

# AWRA 2009 ANNUAL WATER RESOURCES CONFERENCE

November 9-12, 2009

Seattle, Washington

## PRELIMINARY PROGRAM

### POSTER PRESENTATIONS

Monday, Nov. 9, 8:30 AM – 6:30 PM

Tuesday, Nov. 10, 8:30 AM – 3:30 PM

(Note: The Presenter of each paper/poster is in **BOLD** type immediately following the paper title.

Co-authors are then listed in parentheses. **Also:** All session abstracts can be accessed using the Session Title link.)

**Phosphorus Loss with Surface Runoff as Affected by Biomass and Nutrient Management Systems for Bioenergy Production - Aaron A. Andrews**, Iowa State University, Ames, IA (co-authors: Antonio P. Mallarino, Mazhar U. Haq, Matthew J. Helmers)

Research is needed to investigate impacts of expanding bioenergy production systems on soil properties and water quality. Cellulosic biomass is being promoted for use in future bioenergy production systems over the current grain-based bioenergy production systems. Partial- or total-corn biomass removal, in addition to grain harvest may change crop P needs as P will be removed that otherwise would be recycled into the soil. Both sediment and water losses may also be altered and these changes could result in increased P loss from fields. Furthermore, interest in utilizing manure nutrients to minimize fertilizer use necessitates research investigating potential differences between fertilizer and manure management systems. This 2-year study in central Iowa used field plots with Clarion loam soil (mixed, superactive, Typic Hapludolls) and a rainfall simulation technique to study P loss. Nine treatments, each replicated three times, were set up in a completely randomized block design. Treatments consisted of continuous corn (CC) harvested for above-ground biomass, grain, or grain plus a fraction of cornstalks; corn-soybean rotation harvested for grain; and switchgrass harvested once per year for total biomass. Treatments were applied to 174 m<sup>2</sup> plots and managed with fertilizer or liquid-swine manure N-P sources at rates necessary to maintain recommended optimal soil test levels for crop growth. Simulated-rainfall (76 mm hr<sup>-1</sup>) was applied to 3 m<sup>2</sup> microplots, located within the large plots, until 30 minutes of runoff occurred in the fall (after crop harvest) and in the spring (after applying treatments and tillage but before planting the crops). The microplots were located in a different portion of the large plots each season. Crop yield, P removal with crop harvest, residue cover, water loss, sediment loss, and concentration of dissolved reactive P, bioavailable P (estimated by the FeO-impregnated paper method), and total P in runoff were measured. Results showed inconsistent differences for fertilizer or manure treatments. The largest losses of all runoff P fractions were for CC managed with manure and total biomass harvest. The smallest runoff P loss was for corn harvested for grain, soybean harvested for grain, and switchgrass harvested for total biomass.

**A Volunteer Water Quality Monitoring Program in the Upper Illinois River Watershed, Northwest Arkansas - Leslie Bartsch Massey**, Arkansas Water Resources Center, Fayetteville, AR (co-author: Brian E. Haggard)

The Upper Illinois River Watershed experienced a rapid population growth during the past decade, and as a result, dominant land use has shifted from forest and grassland to urban and pasture. To access the changes in water quality throughout the watershed, a volunteer monitoring program was established to compare current water quality conditions with conditions prior to the changes in landuse. The Illinois River Watershed Partnership (IRWP), a non-profit organization subcontracted with the Arkansas Water Resources Center, a water research institution at the University of Arkansas, to manage the volunteer monitoring project and train volunteers to collect samples following EPA approved methods, and to analyze the collected samples. The AWRC trained 26 volunteers to collect water samples at 37 sites that were previously sampled in 1993 and 1994. Samples were collected during baseflow conditions during September and December 2008 and February and May 2009 and analyzed for PO<sub>4</sub>-P, NO<sub>3</sub>-N, SO<sub>4</sub>, Cl, F, TP, TN and TSS. Mean concentrations were calculated and compared to the concentrations observed during the 1993-1994 study. Overall, TP and SRP concentrations significantly increased at 14% and 11% of the sampled sites, respectively, between the previous and current studies, while respective

concentrations significantly decreased at 8% and 16% of sampled sites. The greatest reductions in phosphorus concentrations occurred at sites downstream of effluent discharges, and both TP and SRP concentrations were positively correlated to pasture and urban land use within the catchment ( $R^2 = 0.11$ ,  $P=0.045$ ;  $R^2 = 0.16$ ,  $P=0.015$ , respectively). Similarly, both TN and  $\text{NO}_3\text{-N}$  concentrations were positively correlated to urban and pasture land use ( $R^2 = 0.38$ ,  $P < 0.0001$ ;  $R^2 = 0.29$ ,  $P = 0.0006$ , respectively), and 5% and 14% of the sampled sites significantly increased in TN and  $\text{NO}_3\text{-N}$  concentrations, respectively, between the two study periods. Because volunteers collected samples anytime during the designated month, it was difficult to collect representative duplicate samples, especially during the rainy season when episodic rainfall events occurred more frequently. Volunteer monitoring programs are an excellent way to promote environmental education and stewardship, and they can be useful to document changes in watershed conditions over time.

**Preferences among Hydrologic Models for studies involving Climate Change? - Levi Brekke,** Bureau of Reclamation, Denver, CO (co-authors: Lauren E. Hay, Edward Clark, Nancy Parker, Tom Pruitt, Gregory J. McCabe)

Natural runoff response to climate change in the western United States can be simulated using various types of surface water hydrologic models. For Reclamation's longer-term planning evaluations, scoping teams must: (1) decide on which model-type to use, and/or (2) demonstrate whether that model-type is preferred among available options. Recent research suggests that model structure can significantly influence portrayal of runoff sensitivity to climate warming, particularly in arid basins where evapotranspiration is the dominant fate for precipitation. Four surface water hydrologic model types are distinguished by process representation and basin characterization. This research explores whether preference exists among these model types to simulate changes in natural runoff under climate. The objective is to show how and why model types are more or less robust for simulating runoff in a climate that is different than that underlying the period of model calibration. The approach uses gridded applications, at two resolutions, of four model types (SacSMA, PRMS, VIC, Thornthwaite) in four Colorado River tributary basins (three mountain headwater basins at various elevations with significant snowmelt, and one low elevation arid basin with predominantly rainfall-runoff processes). A consistent calibration and evaluation scheme, which focuses on contrasting historical climate periods (e.g., calibration on cool-wet years and validation on warm-dry years) is applied for each model type. This presentation will summarize basin application decisions for each model type, calibration/evaluation design, and key results.

