & Environmental Engineering
4505 South Maryland Parkway
Las Vegas, NV 89154
sagarika@unlv.nevada.edu
702-774-1416

Ajay Kalra, Ph.D., Desert Research Institute, Las Vegas
Sajjad Ahmad, Ph.D., University of Nevada, Las Vegas

Sea surface and atmospheric variability have been found to be correlated with hydrologic changes across the globe. This study evaluates the possible correlation between unimpaired streamflows and two indicators of sea surface and atmospheric variability i.e., sea surface temperatures (SSTs) and geopotential height (Z500) index. 864 streamflow stations, categorized according to hydrologic unit codes, located throughout the continental United States are used in this study with data from 1950 to 2010. Spatio-temporal statistical technique, singular value decomposition (SVD), is used to evaluate the association between climate variability and streamflow by employing a lead-time approach of six months to obtain the temporal expansion series between the oceanic-atmospheric indicators and water year streamflow values. This was followed by an interdecadal-temporal evaluation of the Pacific and Atlantic Ocean based warm and cold phases of the Pacific Decadal Oscillation (PDO) and Atlantic Multidecadal Oscillation (AMO). This resulted in the identification of new regions of highly correlated SSTs and Z500 that may not be represented by conservative index regions. Results indicated that Pacific SSTs had strong correlations with the streamflow in the Midwest, southern South-Atlantic-Gulf and Pacific Northwest, whereas the Atlantic SSTs showed strong correlations with Souris Red-Rainy, South-Atlantic-Gulf and Upper and Lower Colorado. The Z500 showed strong correlations with New England, parts of the Midwest, and the Texas-Gulf. These inter-relations between sea surface-atmospheric indicators and streamflow can be used as predictors to improve streamflow forecasting models and improve management of expected streamflow volumes, several months in advance.

Simulating Reservoir Operations to Mitigate Impacts on Fish Sustainability Below Shasta Lake, CA Under Extreme Conditions

Joseph Sapin
Masters Student
University of Nevada, Reno
1664 North Virginia Street
Reno, NV 89557
joesapin@gmail.com
831-345-8396

Laurel Saito, University of Nevada, Reno
Rajagopalan Balaji, University of Colorado, Boulder
R. Blair Hanna, Water & Earth Technologies Inc.

The creation of Shasta Dam and Reservoir in 1945 was one of the causes of precipitous declines in Chinook salmon populations on the Sacramento River. A temperature control device (TCD) installed at Shasta Dam in 1997 provides increased capabilities for supplying cold-water downstream of the dam to stimulate salmon spawning while providing hydropower and other water supply needs. However, increased air temperatures due to climate change could make it more difficult to meet downstream temperature targets with the TCD. By coupling stochastic generation of hydroclimatic conditions with reservoir operations modeling, we are simulating TCD operations under extreme climate conditions. Stochastically generated climate and inflow scenarios are used as input for a CE-QUAL-W2 reservoir model to test whether selective withdrawal from multiple gates of the TCD are capable of meeting temperature targets downstream of the dam under extreme hydroclimatic conditions. Moreover, these non-parametric methods for stochastically generating climate and inflow scenarios are capable of producing hydrologic years of extreme wet or extreme dry conditions beyond what is seen in the historical record while maintaining the statistical nature of the system over multiple simulations, which enables simulation of TCD operations for unprecedented hydroclimatic conditions. This presentation will discuss preliminary results of stochastic hydrologic and climatic input generations, and discuss future work analyzing temperature outputs from CE-QUAL-W2 simulations of TCD operations under extreme climate conditions. The scenarios chosen for simulation are tied to real-world managerial concerns through collaborative workshops with reservoir managers to establish which hydroclimatic scenarios would be of most concern for meeting downstream temperature targets. It is hoped that the results of this work will provide seasonal and long-term forecasting for reservoir managers to maintain a sustainable cold-water supply for salmon proliferation.

Optimization of Ozone-Biological Activated Carbon Treatment for Potable Reuse Applications

Ashley Selvy, B.S.E., E.I.T.
Graduate Research Assistant
Department of Civil & Environmental Engineering & Construction
University of Nevada, Las Vegas
4505 South Maryland Parkway, Box 454015
Las Vegas, NV 89154-4015
selvya2@unlv.nevada.edu
702-895-4339

Daniel Gerrity, Ph.D., University of Nevada, Las Vegas

In the face of climate change, pollution andpopulation growth, water scarcity has become a global threat. Many populations have witnessed their drinking water sources dwindle to an unsustainable level. These severe conditions have sparked interest in potable reuse as an increasingly viable alternative to typical 'pristine' drinking water sources. Although potable reuse has been practiced for decades, the public has become more supportive of the concept over the past few years based on the historical success of several benchmark facilities in the United States and abroad. Many municipalities are considering implementing their own projects, but there is considerable debate as to the level of treatment needed to ensure protection of public health.

