WATER CONSERVATION PRINCIPLES: DEPLETION, DIVERSION, AND VALUE

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Presentation Abstract 1

"Water conservation" means different things to different people, and the principles of depletion and diversion are often confounded and misconstrued, particularly when the value of water and different accounting stances are involved. Many public policies and public and private investments have been implemented in the name of conserving water, particularly in irrigated agriculture. Unfortunately, many of these policies and investments cannot make additional water available to new users due to the nature of closed basin hydrology. The assumption that farmers are low-efficiency irrigators is used to justify transfer of income and wealth to agricultural water users and other interested parties through direct investments and cost sharing programs. Instead, these programs serve to sustain and increase consumptive use of water in agriculture. Deficit irrigation practices currently found in many arid climates result in high on-farm irrigation efficiencies and unsatisfied demand for water by agriculture. In this paper and presentation, the water conservation impacts of drip irrigation, irrigation scheduling, and canal lining are discussed in the context of the hydrological assumptions which are used to promote these technologies. The potential of drip irrigation, irrigation scheduling, and canal lining to sustain and increase crop evapotranspiration in deficit irrigation environments is illustrated. Given hydrologic conditions, the authors conclude that accurate accounting of water use, including equitable distribution based on existing legal entitlements would significantly contribute to water conservation efforts.

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HYDROLOGY OF AN EMERGING INFECTIOUS DISEASE: THE ROLE OF WATER IN THE SPREAD OF AVIAN INFLUENZA

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Presentation Abstract 2

The World Health Organization and influenza experts worldwide are concerned that the recent appearance and widespread distribution of an avian influenza virus, Influenza A/H5N1, has the potential to ignite the next pandemic. Migratory waterfowl appear to serve as the main reservoir for most influenza A viruses. The ecology of influenza viruses is a dynamic system in which several factors are interacting, coexisting, changing, and maintaining: the viruses, the wild birds, the water reservoir, and the environment.

A critical factor, but with woefully large knowledge gaps, is the water reservoir. Understanding each relationship will require a combination of empirical, theoretical, and modeling techniques to elucidate patterns and processes. Understanding the importance of the waterways in influenza transmission and evolution will require a diverse interdisciplinary team and a suite of approaches to fill the enormous knowledge gaps required for the foundation of a national avian influenza surveillance program. In addition to quantifying influenza virus isolates from waterfowl, it will be important to quantify influenza in the water of important avian waterways. Studies in the past have suggested that influenza viruses have been maintained in waterfowl by water-borne transmission and that there is year-to-year perpetuation of the viruses in the lakes where the birds breed. The potential pathways and dynamics of influenza in a completely modeled water system would also give insight into the behavior of influenza in the environment. Lastly, the population biology, species differences, and migratory patterns of birds to influenza isolates in relation to waterways will need to be understood to better provide migration tools in the environment to respond to influenza. New Mexico is a critical wintering ground for tens of thousands of migratory waterfowl along the condensed Rio Grande River. New Mexico will be a critical location for monitoring for influenza and investigating the evolution of the virus with the role of water.

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CONCENTRATION AND REMOVAL OF AFLATOXIN FROM WATER USING CARBON NANOTUBES

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Presentation Abstract 3

Aflatoxin is one of the most potent naturally occurring mycotoxin derived from fungi called Aspergillus Flavus. It is known to be a potential carcinogen and mutagen based on animal research data and produces serious acute and chronic health effects. Although occurring naturally, a well processed aflatoxin contains high levels of toxicity and is a possible threat to our drinking water systems in an event of intentional contamination in the name of bioterrorism. Most of the toxins including aflatoxin are colorless and tasteless and therefore cannot be easily assessed by sensory testing kits that are available today. Thus, it is required to develop an effective sensing mechanism that allows simultaneous concentrating and detecting the contaminant. Carbon nanotube technology was identified to have such capability and has a potential to make important advancements in water security and protection from bio-threat agents. The objective of using carbon nanotubes is to develop a membrane-based sensor consisting of functionalized or unfunctionalized carbon nanotubes that allows only water to pass through leaving behind the contaminant, which is subjected to detection by the nanotube sensors. While working in this direction, shaker experiments were conducted to determine the adsorption kinetics and adsorption equilibrium and thereby estimate the adsorption capacity of carbon nanotubes. Samples were collected at various intervals of time to establish the kinetic data. The initial concentration of the toxin used was 9.1 ppm, and it was observed within the first 30 seconds the concentration in the solution dropped to 0.83 ppm. This confirms the grounds for excellent adsorption capacity of aflatoxin on carbon nanotubes. The detection for the presence of aflatoxin was carried out by using LC-MS. The detailed results on adsorption equilibrium and kinetics of aflatoxin on carbon nanotubes will be presented.

