FARM SIZE, IRRIGATION PRACTICES, AND ON-FARM IRRIGATION EFFICIENCY

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Presentation Abstract 1

Relationships between farm size, irrigation practices, and on-farm irrigation efficiency in the Elephant Butte Irrigation District, New Mexico, are explored using water delivery data supplied by the District. The study area is experiencing rapid population growth, development, and competition for existing water supplies. It is assumed that water will ultimately be transferred from agriculture to other uses. Analysis of pecan, alfalfa, and cotton water delivery data, fieldwork, and interviews with irrigators found extremely long irrigation durations, inefficient irrigation practices, inadequate on-farm infrastructure, and lack of interest in making improvements to the current irrigation system or methods on the smallest farms.

These findings are attributed to the nature of residential, lifestyle, or retirement agriculture. Irrigation practices on large, commercial farms are notably different from the smallest farms: irrigation event durations are shorter, less water is applied, and the producers are commercially oriented. With respect to future increases in the efficiency of irrigation water usage, large, commercially-oriented producers already have achieved a high level of physical efficiency.

Many small producers appear to view irrigation as a consumptive, recreational, social, or lifestyle activity, rather than an income generating pursuit, thus the cost of inducing changes in their practices may be extremely high. Small farm operators are likely to show limited interest in improving on-farm irrigation infrastructure, adopting management intensive irrigation technologies or practices, or making significant irrigation investments. Easement and common property disputes over ditch maintenance between owners of small parcels also create disincentives for infrastructure improvements.

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REGIONAL ET ESTIMATION FROM SATELLITES

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Presentation Abstract 2

Crop evapotranspiration (ET) is a major component of the hydrologic system. The ET values are used in irrigation water management, water right allocation, hydrological modeling and water resource planning and management. Traditionally, ET has been estimated using crop coefficient and climatic parameters. Point measurement of ET can also be made through soil moisture monitoring, vapor flux measurement or energy balance using the eddy-covariance method. However, traditional methods will only provide point measurements of ET and does not account for spatial variability of ET in large scale. Recent advances in remote sensing have made it possible to develop regional maps of ET with high precision.

A procedure was developed to use the combination of satellite data, ground level weather stations and point measurements of ET, to estimate and develop regional ET maps. The Regional ET Estimation Model (REEM) is based on energy balance at the crop canopy. The model uses incidental values of NDVI, near infrared temperature and albedo, from satellites to calibrate the sensible heat flux equation. The sensible heat flux equation is calculated daily and is modified spatially using well defined nodes in the watershed based on an optimization technique. The REEM based ET values were compared with direct measurement of ET in pecan in Southern New Mexico. The comparison showed that the crop ET can be calculated from REEM model with high precision.

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SIMULATION OF THE TENDENCY OF SALINE GROUND WATER FROM SELECTED AQUIFERS IN NEW MEXICO TO FORM SCALE DEPOSITS DURING REVERSE OSMOSIS DESALINATION

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Presentation Abstract 3

Maintaining economic activity and quality of life in the desert southwest during prolonged drought periods will demand use of nontraditional water resources such as saline ground water. Current options for desalination of water include “reverse” osmosis (RO) techniques that reject dissolved salts at, while allowing water to pass through, the surface of a semi-permeable membrane. Salts can accumulate over time on the membrane surface, resulting in clogging and decreased efficiency of the RO process. Common clogging salts include CaCO3, CaSO4.2H2O, and amorphous SiO2. Clogging salts are collectively referred to as scale deposits. The suitability of saline water for RO treatment is governed, in part, by the tendency of input water to form scale deposits during the RO process. Simulated evaporation of water can be used to determine the tendency of saline waters to form scale deposits during RO.

Simulated evaporation using PHREEQC was performed on published U.S. Geological Survey analyses of saline water from selected aquifers in New Mexico. All examined ground waters in New Mexico showed a strong tendency to form CaCO3 scale deposits. Properties characteristic of water from selected aquifers include the strong tendency of saline water from the Yeso aquifer to form CaSO4.2H2O scale deposits and the strong tendency of saline water from the Rio Grande alluvial aquifer to form amorphous SiO2 scale deposits. Scale-forming properties can be generally uniform throughout an aquifer as exemplified by the relatively constant tendencies toward formation of amorphous SiO2 scale deposits in saline waters from the basin-fill aquifer of the Estancia Basin and from the San Andres Limestone aquifer. Conversely, scale-forming properties can be nonuniform within an aquifer as exemplified by the highly variable tendencies toward formation of amorphous SiO2 scale deposits in saline waters from the Dockum Group aquifers.

