WATER SUPPLY STUDY OF THE JEMEZ Y SANGRE WATER PLANNING REGION

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Poster Abstract

A water-supply study was conducted in support of a regional water planning process undertaken by the Jemez y Sangre Water Planning Council (JySWPC). A variety of data including climate, surface water availability, surface water quality, ground water availability, and ground water quality were collected. Most data were built into a regional geographic information system (GIS) that was subsequently used for data management and analysis throughout the course of the study. The water supply study focused on developing well-founded water budgets for both surface and ground water and establishing realistic appraisals of the water quality in the planning region. Anthropogenic consumptive uses such as municipal, industrial, and irrigation were considered. For the surface water budgets, surface water inflow/outflow, stream-aquifer exchange, evapotranspiration, and agricultural diversions, depletions and return flows were considered. Surface water quality was evaluated using data from NAWQA studies, as well as ongoing TMDL studies. In developing the regional ground water budget, regional hydrogeology and aquifer characteristics, regional recharge and discharge, and municipal, industrial, and irrigation pumping were considered. Spatial and temporal trends in the regional potentiometric surface were evaluated using the GIS to determine areas where ground water is potentially being mined. Ground water quality over the region was evaluated by analyzing conductivity and TDS, as well as Stiff diagrams. In addition, known ground water contamination sites were compiled and tabulated from a variety of environmental databases. Currently this water supply study is being used to develop the regional water plan for Jemez y Sangre planning region.

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IS DRAINAGE BASIN COMPACTNESS SCALE INVARIANT?

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Poster Abstract

Based on recent completion of sub-watershed (10-40,000 ac.) and watershed (~250,000 ac) delineations for the entire state of Texas, we analyze the scale invariance of Gravelius' compactness (ratio between watershed perimeter and perimeter of equivalent circle with watershed area) for scales ranging from 1:24,000 to 1:250,000. Results presented address scale sensitivity on fractal nature of drainage basin boundaries.

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PREDICTING TRANSPORT OF NUTRIENTS FROM THREE TRIBUTARY RIVERS OF TAAL LAKE, PHILIPPINES

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Poster Abstract

Inflows from the Balete, Wawa and Laurel Rivers and the fishcages within Taal Lake were studied to assess the input of nitrogen (N) and phosphorus (P). Physical parameters were measured in situ and analyzed with Tot-P, Sol-P, NO3-N and NH4-N, for ten months from May 1999 to February 2000. Nutrient concentrations from the river inflows and wind data collected were used as inputs in a modified nutrient transport model that simulate the advection and dispersion of nutrient concentrations in Taal Lake.

Results show that Laurel River had a significantly higher concentration of Tot-P ($P<0.01$) and NH4-N ($P<0.05$) but had less contribution into the lake with average mean discharges of 5 and 4 kg/day respectively. Balete and Wawa Rivers significantly contributed a mean discharge of 85 kg/day NO3-N. TDS and conductivity were also significant ($P<0.01$). Simulated distribution patterns of nutrients during a period of 720 hrs, the NE Monsoon showed that nutrient discharges from the Laurel and Balete Rivers moved southward while nutrients coming from Wawa River moved into two (2) directions, NW and SW directions. During the SW Monsoon, nutrients from Laurel River were transported NW while those of Wawa and Balete Rivers were transported towards SW direction.

High N and P concentrations in the Laurel River could be related with the neutral-pH throughout the study period. Phosphates are soluble and nitrogen-fixers grow best at circum-neutral pH. Both NH4-N and NO3-N are relatively soluble ions and easily leached, so that losses of them from soils to freshwaters reflect the amount of fixation in the soils.

A nutrient transport model in Taal Lake was formulated based on the circulation patterns generated by the wind. Nutrient discharges are transported by water movements that have three main influences: height differences of surface level with gravitational flow; density with buoyancy or sinking and surface wind stress with transfer of momentum as well as energy. The relatively weak currents were responsible for the slow nutrient transport of the lake.

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SIMULATION OF TRANSIENT GROUND-WATER FLOW IN THE BASIN-FILL AQUIFER OF THE TULAROSA BASIN, SOUTH-CENTRAL NEW MEXICO, 1948-2040

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Poster Abstract

A preliminary investigation of the hydrology of the basin-fill aquifer in the Tularosa Basin was carried out through construction and calibration of a transient three-dimensional ground-water-flow model for the period 1948-2040. The model was calibrated by matching simulated water levels in 12 model cells to available ground-water-level measurements made between 1952 and 1986. Individual root mean square errors (RMSEs) of the model simulations at these cells ranged from 0.8 to 17.0 meters. Model results were verified by comparing water levels simulated for and measured in 1991 at 13 model-cell locations. The overall RMSE calculated for model verification was 13.4 meters. The RMSE for model verification decreased to 6.4 meters if three model cells in the area of largest agricultural ground-water withdrawals near Tularosa, New Mexico were excluded from consideration. The distribution of available water-level data restricts the calibrated and verified area of the simulation to the eastern side of the Tularosa Basin. Return flow is that part of a ground-water withdrawal that is available to re-enter the basin-fill aquifer as recharge. Model calibration and verification assumed zero return flow.