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METHOD FOR REPRESENTING BANK STORAGE AT BRANTLEY RESERVOIR IN THE PECOS RIVER RIVERWARE MODEL

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Presentation Abstract 4

In 1988, the construction of Brantley Dam was completed four miles downstream from the old McMillan Dam at a new location that provides a more suitable foundation in the less permeable carbonate facies of the Seven Rivers Formation. Filling Brantley Reservoir inundated Major Johnson Springs and creates the potential for bank storage in the adjacent alluvium and evaporate/carbonate facies of the Seven Rivers Formation. Resulting processes that may affect the water supply in the Pecos River basin are Major Johnson Springs inflow, seepage, and bank storage at Brantley Reservoir. An analysis was completed to develop a method that represents the effect of these processes for different reservoir operations. Based on a literature review and evaluation of available data, it was determined that the flux to and from bank storage is closely related to the change in reservoir stage. Over the long-term, this process conserves volume and effectively alters the elevation-capacity relationship for the reservoir. While the instantaneous inflow from the Major Johnson Springs varies, there is no indication that the long-term inflow is impacted by pool elevations in Brantley Reservoir. Based on these findings, an algorithm was developed for the Pecos River RiverWare model, and results from the method indicate that as the reservoir level returns to its initial level, all water lost to bank storage is returned. Also, there is a consistent gain to Brantley Reservoir from the combined effect of Major Johnson Springs inflow and seepage.

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IMPACTS OF PERSISTENT DROUGHT ON HABITAT IN THE RIO GRANDE AT ELEPHANT BUTTE RESERVOIR

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Presentation Abstract 5

Only 20 years ago, Elephant Butte Reservoir was overflowing with water, but by the end of 2006, lake levels are expected to drop to a historically low level. As the lake size is continually decreasing, the Rio Grande channel has repeatedly become disconnected from the reservoir. To maintain connectivity, a temporary river channel was constructed in 2000 and has been regularly extended as the lake edge recedes. As a result of the increasing length of the Rio Grande and the lowered base elevation created by the rapidly retreating lake boundary, a relatively large headcut developed in 2003. Bed degradation from this headcut measures about 11 feet at River Mile 60 (RM 60), near the upstream boundary of the reservoir pool, with the effects measured as far upstream as RM 72. One effect of the bed degradation is the disconnection of the floodplain from the main channel, such that the shallow groundwater table appears to be lowering. The lowered water table is resulting in significant stress to riparian vegetation. As the upstream end of the Reservoir has an increasing population of endangered Southwestern Willow Flycatchers, the decrease in floodplain inundation and dieback of native riparian vegetation may influence flycatcher habitat characteristics. A response in the flycatcher's population and the species' reproductive success is being monitored closely. As the lake level continues to drop, efforts are ongoing to monitor for any additional headcuts and to produce a model that helps understand the full implications of the channel degradation.

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BASIN-FILL AQUIFER SYSTEMS OF THE BINATIONAL PASO DEL NORTE REGION—RECENT ADVANCES IN CHARACTERATIZATION OF THEIR HYDROGEOLOGIC FRAMEWORK AND DEPOSITIONAL HISTORY

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Presentation Abstract 6

Major progress has been made during the past decade in characterizing the hydrogeologic framework and depositional history of the basin-fill aquifer systems that collectively form the only significant groundwater resource in the Paso del Norte region of south-central New Mexico, western Trans-Pecos Texas, and north-central Chihuahua, Mexico. The region includes the Mesilla and Hueco-Tularosa basins of the Rio Grande rift tectonic province and the Mesilla and El Paso Valleys of the Rio Grande/Bravo fluvial system. Most importantly, the El Paso/Ciudad Juárez/Las Cruces metro-area (with a population of about 2 million) is centered in the river-valley corridor. Hydrogeologic/GIS research described here was coordinated by the New Mexico Water Resources Research Institute; however, it is only part of several ongoing multi-institutional/disciplinary studies of surface-water and groundwater resources. For example, a new phase of hydrogeologic/ geohydrologic investigations has recently been initiated in collaboration with the Universidad Autónoma de Ciudad Juárez—Centro de Información Geográfica and El Paso Water Utilities—Hydrogeology and GIS Sections.

The two major aquifer systems of the Paso del Norte region comprise 1) intermontane-basin fill of the Neogene Santa Fe Gp that is as much as 750m thick and 2) fluvial channel deposits of the Late Quaternary Rio Grande, which are confined to the inner river valley and less than 30m thick. To date, their hydrogeologic framework and depositional history have been digitally characterized with two surficial maps, 36 cross sections, and a structure-contour map of the base of the Santa Fe Gp. The most productive lithofacies assemblages in the basin-fill aquifer system are 1) fluvial and fluvial-deltaic sands of the Upper Santa Fe hydrostratigraphic unit (HSU) deposited by the ancestral Rio Grande and 2) thick eolian-sand deposits in the Lower Santa Fe HSU. The latter lithofacies is mainly restricted to a 200-500m depth zone below the Mesilla Valley floor.

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DISCHARGE MEASUREMENTS USING RHODAMINE WT DYE TRACER AT LOS ALAMOS NATIONAL LABORATORY (LAUR-06-4645)