**Water Quality Factors Shaping Metabolism in the Middle Rio Grande - Roxanne Candelaria-Ley,** University of New Mexico, Albuquerque, NM (co-authors: David VanHorn, Clifford Dahm)

The importance of water quality and aquatic ecosystem health in arid rivers has become increasingly important as decreased precipitation, increased climatic variability and swelling urban populations have placed greater strain upon already limited water resources. In the face of this shortage, cities like Albuquerque, NM, which previously relied solely upon groundwater resources for municipal use, are now turning to surface water to supplement supplies. The relationship of water quality, stream metabolism and both biotic and environmental factors are being evaluated in a multi-year water quality investigation along a 60.3 km reach of the Middle Rio Grande in the Albuquerque area. Autochthonous sources of primary productivity in arid rivers can include phytoplankton, algae and aquatic macrophytes. While water column productivity is limited along the investigated reach, benthic algae are potentially a predominant source of production, despite light limitation due to high levels of turbidity. The impact of urban-runoff from episodic flooding, light availability and substrate type significantly affect not only water quality, but the ratios between primary productivity and the respiration of heterotrophic micro- and macro- organisms. Analyses of temporally and spatially variable water quality data derived from four real-time river monitoring sites tracking parameters such as temperature, pH, dissolved oxygen concentration and turbidity, combined with information on geomorphology and aquatic metabolism, indicate the existence of complex but identifiable relationships that can be used to monitor the holistic health of arid aquatic ecosystems.

**Economic Effects of Water Related Recreation at the Port of Hood River - James Carney,** Tetra Tech Surface Water Group, Seattle, WA (co-author: Ridge Robinson)

The City of Hood River is located sixty miles east of Portland, Oregon in the Columbia River Gorge. Historically an agricultural and industrial economy, recreation-based tourism has grown steadily in Hood

River since the 1980's. The Seattle Times reported in 2008 that Hood River had become a "multisport mecca". This unique availability of outdoor recreation causes Hood River's population of 6,850 to double during the summers from June to October. Most noteworthy are the high winds in the Gorge that made Hood River a world-class windsurfing destination in the late 1980's. In the late 1990's kiteboarding also came to Hood River. In November 2006, unseasonably high rainfall combined with glacial melt from Mt. Hood triggered significant flooding that sent logs, boulders and other debris hurtling down Hood River and its tributaries, resulting in the deposition of about one million cubic yards of sediment at the confluence of the Hood and Columbia Rivers. The sediment fanned out, adding twenty-six acres of sandbar to sediment that had been building since a flood event in 1996. The new land created by the sandbar has blocked access to a boat basin that had historically been used for marine industrial activity. Also, the new land quickly became a favorite spot for the growing sport of kiteboarding. The Port's development planning needed to be revisited to account for the changing waterfront. Tetra Tech, under contract to the U.S. Army Corps of Engineers Portland District, was asked to perform a low resolution economic impact analysis to estimate the current and potential future economic effects of windsport recreation at Port facilities. The analysis relied upon aggregation of existing data collected by the Port, local interviews, and existing reports. The National Park Service's MGM2 model was adapted for use at Hood River. This presentation/poster will present an overview of the Hood River recreation area as well as the economic analysis methods applied to develop estimates of the potential ranges of local economic effects that are attributable to windsport recreation in the City of Hood River.

**Comparison of Reanalysis Datasets with Observed Meteorological Data in the Canadian Prairies Region - Woonsup Choi**, Department of Geography, University of Wisconsin-Milwaukee, Milwaukee, WI (co-author: Sung Joon Kim, Peter F. Rasmussen)

Hydrological studies in remote regions are often challenging because of the lack of observed meteorological station data. Recently released two regional reanalysis datasets, North American Regional Reanalysis and ERA-40, were compared to observed meteorological station data in central Canada in order to investigate the reliability of these reanalysis datasets as a surrogate for observed data for hydrological modeling. Daily time series of precipitation and temperature from the reanalysis were compared to observed data over the Canadian Prairies region which includes provinces of Alberta, Saskatchewan, Manitoba and north-western Ontario. About fifty seven meteorological stations with more than 20 years of operation and with few missing records were selected across the four provinces. The analyses were conducted in two tracks: First, the means of temperature and precipitation from each data set were analyzed on monthly and seasonal bases. Second, the correlation coefficient (R) and root mean squared error (RMSE) between each reanalysis data set and the station data were computed to measure goodness-of-fit. The results show that r-values for temperature are greater than 0.97 with both reanalysis data sets but r-values are lower for precipitation, between 0.6 and 0.8. The r-values of ERA-40 for temperature were slightly higher than NARR, but for precipitation NARR showed better correlations to the station data than ERA-40 in most stations. This study suggests that the selected reanalysis data sets have good potential to be used as surrogates for observed meteorological data in remote regions such as the northern part of the Canadian Prairies region for hydrological research. The NARR data is especially promising in precipitation, which has much larger spatial variability than temperature.

**Impact of Reliability and Security on the Planning of the Kensico-City Tunnel, New York - Eric Cole**, AECOM, New York, NY (co-author: Ryan Edison)

At a price-tag of \$4.5 billion, the Kensico-City Tunnel (K-CT) is one of the largest water tunnel projects planned for the East Coast of the US. Many components of New York's water supply system have been in operation for over 100 years, and in that time there has been very limited opportunity to take the major aqueducts out of service for inspection and repair. To improve system reliability, New York City Department of Environmental Protection (NYCDEP) intends to build a new water tunnel from Kensico Reservoir in Westchester County to Hillview Reservoir in the Bronx, a distance of about 16 miles. The tunnel is referred to as the K-CT. In addition to normal redundancy requirements, system security has played an important role in the planning of the K-CT. Other important factors were the site geology and water quality considerations. Reliability modeling undertaken in the course of the on-going planning studies indicate that the tunnel diameter should be about 23 feet. This will give a capacity of about 1,450 mgd under normal operating conditions, and about 2,000 mgd under extreme conditions, which will be

sufficient to meet the water needs of the 9 million inhabitants in the supply area. The K-CT will be set at a depth of about 600 feet and will be driven by hard rock TBMs.