Simulated water levels near Tularosa were sensitive to return-flow assumptions whereas return-flow assumptions had less effect on simulated water levels in other areas of the model. Simulated water-level declines near Tularosa ranged from a maximum (zero return flow) of 30 meters to a minimum (theoretical maximum return flow) of 15 meters between 1948 and 1995 and a maximum of 25 meters to a minimum of 15 meters between 1995 and 2040. Maximum simulated water-level declines near Tularosa overestimated actual declines between 1948 and 1995. Maximum simulated water-level declines near the City of Alamogordo well field were approximately 15 meters between 1948 and 1995 and between 1995 and 2040. Maximum simulated water-level declines near the Holloman Air Force Base well fields were less than 5 meters between 1948 and 1995 and between 1995 and 2040.

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SIMULATED EFFECTS OF GROUND-WATER MANAGEMENT SCENARIOS ON THE SANTA FE GROUP AQUIFER SYSTEM, MIDDLE RIO GRANDE BASIN, NEW MEXICO, 2001-2040

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Poster Abstract

Future conditions in the Santa Fe Group aquifer system through 2040 were simulated using the most recent revision of the U.S. Geological Survey ground-water-flow model for the Middle Rio Grande Basin. Three simulations were performed to investigate the likely effects of different scenarios of ground-water pumping by the City of Albuquerque on the ground-water system. For simulation I, pumping was held constant at known year-2000 rates. For simulation II, pumping was increased to simulate the use of ground water to meet all projected city water demand through 2040. For simulation III, pumping was reduced in accordance with a plan by the City of Albuquerque to use surface water to meet most of the projected water demand.

The pumping scenarios of simulations I, II, and III have substantially different effects on water-level declines in the Albuquerque area and on the contribution of each water-budget component to the total budget for the ground-water system. Between 2000 and 2040, water-level declines for continued pumping at year-2000 rates are as much as 100 feet greater than for reduced pumping; water-level declines for increased pumping to meet all projected city demand are as much as 160 feet greater. Over the same time period, reduced pumping results in retention in aquifer storage of about 1,536,000 acre-feet of ground water as compared to continued pumping at year-2000 rates and of about 2,257,000 acre-feet as compared to increased pumping. The quantity of water retained in the Rio Grande as a result of reduced pumping and the associated decrease in induced recharge from the river is about 731,000 acre-feet as compared to continued pumping at year-2000 rates and about 872,000 acre-feet as compared to increased pumping.

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ESTIMATING RUNOFF USING NEXRAD RADAR DATA IN RURAL NEW MEXICO

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Poster Abstract

This study seeks the most effective temporal resolution of 6-minute, 30-minute accumulated, 1-hour accumulated, and 1-hour snapshots of NEXRAD (NEXt Generation RADar) data in order to predict peak storm flow and flow accumulation. The primary purpose of this evaluation is to consider if lower temporal resolution is acceptable to estimate peak discharge by using Soil Conservation Service (SCS) Curve Number Loss, the SCS Unit Hydrograph, and the Muskingum-Cunge routing methods. Geographical Information technologies and Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) software are used to determine peak flows and flow accumulations. Information is primarily from the USGS, USDA-NRCS, the NWS and the NCDC. The higher temporal resolution, NEXRAD Level II 6-minute data, is the most accurate method to estimate peak flow. In two of the three cases that use NEXRAD Level II 6-minute data, the peak flows are 48 and 28 minutes within the estimated peak flow with less than 3 and 7 percent difference respectively. The third case had anomalous propagation that results in an overestimated peak flow rate and longer duration. Furthermore, all three lower temporal resolutions are acceptable to derive total volume of flow, but are not sufficient to predict peak flow rate. Although the study results are promising, the lack of high temporal resolution precipitation gauges to correlate the NEXRAD Level II radar data limits the accuracy and reliability of using NEXRAD Level II data.

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SIMULATING SNOWPACK AND RUNOFF IN PAJARITO CANYON USING THE HYDROLOGY MODULE OF THE USDA DEVELOPED SIMULATION OF PRODUCTION AND UTILIZATION OF RANGELAND (SPUR) MODEL

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Poster Abstract

The Cerro Grande fire of May 2000 burned approximately 48,000 acres of the Pajarito Plateau including property in the communities of Los Alamos, New Mexico and Los Alamos National Laboratory. Major fires such as the Cerro Grande fire can cause significant changes in the hydrological behavior of the corresponding burned watersheds, often resulting in increased runoff and flooding. The Pajarito Plateau, located in the high desert of semi-arid north-central New Mexico, consists of a series of mesas and steep-walled linear canyons. These canyons are a result of runoff in ephemeral tributaries to the Rio Grande. Hydrological response in one of these tributaries, Pajarito Canyon, was simulated using the hydrological module of the Simulation of Production and Utilization of Rangelands (SPUR) modeling code developed under the U.S. Department of Agriculture. The hydrological module of the SPUR model calculates the upland runoff volumes, peak flow, snowmelt, stream flow, and upland and channel sediment yields. The simulations were calibrated to measured daily values of snowpack and daily runoff summed to monthly runoff values for two scenarios each of pre-Cerro Grande fire, water-years 1998 and 1999, and post-Cerro Grande fire, calendar year 2001. The primary statistic used to evaluate the simulations, the coefficient of efficiency (E), was 0.927 for pre-fire snowpack and 0.930 for post-fire snowpack. The coefficients of efficiency for runoff in pre-fire conditions were 0.792 and 0.862 with biases of 4% and 5%, respectively. The coefficients of efficiency for runoff in post-fire conditions were 0.746 and 0.821 with biases of 4% and 20%, respectively.