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Presentation Abstract 7

Streamflow measurements in arroyos of the arid regions of the southwestern U.S. are complicated by the ephemeral nature of runoff events, complex cross-sectional channel geometry, and steep slopes. The short duration of runoff events makes it difficult or impossible to use manual onsite discharge measurements to develop stage-discharge relationships. The application of Manning's equation or other mathematical modeling methods is generally employed in these situations. The purpose of this project was to develop stage-discharge rating curves at Los Alamos National Laboratory (LANL) stream monitoring sites using a dye tracer (Rhodamine WT). Four sites were equipped with event activated dye injection equipment and automated water samplers. Varying dye concentrations through a unit hydrograph were converted to discharge (cfs) and regressed against stream stage. A runoff event in Acid Canyon August 2005 was successfully dye-dripped and sampled to develop a stage-discharge rating curve (R^2 = 0.99) from 2 to 47 cfs with an accuracy of +/- 10%. Total suspended solids (TSS) and turbidity varied from 100 to 4,200 mg/L and 50 to 4,200 NTU, respectively, during the event. Total TSS mass transport was 6,000 kg. The study indicates dye tracers can successfully be used to develop stage-discharge rating curves to calculate mass transport of potential pollutants. Information from this study could benefit other research studies conducted by universities and state and federal agencies in New Mexico and the southwest. (LAUR-06-4645)

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CONTROLS ON WATER QUALITY IN A HEAVILY MANAGED ARIDLAND RIVER

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Presentation Abstract 8

The city of Albuquerque, New Mexico, USA, is one of the largest urban areas totally dependent on ground water for its water supply. This will change in 2006, when about 5% of the average annual discharge of the Rio Grande River will be removed for drinking water. Water quality and watershed controls on water quality are now of great interest. Longitudinal sampling over 1200 km of river has shown wastewater effluent, agriculture, and basin tectonics to significantly impact water quality. Recently, we have begun quarterly sampling of all major water conduits along 290 km of the Rio Grande, New Mexico, for water quality parameters. Results to date show wastewater treatment plants to be the most important and consistent sources of nutrient loading to the river and that the river has a limited capacity for retention downstream of these point sources. Although agricultural land use affects water quality, irrigation return flows can contain lower concentrations of nutrients than river water below wastewater treatment plants. Additionally, water quality is strongly modulated by quantity—particularly controlled flooding and water removal for irrigation. Effluent dominated rivers are now common in aridlands, and the amount and ultimate fates of these pollutants is an important research topic.

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ARSENIC SORPTION ONTO LATERITE IRON CONCRETIONS: TEMPERATURE DEPENDENCE

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Presentation Abstract 9

This study investigated the effect of temperature, ionic strength, and pH on arsenate and arsenite adsorption onto laterite iron concretions through batch experiments. Langmuir model satisfactorily fit the arsenate and arsenite adsorption isotherm data. The equilibrium adsorption capacity for As (V) was larger than that for As (III) (0.708 mg/g for As (III) and 0.787 mg/g for As (V)).

Adsorption capacity for both As (III) and As (V) increase with temperature, from 0.787 to 1.428 mg/g for arsenate and from 0.708 to 1.000 mg/g for arsenite when the temperature increased from 25 to 35°C. Both arsenite and arsenate were found to adsorb well over a pH range of natural waters (4-9) with maximum sorption at neutral pH. Increase in adsorption capacity of the laterite iron concretion with temperature may be due to change in surface and thermodynamic properties of the adsorbent.

The calculated thermodynamic parameters including delta G°, delta H° and delta S° reflected the spontaneous nature of As (V) and As (Ill) adsorption onto the laterite iron concretion. The values of delta H° indicated that the adsorption of As (V) was exothermic, whereas that of As (III) was endothermic.

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MODELING RIO GRANDE SILVERY MINNOW POPULATION DYNAMICS AND SENSITIVITIES

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Presentation Abstract 10

A system dynamics model of Rio Grande Silvery Minnow (RGSM; Hybognathus amarus) was built using life history data and information from the literature and from personal communication with regional experts. The model simulates RGSM population dynamics on a monthly time step from 1975-2006 over six reaches from Cochiti Dam to Elephant Butte Reservoir and roughly captures reported regional population dynamics. The model simulates dynamics among male and female fish across 24 and 48 monthly age cohorts, including reproduction and various mortality functions. The model allows numerous user-defined variables to account for uncertain data, uncertain life history and species behavior information, and varying management options; these include variable reproductive rates, upstream and downstream migration, captive release strategies, mortalities related to discharge and ammonia concentrations, and others. The model is useful for integrating existing knowledge on RGSM life history and behavior, identifying data gaps, testing sensitivity of population dynamics to various factors, and for testing outcomes of different management strategies. Results of various sensitivity analyses and management scenarios are described.

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POTENTIAL USES OF SURFACTANT MODIFIED ZEOLITE/ZERO VALENT IRON PELLETS IN THE CHIHUAHUAN DESERT REGION

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Presentation Abstract 11

Surfactant Modified Zeolite (SMZ) enhanced with zero-valence iron (ZVI) has the ability to remove a diverse range of contaminants, including dangerous chemicals and pathogens, from groundwater. SMZ-ZVI costs around $525/metric ton. This presentation will focus on the market potential of SMZ-ZVI pellets, a patented technology, with an emphasis on municipal system design alternatives that utilize SMZ-ZVI for both purification of groundwater and as part of the water treatment process. Further research, including a full scale municipal test, will be needed to determine the viability of these potential applications. Further research into SMZ-ZVI applications will give light to even more potential benefits, possibly extending beyond water treatment.

