# DEVILS HOLE WORKSHOP 2006: ABSTRACTS

## WEDNESDAY AFTERNOON, APRIL 26

### The Need for Federal Reserved Water Rights & the Role of Enforcement: Could Cappaert Happen Again?

Adell Amos, Assistant Professor
Director, Environmental and Natural Resources Law Program
University of Oregon, School of Law

In 1976 the United States Supreme Court issued its decision in Cappaert v. United States and upheld an injunction against private state-permitted groundwater pumping because of its impact on federal reserved water rights for Devils Hole National Monument. This paper will address the need to preserve the federal reserved water rights doctrine to achieve the specific purposes for which federal lands have been set aside and consider the importance of enforcement of these federally created rights.

Though federal agencies increasingly secure necessary water rights under state law, there are situations – similar to the situation at Devils Hole in 1976 – where state law is insufficient to meet the purposes for which federal lands were set aside. In these situations, federal land managers need tools under federal law to carry out their statutory mandate. Beyond the doctrine of federal reserved water rights, Congress and the Executive have explored other mechanisms under federal law to achieve federal purposes.

In addition to recognizing a reserved water right for Devils Hole, the Cappaert decision represented the affirmative effort of the federal Executive to fully protect and enforce the water right for Devils Hole. In addition to considering the need for the federal rights when state law is insufficient, this paper will also examine enforcement mechanisms for federal reserved water rights, specifically asking whether an injunctive action like the one is Cappaert is a viable option today. Further, this paper will consider whether citizens can play a role in the protection of federal water rights on federal lands.

### Devils Hole Update

Michael Bower and Linda Manning, Biologists
Death Valley National Park

A spawning shelf restoration at Devils Hole in February 2005 removed gravels and fine sediment that had been deposited by a flash flood in September 2004 and had reduced habitat available for spawning. Larval fish surveys in spring and summer 2005 showed reproduction occurring but a count in November 2005 showed no increase in the total numbers of pupfish in Devils Hole. One of two populations held in artificial conditions was found to have hybridized with another pupfish species. A science meeting was held in December and recommendations from that group were forwarded to the Recovery Team for their review. A spring pupfish count is scheduled and larval fish surveys are underway. Actions are being taken with the remaining artificial population to improve spawning conditions and maximize reproduction.

This presentation will provide a brief overview of the Devils Hole pupfish status and actions that have occurred since the 2005 Devils Hole Workshop.

## Recovering the Devils Hole Pupfish: An Ongoing Lesson in Conservation Biology

John Wullschleger, Fisheries Biologist
National Park Service, Water Resources Division

The Ash Meadows-Devils Hole Recovery Team was established in 2002 to address the ongoing decline of the only native population of the Devils Hole pupfish (Cyprinodon diabolis). The decline has continued through the present and, in February of 2006, the Recovery Team recommended a suite of actions that are intended to reduce the risk of near-term extinction and provide a foundation for protecting the species and the Devils Hole ecosystem into the future. We discuss these recommendations with reference to the underlying scientific information, uncertainties and data gaps, and hypotheses regarding limiting factors and the reasons for the decline.

## Nye County Natural Resources Stewardship Programs

James Marble, Nye County Natural Resources Office
Mary Ellen Giampaoli, Environmental Compliance Specialist

Since 1998, Nye County has taken proactive steps to increase its role in resources stewardship, including addressing air quality issues in the Pahrump Regional Planning District, public water supply protection, Brownfields management, water resource sustainability, and protection of the unique habitats that sustain a number of endemic species. To begin achieving these goals, the Nye County Natural Resources Office has developed, or is developing, the necessary plans and documents pursuant to county, state, and federal regulations to implement its resource management programs. To this end, the Nye County Board of Commissioners has 1) adopted and implemented the Nye County Air Quality Dust Control Program to ensure compliance with U.S. Environmental Protection Agency ambient air quality standards; 2) prepared draft wellhead protection plans for county-operated systems in Pahrump Valley, Amargosa Valley, and Manhattan for adoption and implementation in accordance with the Safe Drinking Water Act; 3) developed and implemented the Brownfields Land Recycling Program, which will be included in the Nye County Comprehensive Plan; 4) prepared and adopted, in accordance with Nevada Revised Statutes Chapter 278, the Nye County Water Resources Plan and subordinate Water Resources Stewardship Plan; and 5) prepared and implemented habitat conservation plans for the protection of threatened and endangered species at specific sites, and expect to finalize both short- and long-term plans for the protection of the desert tortoise and other species and their habitats in southern Nye County. These efforts are expected to have significant benefits for the environment and human health, while ensuring continued, sustainable community growth.