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ERROR CORRECTION IN MULTI-DATE, MULTI-VENDOR ALSM DATA: IMPACTS ON MAPPING GEOMORPHIC CHANGE IN STEEP, MOUNTAINOUS TERRAIN

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Poster Abstract

Digital elevation models (DEMs) derived from Airborne Laser Scanning Mapping (ALSM) data acquired in 2000 (DEM2000) and 2001 (DEM2001) were used to detect and quantify change due to increased flows through Pueblo Canyon following the 2000 Cerro Grande Fire. Change detection and quantification are based on a difference raster created by (DEM2001 - DEM2000), with which various spatial calculations may be performed in a geographical information system. These calculations are complicated by errors within and between the DEMs, due to processing artifacts, misclassification of ALSM point data, interpolation through no-data areas in one DEM which is unmatched in the other, and positional errors. Uncorrected, the difference raster significantly overestimated the volume of flood-driven scour and deposition through the canyon.

Variable horizontal and vertical offsets between DEM2001 and DEM2000 were primary error sources. The former was manifested as spurious, aspect-dependent deposition or erosion on gully walls that could not be corrected by a single horizontal translation. To correct this, local horizontal shifts of up to 6' west and 2' north were calculated using a surface matching technique which maximized the cross correlation between subimages cut from each DEM. These also corrected a portion of the vertical offsets, with the remainder removed by matching stable surfaces within each subimage. Scour and deposition calculated after the corrections were applied were consistent with observed and modeled quantities. LA-UR-03-4453

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SIMULATION OF GROUNDWATER FLOW AND EVALUATION OF EFFECTS OF PUMPING TO MEET PROJECTED DEMANDS IN THE LOWER ANIMAS AND LORDSBURG BASINS, GRANT AND HIDALGO COUNTIES, NEW MEXICO

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Poster Abstract

For regional water planning purposes, the Office of the State Engineer has evaluated groundwater supplies in the Lower Animas and Lordsburg Basins. Demands in these basins are supplied almost entirely by groundwater. The ability of existing sources to continue meeting demands into the future was evaluated by estimating water-level declines from historical and projected pumping using a numerical model.

The one-layer model simulates groundwater flow in the Upper Gila Group and post-Gila basin-fill aquifer. Discharge to the Gila River was simulated using a constant-head boundary. All other boundaries were simulated as no-flow. Ten hydraulic conductivity zones based on hydrostratigraphic units were adjusted during steady-state calibration; final values range from 0.12 to 50 feet per day. Simulated inflows from mountain-front recharge, underflow from the Upper Animas sub-basin, and minor inflow from the Gila River, and outflows to the river reasonably match estimates. About 85 percent of 89 simulated pre-development heads were within +/- 20 feet of observed. Transient model testing using historical withdrawals and a storage coefficient of 0.1 was reasonably successful at replicating observed water-level changes.

Model calculated declines were used to estimate effects on selected well water columns. By 2040, the municipal and industrial wells evaluated retain over 200 feet of water column, indicating these sources may remain viable. Remaining average aquifer thicknesses in the Lower Animas and Lordsburg Basin irrigated areas of 350 and 300 feet, respectively, indicate the 20 irrigation wells estimated to have less than 100 feet of water column by 2040 could potentially regain production.

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CHARACTERIZING COUPLED GIS-HEC FLOODPLAIN SIMULATIONS ON PAJARITO PLATEAU

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Poster Abstract

Coupled GIS-HEC modeling applications for floodplain analyses are becoming more commonplace because digital elevation models (DEM) are widely available and software developments for geographical information systems (GIS) continue to improve. The River Analysis System (HEC-RAS) developed by the Corps of Engineers' Hydrologic Engineering Center is widely utilized in the USA for flood insurance studies and hazardous waste facility permitting requirements. The one-dimensional finite difference representation of the governing Saint Venant equations are used to describe hydraulics in the channel and floodplain by a series of cross-sections drawn perpendicular to the prevailing flow directions. Costly surveying tasks are minimized because topographic data are extracted from a DEM using a linked Arc-View GIS software interface (HEC-geoRAS). Ultimately, a floodplain inundation map is generated by the intersection of a three-dimensional triangular irregular network (TIN) representing the land surface and a second TIN representing the water surface. The accuracy of this coupled approach may be of concern, however, since a "lake effect" may be observed in many routine applications. Here predicted floodplain reaches are discontinuous and appear as isolated lakes. This problem is persistent even when high-resolution DEM surveys are available from airborne laser altimetery and aerial photogrammetry. Comparisons of floodplain inundation maps generated from gridded 0.3 m (1 ft), 1.2 m (4 ft), and 10 m (33-ft) DEM data are evaluated for several canyon reaches on Pajarito Plateau near Los Alamos, New Mexico. These floodplains were systematically defined at 15 m (50 ft), 31 m (100 ft), and 61 m (200 ft) cross sectional intervals over channel reaches with slopes varying between 1 and 6 percent. In addition, TIN tolerance (or elevation accuracy) varied between 0.15 m (0.5 ft) and 0.61 m (2 ft). Improvements in DEM resolution did not significantly reduce the "lake effect" or alter computed floodplain top widths. Some improvements were achieved by locating cross sections at closer intervals. However, the greatest improvements were achieved when TIN tolerances were decreased from 0.61 m (2 ft) to 0.15 m (0.5 ft). These improvements were accompanied by dramatic increases in computer simulation times.