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NEW MEXICO'S STRATEGIC WATER RESERVE: POLICY ANALYSIS

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Presentation Abstract 12

In New Mexico, as in much of the West, usable water availability is a contentious issue. A strategic water reserve is a way for New Mexico to buy or lease existing water rights, at fair market value, to meet interstate stream compact obligations and provide enough in-stream river flow for endangered species. This concept has been proposed through legislation since at least 1997. Think New Mexico, a non-partisan, action oriented think tank, pushed the most recent proposal. A modified version of their 2003 Rio Vivo! The Need for a Strategic River Reserve in New Mexico proposal passed in the 2005 legislative session.

This legislation establishes a Strategic Water Reserve, allowing purchase, lease, or donation of both surface and underground water rights by the Interstate Stream Commission. Water rights from an acequia or a community ditch association cannot be acquired for the Reserve.

A system dynamics modeling approach used to analyze the SWR Preliminary results shows:
1. It will take many years to 'fill' the reserve at current rates.
2. The cost per acre foot will increase.
3. The majority of the water in the reserve will flow downstream.
4. There will be a noticeable decrease in irrigated agriculture as municipalities compete for diminishing available adjudicated water rights.
5. The adjudication process will increase extra- and over-use of New Mexico's waters.
6. Increasing demands will be placed upon the Legislature for funds to support the SWR.

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COLLABORATIVE MODELING USING SYSTEM DYNAMICS FOR THE GILA-SAN FRANCISCO RIVERS IN NEW MEXICO

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Presentation Abstract 13

Water resource management requires collaborative solutions that cross regional, state, and federal judicial boundaries. As most of the western U.S. experiences drought-like conditions as well as population growth, there is a growing concern over sustainable water resources. In this presentation, we illustrate an on-going effort to create a hydrologic model for the upper Gila and San Francisco rivers. Motivated by a recent water settlement with neighboring Arizona[1], water planning for the southwestern New Mexico region must consider water demands from existing agricultural rights, industrial use, and a growing municipality while ensuring downstream commitments and meeting all federal regulations on endangered species. Teamed with local, state, and federal stakeholders, Sandia uses a collaborative modeling method that is multidisciplinary, largely quantitative, and yet transparent to all interested parties. The goals of the Gila-San Francisco model are to enhance overall understanding of the intricate coupling between water resources and demands, understand the human and ecological impact on the river health in the context of the new settlement, quantify the changes based on different perturbation scenarios, and inform the public. The collaborative effort has produced a set of water balance scenarios based on perturbations to the natural and manmade environments such as forest fires or population growth. The modeling effort is based on system dynamics where dynamic responses of interdependent components within the water cycle are calculated. Thus far, the model components include surface, groundwater, and watershed hydrology. Agricultural, industrial, and municipal water demands overlay the hydrological components and are included to assess their impact on the rivers. Furthermore, this model weighs in the ecological water demands. River flow and climate data are used to calibrate baseline flows.

*Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

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[1] 2004 Arizona Water Settlement Act.

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WATER CONSERVATION THROUGH DEEP WELL PURGE WATER RECLAMATION

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Presentation Abstract 14

The City of Santa Fe operates 13 deep wells near the Rio Grande. Previously, upon starting a well, the first 5 to 15 minutes of sand- and silt-laden water was discharged to local arroyos. To conserve water, the City has installed purge water reuse systems at each well site. Each system includes a fiberglass reinforced plastic (FRP) tank to collect the purge water. The sediment in the water settles to the bottom of the tanks, where it is periodically removed. The partially clarified water is then gradually pumped through a set of filters by a small submersible pump located in each tank. The filters remove any remaining sediment and other contaminants prior to the water passing into the water system. The systems are fully automated so as not to require operator intervention on a routine basis and are tied into the City's SCADA system for remote monitoring and control. The project was partially funded by Governor Richardson's Water Innovation Fund.

The talk will present information on technical issues associated with the design of the purge water reuse systems; construction and operational challenges; construction costs; and how this project has application to other well water systems in the southwest.

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COUPLED GROUND-SURFACE WATER MODEL FOR EVALUATING THE HYDROLOGIC EFFECTS OF ALBUQUERQUE'S SAN JUAN-CHAMA PROJECT

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Presentation Abstract 15

As a basis for granting diversion permits for use of ground or surface water in New Mexico, the New Mexico State Engineer (OSE) requires that water users quantify the hydrologic effects of proposed projects. In the case of groundwater, the effects of most interest are aquifer drawdowns, impacts on neighboring wells, possible water quality issues, and how pumping might induce added seepage from or reduce flow into surface streams. In the case of projects involving diversions of surface water, the major concerns are effects on streamflows and possible impacts on downstream water rights holders – especially during periods of low flow and drought. For a conjunctive use project, such as Albuquerque Bernalillo County Water Utility Authority's (Authority) San Juan-Chama Project, the evaluation of effects becomes more complicated, because of combined groundwater-surface water effects, the use of non-native (imported) water, and because wastewater return flow credits are involved. Return flows must be evaluated along with surface diversions and pumping effects to ensure the State Engineer that the project has a positive overall water rights balance and that the river is "kept whole." The methodology used to address these issues for the San Juan-Chama Project was termed the AWRMS River Model. The model involved a coupling of the State Engineer's Interim ground-water model of the Middle Rio Grande basin with a 'spreadsheet' surface water model. The 'spreadsheet' model used an adjusted record of 1971-98 monthly streamflows on the Rio Grande projected into the future to simulate the years 2006-60 with the San Juan-Chama project in operation. The AWMRS River Model was used in the State Engineer hearing on Application 4830 (completed in February 2003) and for the "effects analysis" in the Environmental Impact Statement for the project which was successfully completed in summer 2003.