Among existing potable reuse guidelines and regulations, the California Department of Public Health (CDPH) provides the most stringent requirements for water quality. Currently, the best way to meet these standards is through the use of full advanced treatment (FAT), which consists of reverse osmosis (RO) and an advanced oxidation process (AOP). Although extremely effective, RO is energy intensive and produces a concentrated brine solution that is both difficult to dispose of and of ecological concern in coastal regions. Alternative treatment trains composed of ozone and biological activated carbon (BAC) have been employed in several locations throughout the world, but these systems have not yet been optimized and are unable to compete with RO-based treatment trains on the basis of total organic carbon (TOC) removal and reductions in total dissolved solids (TDS). While RO-based treatment trains have been known to remove TOC to the ppb levels, ozone-BAC trains have yet to achieve this. One example is the Fred Hervey Water Reclamation Plant in El Paso, TX, which produced an average effluent TOC concentration of 3.2 ppm in 2011.

With the exception of these two categories, which are generally more relevant to aesthetics rather than public health, ozone-BAC is capable of producing a water quality similar to that of RO-based treatment trains on the basis of pathogen reduction, trace organic contaminant mitigation anda variety of other parameters. There are also significant energy and cost savings for the ozone-BAC alternative so there is an incentive to optimize such treatment trains to achieve greater TOC removal. This process requires up to 70% less capital costs and 80% less operation and maintenance costs than FAT.

The purpose of this study is to optimize the ozone-BAC process for TOC removal with respect to ozone dose and empty-bed contact time (EBCT). The experiments will be performed in a one liter per minute pilot-scale reactor at a local water reclamation facility. The effluent TOC concentration from parallel BAC columns will be compared against a 0.5 mg/L TOC benchmark value. CDPH established this benchmark as an indicator for the removal of other regulated and unregulated chemical contaminants that may be found in wastewater. The simultaneous removal of trace organic contaminants will also be assessed. Achieving these goals will provide water reuse agencies with a more cost-effective and sustainable alternative to FAT.

(These preliminary experiments are scheduled to be completed by January.)

Groundwater and Surface Water Interactions at Pond and Plug Restoration Sites in the Northern Sierra Nevada Mountain Range

Karly Wagner
Graduate Student Research Assistant
University of Nevada, Reno
1515 Ellendale Court
Reno, NV 89503
kbwagner2@gmail.com
530-559-5783

Sherm Swanson, Ph.D, University of Nevada, Reno
Adam McMahon, M.S., University of Nevada, Reno
Justin Huntington, Ph.D, Desert Research Institute
Richard Niswonger, Ph.D, U.S. Geological Survey

Restoration of meadows in the Sierra Nevada Mountain Range has increasingly gained prominence in wildlife and hydrology circles. With changes in climate and population growth in California there has become an increasing need for monitoring and conservation of the water in in this region. Much of the degradation of meadows in this region is a result of improper or lack of land and or stream management. The main causes of meadow damage are logging, over grazing, water diversion, and the construction of roads and rail roads. In the Sierra Nevada Region, an effective technique for restoration of degraded meadows is the Pond and Plug method, this method uses the materials available on site to help guide the stream back to a natural path.

For this project eight sites were selected in 2012. These sites have been continually monitored with data loggers in place collecting data on the hour. In both the 2012 and 2013 summer season pond elevations and areas were also monitored. This study aims to learn what drives the hydrology of these meadows post-restoration; through the monitoring of pond, groundwater andstream water levels. Benefits of restoration have been observed in other studies; however, missing from this data set is what is occurring, hydrologically speaking, in the constructed ponds.

Once there is a better understanding of the relationships between ponds and groundwater and ponds and surface water the goal is to classify the meadow or parts of the meadow into one of three proposed hydrological models. The aforementioned models are: sponge valve and drain. In the sponge model, porous sediment in meadows store snowmelt runoff during the spring months then gradually replenishing the streams during water short summer months. The valve model conceptualizes a meadow where the groundwater discharge is slowed due to the low permeability of the meadow composition. The drain model describes a meadow where the created ponds or alluvial aquifer serve to recharge the groundwater and aquifers below the meadow. These hydrological models consider subterranean variations in soil and rock type along with the above mentioned pond interactions. With the data collected it is hoped that it will be possible to classify each of the meadows into one of the theoretical models.

On behalf of the Nevada Water Resources Association,
we would like to thank you for your dedication and support of NWRA.
Thank you for attending the Annual Conference and we hope to see you at future NWRA events.

NOTES

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NWRA
P.O. Box 8064
Reno, NV 89507
775-473-5473
www.nvwra.org