## Pahrump Valley Growth - Another Year Later . . .

Walt Kuver, Pahrump Valley Community Action Team
Donna Lamm, Southern Nye County Conservation District

Growth projected for the Pahrump Valley at the 2005 Devils Hole workshop is now actually happening. Several high-density subdivisions are in their first phase of construction and the pace of custom home building and manufactured housing installation remains high. Demand is likely to increase, as the median price of homes in Las Vegas is still more than $300K, and one of the last restraints on growth is about to disappear with the opening of the Pahrump hospital.

This presentation updates housing growth numbers and examines where Pahrump Valley is growing. Population estimates are revisited and compared with the ten-year projections made last year. Consumption estimates are revisited and refined. Events indicating increased awareness of the need for a water and sewer utility infrastructure are noted.

Local groundwater resource planning efforts in the valley this past year focused on establishing a water conservation ordinance that officially recognizes the need to conserve water to delay the need for water importation, including regulating artificial lakes, limiting the use of grass turf in landscaping, and encouraging effluent use.

The need to adequately fund Pahrump basin water studies has been made more urgent by potential residential development in bordering Inyo County, California. Considerably more measurement and modeling is required to determine whether groundwater pumping in Pahrump truly has an effect on the water level in Devils Hole. Nothing has changed financially; in the long term, only federal funding will make these studies happen.

## NUREG-1710 Series: History of Water Development in the Amargosa Desert Area

Neil M. Coleman and Michael P. Lee, Senior Staff Scientists
Advisory Committee on Nuclear Waste

The NUREG-1710 series consists of three volumes. In Volume 1, historic accounts and geologic treatises describe the chronology of growth in the Amargosa Desert area of Nye County during the past 150 years. Portions of the Nevada Test Site are contiguous with the Amargosa Desert and thus have shared some of the same history. Those events affecting water development within NTS are summarized in Volume 2. Volume 3 describes the timing and rate of well-drilling activity in the Amargosa Desert, Crater Flat, and Jackass Flats areas based on public drilling records. In general, the background provided in the first two volumes of this NUREG series is intended to contribute to the understanding of the well-drilling summary in Volume 3 (in press), by providing the necessary historic context.

The literature suggests that the earliest sources of fresh water supply were the abundant, naturally occurring artesian springs in Ash Meadows. The first hand-dug well was the Franklin Well; it was dug in 1852. The first mechanically bored wells were drilled for local railroads sometime between 1905–07. About 1917, the first irrigation well was drilled for an experimental farm. In the late 1940s, permanent interest in the area was established, in large measure because of Federally-sponsored desert reclamation programs. Designation of local aquifers in the area as "protected," in 1979, has favored new well permitting for residential and commercial uses. The literature indicates that more than 1200 boreholes have been drilled in the Amargosa Desert area.

Because of economic and technical factors, alluvial aquifers have historically been the most important sources of ground-water supply. In general, drilling activity historically preceded geologic understanding of the ground-water resource.