**Deep Drilling in Tuff Conditions to Solve Challenging Groundwater Problems at Los Alamos National Laboratory - Andy Crowder**, TerranearPMC, Los Alamos, NM (co-authors: Steve White, Ryan McGuill, Linda Fluk, Rich Leishman, Robert Stadel, Mark Everett)

Groundwater contamination was detected in the regional aquifer beneath Los Alamos National Laboratory (LANL), New Mexico. Forty-two wells were drilled (from 1998-2005), completed, and sampled for hydrogeologic characterization. Concerns were raised that drilling methods, using bentonite and polymer drilling fluid additives, may have affected sample quality. As a result LANL initiated a drilling program and groundwater monitoring network to obtain representative groundwater samples using appropriate drilling methods, per a 2005 Compliance Order between the Department of Energy, LANL, and New Mexico Environment Department. This presentation summarizes the most recent drilling approach for thirteen wells to obtain high-quality groundwater samples and assess groundwater chemistry in aquifers beneath Los Alamos. TerranearPMC's drilling approach uses the best available technology to drill through difficult conditions, including welded and non-welded tuff, basalt, and soft-sediments. A Foremost DR-24HD dual rotary, fluid-assisted, air-rotary drilling method, proved optimal for drilling through this varied strata in order to install wells and obtain high quality groundwater samples. The Foremost DR-24HD dual rotary rig has independent upper and lower rotary drives which allow for simultaneous drilling and casing. This method enables us to drill through varied formations without using bentonite-based drilling mud or other additives in the target aquifer, and therefore preserving sample chemistry. Temporary casing strings (up to 18-in.) were advanced with fluid-assisted air-rotary methods through volcanic tuff deposits. An open borehole was advanced with fluid-assisted air-rotary methods through lava flows. The open borehole enabled us to perform video inspections for perched water. Drilling fluids, consisting of potable water and foaming agent, were used to 100 ft above the target aquifer. Smaller diameter casing was advanced without fluid additives through volcanoclastic sediments to total depths (as deep as 1415 ft). Monitoring wells were installed and completed with either one or two screens. The drilling approach proved to be efficient, safe, and cost effective, while preserving sample integrity and allowing for excellent hydrological, geochemical, and geological data. TerranearPMC is drilling more wells for LANL using this successful drilling approach to evaluate the distribution of groundwater contamination.

**Building Toward a National Water Allocation Model on the NHDPlus Network - Michele Cutrofello**, RTI International, Washington, DC (co-authors: Brandon Bergenroth, Jay Rineer, Keith Little)

While numerous watershed and water quality models exist and have been applied around the nation, few have the capabilities or data requirements that would facilitate national or regional analyses. With the increasing opportunity to develop and apply watershed management plans in a regional context, a need has arisen for a watershed model that can be readily applied over a larger watershed area. RTI seeks to fill this need by developing a water allocation model based on the Generalized Watershed Loading Function (GWLF) with enhancements on the National Hydrography Dataset Plus (NHDPlus) using available national and regional datasets. GWLF has been utilized in numerous areas of the country and for a wide variety of issues. With its reliance on the Universal Soil Loss Equation (USLE) and SCS Curve Number methods for runoff and sediment calculations, application on a smaller watershed scale is warranted. The NHDPlus scale (average catchment size 2.5 km<sup>2</sup> nationwide) provides a reasonable watershed size on which to develop individual, but networked GWLF applications. The intermediate level data requirements of the model can be met with georeferenced national datasets (SSURGO, NLCD, etc.) and developed regional datasets (months of growing season, evapotranspiration cover factors, etc.). The network of COOP weather stations available from the National Climatic Data Center provides the precipitation and temperature data inputs required of the model. The streamflow gages indexed to the NHDPlus in the USGS National Water Information System provide flow measurements for calibration and validation of the model. "What if" scenarios developed based on the model parameters can analyze multiple issues of sustainability, ecosystem health, or management plans across the various watershed scales developed from NHDPlus networked catchments. For instance, variation of temperature and precipitation values according to climate change model simulations may examine the effects of climate change on total watershed yield, individual catchments that will not meet low flow requirements, or areas in which sensitive species will be in danger.

**Stream and Watershed Restoration Costs to Address a Hypothetical Mine Tailings Impoundment Failure - Kathleen Dixon**, Ecology & Environment, Seattle, WA (co-authors: Paul Cocca, Alexander Whitman, Kris Erickson)

Plans to expand the size of an existing mine tailings impoundment prompted a state agency to assess the potential downstream impacts of a catastrophic failure of the impoundment, and the costs to restore the downstream reaches and floodplains. Located adjacent to the river, the impoundment has a proposed capacity of 14 million tons, and contains tailings with elevated levels of metals and cyanide. To assess potential environmental damages, the hydrology and hydraulics (H&H) and sediment transport associated with the dam failure were simulated. HEC-HMS was used to model the hydrology of the dam failure and upstream subbasin flows. The HEC-RAS hydraulics model was used to simulate flow, transport and deposition of mine tailings, as well as scour and deposition of river and floodplain sediments. Low-flow conditions were modeled to simulate the worst-case scenario. Model inputs included dam break parameters, channel and floodplain cross-section data derived from topographic data, and sediment source grain size distributions. The modeling results delineated a potential area of impact which was used during the field reconnaissance to undertake a baseline characterization of representative areas. Applicable restoration measures were based on the results of the hydrologic and hydraulic modeling, coupled with baseline conditions, and were chosen using a function-based planning approach to facilitate recovery of the ecological functions that the natural resources provide. Restoration measures were classified by damage type - scour or deposition – and illustrations were provided. For scour areas, design elements were recommended that are appropriate for channel stabilization and restoration. For depositional areas, design elements/approaches were recommended that are appropriate for use in restoring areas affected by sediment deposition. The volume of tailings requiring excavation and removal were determined based on areas where deposition exceeded a toxicity-based depth threshold. Additionally, miles of river reach requiring restoration were calculated based on locations where scour depths were excessive or tailings deposition exceeded the toxicity-based depth threshold. A literature review was conducted to identify studies with river restoration costs. Restoration costs per mile associated with these studies were used, in conjunction with standard excavation and fill costing techniques, to derive an overall restoration cost estimate.

**Retrofitting of Urban and Industrial Areas to Protect Water Quality in Puget Sound Tributary Streams - Mike Giseburt**, R. W. Beck, Inc., Seattle, WA (co-authors: Ralph D. Nelson, K.A. Ludwa, R. York, R. Duffner,)

Stormwater is a significant source of contaminants entering Puget Sound. Much of the stormwater pollutant loading originates from developed areas that were constructed before stormwater controls were required. Efforts to restore and protect Puget Sound will require existing develop areas to be retrofitted to reduce pollutant loading from stormwater. The Port of Seattle recently retrofitted the Seattle-Tacoma International Airport to reduce pollutant loadings and achieve numerical effluent limits. Runoff from the airport enters salmon-bearing streams leading to Puget Sound. Approach: The Port of Seattle initiated a number of steps to guide the retrofit. Much of the stormwater treatment focused on removals of total suspended solids and metals. The approach taken by the Port included: an aggressive sampling program to identify pollutant sources; testing for the toxicity of stormwater and receiving water to confirm allowable effluent limits; assessing the ability of various filtration media for treating stormwater; and an evaluation to determine the most cost-effective means to treat stormwater.

