

**American Water Resources Association**  
**2009 ANNUAL WATER RESOURCES CONFERENCE**  
**November 9-12, 2009**  
Seattle, WA

**Monday, Nov. 9**

**10:30 AM – 12:00 Noon**

**SESSION 5: Irrigation and Erosion Control**

**Accuracy and Cost/Effectiveness Analysis of Various Reference Evapotranspiration Equations - Michael Exner-Kittridge**, Headwaters Hydrology, LLC, Seattle, WA (co-author: Mark Cable Rains)

The objective of this study was to conduct an accuracy and cost/effectiveness analysis of various reference evapotranspiration (ET<sub>o</sub>) equations that rely solely upon the collection of meteorological data. A meteorological station was established in an open grassland near Ft. Meade, Florida. The American Association of Civil Engineers (ASCE) Penman-Montieth (PM) equation with all parameters measured (Full ASCE-PM equation) was set as the standard to which nine variants of five equations were compared. The number of parameters that had to be measured for each equation ranged from five (Full ASCE-PM equation) to one (Hargreaves equation). ET<sub>o</sub> was computed on daily time steps. A variant of the ASCE-PM equation with just solar radiation, wind speed, relative humidity, and temperature measured and the Simple equation were most accurate, while a variant of the ASCE-PM equation with just solar radiation and temperature measured, the Simple equation, and a variant of the ASCE-PM equation with just solar radiation, wind speed, relative humidity, and temperature measured were most cost/effective. The most accurate and cost/effective alternative equations were those in which some of the less-important energy and mass-transfer terms were omitted and/or net radiation and soil heat flux density data were computed from less-expensive solar radiation data. The latter reduces the cost of the equipment by ~50% but only reduces the effectiveness by ~4%. The Simple equation requires only solar radiation data yet was one of the most accurate and cost/effective equations. With the Simple equation's minimal data requirements and superior accuracy and cost/effectiveness, the Simple equation could be a viable tool for the estimation of ET<sub>o</sub> in situations where funding is limited.

**Influence of Irrigation Recharge on Groundwater NO<sub>3</sub>-N Concentrations in the Greenfields Bench Aquifer, Teton County, Montana - Christian Schmidt**, State of Montana Department of Agriculture, Helena, MT

The Greenfields Bench is located in north-central Montana northwest of Great Falls and encompasses 83,000 acres. Consisting primarily of gravels overlying bedrock, the Bench is dominated by well-drained to excessively drained soils. An extensive canal system provides irrigation water to ~95% of the acreage on the Bench. Canal losses and on-farm irrigation provide 70% of aquifer recharge. Domestic and public water supplies drawn from the sole-source aquifer are susceptible to drought and contamination from surface applied agricultural chemicals and fertilizers. The Montana Department of Agriculture (MDA) has analyzed shallow groundwater on the Bench for agricultural contaminants since 1994. From 1998-2008, the median NO<sub>3</sub>-N concentration was 5.0 mg L<sup>-1</sup> with an observed decrease in NO<sub>3</sub>-N concentrations over the course of the study period (n=171). Public water supply wells (n=3) had median values of ≤ 4.8 mg L<sup>-1</sup> NO<sub>3</sub>-N. Isotope analyses (n=16; 1998) determined that NO<sub>3</sub>-N observations were derived from inorganic fertilizers and soil organic nitrogen. MDA data was compared with NO<sub>3</sub>-N data obtained from shallow groundwater sampling on the Bench in 1980. The datasets were not significantly different ( $\alpha=0.05$ ) however an increase in median NO<sub>3</sub>-N concentrations was observed. Flood irrigation has decreased from the dominant delivery system in 1980 (90%) to significantly lesser amounts in 2008 (55%) as more efficient sprinkler systems (wheel line, center pivot) have replaced flood irrigation. Decreases in observations within natural background NO<sub>3</sub>-N concentrations (≤ 2 mg L<sup>-1</sup>) were also observed (1980=25%, 1998-2008=0%). An irrigation recharge study completed on the Greenfields Bench in 2001 found wheel-line and center pivot irrigation deliver 70% and 90% less recharge respectively to groundwater than flood irrigation systems. Increased irrigation efficiency leads to decreased aquifer recharge resulting in decreased NO<sub>3</sub>-N loading and dilution. Under increased irrigation efficiency,

irrigation season (May-July) precipitation may become a significant mechanism transporting NO<sub>3</sub>-N to groundwater if the vadose zone becomes a NO<sub>3</sub>-N reservoir. Elevated NO<sub>3</sub>-N in groundwater as a result of agronomic practices exists in the Greenfields Bench aquifer, but concentrations do not pose a significant risk to human health.

**Assessing the Impact of Irrigation Efficiency and Farming Practices on Agricultural Hydrology and Producer Economics - Derrel Martin**, University of Nebraska, Lincoln, NE (co-authors: Dean Eisenhauer, Raymond Supalla)

States in the High Plains are faced with diminishing groundwater supplies, streamflow depletions, increasing demands for in-stream flows for endangered or threatened species, and downstream demands for water supplies or water quality protection. Simultaneously, in Nebraska water management agencies have established water allocation programs to control the withdrawal of groundwater and to apportion groundwater among irrigators using a correlative rights system. In some cases the allocations are affected by litigation between states or between surface water and groundwater users. We discuss how producers have changed irrigation and farming practices over time and highlight the impact of those changes on irrigation efficiency, return flows, groundwater recharge, and farm economics. Farmers have widely adopted automated irrigation systems, primarily center pivots, to minimize pumping and labor requirements. Producers have also adopted conservation farming practices to minimize runoff and evaporation from irrigated land. Conservation practices have also been employed in dryland farming production which affects agricultural hydrology as well. These systems allow for higher irrigation water use efficiencies which usually means less water applied and higher profits at the farm level. However, the impact of the increased irrigation efficiency affects the agricultural watershed as well. Reduced pumping minimizes groundwater extraction but does not reduce consumptive use by equal amounts. We used simulation models to address the effect of irrigation and farming practice changes and water allocation programs on the local water balance and estimated the effects of these changes on evapotranspiration or consumptive use, deep percolation, runoff, and irrigation economics at several locations across Nebraska. The results illustrate the complexity of assessing irrigation and farming practice changes and provide for improved comparison of water policy alternatives. The results also illustrate the need to consider these changes when simulating the impact of policies on groundwater systems and the inputs for groundwater and surface water models.