### Regional Versus Local Groundwater Conditions in the Yucca Mountain Region

Thomas S. Buqo, Consulting Hydrogeologist

Nye County has recently developed wellhead protection plans for all public water supply systems in the Pahrump valley and all county-operated systems in Amargosa Desert. Part of the development of these plans included the identification of the extent of capture zones associated with each public water supply well, using the U.S. Environmental Protection Agency wellhead protection analysis (WHPA) model. The capture zones for this model were based on a number of criteria, including the direction of flow and gradient; aquifer transmissivity, porosity, and thickness; and well pumping rate and diameter. Well driller reports, pumping records, published reports, and the results of well or aquifer tests provided information about aquifer properties and well pumping characteristics. Information about flow directions and gradients was obtained from potentiometric maps. Published potentiometric maps of the Yucca Mountain region were evaluated for use in the WHPA model; these maps were found to be unsuitable because of the lack of definition of drawdown in the vicinity of pumping centers associated with agriculture and municipal water supplies. Because of these limitations, detailed potentiometric maps were developed to more accurately portray the potentiometric surface of the shallow aquifer system, which is the source of drinking water supplies for the region. These detailed maps were based on hand-drawn contours developed from computer-based first approximation methods. The results are consistent with those of the recent U.S. Geological Survey transient simulations of groundwater withdrawals in the Death Valley regional groundwater flow system. Further, the results demonstrate that groundwater flow directions and gradients can be accurately represented only on the basis of local water level data, and that the use of "regional" potentiometric surface maps results in significant error in defining the capture zones for individual water supply wells.

## THURSDAY MORNING, APRIL 27

### Nye County Alluvium Tracer Tests – Preliminary Results from Modeling

John Campanella, Questa Engineering Corporation

Multiple tracer tests have been conducted in the saturated alluvium at Site 22 in lower Fortymile Wash as part of the Nye County Independent Scientific Investigations Program. Non sorbing solute tracers with differing diffusion coefficients were used for two consecutive single-well push-pull tracer tests, beginning in December 2004. Data were obtained for estimating porosity, dispersivity, and possible diffusion into immobile water in the system. These single-well tests were followed by two multi-well cross-hole tracer tests using conservative, reactive, and microsphere tracers, beginning in January 2005. For example, the redox sensitive tracer perrhenate (ReO4-1) was used in the second cross-hole test to simulate the transport behavior of the radionuclide technetium. Both cross-hole tests provided information over a larger scale, including directional effects and fast flowpaths.

Preliminary analysis of the tracer tests using both analytical and numerical simulation indicates that diffusion into immobile water was minimal or nonexistent, and that a fast flowpath exists between one of the injection wells (22PA) and the pumping well (22S) in the shallow alluvial aquifer. A long pumping interruption between the two cross-hole tests allowed the natural groundwater drift to move the tracer plumes: as a result, the tracer response curves contain information about the site's natural gradient magnitude and azimuth. The response obtained from the perrhenate test supports DOE performance assessment calculations for technetium; that is, it would behave conservatively under oxidizing conditions and not sorb or precipitate in the alluvium.

## Vapor Transport, Performance Assessment, and Design

John Walton, University of Texas at El Paso
George Danko and Davood Bahrami, University of Nevada at Reno

The redistribution of percolation water with associated vapor flow and condensation in waste emplacement drifts during the thermal period is a major consideration in the conceptual design and performance assessment of the Yucca Mountain repository. Current models assume a closed emplacement system and predict the migration of vapor to be predominantly into the rock, leading to condensation within the rock and the resultant shedding of water around the drifts by gravity-driven flow. This predicted shedding of water between drifts removes soluble salts from the system, thereby preventing accumulation. Estimations of the waste package environment, which form the basis of the corrosion testing program and performance assessment, are highly dependent on the assumption that vapor transport is primarily into the rock.

A back-of-the-envelope analysis, as well as recently developed three-dimensional models, indicates that the predominant direction of vapor migration during the thermal period is into the drifts rather than into the rock. Vapor moves along the drifts from the warmer central section to the cooler outer sections, where it condenses. New results support the water redistribution predictions published at the 2005 Devils Hole Workshop. The current study applies the results of vapor and water flow, and extends the analysis to salt accumulation predictions.

The presence of significant accumulations of chloride in an environment with cyclical changes in relative humidity is likely to present a challenging environment for drip shields composed of Alloy-22. A below-boiling repository design would significantly reduce water vaporization and potential salt accumulation, decreasing the likelihood of localized corrosion.

## The Amargosa River – A Rare Desert Resource

Brian Brown, The Amargosa Conservancy

Although most people interested in the Mojave Desert know of the Amargosa River, few are familiar with the river in its entirety. This program will give a visual tour of the Amargosa from the headwaters in Nevada to the endpoint at badwater in Death Valley. Along the way, it will catalogue the major springs that contribute to the flow, look at some of the unique flora and fauna, and consider some of the possible threats to maintaining a surface flow in critical areas along the rivers course.