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NITROGEN DYNAMICS IN HYPORHEIC SEDIMENTS USING $15NO_3$-N TRACERS

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Presentation Abstract 16

Understanding uptake and transformation of NO_3 in hyporheic sediments in streams with varying levels of anthropogenic N inputs is necessary to understand how human disturbance (urbanization and agriculture) affects these processes. Bromide and $15N–NO_3$ were co-injected for 24 hours in multiple streams (native, urban, and agricultural areas) in the southwestern USA. Groundwater wells were sampled along a longitudinal gradient within the15N injection sites. Water and gas samples were taken prior to, during, and after injections and were analyzed for O_2, major cations and anions, DOC and 15N (gaseous and aqueous). Transient storage parameters were calculated using OTIS-P. As/A values ranged from 4.04E-01 to 3.92E-03 and alpha (storage zone exchange coefficients) ranged from 3.35E-04 to 6.35E-05 sec-1 in native and impacted sites, respectively. Wells contained >80% surface water at three sites with varying N-loads. These wells also had higher enrichment levels of 15N for various transformation products of NO_3 than stream water. These data suggest that hyporheic zones may be a significant site of uptake and processing of NO_3 in human disturbed streams.

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MONTHLY RIO GRANDE STREAMFLOW FORECASTS USING TRANSFER FUNCTION – NOISE MODELS

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Presentation Abstract 17

Streamflow forecasting is of great importance to water resources management and planning. Particularly, the monthly time scale forecasting is very useful in reservoir planning and operations and irrigation management. The purpose of this research is to stochastically forecast the monthly Rio Grande streamflow using seasonal autoregressive integrated moving average (SARIMA) models, and then to improve the monthly streamflow forecasts by establishing single-input transfer function-noise (TFN) models with appropriate exogenous variables, such as El Nino southern oscillation (ENSO), pacific decadal oscillation (PDO), palmer hydrological drought index (PHDI), palmer z-index, as well as precipitation. A preliminary analysis of cross correlations of monthly ENSO and PDO time series with the Rio Grande monthly streamflow did not show the possibility of significant further improvements of forecasts when incorporating these input variables. By contrast, TFN models that incorporate the other variables have improved monthly streamflow forecasts compared to the SARIMA model forecasts. The root mean squared error (RMSE) of one-step-ahead forecasted values for 24 months by TFN model using PHDI as an input variable is reduced by 7% and 15% of the forecasts of SARIMA models for San Marcial and Otowi bridge gaging stations of Rio Grande respectively, and the coefficient of determination (r^2) is increased from 0.25 to 0.37 for San Marcial, and from 0.63 to 0.73 for Otowi bridge gaging stations. The results of this study suggested that palmer hydrological drought index (PHDI) and palmer z-index could be significant exogenous variables in building TFN models for monthly streamflow forecasts.

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DETERMINATION OF CANAL LEAKAGE POTENTIAL USING CONTINUOUS RESISTIVITY PROFILING TECHNIQUES IN WESTERN NEBRASKA AND EASTERN WYOMING

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Presentation Abstract 18

In the North Platte River Basin, a ground-water model is being developed to evaluate the effectiveness of using leakage of water from selected irrigation canals to enhance ground-water recharge. The U.S. Geological Survey, in cooperation with the North Platte Natural Resources District, used land-based capacitively coupled and water-borne direct-current continuous resistivity profiling techniques to map the lithology of the upper 8 meters and interpret the relative canal leakage potential of 110 kilometers of the Interstate and Tri-State Canals in western Nebraska and eastern Wyoming. Lithologic descriptions from 25 test holes were used to evaluate the effectiveness of both techniques for indicating relative grain size. An interpretive color scale was developed that symbolizes contrasting resistivity features indicative of different grain-size categories. The color scale was applied to the vertically averaged resistivity and used to classify areas of the canal as having either high, moderate, or low canal leakage potential.

When results were compared with the lithologic descriptions, both land-based and water-borne continuous resistivity profiling techniques were determined to be effective at differentiating coarse-grained from fine-grained sediments. Both techniques were useful for producing independent, similar interpretations of canal leakage potential.

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STREAMFLOW, TURBULENT EDDIES, INTERFACIAL EXCHANGE, AND HEAT TRANSPORT IN THE HYPORHEIC ZONE

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Presentation Abstract 19

Permeable sediments often underlie channels, streams, and rivers. Fluid exchange between the water column and the sediments is forced by spatially varying head gradients along the sediment-water interface (SWI), due to current-bedform interaction, and by ambient groundwater discharge (AGD), due to regional head gradients. We investigate the competing effects of current-bedform induced flow and AGD on the interfacial exchange of fluid, and the resulting flow field and thermal regime within sediments, for sediments with dune topography. Heat transport is forced by a diel variation of temperature in the water column. Coupled models simulate turbulent flow in the water column and Darcy flow and heat transport within sandy sediments. Current-bedform induced fluid flow in the sediments results in a complicated but predictable interfacial exchange zone (IEZ) pattern and transient heat distribution. When AGD is present, the influence of current-bedform induced advection becomes subdued until, at higher rates of AGD, fluid flow and heat transport become essentially vertically one-dimensional. For lower AGD rates, with the complex IEZ pattern, strong diel temperature variations may be found horizontally adjacent to zones lacking any substantial temperature variations. The zones with weak temperature variations are found close to crests of dunes where pore water is upwelling from deeper areas of the sediments. Strong temperature variations are observed underneath areas along the lower part of the stoss face of the dunes, where water is recharging the IEZ from the water column. Current-bedform induced fluid flow and AGD substantially affect the interfacial exchange and thermal regime of permeable sediments and should be considered in studies of hyporheic ecological and biogeochemical processes.