**Using LiDAR, Hydrologic Models, and Global Climate Data to Predict the Effect of Climate Change on Hydrologic Ecotones in the Lower Tualatin Watershed - J. Ruben Gonzalez-Baird**, Portland State University, Portland, OR (co-authors: Susan Wherry, Hamid Moradkhani)

Current modeling efforts continue to indicate that the effects of climate change will be both global and local in scale, and that ecohydrologic factors including altered precipitation events, reduced system yields due to streamflow changes, increased flooding and changes to current floodplain characteristics, and changes in vegetation will be affected. Therefore, using technology such as light detection and ranging (LiDAR) data, future general circulation model (GCM) data, and advanced floodplain analyses to predict the changes to ecohydrologic factors is critical for understanding the effects of climate change on the regional scale watershed. This study considers the effects of climate change scenario A2 (higher

emissions) as proposed by the Fourth IPCC Assessment over the period 1990-2040 within the Lower Tualatin watershed in Tualatin, Oregon. Using the LiDAR data, Soil and Water Assessment Tool (SWAT) software and HEC-RAS, we were able to delineate the basin and extract the vegetative features, calculate the 50-year return interval flow within the basin and predict the 50-year floodplain for 2040. A specialized geo-processing algorithm was developed to delineate hydrologic “ecotones”, a floodplain-connected area used in evaluating the condition of riparian areas and streams. A complete current and future conditions analysis was performed for the vegetation within the ecotones in order to: 1) provide an existing inventory of vegetation within the watershed and 2) to predict the affect that climate change may have on vegetation within the watershed.

**Estimating Winter Cover Crop Nitrogen Uptake Using Satellite Imagery: Four Years of Data from the Choptank River Watershed CEAP - W. Dean Hively**, USGS Eastern Geographic Science Center, Beltsville, MD (co-authors: Megan Lang, Greg McCarty, Ali Sadeghi, Jason Keppler)

The Choptank River Conservation Effects Assessment Project (CEAP) has now accumulated a four-year set of quarterly SPOT satellite images taken over the Eastern Shore of the Chesapeake Bay watershed. Imagery collected in December and March of each year were used to estimate the productivity and nutrient uptake associated with 2390 farm fields that were enrolled in Maryland Agricultural Cost Share (MACS) programs for winter cover crops between 2005 and 2009. Agronomic data for each field (planting date, planting method, species, previous crop) were provided by MACS documentation. On-farm biomass sampling at approximately 90 cover cropped locations per image date were used to (1) calibrate a model to correlate satellite-derived Normalized Difference Vegetation Index (NDVI) to estimated above-ground cover crop biomass, (2) measure cover crop tissue nitrogen concentrations, and (3) observe cover crop effects on residual soil nitrate. Overall, on-farm cover crop implementation underperformed in comparison to plot-scale research results, with performance reductions largely attributable to late planting dates and species choice. Results of satellite vegetation analysis can be used to (1) calculate nitrogen uptake associated with winter cover crops on a watershed basis, (2) improve cover crop implementation strategies, and (3) calculate the observed dollar costs per kilo of N sequestered using various cover cropping strategies.

**The Arizona Water-Energy Nexus - Joseph H. Hoover**, University of Denver, Denver, CO

The water-energy nexus is the dependent relationship between water and energy resources. The nexus results in complex policy and management challenges for resources that have been historically managed independently. This study quantifies electricity used for water service provision in Arizona. Employing the water use cycle as an analysis tool, this study divides municipal water use for the Tucson metropolitan area and city of Phoenix into four components. The findings suggest that energy intensity differences between Phoenix and Tucson exists due to geographic variables. The city of Phoenix and Tucson metropolitan area currently consume 1.2% of statewide electricity for water and wastewater service. Electricity demand for water and wastewater service in Tucson for 2008-2030 will be 110-131%, which is greater than the 85% electricity growth statewide. Water and wastewater agencies now face decisions regarding future plans to meet water demand and maintain a low overall energy use for service provision.

**Bacteria Sourcing in the Central Valley (California) - Michael Johnson**, Michael L. Johnson, LLC, Davis, CA (co-authors: Lizabeth Bowen, Melissa Turner)

The East San Joaquin County Water Quality Coalition (ESJWQC) is a consortium of agricultural producers who discharge either irrigation tailwater or storm water runoff to local water bodies. Due to repeated detections of E. coli in water bodies within the Coalition region, the ESJWQC conducted a Bacterial Source Identification Study to identify the species responsible for E. coli exceedances and to guide the implementation of management measures aimed at eliminating future exceedances. The relative percentages of human, bovine, and chicken Bacteroides were determined for 27 samples selected at random from from sites at which E. coli had been detected or upstream of sites where E. coli had been detected. Bacteroides was selected because it represents recent fecal contamination. The overwhelming majority of the Bacteroides DNA in the samples were of human origin. Only six of the samples representing three watersheds had any bovine DNA. Chicken DNA was detected in very small percentages in four samples from three watersheds. The relationships between coliform counts and Bacteroides presence were not significant. The potential sources of human Bacteroides include

improperly treated sewage from waste water treatment plants, leaky sewer systems, or direct defecation in surface waters. Later inspections of several creeks indicated the presence of unpermitted discharges of sewage from local dwellings. The small percentage of bovine *Bacteroides* present in the system is most probably from irrigation return flows from irrigated pasture. Interestingly, there were significant relationships between fecal and total coliform counts and species' *Bacteroides* CT values. CT values are not quantitative in an absolute sense and should not be related to any absolute measure such as MPN/100mL. More research is needed to determine if the relationships are real or an artifact of the analyses. Further research should be conducted to develop absolute quantification of *Bacteroides*, investigate runoff at additional times of the year, and include additional constituents to validate the predominance of human *Bacteroides* during the late summer.

#### **Uncertainty Assessment For Two Hydrologically Distinct Watersheds In The Willamette River Basin - Il-Won Jung**

Portland State University, Portland, OR (co-authors: H. Moradkhani, H. Chang)

We investigated hydrologic uncertainty to assess climate change impact on two basins with different hydrological processes, the Clackamas River basin (snowmelt-dominated) and the Tualatin River basin (rainfall-dominated). Three hydrological models – Precipitation Runoff Modeling System (PRMS), Sacramento soil moisture accounting model (SAC-SMA) + Snow-17, Hydrologic MODel (HyMOD) + Snow-17 - were used to consider the uncertainty associated with different model structures. A Bayesian method was applied to analyze the uncertainty of model parameters. We considered the uncertainty of climate change projections using combinations of 8 GCMs and 2 emission scenarios (16 simulations in total) simulations. The results demonstrated that uncertainty from GCM simulations is higher than hydrological modeling. Runoff changes were more sensitive to climate change in the snowmelt-dominated basin than in the rainfall-dominated basin because snowmelt was highly dependent on temperature change.