As with all areas of the southwest facing increased demands on the water supply, The Amargosa water course has limits of sustainability, but where that point may be is unknown at this point in time. Increasing populations, commercial dairies, and large scale real estate speculation in the area all add to the urgency of finding out some of this critical information and making allowances to preserve existing sensitive and unique areas.

The Amargosa Conservancy is a newly formed non profit organization which has a primary interest in preserving special areas and critical surface water flows in the Amargosa drainage. Throughout this presentation, we will explore the purpose of this organization and the goals it hopes to accomplish. Contact information for the audience will also be offered.

## Life at the Limits: Molecular-Enabled Tools for Explorations of Microbial Diversity in Extreme Environments

Duane P. Moser, Brian P. Hedlund, Jason Navarro, Andrea Flores
Desert Research Institute,

Owing to the development of powerful molecular techniques, our understanding of microbial diversity and ecology has expanded dramatically in recent years. Illustrative of this point, from 1987 to 2003, the number of recognized and proposed bacterial phyla expanded from 12 to 78. Increasingly, the search for novel microbial life (often in service of the emerging field of astrobiology) is now focused on extreme terrestrial habitats. "Extremophile" communities have been detected in association with almost every conceivable niche on earth, covering a wide range of temperatures, salinities, water activities, and pH and radiative flux values. A significant amount of high-profile extremophile research today is focused on the geothermal features of Yellowstone National Park. Death Valley by contrast, while literally one vast extreme environment, remains comparatively little-studied. This seminar will introduce a collection of new molecular tools, developed during a deep biosphere study in the mines of South Africa, for the tracking of environmental microorganisms within a geochemical context. The availability of such tools should enable the comprehensive study of microbial community structure in the springs and evaporitic habitats of Death Valley; potentially revealing novel organisms existing at near the limits of life and biogeographic evidence for extant or historic hydrologic connectivity (e.g. microbes as tracers). New results from a microbial ecology/biogeochemistry study, performed during the anomalously wet period of 2004/2005 on Silver Lake Playa, will be presented.

## An Investigation of Tectonic Deformation on Water Levels in Devils Hole, Death Valley National Park, Nevada

Gregory Robertson and Shemin Ge, University of Colorado at Boulder

The purpose of this study was to examine the effects of tectonic deformation on the water level in Devils Hole, south-west Nevada. Devils Hole is a large fault cavern located along a 10 mile spring discharge line in a carbonate aquifer 150 miles west of Las Vegas, Nevada. It is an area of high attention as it provides the habitat to an endangered species of fish, Cyprinodon diabolis. The survival of the fish is dependent upon a bounded water level in Devils Hole. Tectonic deformation was examined using the volumetric strain field present throughout the Great Basin. Extension in the Devils Hole area is N 65 W at a rate of 8 nanostrain/yr. The carbonate aquifer that provides water to Devils Hole is heterogeneous and anisotropic containing fractures and faults of multiple scales. Rates of pressure head fluctuation are on the order of mm/yr due to strain. Strain was incorporated into a numerical ground water flow model through initial hydraulic head values. Hydraulic head values altered by strain were calculated using an external program. These values were then used as initial conditions in MODFLOW for flow simulations. Implications of ground water pumping have previously been investigated and show that the long term trend in water level declines is strongly influenced by distant pumping. The relationship between ground water pumping, precipitation and strain was examined in this study and shows that ground water pumping and precipitation are the dominating factors controlling the observed water levels in Devils Hole. Results of strain simulations show that tectonic deformation can cause the water level in Devils Hole to decline up to 2 mm over the course of 11 years for maximum strain cases. When results of strain cases, which include yearly precipitation, were added to previously determined pumping results, the trend of the observed water level in Devils Hole was satisfactorily matched. To further account for differences in modeled to observed water levels, more accurate measurements of strain, precipitation, and other atmospheric and environmental parameters need to be assessed in the Devils Hole area.