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HIGH EFFICACY PATHOGEN REMOVAL FROM CONTAMINATED WATER VIA INORGANIC CLUSTER/AMPHIPHILE-BASED COAGULATION SYSTEMS

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Presentation Abstract 20

Waterborne pathogens continue to emerge at an alarming rate, and sources of potable water contamination, which include industrial, agricultural, and natural sources, as well as terrorist attacks and natural disasters, are unpredictable, making water treatment costly and its efficacy variable. The development of more efficient, cost-effective methods to remove pathogens from contaminated water supplies will help mitigate the health and economic impacts associated with water-related diseases. No single water decontamination method meets EPA standards for pathogen removal (4-log, or 99.99%) alone, but coagulation technologies are promising as they are cost-effective and do not produce carcinogenic byproducts. State-of-the-art polyaluminum chloride (PAC)-based coagulation systems are limited in that the pH adjustment step necessary to initiate precipitation destroys the active specie and causes partial re-release of the captured pathogens such that the maximum efficacy of the PAC system is limited to 2.5-log removal. Additionally, the precipitate is hydrophilic, and the necessity for dewatering is a technical shortcoming of this approach. Therefore, we report an improved coagulation method that utilizes amphiphiles to initiate precipitation, thereby increasing the pathogen removal efficacy over current methods and eliminating the need for precipitate dewatering. Using model viral and bacterial pathogens, we have demonstrated that, in bulk systems, our system can achieve 4-log removal in a single step using polycationic alumina clusters and polyanionic polyoxometalate clusters as coagulants. Additionally, polyionic clusters can be conjugated onto beads in order to make a pseudo-packed bed reactor, offering another method to remove pathogens from contaminated water with high efficacy.

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MULTIVARIATE STATISTICAL ANALYSIS OF THE TULAROSA BASIN

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Presentation Abstract 21

The border region is growing rapidly and experiencing a sharp decline both in water quality and availability, putting a strain on the quickly diminishing resource. Since water is used primarily for agricultural, domestic, commercial, livestock, mining and power generation, its rapid depletion is of major concern in the region. Tools such as Principal Component Analysis (PCA), Correspondence Analysis, and Cluster Analysis have the potential to present new insight into this problem. The Tularosa-Hueco Basin is analyzed here using some of these Multivariate Analysis methods. PCA is applied to geo-chemical data from the region and a Cluster Analysis is applied to the results in order to group wells with similar characteristics. The derived Principal Axis and well groups are presented as biplots and overlaid on a digital elevation map of the region providing a visualization of potential interactions and flow path between surface water and ground water. Simulation by this modeling technique gives valuable insight to the water chemistry and the potential pollution threats to the already water diminishing resources.

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USING SURFACE GEOPHYSICAL DATA TO MORE ACCURATELY ACCOUNT FOR CANAL LEAKAGE IN A GROUNDWATER MODEL: WESTERN NEBRASKA AND EASTERN WYOMING

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Presentation Abstract 22

To support the development of an Integrated Management Plan (IMP) for water use, a ground-water flow model was developed to evaluate the effects of using leakage of water from unlined irrigation canals and laterals to enhance ground-water recharge. For the ground-water flow model to accurately simulate current or predict future conditions, specific inputs, such as the spatial distribution of canal leakage, are essential. Canal leakage in a model often is estimated based on lithologic data from boreholes that may be several kilometers apart and not in the proximity of the canals. The estimation of model inputs using distant lithologic data may introduce potential errors in the groundwater flow model. This presentation will describe how electrical resistivity results were used to more accurately account for canal leakage in a groundwater model.

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A PHYSICALLY-BASED MULTIVARIATE-REGRESSION APPROACH FOR DOWNSCALING NEXRAD PRECIPITATION IN MOUNTAINOUS TERRAIN

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Presentation Abstract 23

Precipitation temporal and spatial variability often controls terrestrial hydrologic processes and states. Common remotely-sensed precipitation products have a spatial resolution that is often too coarse to reveal hydrologically important spatial variability. A parsimonious physically-based multivariate-regression algorithm, referred to as multi-level cluster-optimizing ASOADeK regression, is developed for downscaling low-resolution spatial precipitation fields. This algorithm auto-searches precipitation spatial structures (e.g., rain cells) and atmospheric and orographic effects to estimate precipitation distribution without prior knowledge of the atmospheric setting. The only required input data for the downscaling algorithm are a large-pixel precipitation map and the DEM map of the area of interest. We tested the algorithm on NEXRAD precipitation fields with 4km x 4km large pixels from events over the mountains of Northern New Mexico and the Hill Country of Texas. The algorithm generated 1km x 1km downscaled daily precipitation maps, which we judge successful for the mountainous terrain in terms of precipitation spatial statistics and pair comparisons of pixel values and rain gauges. It produced acceptable downscaled hourly precipitation maps in terms of precipitation spatial statistics, but not in regard of pixel-gauge comparison. The algorithm also successfully retrieves the overall moisture flux direction for the precipitation field. These promising results suggest that the algorithm is worthy of further exploration and development.