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COAL-BED METHANE PRODUCED WATER FOR BENEFICIAL USES:
A NATIONAL GROUP TO DEVELOP STANDARDS FOR
DESALINATION CONCENTRATE MANAGEMENT

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Presentation Abstract 4

Coal Bed Methane (CBM) accounts for about 7% US gas production and could double in 8-10 years. Large water volumes are produced with CBM; wells often produce ~400 barrels/day. Produced water quality ranges from almost fresh to 100,000 mg/l TDS. Operators face increasing environmental and financial problems in disposing of produced water ($1-$4+/ barrel, San Juan Basin), problems that may severely restrict gas flow. Sandia, New Mexico Tech, and New Mexico State University are attempting to turn this environmental liability into an asset: treat, use produced water for rangeland improvement.

The San Juan and Raton Basins have little infrastructure. Produced water treatment may occur on well-pad bases. Different processes are investigated.

First 15 month progress includes:

- Ion Sorption/Exchange Desalination
  – Initial testing promising; for rangeland, industrial applications
- Nano Filtration Desalination
  – Initial testing promising: for industrial, possibly rangeland applications
- Capacitive Deionization
  – Evaluation scheduled, summer 04

Native and non-native grasses were planted to see which would thrive naturally in the San Juan Basin. Later, grasses were planted and watered on a limited schedule with CBM water. Sprouting, soil chemistry, and SAR results are encouraging. This is a new water source for the parched southwest.

Additionally, Sandia and New Mexico State University are setting up a National Task Committee to develop standards for desalination concentrate management. This would be under auspices of the Environmental & Water Resources Institute of American Society of Civil Engineers, AWWA Water Reuse Foundation, and involve relevant national organizations.

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HYDROLOGIC PROCESSES IN THE RIO GRANDE BASIN ABOVE EL PASO, TEXAS: A BASIN SCALE VIEW WITH O AND H ISOTOPES

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Presentation Abstract 5

The Rio Grande, like many rivers in arid regions, exhibits reductions in streamflow and degrading water quality with distance downstream as a result of decreasing inflows, increasing evapotranspiration, and the addition of natural and anthropogenic solutes. We use geochemical tracers to evaluate how these processes result in the observed basin-scale water and solute balances. During the past five years of the regional drought we have conducted biannual synoptic sampling of the Rio Grande from its headwaters in Colorado to ~150 km below El Paso, Texas. Recently several studies have also focused on the associated alluvial aquifer system, allowing an evaluation of the role of groundwater/surface water exchanges.

Within the river system our results indicate that runoff from high-elevation areas in Colorado and northern New Mexico -primarily as snowmelt - is the source of river water. This water then exhibits progressive evaporation with distance downstream, with the greatest evaporation occurring at Elephant Butte Reservoir. Studies of groundwater along the Rio Grande indicate that river water is an important source of recharge to the alluvial aquifer system. In addition we are also using multiple environmental tracers (e.g., Cl/Br, ^{36}Cl, and ^{87}Sr/^{86}Sr) to “fingerprint” and quantify solute sources. All tracers identify saline groundwater as the significant solute addition to the Rio Grande. During the course of the drought we observe a progressive increase in salt concentrations and more localized increases in O and H isotopes in areas with significant evaporation (e.g., from Elephant Butte Reservoir and wetted sand in the Albuquerque region).

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NON-POTABLE SALINE GROUND WATER FOR TURFGRASS IRRIGATION?