## Evaluation of Ground-Water Flow in the Southern Part of the Amargosa Desert, Nevada and California

Wayne R. Belcher, U.S. Geological Survey

The USGS proposes to evaluate potential impacts from pumping to water levels and discharge within areas of concern within the southern part of the Amargosa Desert (including Ash Meadows, Devils Hole, and selected reaches of the Amargosa Desert) by developing and applying a numerical ground-water flow model. A recently calibrated numerical model of the Death Valley regional ground-water flow system (DVRFS), which includes Amargosa and Pahrump Valleys, will be used to develop a finer-resolution flow model. The finer-resolution flow model will be embedded in the DVRFS model to more accurately simulate water levels within these areas of concern.

## Evaluation of Ground-Water Pumping Effects in the Death Valley Regional Model Using Regional-Scale and Locally Refined Grids

Steffen Mehl, Claudia Faunt, Randell Laczniak, Zhen Li, and Mary Hill
U.S. Geological Survey

There is current interest in evaluating ground-water supply for the Nevada Test Site by means of a ground-water flow model. Accurate evaluation requires knowledge of the regional-scale flow system and hydrogeologic parameters at the local scale. Large scale regional models usually have physically based boundary conditions but have grids that are too coarse to represent drawdown near pumping wells accurately, and therefore are inappropriate for evaluating local-scale parameters based on pumping tests. Local-scale models can adequately discretize the system near the well, but often have tenuous boundary conditions. A rigorous numerical coupling between the regional and local models is required for more detailed representation of drawdown near the well while obeying the dynamics of the regional flow system. A detailed understanding of estimating parameters in regional models with locally refined grids is currently lacking. This work examines some of these issues using the complex three-dimensional model of the Death Valley regional flow system (Faunt et al., 2004) coupled to local scale models. Effects on sensitivity analysis, parameter estimation, and long-term predictions are considered. Of concern in this work are (1) how do sensitivity of transmissivity and storage change with grid size and observation location, (2) what are the numerical problems that need to be addressed, and (3) what are the effects of the coupling boundary conditions on locally refined models. The results are produced using MODFLOW-2005 (Harbaugh, 2005) with local grid refinement (Mehl and Hill, 2005) and UCODE_2005 (Poeter et al, 2005).

## New Ghost-Node Method for Linking Different Models with Varied Grid Refinement

Jesse E. Dickinson, U.S. Geological Survey
Scott C. James, Sandia National Laboratories
Steffen W. Mehl, U.S. Geological Survey
Mary C. Hill, U.S. Geological Survey
Stanley A. Leake, U.S. Geological Survey
George A. Zyvoloski, Los Alamos National Laboratory
Al Aziz Eddebbarh, Los Alamos National Laboratory

A flexible, robust method for linking grids of locally refined ground-water flow models constructed with different numerical methods is needed to address a variety of hydrologic problems. This work outlines and tests a new ghost-node model-linking method for a refined "child" model that is contained within a larger and coarser "parent" model that is based on the iterative method of Steffen W. Mehl and Mary C. Hill (2002, Advances in Water Res., 25, p. 497–511; 2004, Advances in Water Res., 27, p. 899–912). The method is applicable to steady-state solutions for ground-water flow. Tests are presented for a homogeneous two-dimensional system that has matching grids (parent cells border an integer number of child cells) or nonmatching grids. The coupled grids are simulated by using the finite-difference and finite-element models MODFLOW and FEHM, respectively. The simulations require no alteration of the MODFLOW or FEHM models and are executed using a batch file on Windows operating systems. Results indicate that when the grids are matched spatially so that nodes and child-cell boundaries are aligned, the new coupling technique has error nearly equal to that when coupling two MODFLOW models. When the grids are nonmatching, model accuracy is slightly increased compared to that for matching-grid cases.

Overall, results indicate that the ghost-node technique is a viable means to couple distinct models because the overall head and flow errors relative to the analytical solution are less than if only the regional coarse-grid model was used to simulate flow in the child model's domain.

## Death Valley National Park Springs: A Geochemical Investigation

Michael King, The Hydrodynamics Group
Arturo Woocay, University of Texas at El Paso

Yucca Mountain, Nevada is under study as the site of the only proposed high-level nuclear waste repository in the United States. Underlying the repository is an extensive Lower Carbonate Aquifer. Inyo County, as an affected unit of local government under the Nuclear Waste Policy Act is concerned with the connections between the Lower Carbonate Aquifer underlying Yucca Mountain and the carbonate sources of waters in the Death Valley region.