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EVALUATION OF A LONG-TERM AQUIFER TEST - PREDICTED VS. OBSERVED DRAWDOWN USING A REGIONAL MODEL FOR PAJARITO PLATEAU

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Poster Abstract

Aquifer tests, or pumping tests, are generally conducted to evaluate the physical properties of water bearing units that control the movement and storage of groundwater. Typically, these aquifer parameters include transmissivity (T) and storage coefficient (S). These parameters, along with other data, are used in a wide variety of applications, including the calculation of optimal well spacing intervals for municipal water supply wells, estimation of maximum sustainable aquifer yield, delineation of groundwater flow paths, estimation of contaminant travel times in aquifers, and optimal locations for monitoring wells. A 25-day pumping test, followed by a 25-day recovery period, was conducted in early 2003 on Pajarito Plateau as part of the Hydrogeologic Characterization Program. Besides the pumping well, four observation wells recorded drawdown during the test, including two multi-screened observation wells equipped with WestbayTM packer systems. Each of these multi-ported wells has three separate screens. These data are evaluated for standard aquifer parameters, including the effects of anisotropy. These test results suggest that the regional aquifer below Pajarito Plateau behaves like a complex leaky confined system, including complex interaction between canyon recharge sources and vertical flow between adjacent hydrostratigraphic units. Simulated drawdown effects from the regional model for the plateau are compared to observed drawdown. These comparisons provide an important method of model validation. In addition, these comparisons suggest important model alterations, additional input data refinements, and additional future testing alternatives.

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MODELING RESERVOIR OPERATION EFFECTS ON SURFACE WATER QUALITY: THE UPPER RIO GRANDE BASIN 1975-2001

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Poster Abstract

The impacts of reservoir operations on surface water quality are of increasing concern to professionals faced with balancing the storage and delivery of water for agricultural, domestic, industrial, and environmental use. Aquatic and riparian ecosystems in semi-arid and arid basins of the southwestern United States are particularly sensitive to changes in water quality, and may be adversely affected by a variety of reservoir operations. The purpose of this study is to develop a predictive water quality model that will help guide the decision-making process for flood control operations, water accounting, and evaluating water operations alternatives in the Upper Rio Grande Basin between the headwaters in Colorado to Fort Quitman, Texas. The results will provide the basis for an environmental impact statement (EIS), and will be used to model the potential impacts of a variety of reservoir operation alternatives within the Upper Rio Grande Basin. A comprehensive, basin-wide analysis of water quality data from 1975 to present identified gaps in available water quality data and characterized historic and current water quality conditions within the Basin. Gages and reaches of the Rio Grande with adequate data were selected to determine the relationships between surface water quality and reservoir operations. At each selected location, correlation statistics were used to derive relationships between water quality constituents and operations. For a given flow, we generated site-specific models that calculate physical, chemical, and organic characteristics of water quality. Modeling results will be used to estimate the impacts of various water management decisions in the Basin.

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RECENT WATER RESOURCE MODELING OF THE ALBUQUERQUE BASIN

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Poster Abstract

A new groundwater model of the Albuquerque (or Middle Rio Grande) Basin has been developed by the USGS and the New Mexico Office of the State Engineer using MODFLOW-2000 software, and was published in 2002 as USGS WRIR 02-4200. This model was the culmination of a 6-year in-depth hydrologic and geologic investigation of the Basin by the USGS, and included recent data collected by numerous State and Federal agencies. This model is calibrated to hundreds of water level measurements representing predevelopment to 2000, including hydrographs and vertical hydraulic-head distributions, and to streamflow loss data from an extensive analysis of the flows of the Rio Grande surface-water system.

The McAda and Barroll (2002) model is the latest descendant of the Kernodle et al. (1995) model, which was originally developed by the USGS at the City of Albuquerque's behest, when it became evident that groundwater development was having potentially problematic effects on the aquifer. One difference between this model and its predecessors is that much lower mountain-front and subsurface recharge are input, based upon new hydrogeochemical studies (43,000 AF/yr versus well over 100,000 AF/yr in earlier models). Another significant difference is that horizontal anisotropy is included in the 2002 model to represent areas dominated by numerous north-south striking faults, which are thought to impede the movement of groundwater perpendicular to strike. Despite these changes, and despite the extensive additional data brought into the development and calibration of this model, the main conclusions reached using the 2002 model are similar to previous model findings, that is: the aquifer is at risk from excessive groundwater development. Drawdowns and stream depletions predicted using this model are similar to those calculated using the preceding models.

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GROUNDWATER MODELING OF THE ROSWELL ARTESIAN BASIN AND CARLSBAD AREA FOR WATER RESOURCE APPLICATIONS

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Poster Abstract

The Office of the State Engineer (OSE), together with consultants from INTERA, D.B. Stephens & Associates, and S.S. Papadopulos and Associates, have developed and calibrated MODFLOW models of two major groundwater systems on the Pecos River: the Roswell Artesian Basin (RAB) and the Carlsbad area. These models are used to estimate the effect of changes in groundwater use and irrigation management practices on water levels and on the flows of the Pecos River. The models have been applied to EIS analyses, adjudication settlement negotiations, and water rights administration.