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Presentation Abstract 6

Despite the economic importance and continued public demand for turf areas, the current water shortages in the Southwest clearly set limits on expectations and water consumption available for landscape irrigation. To reduce the amount of potable water used in landscape irrigation as part of a water conservation plan, effluent water or low quality ground water that does not meet standards for human consumption could be used instead. An estimated 75% of the groundwater present in New Mexico is considered saline or brackish and is considered unusable for human consumption. A long-term study is underway at the New Mexico State University's Golf Course to assess the feasibility of using saline ground water to irrigate turfgrasses. The research area includes two irrigation types (sprinkler and subsurface drip) as the main block factor, three water quality levels (potable, saline, 50/50 mix) as the split-block factor, and cool and warm season grasses (alkaligrass, fine fescue, perennial ryegrass, tall fescue, Texas bluegrass, bermudagrass, buffalograss, saltgrass, seashore paspalum, and zoysiagrass) as the split-split factor. All treatment factors are replicated three times. The objectives of the study are to determine if 1) non-potable, saline ground water can be used for turfgrass irrigation and 2) if adequate turf quality can be achieved by using subsurface irrigation. First year data on turfgrass establishment and turf quality will be presented.

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FIELD TESTING AND NUMERICAL SIMULATION OF RETURN FLOW FROM SEPTIC LEACH FIELDS IN THE VICINITY OF ROSWELL, NEW MEXICO

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Presentation Abstract 7

When water rights are transferred from agricultural to other uses within New Mexico, only the consumptive use portion of the right (which is often much less than the diversion amount) is transferred. A typical condition associated with such transfers is that the new owner has the opportunity to divert an additional amount of water, possibly up to the original diversion amount, if it can be demonstrated that the difference between the diversion and the consumptive use amounts at the move-to location returns to the source of the diversion. The demonstration is made through development of a return flow plan that is submitted to the New Mexico Office of the State Engineer for approval. As part of a water right application for return flow credit, the volume and timing of return flow from more than 1,500 septic leach fields in the vicinity of Roswell, New Mexico were evaluated. Test drilling was conducted at seven locations to collect sediment samples for laboratory analysis of vadose zone and physical parameters. The drilling information was analyzed in conjunction with well log and water quality information to develop conceptual models of return flow for several hydrogeologic conditions that occur within the region of interest. One- and two-dimensional variably saturated groundwater flow modeling was used to quantify return flow volumes and timing and to demonstrate potential return flow pathways even where nearly impermeable clay lenses exist.

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WATER CONSERVATION IN POWER PLANTS - ENHANCED AIR COOLED CONDENSERS

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Presentation Abstract 8

Thermo Electric power plants with wet cooling towers use large quantities of cooling water as a heat transfer medium to reject waste heat to the environment. Make up water has to be added continuously to replenish water lost to evaporation, blowdown and drift, amounting to ~360 gal/MW-hr of power generated. In a 500 MW plant, this demand translates to ~ 4 MGD, enough to provide the potable water demand of ~40,000 people.

Evaporative cooling involves enormous condensing plumes, annoying questions of “blowdown” discharges to hydrosphere, soil pollution, and potential to emit PM10, brine, and legionella.

An alternative to the water – consumptive wet- cooling technology is dry- cooling, as it is less water consumptive, offers ease of siting power plants, eliminates above problems associated with wet cooling towers.

One of the reasons for Power industry reluctance to adapt them is slight loss of efficiency, especially at higher ambient temperatures. The aim of the modeled approach is to alleviate the draw back of low thermal efficiency due to high ambient temperatures. In the proposed approach, thermal energy storage (TES) maintains chilled water that is used to pre cool the air inflow in dry cooling systems to maintain design air inlet temperature. The temperature of TES is maintained by absorption refrigeration system (ARS), which in turn is driven by low quality waste heat from the power plant. A process model integrating a combined power cycle with the ARS and the TES system has been developed to optimize the volume of TES.

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WATERSHED MANAGEMENT TOOLS IN THE UPPER RIO GRANDE BASIN

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Presentation Abstract 9

The Upper Rio Grande Basin Water Operations Review and Environmental Impact Statement (Review and EIS) is a multi–agency and stakeholder cooperative review that focuses on planning for positive benefits, considers system complexities and provides a comprehensive baseline of the Rio Grande basin that can be used as a foundation for future work. The presentation focuses on the Review and EIS, key tools that were developed for use in the Review such as the Upper Rio Grande Water Operations models. It also describes several other watershed management tools that have resulted from the Review and EIS: FLO-2D models of the Rio Grande, Aquatic Habitat Model, GIS thematic mapping, Vegetation Surveys, Water Quality Model, Decision Analysis and more.