#### **Analysis of NEXRAD and Rain Gauge Precipitation Data in Northeast Indiana - Myriam Larose**

Purdue University, West Lafayette, IN (co-authors: Gary C. Heathman, Darrell Norton)

Spatially distributed rainfall is a critical input to watershed hydrologic models. The Next Generation Weather Radar (NEXRAD) data from the National Weather Service can capture the spatial variability of precipitation. Nonetheless, rainfall rates estimated from the NEXRAD are subject to errors that require correction based on available rain gauge data. In this study, the quality of NEXRAD multisensor precipitation estimates (MPE) was investigated using precipitation data from rain gauges that are independent from the MPE in northeast Indiana. A power model was adapted to the data to describe the relationship between radar precipitation estimates as a function of rain gauge data from the National Soil Erosion Research Laboratory. The results indicate that this procedure improved considerably the RMSE, from 4.99 mm to 1.74 mm, over the mean field bias adjustment at the subwatershed and watershed levels. This research should benefit future hydrologic model applications using NEXRAD precipitation estimates for improved water resource management.

#### **Development of a Nearest Neighbor Resampling Model to Downscale GCM Output - Mark Lee**

University of Manitoba, Winnipeg, MB, Canada (co-author: Peter F. Rasmussen)

The potential of climate change to affect hydrological regimes has increased the need for simulation of future trends in hydrological variables. Global Climate Models (GCMs) are commonly used to provide possible future climate scenarios. The coarse resolutions of GCMs lead to poor representation of local features and significant biases in key variables, making it difficult to use the data directly for hydrological modeling. Post-processing of the GCM data is necessary to provide data of appropriate scale. Application of statistical methods to downscale the data is a common solution to the disparity of scales. The large uncertainty in the future climate is a significant difficulty in assessing climate change. To gain a broad spectrum of possible future conditions, a climate change assessment of a streamflow should include projections from multiple GCMs which are downscaled via multiple downscaling methods. Furthermore, an assessment should utilize more than one hydrological model. There are currently a few popular statistical downscaling methodologies and software packages available. These include the SDSM and LARS-WG software packages. Since the selection of the downscaling model is a source of uncertainty, it is valuable to use as many models as possible. The development of a statistical downscaling model based on nearest neighbor resampling to provide temperature and precipitation data for climate change

assessments is presented. Although the nonparametric nature of the resampling algorithm avoids the extensive parameterization required by other statistical downscaling methods, it was necessary to develop an optimization routine to maximize the performance of the model. A case study where the model was applied in the Winnipeg River Basin as part of an assessment of water availability for hydropower generation is presented. The case study demonstrates the value of the nearest neighbor model as a supplement to the other popular downscaling models in climate change assessments.

**Improved Snow Water Equivalent Prediction Using Ensemble Data Assimilation Methods - Marc Leisenring**, Portland State University, Portland, OR (co-authors: Hamid Moradkhani)

Accurate estimates of accumulation and ablation of snowpack is critical for reliable water supply and flood forecasting. However, despite improvements in snow measurement and modeling methods over the past 30 years, reliable snow accumulation and melt prediction is still a challenge today; particularly in the mountainous western United States where snowpack properties can be highly heterogeneous. Sequential data assimilation techniques that stochastically combine field measurements, remote sensing data, and model results can significantly improve the prediction skill of snowmelt models. Using the National Weather Service's SNOW-17 model, this study compares two common types of sequential data assimilation methods, the ensemble Kalman filter (EnKF) and the particle filter (PF), to predict seasonal snow water equivalent (SWE) within a small watershed in the Lake Tahoe Basin. Various uncertainty assumptions are required in data assimilation including error magnitudes and distributions for the forcing data and state variables. An inherent assumption in all Kalman filters is that the model errors are normally distributed; an assumption that rarely holds in hydrological models. Particle filtering is an alternative data assimilation scheme that does not require a fixed assumption for the shape of the posterior distribution. Instead, the probability distribution of model states is computed as a weighted combination of the ensemble members, or particles. Using this approach the model states are not updated as in other data assimilation schemes; rather each particle is assigned a probability of successfully predicting the model state. This study evaluates the use of an empirical cumulative distribution function (ECDF) for computing the particle weights as an alternative to the commonly used Gaussian-based likelihood estimate. The results of this study found that both the EnKF and particle filter can significantly improve estimates of SWE, but the PF with the sampling strategies above result in less uncertainty with higher accuracy. However, the PF is computationally more expensive due to the large number of ensemble members required. Further improvements to the PF algorithm were realized by using the ECDF for computing particle weights followed by the weighted random resampling with replacement method.

**Groundwater Hydrology in a Small Constructed Riparian Wetland in the Ridge and Valley of Virginia - Andrea Ludwig**, Biological Systems Engineering, Virginia Tech, Blacksburg, VA (co-author: W. Cully Hession)

A half-acre plot of pastureland was converted to a riparian wetland as part of a study on the effectiveness of innovative best management practices on stormwater nutrient management in the Opequon Creek Basin, a tributary to the Chesapeake Bay. The objective of the study was to characterize the influence of groundwater contributions during the establishment period of the wetland to determine if the wetland meets jurisdictional wetland criteria for wetland hydrology and to inform future model inputs for wetland water budgeting. Groundwater movement was measured through nested piezometers throughout the wetland for 1.5 years. Piezometric surfaces and hydrologic gradients characterized the movement of groundwater from the adjacent hill slope and up-gradient contributing areas, through the wetland, and into the receiving Opequon Creek. Slug tests were analyzed using the Horslev method and were used in calculations of flow and estimates of hydraulic retention time in the floodplain. Localized gaining and losing areas delineated possible preferential flow paths and their responses to precipitation. Water table elevations showed that the hydrologic criteria for a jurisdictional wetland were met on the site, and that possible confining layers create a perched aquifer during dry periods. Future work includes determining nutrient attenuation in the constructed wetland and estimations of annual nutrient load reductions in Opequon Creek.

**Developing the LUOM in Southern Guam Watersheds Without Flow Data – Q. C. Luo** WERI, University of Guam, Mangilao, Guam (co-author: S. Khosropanah)

The Large-scale, Unified and Optimization Model, LUOM (Luo, 2007) is a fully physically based, two-dimensionally distributed watershed model simulating the hydrologic cycle on a watershed scale. The model discretizes the watershed into rectangular grid cells and makes use of spatial distributed GIS data such as DEM, vegetation, soil and aquifer data, to output one-dimensional discharges and two-dimensional hydrologic quantities. In southern Guam, there are some watersheds with both rainfall and flow data, but also some other watersheds with only rainfall data but no flow data. The objective of this study is to calibrate the LUOM (Luo, 2007) in a watershed with both rainfall data and flow data and apply the calibrated model to the adjacent watersheds without flow data. In this study, Ugum watershed, which has both rainfall and flow data, was selected for model calibration. The model will be applied to the other watersheds in Southern Guam, such as Inarajan watershed. The model and the preliminary results will be presented at the conference.

