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GIS & Water Resources VI
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Tuesday, March 30
8:30 AM – 10:00 AM
SESSION 12: Groundwater III

An GIS-enabled Realtime Interactive Groundwater Modeling Environment - Shu-Guang Li, Michigan State University, East Lansing, MI (co-author: Huasheng Liao)

A 1987 landmark NSF report on scientific computing and visualization envisioned the future of scientific computing to be real-time interactive with the modelers being dynamically-engaged and in full control throughout the computational process. The report stressed: scientists not only want to solve equations or analyze data that results from computing, they also want to interpret what is happening to the data during computing. Researchers want to steer calculations in real-time; they want to be able to change assumptions, conceptual framework, resolution, or representation, and immediately see the integrated effects and complex interrelationships presented in a meaningful context. They want to be an equal partner with the computer, interact on-line with their data, and drive in real-time the discovery process. In this paper, we present a new computing paradigm and a novel computational environment that enables taking advantage of today's computing power and allows real-time 3D groundwater modeling. The new environment, called Interactive Ground Water (IGW), utilizes a "parallel computing", "dynamic visualization", and "computational steering" methodology, restructuring and integrating the entire modeling process. This environment enables dynamic data routing and fusion of flow modeling, transport modeling, subscale modeling, uncertainty modeling, geostatistical simulation, GIS mapping, and visualization. IGW functions as an intelligent "numerical laboratory" in which a modeler can freely explore: visually creating aquifers of desired configurations, interactively applying stresses, and then investigating on-the-fly the geology, dynamic flow and transport in three space dimensions. At any time, a modeler can edit, monitor and interact with virtually any aspects of the integrated modeling process; the modeler can initiate, pause, or resume particle tracking, plume modeling, multi-scale modeling, stochastic modeling. IGW dynamically merges geospatial data, modeling inputs and outputs, and stratigraphic and sampling information into composite 2D and 3D graphical images - providing a more complete view of the complex interplay among the geology, hydrology, and transport. The capabilities of real-time simulation, steering, and presentation expand the utility of modeling as a tool for research, education, and integrated management decision support.

Suitability Analysis for Groundwater Recharge for the Freeport Element of the American River Use Strategy in San Joaquin County, California - Sarah Watkins, GEI Consultants, Inc., Rancho Cordova, CA (co-authors: Ron Schnabel, Mark Williamson)

San Joaquin County, 50 miles south of Sacramento and 60 miles east of San Francisco, holds a water right application for diversion of up to 350 cubic feet per second from the South Fork of the American River. This supply is being sought to offset an estimated 150,000 acre-foot annual groundwater overdraft. The County seeks to make use of excess capacity in a facility, which has a point of diversion near the town of Freeport, to deliver up to 54,000 acre-feet per year. This is part of the County's effort to develop locally supported projects that improve water supply reliability and sustainability in San Joaquin County. To support the water right application, a regional (914,167 acres) analysis was performed to define the most suitable recharge areas for a variety of recharge methods: Urban In-Lieu, Agricultural In-Lieu, Recharge Ponds, Injection Wells, Field Flooding. This analysis evaluated the physical characteristics (e.g., soil type, depth to water, hydrogeology) and anthropogenic conditions (e.g. land use, parcel size) that affect where in-lieu operation (using the Freeport Element surface water instead of pumping groundwater) may be conducted, or direct recharge (ponds, injection wells, field flooding) or injection facilities are to be located. There are many key factors in the success of any recharge operation (such as site condition and access to appropriate lands), as well as factors that are only key to a particular type of recharge (geology and soil type are key for direct recharge while land use and parcel size are key for in-lieu recharge). This presentation outlines the GIS processing of relevant data layers, creation of a geoprocessing model in ArcGIS ModelBuilder, and summarization and display of the results of a GIS-based recharge suitability and constraints model. This analysis was conducted for the San Joaquin County Department of Public Works, by GEI Consultants, Inc., Bookman-Edmonston Division.

Comparison of Empirical Estimates of Mountain Front Recharge for the Southern Jornada Del Muerto Basin, New Mexico - Bvn Kambhammettu, New Mexico State University, Las Cruces, NM (co-authors: James P. King, Praveena Allena, Bobby J. Creel)

Technically sound water management practices in arid and semi-arid regions require effective quantification of model input parameters. Mountain front recharge (MFR) is considered to be one of the most uncertain parameters used in groundwater flow models of southwestern United States due to the complexity in estimation. This paper tested three empirical estimates of recharge using a numerical groundwater flow model developed for the Southern Jornada Del Muerto (SJDM) Basin, New Mexico. GIS based tools were used in delineating the recharge zones of the study area from the digital elevation model (DEM) and precipitation distribution. The model was simulated from 1968 to 2007 on seasonal basis by distributing the recharge fluxes in proportion to precipitation. The model was calibrated against static water levels in the monitoring wells to estimate the hydraulic and storage characteristics of the basin. The calibrated model was tested with three empirical estimates of MFR in order to i) select the final method that best reflects the basin characteristics based on residual statistics, and ii) estimate zone wise distribution of recharge flux in the SJDM Basin. Approximately 3,300 ac-ft of precipitation was estimated to enter the Basin annually through the ephemeral streams. Results of the analysis conclude that the Waltemeyer equation proved to be more efficient in estimating the mountain front recharge flux due a close match between the observed and simulated piezometric heads, and other basin specific characteristics.

3-D Volumetric Analysis of Groundwater Resources in Nolan County, Texas - Beronica Lee-Brand, Daniel B. Stephens & Associates, Austin, TX (co-authors: Michelle Sutherland, Allan Standen)

The State of Texas has mandated that by September 2010 each groundwater management area (GMA) must determine a desired future condition (DFC) for each aquifer within each county for the next 50 years. The Wes-Tex Groundwater Conservation District (GCD), which includes Nolan County, Texas (approximately 900 mi2), has complex basin edge hydrostratigraphy and includes Permian clastic and evaporite units (Blaine, Whitehorse and San Angelo Aquifers), Triassic (Dockum Aquifer) and Tertiary (Ogallala Aquifer) clastic units, and Cretaceous carbonate and clastic units (Edwards-Trinity Plateau Aquifer). The delineation of aquifer boundaries and the quantification of the net effective saturated thickness (clay, shale, and non-water-producing horizons removed) of each of these aquifers is critical for determining and monitoring a DFC and effective future groundwater management. An ESRI GIS geodatabase was developed for the Wes-Tex GCD that included 323 interpreted well drillers reports, 43 geophysical logs, digital aerial imagery rasters, surface geology vector files, a 30 meter digital elevation model, hydrographic datasets (recent water levels and water quality), and county, city, road and state survey shapefiles. Upon completion of stratigraphic interpretations, the dataset shapefiles were imported into CTech's Mining Visual Software, and a 3-D hydrostratigraphic model for Nolan County was created. A 3-D water level surface was created in the model and used, along with grain size descriptions from drillers' reports and published specific yield values based on average grain size, to calculate the net effective saturated thickness and the total available groundwater in storage for each aquifer. The 3-D Nolan County hydrostratigraphic model provides local decision makers with a visual model to better understand the impact of the selected DFC and the vertical and lateral distribution of groundwater within the county, thereby assisting in permitting reviews and design and implementation of future water level monitoring of the DFC status.