URGWOM is a set of daily time-step, river and reservoir models customized to the Upper Rio Grande basin utilizing a numerical computer modeling software (RiverWare®). From software selection to current applications, model development underwent many adjustments to the changing hydrologic conditions and variable regime of the Rio Grande. Each step of the technical development, review, testing, and documentation has been conscientiously undertaken to develop an effective tool for enhanced system management under continually changing conditions. With URGWOM, as with all models, there are assumptions and limitations to its use. URGWOM information and documentation are available at http://www.spa.usace.army.mil/urgwom.

The upper Rio Grande basin is an extremely complex basin. URGWOM has a great potential for collaboration to help solve problems on a basin-wide scale. URGWOM can be used for making decisions in a timely fashion to ameliorate drought impacts, answer scheduling and delivery questions for specific resources, including protection of endangered species, and illustrate management tradeoffs in a consistent and realistic manner. This presentation also describes uses of URGWOM in short term management strategies for drought relief, in combination with other tools for selection of an integrated plan for basin water operations in the Upper Rio Grande Basin Water Operations Review and Environmental Impact Statement (http://www.spa.usace.army.mil/urgwops/), and in promoting understanding of alternate water management strategies.

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A SURFACE ENERGY PARTITIONING MODEL FOR HILLSLOPE ET MODELING (SEP4HILLET)

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Presentation Abstract 10

Evapotranspiration (ET) is an important and often predominant water balance component in semiarid environments. Good ET estimates are thus critical for quantifying the smaller components (e.g., groundwater recharge) of the water balance equation, and for understanding the ecotones observed in semiarid environments, especially on hillslopes with different aspects. ET is a combination of two distinctive processes, evaporation of water from the soil and wet vegetation surface, and transpiration of soil water via plant biological activity. Partitioning between E and T strongly depends on the vegetation coverage, and the underlying soil moisture distribution. Topography (slope and aspect) affect E and T partitioning by several mechanisms: (1) developing different vegetation between slopes with different aspects; (2) affecting total available energy for ET and sensible heating; (3) controlling the water availability in the soil.

We develop a surface energy partitioning model to estimate daily potential ET (SEP4HillET), in which the vegetation effect, slope steepness and aspect effect, rainfall interception, snow and snowmelt are considered. The model agrees well with data from an ET study at the Sevilleta LTER, and with Rio Grande Riparian ET measurements. We apply this model to the Magdalena Mountains, coupling with near surface hydrologic modeling, to understand the vegetation development on two opposite slopes at South Baldy, and the potential for diffuse mountain-block recharge.

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COUPLED MODELING OF RIVER-HYPORHEIC ZONE FLUID FLOW WITH EXPLICIT BED FORMS

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Presentation Abstract 11

"Hyporheic zones" are areas where water flows (exchanges) between streams, stream sediments, and stream banks. Ecologically and environmentally significant biogeochemical processes occurring in these zones control the distribution of solutes, colloids, and dissolved gases from ripple to watershed scales. These chemical processes are mediated by fluid flow as mass diffusive flux is usually orders of magnitude smaller than that of advective transport.

A common practice in modeling of porous media flow through streambeds is the imposition of a Dirichlet type boundary on the flat (no topography) top section of groundwater flow models. These boundaries represent the pressure distribution typical of streambeds and include pressure variations which arise either due to surface water topography or streambed topography. In reality, streambeds are not flat and the approximation of a variant pressure distribution as a proxy for bed forms may lead to inaccurate results. Furthermore, the imposed pressure boundaries are usually based on limited measurements conducted in flume experiments with impervious bottoms. Bed form configuration and surface water conditions are inherently dynamically linked. In order to assess how these affect advective hyporheic exchange, we implemented sequentially coupled modeling of river and streambed fluid flow. The multiphysics finite element code (FEMLAB) that we used solves the incompressible Navier-Stokes equation in the river domain and the Darcy equation for the porous streambed. Sequential coupling is implemented by imposing the streambed pressure distribution from the Navier-Stokes equation as a Dirichlet boundary for the Darcy equation. We present results of simulations designed to investigate the influence of Reynolds number, bed permeability, and the length, height, and asymmetry of dunes on stream bottom fluid fluxes and on the vertical extent of the hyporheic zone.