The Roswell Artesian Basin (RAB) consists of an extremely transmissive artesian aquifer overlain by a confining unit, and topped by a shallow alluvial aquifer, which is connected to the Pecos River. The RAB groundwater model simulates this aquifer system, and its hydrologic connection with the Pecos River. Model stresses include large amounts of irrigation well pumping and return flow, natural recharge, and natural evapotranspiration. The model successfully reproduces historically observed changes in water levels and in groundwater discharge to the Pecos River, including a strong seasonal component of variation.

The main aquifers of the Carlsbad area are an extremely transmissive carbonate reef aquifer partly overlain by a shallow alluvial aquifer, which discharges groundwater to the Pecos River. The Carlsbad Groundwater Model (CAGW) simulates these aquifers, and connection between these aquifers and the Pecos River and Carlsbad Springs. Natural and anthropogenic stresses are simulated. The largest stresses are associated with the operation of the Carlsbad Irrigation District, which diverts and applies Pecos River water for irrigation, using supplemental wells as needed. The calibrated model adequately simulates the historically observed variation in water levels and groundwater discharge to the Pecos River.

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MODELING THE IMPACTS OF REGIONAL WATER PLANNING ALTERNATIVES

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Poster Abstract

As part of the third phase of the Middle Rio Grande Water Supply Study, S.S. Papadopulos & Associates (SSP&A) is providing technical support to the Socorro-Sierra and Middle Rio Grande planning regions in evaluation of their respective regional water planning alternatives. One component of this support is evaluating the regional planning alternatives using the SSP&A probabilistic water budget model of the Middle Rio Grande basin. For each region, proposed alternatives are reviewed with respect to both their hydrologic impacts, and to establish the sensitivities and relationships between alternatives and between alternatives and model parameters. Based on this evaluation, alternatives are divided into "packages" for modeling analysis. Packages are determined based on how the alternatives mesh with the model structure and how significantly they impact consumptive use. Modifications are made to the model to reflect the proposed packages, and the regional water budget is then evaluated as a subset of the basin-wide water budget. Once alternatives have been evaluated for each of the regions separately, a third set of packages will be constructed combining the alternatives for the two regions, to examine the impact of joint implementation of the regional water plans. To date, modeling analyses have been run for the Socorro-Sierra region; results are presented as both average impacts and as probability distributions.

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FT. SUMNER IRRIGATION DISTRICT RETURN FLOW CALCULATIONS, FT. SUMNER, NEW MEXICO

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Poster Abstract

The Pecos River RiverWare Operations Model, one component of the Pecos River Decision Support System, requires an algorithm for estimating the return flow to the Pecos River from Ft. Sumner Irrigation District (FSID) operations in Fort Sumner, De Baca County, NM. Because no accepted groundwater model for the FSID area exists, the goal of this work is to develop an appropriate method to estimate FSID return flow.

The return flow method is based on actual FSID diversion, incidental depletions, consumptive irrigation requirement (CIR), and annual irrigated acreage. In addition, the method incorporates project efficiency, project demand, and “non-diverted” water. Stream flow data from several U.S. Geological Survey (USGS) stream gages are used.

It is important for the algorithm to simulate the variability in return flow that would be anticipated with variation in FSID diversion and variation in the amount of lands irrigated. Furthermore, a reasonable return flow time lag function is needed to describe return flows that are apparent during winter months (November through February). The method also incorporates the influence of the pumping operation at the pumping station located in the southern portion of the district. This pumping operation diverts to the distribution system drain water that otherwise would have returned to the Pecos River.

To evaluate the method, it is applied in predictive mode to simulate the flow at the Below Taiban Creek gage. Generally, the simulated flow is in good agreement with the observed flow at this gage.

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GROUNDWATER LOSS FROM PLAYA LAKES IN THE ESTANCIA BASIN, CENTRAL NEW MEXICO

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Poster Abstract

The 5000 km2 topographically closed Estancia basin contains a complex of more than 80 groundwater-discharge playas that expose approximately 50 km2 of the basin floor to direct loss of groundwater by evaporation. Hydrologic and meteorologic measurements collected at study sites since 2000 provide model estimates of evaporation loss from the playas. Multi-depth piezometers at study sites reveal increasing hydraulic head with depth at shallow levels beneath the playas. At playa E12 on the southeastern margin of the playa complex vertical hydraulic gradients are on the order of 0.2 (upward gradient) and estimated values for hydraulic conductivity (10-2 to 10-3 m/day) suggest less than 25 cm/yr of groundwater is being discharged as a result of the upward gradient. Near-surface meteorologic measurements at Laguna del Perro on the western side of the playa complex indicate that evaporation is strongly dependent on playa wetness, with dry periods and accompanying precipitation of salts associated with increased albedo and less energy for evaporation. During winter months, when daily net radiation is at a minimum, groundwater discharge alone is insufficient to maintain standing water on the playas. This observation and meteorological measurements during cool-dry periods at Laguna del Perro suggest groundwater discharge rates of less than 2-3 cm/month, similar to estimates based on hydraulic measurements at playa E12. These estimates of discharge, when integrated over the entire playa complex, imply a net evaporation loss of groundwater of less than 15 million m3/yr (<12,000 acre ft/yr), significantly less than the ~30,000 acre ft/yr generally quoted as the amount of basinwide recharge to the groundwater system. Leakage from the basin under Holocene conditions is thought to be minimal, and some of this apparent difference between recharge and evaporation discharge may be attributable to anthropogenic groundwater withdrawals.