The overall goal of this study was the evaluation of far-field issues related to potential transport. by ground water, of radionuclides into Inyo County, including Death Valley. Death Valley is believed to be a discharge point for regional ground water aquifers below Yucca Mountain. The objective of this geochemical study of spring waters was to characterize the groundwater in the Death Valley mountain blocks, and to determine the source of these waters. Water samples were collected from over 40 springs throughout Death Valley National Park. Samples were analyzed for major anion and cations, and the stable isotopes of Strontium isotope 87Sr, Uranium 234U/238U, and Deuterium and Oxygen-18. The results of our study showed that water sampled and analyzed from small-local springs in mountain ranges in the vicinity of Death Valley have a major ion signature that groups the waters nicely by mountain range. The amount of local recharge is less than 10% of the regional spring discharge in the Furnace Creek area. This is further evidence that the major springs in the Furnace Creek area discharge from the regional carbonate aquifer.

## Geophysical Investigations to Map the Gravity Fault in Ash Meadows and Karst Features Adjacent to Devils Hole

John Jansen, Aquifer Science & Technology
Michael King, The Hydrodynamics Group
Ted Powell and Joy Loughry, Aquifer Science & Technology

A pronounced anomaly has been detected on regional gravity and aerial magnetic data along the eastern wall of Carson Slough from Death Valley Junction into the Ash Meadows area (Blakely 2000). The anomaly is assumed to be caused by a fault and has been called the gravity fault. Blakely (1998) has hypothesized that the offset of the fault may truncate permeable formations and form a hydraulic barrier in the alluvial aquifer and potentially in the carbonate aquifer. Ground based magnetic surveys found anomalies that confirmed the presence of the aerial magnetic anomalies and suggested buried faulting under Ash Meadows (Blakely et al., 2005).

In January of 2006, we conducted a geophysical survey in Ash Meadows to confirm the presence of a major fault in the area and define the shape of the basin floor. We collected approximately 19 miles of gravity data along four profile lines with a station interval of 500 feet. Magnetic data was collected along the gravity lines with a station interval of about 20 feet. We also collected 11 deep TEM soundings along three profile lines.

Modeled cross sections of the gravity data indicate the presence of a bedrock high near the state line and a large trough between the bedrock high and the Devils Hole area. This is generally consistent with the gravity inversion done by the USGS using regional data (Blakely, 1998). The interpretation of the TEM and magnetic data are in progress. The shape of the bedrock surface is consistent with a positive element related to the State Line fault system and a normal fault on the floor of the basin that trends roughly north-south and lies approximately 2 miles west of Devils Hole.

We also collected 62 gravity stations along two 300 foot long profile lines immediately east of Devils Hole. The gravity data was not collected to normal microgravity standards, but the data does show four minor gravity anomalies that can be modeled as narrow, vertical low density features that resemble voids or karst features. A total of 15 three component TEM soundings were collected in the same area to determine if these features can be correlated to vertical conductors. Interpretation of this data is still in progress. The preliminary results of this work suggest that there are significant karst features present in the subsurface around Devils Hole that can be mapped with geophysical methods.

## The Lower Carbonate Aquifer as a Barrier to Radionuclide Transport

John Bredehoeft, The Hydrodynamics Group
Chris Fridrich, U.S. Geological Survey
Michael King, The Hydrodynamics Group

Yucca Mountain is the site of the only proposed high-level nuclear repository in the United States. The repository was designed using the philosophy of multiple barriers, both engineered and natural, each of which impede the movement of contaminants. Underlying the repository at approximately 2 km (6,000 feet) is an extensive Lower Carbonate Aquifer (LCA) known to be highly permeable. Several points of potential discharge are the springs on the east side of Death Valley, within Inyo County. The LCA has the potential of there providing a conduit for radionuclide transport, or a barrier to transport due to a regional upward gradient.

This paper presents the results of our study program to evaluate the LCA as a barrier to radionuclide transport into the major Furnace Creek springs in Death Valley National Park. The focus of our study is a MODFLOW groundwater model that simulates groundwater flow through the Funeral Mountains. The model is supported by our current monitoring well drilling program in the Southern Funeral Mountain Range, surface and subsurface geology mapping, and water chemistry analysis. The results of our model are further supported by our water budget analysis of the Furnace Creek spring system. The model recreates the flow of the various springs in Death Valley. The model is also a tool to evaluate potential impacts of ground water development of the LCA on the major water supply springs in the Furnace Creek Ranch area of Death Valley National Park.