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ESCHERICHIA COLI SOURCE TRACKING BY DNA FINGERPRINTING IN DIVERSE WATERSHEDS OF NORTHERN NEW MEXICO

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Presentation Abstract 12

The purpose of this project is to identify sources of fecal contamination in surface waters as human or non-human by DNA fingerprinting (ribotyping) of *E. coli* isolates. Four stream monitoring sites surrounding the city of Las Vegas, NM support unique watershed characteristics and are currently monitored for fecal coliform. These include a catastrophically burned forest (Cow Creek near Pecos, NM), a mixed conifer forest (Gallinas River near Montezuma, NM), rangeland prairie (Spring Arroyo NW of Las Vegas) and commercial/urban land use (Gallinas River below Las Vegas). The forested Gallinas River watershed provides 95% of the water supply for the City of Las Vegas. Isolates were collected from spring, 2004, snowmelt and base flow conditions. Initial studies indicate that *E. coli* at each monitoring site originates from non-human sources. Identification of *E. coli* sources as human or non-human will allow for better site-specific management practices by the city to better protect the water source.

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REFINEMENTS TO A WATER OPERATIONS MODELING SYSTEM FOR THE UPPER RIO GRANDE

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Presentation Abstract 13

The Upper Rio Grande Water Operations Model (URGWOM) is a system of three models that simulate both water operations and flow in the river and its tributaries. The URGWOM was developed as part of a multi-agency effort to improve understanding of the hydrology of the Rio Grande and its tributaries and to aid in the management of this resource. The modeling system was designed for long-term use; thus, as new data are collected and new modeling methods are developed, the models are refined to enhance the system's capability.

A snowmelt–runoff simulation and prediction model that uses the Modular Modeling System is under development for use with the forecast model to prepare the input for the water operations model. One simulation objective of the URGWOM is to determine how much upstream storage and release is required to meet downstream minimum and maximum target flows. This function is being expanded to meet target flows under shortage conditions resulting from drought.

To account for surface water (SW) and ground water (GW) interaction, the water operations and planning models were linked to a SW/GW model that was developed using MODBRANCH for the river reach from San Acacia to San Marcial. The link was established by using monthly lookup tables to determine river seepage and conveyance channel gains based on flows upstream. The SW/GW model used to develop the tables takes into account the daily changes in streamflow and evapotranspiration of riparian vegetation.

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SURFACE WATER INTERACTIONS WITH SHALLOW GROUNDWATER FLOW IN AN IRRIGATED AGRICULTURAL CORRIDOR

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Presentation Abstract 14

To enhance water resources management with improved understanding of surface water–groundwater interactions, we investigated the effects of ditch and flood irrigation seepage on shallow groundwater flow in the agricultural corridor between an unlined irrigation ditch and the Rio Grande at New Mexico State University's Alcalde Science Center. We used impoundment tests to measure seepage rates from the ditch; we installed nine 5-cm diameter wells 8-15 m deep in three transects between the irrigation ditch and the river; we measured water levels in the wells and the ditch from late 2002 through 2004; and we generated maps of the piezometric surface. In 2004 we are measuring and modeling flood irrigation seepage to shallow groundwater under alfalfa. On average, 11.3 cm/day seeps out of the ditch. Water quality analyses show that ditch seepage reaches shallow groundwater rapidly. Within 3-4 weeks of the onset of the irrigation season, shallow groundwater levels near the ditch and in the middle of the irrigated corridor rise 0.5-1.0 m and groundwater flow paths orient towards the river. A brief rise in groundwater levels at wells near the river persists for two-three weeks, and is followed by a drop in the near-river wells. Preliminary modeling results suggest that groundwater elevation spikes observed during the growing season are due to flood irrigation seepage. These results are consistent with the conceptual model we are testing to show controls on shallow groundwater flow beneath irrigated corridors from ditch seepage inputs, flood irrigation inputs, river stage fluctuations, and riparian evapotranspiration extractions.