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DETERMINATION OF PECOS RIVER LOSSES USING SEEPAGE STUDIES AND GROUNDWATER MODEL

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Poster Abstract

Estimating flow losses in the reach of the Pecos River between USGS gage near Acme and USGS gage near Artesia (84 miles), which is generally considered as a gaining reach, is very important in managing the river system. This is because flow losses are critical for computing offset to the net depletion associated with modified Sumner Dam operations for the benefit of the Pecos bluntnose shiner and estimating the effective flow to Brantley Lake for future augmentation pumping. In this line, the objective of this study is to determine if seepage loss exists within the defined reach, in addition to evaporation and transpiration losses.

Data of seepage investigations (13 studies) conducted in this reach by the USGS during the winter of the 1950s and 1960s was examined and analyzed. For the purpose of analysis, this reach was divided into 5 shorter sub-reaches: Acme to above Rio Hondo; above Rio Hondo to Dexter Bridge; Dexter Bridge to above Rio Felix; above Rio Felix to Lake Arthur; and Lake Arthur to near Artesia. The results of the analysis show that the reach is generally a gaining reach with an average gain of 0.29 cfs/mile. The results also show that the sub-reach between Lake Arthur and Artesia was losing in 7 of the 13 studies. The sub-reach Acme to above Rio Hondo was losing in one seepage study and was determined not to gain any water in two studies.

The Roswell basin groundwater model, which is a MODFLOW model with 3 layers, was also used to examine the losses within the reach. The results of the model application indicate that:

1. Generally, Acme to Artesia is a gaining reach;
2. The reach above Hondo to Dexter is a seasonal losing reach; and
3. Although other sub-reaches contain losing segments, the net effect to the river is positive.

Since the scale of the model limits a detailed analysis as to the exact location and accurate quantity of seepage loss, a more sophisticated surface water - groundwater interaction module is needed to predict seepage magnitude and seasonal water movement between the river and the aquifer in these reaches.

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UNSATURATED FLOW MODELS OF GROUNDWATER RETURN FLOW IN NEW MEXICO

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Poster Abstract

The Office of the State Engineer (OSE) administers the state's ground and surface water. Return Flow Credits (RFCs) to a permitted groundwater diversion are sometimes granted when some portion of the water diverted is shown to return to the source of supply. RFC's have been recognized at locations when treated effluent is returned to a stream near where groundwater pumping depletions are occurring. Occasionally, water rights applicants seek RFC's for water leaching through the vadose zone to the water table, such as beneath leach fields.

The conditions under which seepage may truly reach groundwater depend greatly on project design, climatic conditions, presence of vegetation, geology, and depth to groundwater. To characterize subsurface infiltration requires drilling, sampling and testing for hydraulic properties. Absent these data, the OSE Hydrology Bureau must resort to conservative models to estimate potential return flow.

To examine return flow under various scenarios the Hydrology Bureau conducted hypothetical model runs using the USGS unsaturated flow model VS2DT. The models are very sensitive to vertical hydraulic conductivity, which means that clay and interstratification severely impede infiltration. In addition, typical New Mexican evapotransipiration rates cause a substantial flux of soil moisture to the atmosphere. Based on these models, the Hydrology Bureau has recommended technical guidelines for RFC reviews in the absence of detailed documentation provided by RFC applicants.

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USING GFLOW TO MODEL INTERACTIONS BETWEEN SURFACE WATER AND GROUNDWATER: THE LOWER VALLEY OF EL PASO CASE STUDY

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Poster Abstract

As a result of the prevalent drought, southern New Mexico and Far West Texas that share surface water from the Rio Grande project are experiencing water shortage. Regional irrigation districts realize the urgency of water conservation and improvement of delivery system efficiency. The authors use analytic element model GFLOW to evaluate surface water and groundwater relationship under different surface water flow conditions so that we can help irrigation districts to develop guidelines for water conservation and improvement of delivery efficiency. Resistance value R, which equals to the thickness of the resistance layer between the surface water feature and the aquifer divided by the average vertical hydraulic conductivity of the resistance layer, were used to characterize the interaction of surface water and groundwater. Wells are also included to simulate impacts of groundwater pumping on the interaction of surface water and groundwater.

Preliminary results indicated that water levels in the shallow aquifer are very sensitive to the resistance value R. As R increases, surrounding aquifer water levels drop because less seepage recharge is received from the canals and laterals. The results also show groundwater pumping will increase seepage from unlined canals and laterals if wells are located close to these conveyance channels. Some drains may also be dried up because the excessive well pumping lowers the water level in the aquifer below the drains. At the same time the groundwater flow between canals and drains will also reshape the cone of drawdown caused by groundwater pumping.