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PRELIMINARY STUDIES FOR FLUORIDE AND ARSENIC REMOVAL FROM GROUNDWATER USING SOL-GEL DERIVED MESOPOROUS ALUMINA

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Presentation Abstract 24

Access to adequate quality drinking water is a problem that exists along the U.S.-Mexican border region. Groundwater wells in the Columbus, NM and Palomas, Mexico border region show high levels of arsenic (> 40ppb) and fluoride (7-8 ppm). Skin cancer is a well known health risk that is associated with arsenic ingestion. Fluoride ingestion at high levels can lead to fluorosis. A research project funded by EPA through the Southwestern Consortium for Environmental Research and Policy (SCERP) is being carried out to search for effective and economical ways for purifying drinking water specifically for this border region.

Mesoporous activated alumina adsorbents were synthesized by a sol-gel technique and studied for their adsorption equilibrium and breakthrough properties. Adsorption equilibrium of fluoride and arsenic in water on the sol-gel derived alumina was studied using an orbital shaker over a 7-day period. A packed bed of sol-gel derived alumina was used to study the breakthrough of arsenic since July 2005 without a breakthrough. The sol-gel derived alumina has BET surface of 312 m^2/g, pore volume of 0.30 cm^3/g and uniform pore size between 3-6 nm. The adsorption of arsenic and fluoride on alumina follows the Freundlich adsorption isotherm. The adsorption capacity of arsenic on the sol-gel alumina estimated from the breakthrough experiment is 12 mg/g. The corresponding arsenic adsorption equilibrium constant is 60 L/g, which is significantly higher than results under similar conditions published by Khandaker, et al. (2.3 L/g for activated alumina and 14.9 L/g for granular ferric hydroxide). A prototype of the adsorption column using the sol-gel derived alumina will be installed in Columbus, NM.

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A JOINT INVESTIGATION OF EVAPOTRANSPIRATION DEPLETION OF TREATED AND NON-TREATED SALTCEDAR AT THE ELEPHANT BUTTE DELTA, NEW MEXICO

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Presentation Abstract 25

The control of saltcedar (Tamarix sp.) has become a major concern since studies in the past have shown that evapotranspiration (ET) of saltcedar ranges between 3 ft - 5 ft of water per year. In an effort to study the reduction of saltcedar ET by herbicide treatment, a large area of dense saltcedar was treated and an adjacent area was left untreated in order to compare the effects of ET losses after herbicide treatment. Evapotranspiration measurements from both sites using the eddy covariance method indicated that the treated saltcedar stand during a comparison of 83 growing days was less than the non-treated site by about 57%. Total ET of 327 mm was measured at non-treated site and 142 mm at the treated site. For the 149 days of data compared during the non-growing season, it was observed that the treated site had more evapotranspiration than the non-treated site by 37%. Total ET of 161 mm at non-treated site and 220 mm at the treated site was measured. ET of non-treated site was estimated during the entire year of 2005 using crop coefficient as a function of cumulative GDD (growing degree days) developed based on ET measurements at Bosque del Apache National Wildlife Refuge in 2005. This estimation showed 61% higher ET at the non-treated site when compared to the treated site.

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A NETWORK OF SCINTILLOMETERS FOR GROUND-TRUTHING OF SURFACE FLUXES IN NEW MEXICO

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Presentation Abstract 26

A network of scintillometer transects over different soils, vegetation types, and altitudes is being established in New Mexico. Scintillometers measure spatially-averaged sensible heat fluxes over transects of 0.5 - 4 kms, i.e., over footprints comparable in size to several pixels of a satellite image.

The Surface Energy Balance for Land (SEBAL) algorithm is applied to radiances from Landsat and MODIS to obtain net radiation Rnet, soil heat flux G, and sensible heat flux H. The latent heat flux is obtained from the equation for the energy balance as LE = Rnet - G - H. The scintillometer measurements are used to validate and calibrate the SEBAL sensible heat flux product. Initial results from this ground-truthing experiment and plans for automated and calibrated daily ET maps will be presented.

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HYDROLOGIC DESIGN IN NEW MEXICO IN A TIME OF CLIMATE CHANGE

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Presentation Abstract 27

While probably not a universally held belief, I believe that most engineers and geoscientists involved in water resources management have come to the conclusion that global warming is for "real". A smaller sub-set, but still a majority of the professionals in our field, probably believe that we are in a period of climate change. The importance of human activity in the overall global warming process remains unquantified. Like many, I believe that the earth's climate is changing and that we will see many more hydrologic events that lie in the tail-ends of distribution curves, some of which will fall far outside that expected, based on a distribution curve of past, observed data. In the future, I believe that we will experience hydrologic events of greater, and of lesser, magnitude than we would have statistically anticipated based on recorded hydrologic occurrences.