## THURSDAY EVENING, APRIL 27

### Estimated 1937 and 1947 Water Levels in Devils Hole

J.R. Harrill, M.S. Bedinger, and W.L. Werrell, Hydrogeology Consultants to the National Park Service

Two photographs of Devils Hole, taken June 1937 and December 1947, were used to estimate the water level. These estimates provide information prior to 1962 when continuous water-level monitoring of Devils Hole began. The earliest photograph was taken by Dr. Robert Miller on June 5, 1937. The second photograph was taken by Gus Bundy on December 31, 1947. The water levels were estimated by comparing these photographs to photographs taken on June 9, 2001 containing a calibrated staff gage held at the water level and a floating pipe to mark the water level. The distance of the water level below the Devils Hole reference datum was also known in the 2001 pictures. The 1937 level was estimated by overlaying the 1937 and 2001 photographs and determining the difference between the two. The 1947 estimate was made by calibrating selected features on the 2001 photograph and then transferring this calibration information to the same features on the 1947 photograph. The distance from a solution notch with a known elevation down to the water level was determined using the scale transferred from the 2001 photograph (tape-down method). All estimates were adjusted to better represent the water level at the average tidal strain for the month in which they were taken and to better represent the mid point of an annual barometric fluctuation. The estimated water level below the Devils Hole reference in the 1937 photograph was 1.16 feet using the overlay method and the estimated water level in the 1947 photograph was also1.16 feet below the Devils Hole reference. Given the estimated possible error, the water level is probably within +/- 0.15 feet of the estimates. There was no discernable water-level trend between 1937 and 1962.

The procedures used to develop these estimates and a more detailed discussion of the results are described in:

Harrill, J.R., Bedinger, M.S., and Werrell, W.L., 2006 (in press), Documentation of procedures used to estimate 1937 and 1947 water levels in Devils Hole from Photographs.

In the near future this report will be available on the National Park Service website, http://www.nature.nps.gov/water/technicalReports/PacificWest.cfm

Visit this website for other technical reports of the National Park Service and other reports on ground-water resources of Death Valley National Park.

## A Study of Select "Bomb-Pulse" Isotopes in Yucca Mountain Rock, Soil and Seep

James Cizdziel and Yixin Wei
Harry Reid Center for Environmental Studies, University of Nevada at Las Vegas

Chlorine-36 (Cl-36) and Technetium-99 (Tc-99) are two long-lived radionuclides that can be associated with radioactive fallout which peaked during the above-ground tests of thermonuclear weapons conducted in the late 1950's and early 1960's. Both of these isotopes have a bomb-pulse signature and have been used as hydrologic tracers because of their solubility and generally conservative behavior. Chlorine-36 has been used by scientists at Los Alamos National Laboratory and the United States Geological Survey to test for the presence of fast pathways at the proposed Yucca Mountain high-level nuclear waste repository. The goal of these studies was to determine whether or not fluids containing bomb-pulse Cl-36 traveled along fast travel pathways and reached the repository horizon, however, the two groups followed somewhat different procedures and sometimes produced conflicting results. We have been tasked to obtain additional data and to determine whether or not there are bomb-pulse isotopes at the repository horizon. To that end we have collected rock from inside the exploratory studies facility, soil from the surface of Yucca Mountain, and seep from the south portal, and analyzed the samples for Cl-36 and in some cases Tc-99. We used accelerator mass spectrometry and inductively coupled plasma mass spectrometry to measure extremely low concentrations of the isotopes. This poster will discuss our study, highlighting key results and conclusions.

## Infiltration Dates Derived from Chloride Mass Balance

Arturo Woocay and John Walton, University of Texas at El Paso

Chloride mass balance was applied to drill cuttings samples from five Early Warning Drilling Program boreholes where air was used as the drilling fluid. For all five boreholes, infiltration dates before the present were calculated using a range of annual chloride deposition rates obtained from literature. Results indicate that infiltration rates among the boreholes differ at most by a factor of approximately 3.5. Borehole 22SA, near Fortymile Wash, exhibits the most rapid infiltration rate; boreholes further from the wash demonstrate lower rates. This contrast is consistent with groundwater chemistry trends indicating that the most dilute and younger groundwater occurs beneath the wash. Thus, differing infiltration rates among boreholes are likely caused in part by surface runoff along the wash, which accelerates infiltration.