#### **Impact of Vegetation Cover on Regime and Quality of Groundwater, Belgrade, Serbia Case Study -**

**Dejan Milenic**, Hydrogeologist, Belgrade, Serbia (co-authors: N. Savic, Z. Veljkovic, Dj. Stanojkovic) Forests occupy less than 27% of the total surface area of Serbia. According to the Spatial Plan of the Republic, the afforestation of additional areas to the optimal forestation, which for Serbia amounts 41 %, is planned. Such a change in soil utilisation always results in corresponding nature changes. Essential effects will be reflected in eco system changes, microclimatic variations, circular water cycle, soil erosion, etc. However, it is likely that the highest afforestation impact will be on the quantity and quality of groundwater. Bojčinska šuma (forest) in the vicinity of Belgrade has been determined as an experimental field. Detailed examinations of this locality, including test drilling, groundwater table monitoring, preliminary data on water chemism, etc, have been among the main aims of investigations carried out so far. There have been three experimental fields in the area of Bojčinska šuma (forest): The No. 1– control surface, grass, the No. 2– mature forest, the No. 3– young planted forest The groundwater table and qualitative characteristics of groundwater were being watched on these fields for one year. Results of grain size analyses point out that the layers, close to the surface, immediately below the humus cover, are represented by clay alternating with loess formations to enter eventually sandy loam, namely fine grained sand deeper. Chemical analyses of sediments from the No. 3 drill hole have pointed out an interesting phenomenon, that the values of all elements representing nutrients for tree growth decrease till depth of four to six metres and then increase and return to initial values. The No. 3 drill hole was drilled in the space covered with a 25 year old peduncle oak forest. Bearing in mind that fact, there is a high probability that the four to six metre zone is in fact, a pumping zone from which mineral materials are derived by the oak root system. It is mostly shown by the decreased contents of potassium, magnesium, and iron in the zone between four and five metres. This depth also corresponds with the depth of the root system, as well as the depth to the groundwater table.

#### **Reach-Scale Effectiveness Monitoring of Stream Restoration Projects in the Pacific Northwest -**

**Jennifer O'Neal**, Tetra Tech EC, Inc., Bothell, WA (co-author: Tricia Hoffer) The Washington State Salmon Recovery Funding Board (SRFB) was created by the Washington State Legislature in 1999 to provide grants and loans for salmon habitat projects and salmon recovery activities. The SRFB has funded more than 1,126 projects and spent more than \$336 million in state and federal funds toward salmon recovery. In order to determine the relative effectiveness of project categories, the SRFB approved funding for the Reach-Scale Effectiveness Monitoring Program in 2004. Funding for the Reach-Scale Effectiveness Monitoring Program includes funding from the Pacific Coast Salmon Recovery Fund, a federal funding source for salmon recovery in the Pacific Northwest. This funding is distributed to states with habitat for Pacific salmon including Washington, Oregon, California, Alaska and Idaho. These states are developing state-wide effectiveness monitoring programs to report back to Congress on the success of restoration efforts. Expanding coordination of these monitoring efforts in the Pacific Northwest will give the federal legislators needed information for future funding decisions for salmon habitat restoration. Comparable data collected across the region will also provide better information to aid resource managers in making decisions regarding listed salmon species, many of which have habitat that ranges across state lines. In addition, results of a monitoring program could be shared with project sponsors to help improve communication about successful restoration approaches and lessons learned, and the best ways to approach project designs. Results to date from the SRFB Reach Scale Effectiveness Monitoring Program indicate that some project categories are showing significant changes in the first one to three years following implementation. Many of the variables monitored in the Fish

Passage, In-Stream Habitat, Livestock Exclusion and Channel Connectivity Project categories have shown an increase greater than 20 percent over baseline. In addition, functional evaluations for many indicators show effectiveness has been reached before the timeframes established in the objectives for each monitoring category. The remaining variables are likely to require additional time and more projects to identify significant change. As more years of data are collected, it will be possible to determine the presence of trends through time for variables in each monitoring category.

**Real Time Estimation of BOD by the Rapid Determination of Chemical Oxygen Demand (COD) - Lindsay Peddle**, ManSci Inc, Guelph, ON, Canada (co-author: Michael Essler)

Chemical Oxygen Demand (COD) is probably the single most diagnostic parameter for the determination of water quality in both natural waterways and industrial and domestic waste streams. The continuous monitoring of organic load in either industrial outfalls or natural waterways is becoming more essential to comply with regulatory requirements. Given the 5 days required for a Biological Oxygen Demand (BOD<sub>5</sub>) test, a rapid COD method as an indicator of organic load is highly desirable. This paper reports recently developed (patented) photoactive TiO<sub>2</sub> nanomaterials that provide an alternative means to standard COD methods. Based on exhaustive photoelectrochemical oxidation in a micro cell, this technology (called the PeCOD) is able to quantify COD with a sensitivity and speed far greater than any standard method at a fraction of the operating cost. The standard dichromate COD method is slow, limited in sensitivity and oxidizing power, and requires the addition of toxic chemicals such as mercury to eliminate interferences such as chloride. The new green chemistry PeCOD method eliminates disposable costs of the hazardous chemicals ensuring a safe method for chemists and operators. This technology directly measures the amount of oxidizable material. This makes it unique, as all other COD methods provide an indirect measure by determining the amount of leftover oxidant. The consequence of this is sensitivity at levels in the ug/L range. Also, the rapidity of measurement allows, for the first time, online COD determination, and the ability to measure input load at municipal wastewater treatment plants. Finally, it is capable of determining COD in seawater matrices, something that the dichromate method is incapable of. Correlation studies have been performed at several industrial sites, including a sugar refinery, a sugar mill, and a brewery. In each case good correlation was observed between COD as determined with the PeCOD device and independently determined BOD.

**Rapid Multi-Parameter Analysis Using the New Rapidduo by Man-Tech - Lindsay Peddle**, ManSci Inc, Guelph, ON, Canada (co-author: Robert Menegotto)

Ten years ago, Man-Tech delivered multi-parameter solutions to the environmental industry, meeting the requirements of unattended analysis. In today's ever-changing market, environmental laboratories are challenged to deliver results even faster, while still remaining accurate and precise. To meet the demands of today's environmental market, Man-Tech has developed the RapidDuo, which enables rapid multi-parameter analysis from a single sample. The RapidDuo can measure pH, conductivity, alkalinity, fluoride and turbidity in 4 minutes or less while still following EPA-approved methods. One of the key aspects to the success of the RapidDuo is the TitraSip system. The TitraSip system is currently utilized in many labs around the world for its multi-functional capabilities. It automatically pipets the sample into a separate vessel, it runs the appropriate analyses, drains the analyzed sample directly to waste, and automatically rinses the analysis vessel and probes between measurements. While already hugely successful in its ability to run unattended multi-parameter analysis, the TitraSip system was upgraded to utilize a smaller, 35mL analysis vessel which significantly cut down on the sample size required for many different analyses. For certain measurements, such as alkalinity, a smaller sample volume means less time to titrate and therefore saves time. The PC-Titrate software is another important component to the RapidDuo. The PC-Titrate software allows the control of two or more TitraSip modules in a single system. This means that a single sample can be pipetted simultaneously into separate vessels, each containing their own electrode. This means that different analyses can be performed simultaneously instead of in turn. Further details on the schedule of operation will be discussed, and data obtained using the RapidDuo system will be presented.