If we are in a period of global warming and climate change, it is easy to picture or list a number of catastrophic consequences that our global society and the environment will suffer: more frequent severe rain and snow storms that result in great floods; more frequent large scale tornados, hurricanes and cyclones that result in significant damage; more forest fires; longer periods of drought; and the flooding of coastal cities. What to do? The only remedial action that has been proposed is the world-wide reduction in the generation of "greenhouses gases" in the hopes of reversing the warming process. But that is only a "hope". I believe that the engineering-design and geoscience community can contribute by revising the hydrologic procedures involved in the design of structures such as dams, levees, highways, culverts and bridges, water-supplies, wind-turbines, microwave towers, tall buildings, roof structures, heating and cooling systems, electrical power distribution networks, and on and on.

An acceptable, or safe, design that involves hydrologic considerations includes a probability statement of the occurrence of the design hydrologic-event and some measure of the nature and severity of potential harm, should a design failure occur. That is, the inclusion of some form of a safety factor that takes into consideration the risks associated with the design hydrologic-event being exceeded. In the design of structures, where hydrologic events must be considered, an unarticulated risk-assessment, based on engineering judgment, may be incorporated into the responsible state or federal agency's, mandated, design criteria. Design criteria are often in the form of the prescribed return period for the hydrologic event, and/or the magnitude of the design hydrologic-event. The "return period" of a hydrologic-event is the average, historic, elapsed-time between occurrences of an event of a certain magnitude or greater. Note that the return period is based on a frequency analysis of recorded observed events.

This is the heart of the problem: if were are in a period of climate change, then we must anticipate that future, critical, hydrologic events will fall significantly outside those experienced in the past. The paper describes the need for revising the hydrologic procedures used in the design of structures and offers some approaches that should be considered by the state and federal agencies charged with the review and approval of new or rebuilt structures where hydrologic concerns are involved. The paper also suggests ways that the water resources community can become involved.

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IMPROVED FLOOD FORECASTING FROM BASIN ELEVATION DISTRIBUTION

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Presentation Abstract 28

In this research I explore the use of the statistical characteristics of the distribution of elevation points within a basin for predicting the rate at which a peak in rainfall at some point within the basin becomes a peak in runoff at the outlet of that basin. I develop a simplified model of a basin with stream and show how basin factors that affect runoff – area, slope, stream network development, and basin shape – could be represented by the statistical characteristics N (count), standard deviation, median less minimum, skewness, and kurtosis. Using daily measurements from a rain gauge within a basin and a streamflow gauge at the outlet of a basin, I perform a cross correlation to determine the time it takes for a peak in rainfall to be translated into a peak in runoff. This time is similar to the basin lag of a hydrograph. It differs in that the basin lag is calculated for an entire basin and not for a point within a basin. Using the time to peak and linear distance between rainfall and streamflow gauges I calculate an average runoff accumulation rate. Linear regression of average runoff accumulation rate on the statistical characteristics of the distribution of elevation points within a basin showed N, median less minimum, and skewness to have a significant effect with an R^2 of 83%. I should be able to extend these results to ungauged basins based on the similarities in basins as expressed by the statistical characteristics of the elevation distribution.

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WATER MANAGEMENT COLLABORATION ALONG THE SAN JUAN RIVER IN NEW MEXICO

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Presentation Abstract 29

In the summer of 2002, the Navajo Reservoir water levels were not recovering as normal after the spring run-off from the San Juan Mountains due to an ongoing drought and high reservoir water releases. The Navajo Nation's primary concern involved a contract water right for the Navajo Indian Irritation Project. To ensure the Navajo Reservoir water supply was not severely impacted from the high releases and the anticipated low snow precipitation the Navajo Nation, in August 2002, requested Bureau of Reclamation (Reclamation) to begin reducing the water releases from the Navajo Dam. The request was to prevent the reservoir water level from dropping to a level for the first time that would severely impact the Navajo Indian Irrigation Project. By May 2003, Reclamation facilitated a one-year agreement between the reservoir contract and run-of-the-river water users entitled "Recommendations for San Juan River Operations and Administration for 2003." The agreement was accepted by the New Mexico State Engineer and prevented timely and costly litigation. The agreement created a water budget for the reservoir contract and the run-of-the-river water users and allowed additional protections for the power plants in the event of a shortage. The agreement provided flow recommendations, short-term administration recommendations and contributed in the reservoir storage recovery. The agreement has been endorsed for a fourth year, and the water users are contemplating a multi-year agreement for the future.

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WATER RESOURCES SUPPLY DECISION SUPPORT SYSTEM FOR SANTA FE COUNTY

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Presentation Abstract 30

INTERA is currently working with Santa Fe County, New Mexico, to develop a regional groundwater availability model and decision support system (DSS) to assist the County in evaluating potential well locations for ground water supply sources to supplement surface water in a conjunctive use strategy. The groundwater availability model will be used as part of a site suitability analysis DSS using multi-attribute utility theory (MAUT) to determine potential supply well locations. Using a geographic information systems (GIS) approach, the DSS will identify potential supply well locations for the County that minimize impacts (and hence proximity) to existing supply wells, streams, and springs, while maximizing proximity to existing infrastructure, population centers, and areas of favorable geology and land ownership using a MAUT approach. As a final step, potential supply well locations will be evaluated using the groundwater availability model to further refine the location alternatives to identify the most promising locations. This approach will provide County decision-makers and the public with a structured, scientifically defensible, and unbiased method of identifying potential supply well locations.

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