# Abstract

Peter A. Fahmy

## A *Cappaert* Retrospective: What Has Changed in the Past Thirty Years?

On June 7, 1976, the United States Supreme Court handed down a unanimous decision in *Cappaert v. United States*. Since its announcement, this decision has been recognized as a landmark water law decision. Now that almost thirty years have passed since this case was decided, it seems appropriate to pause, look back, and assess the changes that have occurred since then. It also seems prudent to consider the significance of these intervening developments and what they may mean for the future of Devils Hole and its unique residents.

Abstract: Devil's Hole Workshop
April 27, 2006

## Springs—The Lifeblood of the Amargosa

John Hiatt

The unique ecosystems of the Amargosa region are heavily dependent on spring flow. While some springs are named and well known (e.g., the Shoshone spring and several Ash Meadows springs), there are literally hundreds of others that contribute life to riparian and aquatic environments along the Amargosa corridor. However, for even well known springs, there is a dearth of information about their sources and even amounts and variability of flows. Direct human population growth in the region, combined with expanding groundwater pumping for export to Las Vegas, may well put these springs, and the Amargosa ecosystem, at risk. Increased resources must be devoted to understanding the hydrology of these springs, developing effective baseline information about their flows, and establishing legal protection for them based on predictive models and early warning signs of decreased flow.

# A Novel Installation for Geochemical and Hydrological Monitoring at NC-EWDP-24PB

Dale Hammermeister, Barry Freifeld, Jamie Walker, and Paul Reimus

Understanding the Amargosa Valley groundwater system is important because of its downgradient location south of the proposed high-level radioactive waste repository at Yucca Mountain, NV. Borehole NC-EWDP-24PB, within Amargosa Valley, is a multipurpose testing location for new wellbore technologies, intended to meet the monitoring requirements of the Nye County's Early Warning Drilling Program (EWDP) and also to serve as a platform for an Office of Science and Technology and International (OST&I) reactive transport study. The OST&I research program "Field Studies for the Determination of Transport Properties of Radioactive Solutes and Colloids Using Chemical Analogues" aims to characterize radionuclide sorptive processes in the Bullfrog and Tram tuffs using injection/pumpback tests. To meet the needs of both of these programs, NC-EWDP-24PB has been completed with multilevel U-tube samplers, a fiber-optic distributed-temperature sensor, and a continuous wellbore heater for performing fluid flux measurements. Pending radionuclide surrogate tracer approval, reactive transport studies are expected to start by Fall 2006, and NC-EWDP-24PB fluid samples and groundwater head measurements will be collected for incorporation into the EWDP database.

# Flowing Fluid Electrical Conductivity Logging of Boreholes in the Amargosa Valley

Barry Freifeld, Dale Hammermeister, Jamie Walker, Raymond Federwisch,
and Paul Reimus

As part of Nye County's Early Warning Drilling Program, boreholes NC-EWDP-24PB and NC-EWDP-32PB were drilled in the Amargosa Valley, targeting volcanic tuffs and alluvium, respectively. The borehole locations, south of the proposed Yucca Mountain Nuclear Waste Repository, are significant because they may be along groundwater transport pathways that underlie the potential repository and that could be considered possible routes for radionuclides migrating through the saturated zone and into the biosphere. A suite of standard borehole logs, including caliper, gamma, self-potential, resistivity, and downhole video, was acquired at each drill site. Flowing electrical conductivity (FEC) logging was performed under both ambient and forced gradient conditions. Using this method, the formation fluid in the borehole is replaced with deionized water, and the inflow of the more-saline, natural formation fluid is monitored by logging fluid electrical conductivity. Preliminary interpretation of the FEC logs has identified groundwater flow paths and intraborehole hydraulic gradients. Additional analysis will be required to use the FEC data to estimate regional groundwater discharge and transport velocities at both of these locations.