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DEVELOPMENT AND APPLICATION OF UNIT RESPONSE FUNCTIONS FOR GROUNDWATER PUMPING IN THE ROSWELL BASIN

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Poster Abstract

As part of analyses supporting the Pecos River Compact Compliance Consensus Plan and water rights evaluation, unit response functions for groundwater pumping in the Roswell Basin were developed and applied. The unit response functions (URFs) quantify the temporal relationship between the pumping of a unit of groundwater at any location in the basin and changes to base inflows to the Pecos River from the groundwater system. URFs were developed for both the shallow alluvial and deep artesian aquifers using the Office of the State Engineer's (OSE's) Roswell Artesian Basin Groundwater (RABGW) model. The URFs developed from the model rely on a version of the RABGW model designed to facilitate application of the Principle of Superposition, a mathematical characteristic of linear differential equations that permits one to develop solutions for complex problems via summation of solutions of simpler problems. In the case of the Consensus Plan, the state anticipates a need for evaluating the hydrologic value (in terms of CID water supplies and increased state-line flows) of water rights acquisitions in the Roswell Basin. Historical pumping in the Roswell Basin has significantly reduced base inflows from the groundwater system to the river, and the intent of the water rights acquisitions is to help restore the base flow and hydrologic balance to the lower Pecos Basin. Rather than relying on detailed modifications to the RABGW model stress files for evaluation of every water-rights offer, the tabulated URF for the model-grid cell corresponding to the location of any particular offer could be inspected for an immediate estimate of the impact of reduced pumping on base inflows to the river.

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CONJUNCTIVE USE GROUNDWATER AND SURFACE WATER MODELING FOR DENVER SOUTH METRO WATER SUPPLY STUDY, DENVER BASIN, COLORADO

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Poster Abstract

Pursuant to an agreement between the Douglas County Water Resource Authority, Denver Water, and the Colorado River Water Conservation District, a conjunctive use water modeling system was developed. The models are being used to investigate coordinated use of surface water and groundwater resources and facilities to produce a larger, more reliable, and cost effective combined water supply than could be generated from either source alone. The modeling system involved three major components: (i) a regional Denver Basin groundwater model for simulating heads on a 1-mile grid scale, (ii) a local groundwater model for simulating draw-downs at the well-bore radius, and (iii) a surface water operations model for simulating coordinated operations of the Denver Water system together with 12 municipal water utilities in Douglas County. This plan for conjunctive use relies heavily on the use of Denver Water's existing infrastructure for water deliveries from the South Platte and Blue River Basins. The plan would utilize excess capacity in Denver Water's system to deliver flows to Douglas County during peak runoff periods. It would also include deliveries from Denver Water's existing surface reservoirs, with payback to Denver from Douglas County's groundwater resources in years when Denver's reservoirs do not subsequently refill under junior water rights. Any excess water delivered to the South Metro water providers would be injected into the groundwater system as aquifer storage and recovery or stored in local surface water reservoirs. During periods of low surface water supplies, the groundwater system would be tapped to meet water utility demands in Douglas County, and to provide additional drought protection to Denver Water and Blue River basin interests. This paper describes the modeling system, and presents model results for three separate future water management scenarios through 2050.

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HYDROGEOLOGIC UNITS IN GIS AND MODFLOW AT PLACITAS, NEW MEXICO

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Poster Abstract

A GIS hydrogeologic database for Placitas, New Mexico is based on the geologic and hydrologic characteristics described by Johnson (2000) and on data derived from an exploratory drilling and aquifer-testing program. A MODFLOW model simulates groundwater flow through hydrogeologic units in three dimensions using the Hydrogeologic-Unit Flow Package. Geologic-solid models were produced using custom GIS data objects developed for ESRI ARCMAP.

The model simulates the hydrologic interaction of the Placitas aquifer system: natural recharge, evapotranspiration, spring discharge and routing through streams, agricultural operations, groundwater diversions by existing and future wells and return flows. The model calculates the impacts to the Placitas area hydrologic system from growth of water use during a historical period (1953 to 2002) and a projected 100-year future period (2003 to 2103). Water-level trends from groundwater withdrawal in the Middle Rio Grande Basin are applied as a boundary condition to the model of the Placitas area.

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IMPACTS OF GROUNDWATER PUMPING ON THE SURFACE WATER AND GROUNDWATER INTERACTION IN THE MESILLA VALLEY

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Poster Abstract

In many areas where groundwater resources, wetlands, and surface water flows are already being stressed, groundwater-surface water interaction is becoming an important topic and must be addressed in the development of water management plans and policies. Streams interact with aquifers in two ways: either they receive water from the aquifers beneath them, or they lose water to the aquifers by seepage through the streambed. This paper is to quantify hydrologic exchange fluxes between groundwater and surface water in the Mesilla Valley located in the Southern New Mexico and Far West Texas.

Canals and laterals recharge the shallow aquifer by the seepage through the stream beds, while drains collect water from the irrigated land through the shallow aquifer and return to the river. The stream flow routing package that has been written for MODFLOW is used to simulate the surface-water interaction with ground water. Numerical simulations provide insights into the sensitivity of this complex hydrological system to the surface water recharge. The seasonal variations in the water levels in response to the seepage of the canals are evaluated to comprehend the groundwater-surface water interaction. Impacts of drought on the groundwater are also assessed using the model. Additional groundwater pumping during the drought not only lowers the water level in the aquifer, but also dries up some of the drains. The seepage losses will also increase with the increased pumping of groundwater. The insights into the interaction of surface water and groundwater will help us develop better strategies for regional water resources management.