**Relationship Between Rainfall and Evaporation for Urban Area in Cuiabá City, Brazil - Mariele Regina Pinheiro**, Federal University of Mato Grosso, Cuiabá, MT, Brazil (co-authors: Maricéia Tatiana Vilani, Luciana Sanches, Marcelo de Carvalho Alves, José de Souza Nogueira)

Since 1999, the Manso hydropower plant has been regulating the Cuiabá River in Brazil and it can be affecting the climate in urban area, Cuiabá city. Meteorological data from local weather station allows the evaluation of evaporation and rainfall at local scale, urban area in Cuiabá city, Mato Grosso state, Brazil. Daily continuous measurements were made at the study site from 1992 through 2003 in Weather Station "Bombed Master" located in Federal University of Mato Grosso (15,1°33'S; 56°07'W) belonging of the Cuiabá River watershed. It is one more important sub-watershed of "Alto Paraguay". The climate local is hot and humid and the hydric cycle was characterized by a pronounced humid period with duration of seven months (from April through October) with an average monthly of air temperature and humidity of 26.2°C and 71.25%, respectively. Average evaporation decreased from 246 mm month<sup>-1</sup> during the July to 152.18 mm month<sup>-1</sup> during the February, in parallel with decreasing humidity and air temperature. Average evaporation and rainfall were 1760 and 1566 mm year<sup>-1</sup>, respectively. The ratio between rainfall and evaporation varied from 0.767 (2002 year) to 1.580 (1995 year). Our results suggest that in last three years in this study (2000 to 2002) occurred an evaporation lesser than in the before years due to lower air humidity; probably for regulating of flux in the Cuiabá river in this period.

**A Pseudo-Transient Continuation Dam/Levee Failure Hydrodynamic Model - Gauarv Savant, USACE-ERDC, Vicksburg, MS (co-authors: Charlie Berger, Tate McAlpin, Jennifer Tate)**

The usage of the Pseudo-Transient Continuation (PTC) concept to efficiently simulate dam and levee failure is presented. PTC is a technique for the nonlinearly implicit computation of steady-state partial differential equations (PDE). In general PTC is a predictor-corrector technique for temporal integration in which the time step is increased or decreased as the objective of the convergence nears a solution or variation tolerance. Even though PTC is designed to address steady-state, the maximum time step can be limited and PTC used to select time step size for unsteady problems. PTC provides a multitude of advantages towards the goal of efficiently simulating the hydrodynamic behavior of a dam or levee failure owing to rapid expansion of the utilized timestep as well as adequate reduction of timestep as required. Due to its implicit nature timestep size can be expanded in accordance with problem expansion. PTC is a promising technique towards increasing the efficiency of finite element dam and levee failure hydrodynamic models. The authors will present results from validation test cases as well as several hypothetical dam and levee failures to illustrate the benefits of utilizing PTC in a finite element hydrodynamic model. It is anticipated that the technique will result in a more widespread utilization of finite element hydrodynamic models towards the simulation of dam and levee failures.

**A Soil Moisture Point for Mature Pecan to Maintain Healthy Growth - Zhuping Sheng, TAMU, El Paso, TX (co-authors: Yi Liu, Nicole Kyger, Frank Reyers)**

For each irrigation cycle, pecan trees experience different moisture status. It is suggested that a soil moisture point exists between field capacity and permanent wilting point for mature pecan to maintain healthy growth. The authors defined it as healthy moisture point. The moisture data was collected from July 2007 to February 2008 in a pecan field using a ECH2O moisture monitoring system with an interval of 15 minutes at depth of 3 ft because pecan evapotranspiration (ET) dominates soil moisture fluctuations at this depth. The observed field capacity is around 37.7%. Wilting point is supposed to be 15%. The healthy point is determined using a significant deflection point of daily moisture rate caused by pecan ET. It is found to be between 30.7 and 32.7%. The results show that pecan ET uptakes 0.99 to 1.36 % soil moisture a day if the soil moisture is above the healthy point; otherwise it only takes 0.2 to 0.3 % a day. This diurnal decrease of moisture availability from soil ranges from 70 to 80 % and explains why pecan growth usually decreases before signs of permanent wilting occur. In El Paso pecan orchards, irrigation usually occur when soil moisture is 1.5 to 2.5 % less than the health point or approximately 12% higher than the wilting point. This is a good indicator for farmers to schedule irrigation to maintain healthy growth and good production while improving irrigation efficiency.

**Providing Environmental Services from an Agricultural Impoundment in South Florida - Sanjay Shukla, Ag and Bio Eng Dept, University of Florida, Immokalee, FL (co-authors: Alphonse Guzha, Patrick J Bohlen, Mark W. Clark, Sarah Lynch, Len Shabman )**

The Florida Ranchlands Environmental Services Project (FRESP) aims to design, test and evaluate a market-based program to pay for environmental services on ranchlands. These services are water storage and phosphorus (P) retention. The project contributes to the goals of the Comprehensive Everglades Restoration Program (CERP) to reduce phosphorus loadings to Lake Okeechobee from

contributing watersheds. Eight pilot sites were identified and instrumented for quantifying water storage and nutrient retention. These sites provide water and nutrient treatment in pastures, wetlands, and storm water impoundments. Results from a pilot study for a storm water impoundment site are presented here. The site is a 1000 hectare impoundment containing wetlands within a cattle ranch in the Highlands County of southwest Florida. The environmental services are water storage and P removal from a regional public canal. Water pumped from the canal inundates the impoundment and water outflow is measured at the downstream and returned back into the canal. Nutrient concentrations in the inflow and outflow water are measured. Water budget analyses for the period of July 2008 to March 2009 show total water inflow of 300 cm and this consists of 198 cm of water pumped from the canal and 103 cm from rainfall. Discharge amounted to 122 cm (40.3%) while losses to evapotranspiration and seepage accounted for 29.5% and 13% respectively. An estimated 51 cm (17%) was still stored in the impoundment in March 2009. The maximum observed surface water storage in the impoundment was 110 cm. Use of impoundment helped reduce the canal flows by 13%. Approximately  $5.9 \times 10^3$  kg of P was pumped into the site and  $2.6 \times 10^3$  kg was discharged, indicating a removal of  $2.7 \times 10^3$  kg of P (55% treatment efficiency) from public canal that otherwise would have been discharged to the Lake Okeechobee. The N treatment efficiency for the same period was 38%. Results from this pilot site indicate that agricultural impoundments can successfully provide water storage and phosphorus retention services and help achieve the water quality goals as well as provide additional income to the agricultural landowners for providing the environmental services.