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REQUIREMENTS FOR DEFENSIBLE GROUND WATER MODELING

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Presentation Abstract 15

In times of drought, as we are experiencing at present in the southwest, many difficult questions of water resources management must be answered. The answers to these questions may be costly, substantially change the livelihoods of numerous stakeholders, and affect the futures of growing communities. If ground water models are to be used to evaluate questions of water resources management, then these models should be applied in a defensible manner. Requirements for defensible ground water modeling should be developed and include a process for the selection of the most appropriate tools and requirements for the careful evaluation of all available data, particularly in cases of major, contested water resource questions. We provide a partial case history to illustrate why we believe there is a need for these types of requirements.

At a proposed development site in New Mexico, one of the issues of the litigation was the potential for impacts of operational pumping at the site on neighboring water resources. As proponents for this project, we built a three-dimensional numerical flow model which was developed and calibrated using standard industry protocol (ASTM D5447-93). The opponents of this project employed a two-dimensional flow model that ignored much of the available subsurface data.

Not surprisingly, the outcomes of these two approaches were substantially different. Our model showed little to no impact outside the immediate area of the development, while the opponent's model showed significant impact to neighboring properties. These two differing results had the potential to significantly affect the future outcome of the proposed project.

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LONG-TERM AMMONIA DYNAMICS AND POTENTIAL TOXICITY TO FISH SPECIES IN THE RIO GRANDE, 1989-2002

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Daily dissolved un-ionized ammonia (NH_3-N) concentrations in the Rio Grande the City of Albuquerque's treated sewage outfall into the Rio Grande were modeled in a system dynamics platform for 1989-2002. Data for ammonium (NH_{4+}) concentrations in the sewage and discharge, temperature and pH for both sewage effluent and the river were used. We used State of New Mexico acute and chronic NH_3-N concentration values (0.30 and 0.05 mg/L NH_3-N, respectively) and other reported standards as benchmarks for determining NH_3-N toxicity in the river and for assessing potential impact on population dynamics for fish species. A critical species of concern is the Rio Grande silvery minnow (Hybognathus amarus), an endangered species in the river near Albuquerque. Results show that NH_3-N concentrations matched or exceeded acute levels 13, 3 and 4 percent of the time in 1989, 1991 and 1992, respectively. Modeled NH_3-N concentrations matched or exceeded chronic values 97, 74, 78, and 11 percent of the time in 1989, 1991, 1992, and 1997, respectively. Exceedences ranged from 0-1 percent in other years. Modeled NH_3-N concentrations may differ from actual concentrations because of ammonia and ammonium loss terms and additive terms such as mixing processes, volatilization, nitrification, sorbtion, and ammonium uptake. We conclude that ammonia toxicity must be considered seriously for its potential ecological impacts on the Middle Rio Grande, and as a mechanism contributing to the decline of the Rio Grande fish community in general and the Rio Grande silvery minnow specifically.

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GROUND WATER AND SURFACE WATER ELEVATION DATA COLLECTION IN THE MIDDLE VALLEY

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A data collection program for the shallow groundwater and surface water elevation in the middle valley is underway. The purpose of this study is to provide surface water elevation and shallow ground-water elevation data that can be used for definition of surface water-ground-water interaction, surface-water gradients along the length of Rio Grande and riverside drains in the basin, gradients between the Rio Grande and riverside drains at a selected sections across the river and riverside drains, and to establish a coarse network of river and land surface elevations adjacent to the river and drains along the entire basin. In 2003, a cross section was established at the Rio Bravo Bridge. Surface-water and ground-water-level data from this site are currently available and can be accessed by clicking on Surface-water levels -Hourly values and Ground-water levels – Hourly values. In 2004 and 2005, seven additional cross sections will be established in the Albuquerque area. Cross-section locations include the Alameda, Paseo del Norte, Montano, I-40, Central, Bridge, and I-25 Bridges. From 2005 to 2007, additional cross sections will be established from Cochiti Dam to Bernalillo, I-25 to Bernardo, and Bernardo to San Acacia. The cross sections will use monitoring wells (piezometers) for ground-water-level data collection and stream flow gaging stations for surface-water-data collection.

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