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A NEW PERSPECTIVE ON THE HYDROGEOLOGIC FRAMEWORK AND BRACKISH-GROUNDWATER RESOURCES OF THE ESTANCIA BASIN, CENTRAL NEW MEXICO

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Poster Abstract

Our ongoing studies of hydrogeology, brackish-groundwater resources, and recharge mechanisms in the Estancia Basin (EB) demonstrate that prevailing interpretations of basin hydrogeologic framework and certain concepts of regional groundwater flow need to be reevaluated. Emphasis here is on:

1. An updated hydrogeologic-framework model based on recent characterization of the subsurface geology of the EB by Broadhead (1997, NMBG&MR Bull. 157). He documents that three interconnected, but distinct structural subbasins form the major subsurface components of the topographic EB. Each are bounded by complex fault and shear zones produced by late Paleozoic to Neogene compressional/extensional tectonism. The "western subbasin" forms much of the primary EB groundwater basin south of Moriarty (Madera Gp and basin-fill aquifers). It is flanked by the Manzano-Manzanita range and includes the western (pluvial) Lake Estancia plain (elev. 6,100-6,200 ft). The "northern subbasin" is a north-plunging syncline (Laramide Galisteo basin) that underlies much of the South Mountain to Stanley area north of Moriarty. The "south-central (Perro) subbasin" is the structurally deepest part of the EB and underlies the saline playas of the Laguna del Perro area. Nonmarine Pennsylvanian strata dominate a very thick sequence of sedimentary rocks capped by Permian and Triassic units. Saturated basin fill is thin.

2. Reevaluation of brackish groundwater resources in bedrock aquifers of the eastern EB and their recharge mechanisms. This is the area of greatest production and recharge potential for brackish groundwater. It includes the Perro subbasin, Lobo Hill uplift, and much of the eastern Salt Creek-Armijo Draw drainage basin. The recharge area includes high tablelands that form the western watershed of the Glorieta Mesa-Pedernal Hills region (upland area of ~250,000 acres; max. elev. 7,000-7,400 ft; est. MAP 14-18 in).

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CALIBRATION OF ROSWELL BASIN GROUNDWATER MODEL USING PEST

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Poster Abstract

The Roswell Artesian Basin Groundwater (RABGW) model was developed as part of the Pecos River decision support system to provide a quantitative framework for managing water resources and evaluating the impacts of alternative groundwater pumping strategies on stream flow in the Pecos River. This paper describes the most recent update of the model, originally developed by the NM Office of the State Engineer, which was refined and recalibrated using historical water level data and streamflow gain data as targets. The RABGW model was revised primarily to include seasonal variations and depth-dependent evapotranspiration rate by utilizing the MODFLOW ETS package (MODFLOW 2000). The revised model was calibrated using the general parameter estimation software, PEST-ASP (2001). Streamflow gains between Acme and Artesia were the primary calibration targets and annual average groundwater levels at 41 well sites were secondary calibration targets. Both annual (1905-2000) and monthly (1905-2000) streamflow gains were used as targets depending on the circumstances of the parameters being estimated. In addition, the hydraulic conductivity and boundary inflows were estimated using a 'pilot-point' (Doherty J. 2001) approach with the annual average groundwater levels as calibration targets. The model calibration process with the selected model parameters involved in the revised groundwater model was able to reduce the standard error for estimated monthly streamflow gain from 881 AF/month to 706 AF/month and for estimated annual groundwater levels from 31 ft to 22 ft. The resulting calibrated RABGW model provides a useful tool for predicting the impacts of alternative groundwater pumping strategies on stream flow in the Pecos River.

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MODELING AVAILABLE MINNOW HABITAT AS A FUNCTION OF RIVER DISCHARGE FOR THE PECOS RIVER

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Presentation Abstract

Sandia National Laboratories is providing technical assistance to farmer members of the Carlsbad Irrigation District (CID) to better plan the storage, delivery, and application of water to the Carlsbad Project. The surface waters along the Pecos River are allocated by the state of New Mexico to three major entities: 1) The State of Texas - each year a percentage of water from the natural river flow must be delivered to Texas as governed by the Interstate Streams Commission; 2) CID farmer members - a fixed portion of water must be delivered to the farming members of the CID; and 3) wildlife - an amount of water must be allocated to support the wildlife habitat in the Pecos River, most notably, the endangered Pecos Bluntnose Shiner Minnow. The Pecos Bluntnose Shiner Minnow habitat preference is under investigation by other state and national agencies and preliminary work has established that water depth, water velocity, and sediment activity (dunes, ripples, etc.) are the key parameters influencing minnow habitat preference. The amount of water (river flow rate) necessary to maintain a preferable habitat to support this species has yet to be determined. With a limited amount of water in the Pecos River and its reservoirs, it is critical to allocate water efficiently such that habitat is maintained, the farmers of the CID are supported, and New Mexico meets its commitments to the State of Texas. This study investigates the relationship between flow rate in the river and water depth, water velocity, and sediment activity. The goal is to establish a predictive tool that supports informed decisions about water management practices along the Pecos River that will maximize water available for agriculture and the State of Texas while maintaining the aquatic habitat.

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