**Water Quality Effectiveness of an Agricultural Stormwater Impoundment in the Everglades Watershed - Asmita Shukla**, Agricultural and Biological Engineering, University of Florida, Immokalee, FL (co-author: Sanjay Shukla)

Excessive phosphorus (P) loading to the Florida's Everglades ecosystem is adversely affecting sawgrass, its natural vegetation, by replacing it with non-native vegetation. Runoff and drainage from agriculture is one of the main sources of P loadings. A variety of Best Management Practices (BMPs) including agricultural stormwater detention areas (ASDAs) are currently being promoted to reduce farm-scale nitrogen (N) and P loadings. Although, ASDAs are assumed to be one of the most effective BMP's, limited information exists on their effectiveness in reducing N and P discharges. A study was started in 2008 to quantify the treatment efficiency of an ASDA located in the Everglades watershed. The results for part of the 2008 wet and dry periods are discussed here. Flow and P concentrations, measured at the inflow and outflow locations, were used to construct water and P balances. The Soil Phosphorus Storage Capacity (SPSC) of the ASDA was also quantified. The P inflow to the ASDA was 12.93 Kg while the outflow was 20.13 Kg. The inflow and outflow P concentrations ranged from 22.92 to 132.63 ppb and 21.93 and 332.00 ppb, respectively. The N and P treatment efficiencies of the ASDA were 15% and -55%, respectively. The negative P treatment efficiency was mainly due to TP concentration of 332 ppb in one outflow sample. If this sample was to be considered an anomaly and replaced with the average outflow concentration, the treatment efficiency would be 31.28%. The measured SPSC value for the ASDA was negative (-2.39 mg/Kg) indicating that the soil within the ASDA could be a source of P by releasing the soil adsorbed P into the water column. Another factor that may have caused negative P treatment efficiency is lack of one full year of data, since P inflows for the early part of the wet period (July, 2008) may have been temporarily stored and discharged later after the monitoring started in August, 2008. Several enhancements such as modifying the topography and flow pathways to reduce short circuiting and harvesting and use of biomass from the ASDA were identified for increasing the treatment efficiency of the ASDAs.

**Storm Response to Barrier Island Restoration in Southeast Louisiana - Alison Sleath Grzegorzewski**, USACE Engineer Research & Development Center, Vicksburg, MS (co-authors: Mary Cialone, Tate McAlpin,)

Natural landscape features such as barrier islands have the potential to create frictional and bathymetric resistance and affect storm surge and wave energy even when submerged. Numerical modeling was employed in this study in order to evaluate the benefits associated with barrier island restoration in terms of storm protection. Results from this modeling study support the use of barrier islands as a first line of defense against hurricane impacts. There is growing consensus among scientists involved with hurricane risk that future risk reduction projects must include plans to sustain or enhance surrounding natural

landscapes (USACE 2006), such as barrier islands. Understanding the interaction between hurricanes and coastal landscapes is fundamental in planning hurricane flood protection systems and reducing risk. While a qualitative understanding of these interactions is available in scientific literature, quantifying these interactions with numerical models is a new approach and an area of active research that suffers from a lack of quality field and laboratory data. In order to evaluate the restoration of barrier islands in terms of the storm protection they offer inland, numerical modeling was employed to quantify the storm surge and wave response to three scenarios (existing conditions, degraded, and restored). The modeling scenarios represent a potential result of natural and anthropogenic alteration of barrier island topography and bathymetry in Southeast Louisiana. This study extended the work of Grzegorzewski et al. (2009) to focus on the benefits associated with barrier islands in altering the time history and magnitude of storm surge for inland marshes in Southeast Louisiana. Results indicate that the restored barrier islands have the potential to reduce the magnitude of storm surge by 5 to 25%. The storm surge reduction that barrier islands provide is spatially variable and non-linear, and it is strongly dependent on the storm characteristics and the scale of the restoration.

**Understanding Rural Water Systems in Developing Countries: Environment, Economics, & Policy - Nick Stacey**, Lafayette College, Easton, PA (co-authors: Lindsay Weir, Anya Abseen, Ting Chiu, Sharon Jones)

Water is a vital resource. The production, treatment, and distribution of water, as well as the ultimate management of the resulting wastewater are some of the biggest challenges of the twenty first century. To maintain sustainable water infrastructure in rural communities in developing countries, attention must be paid to the environmental and economic inputs and outputs of such systems, as well as the policy context. Unfortunately, a review of published studies regarding water systems shows that the focus is primarily on urban centralized systems. Centralized water-wastewater infrastructure accounts for 94% of urban water provision, and 86% of urban wastewater management systems globally. Although urbanization is increasing globally, 53% of the world's population still lives in rural areas that often do not have centralized water systems, and employ very different approaches to system management. The lack of data for rural systems in developing countries means that it is difficult to develop policies to improve sustainability. And, it is these rural villages that have the least resources for providing sustainable water-wastewater infrastructure. In this paper, we extrapolate from a combination of published data for urban systems in developed countries, rural systems in developed countries, and urban systems in developing countries, to develop a conceptual snapshot of the environmental, economic, and policy issues for rural water-wastewater systems in developing countries.

**Development of a Detailed Customer Water Demand Database - Shawn Stoddard**, Truckee Meadows Water Authority, Reno, NV

Only a few water utilities have developed detailed databases of customer water use information that is in an analysis ready form. A water utility's billing system generally has large volumes data about customer's bills, payment history, amount of water used, however, this information often requires considerable time and resources for use in any statistical study, such as a water demand study. A case is made for pro-actively developing a load research database of customer water use information that is in a form ready for statistical analysis. The Truckee Meadows Water Authority has developed such a database and has seen many benefits in the areas of resource planning, cost of service studies, finance and rate design, engineering, and customer service. The database developed maintains monthly customer water used, property information from the County Assessor's records, and ties to the utility's facilities using GIS. This presentation outlines types of data stored, development process, and examples of the benefits received.

**Rainfall and Land Use Effects on Water Quality in the Florida Intracoastal Waterway - Jessie Taft**, BCI Engineers and Scientists, Jacksonville, FL (co-author: Sarah Setiz)

Surface water samples were collected monthly, from May 2006 to May 2009, at fourteen sites in the Intracoastal Waterway of St. Johns and Flagler counties in Florida. Sites were located between C.R. 210 south to S.R. 100 in Flagler County. All samples were analyzed for total and fecal coliform. Field parameters and lab analysis of water quality at each site were also determined. Coliform levels in these areas are of particular importance due to the amount of shellfish harvested here. Because shellfish harvesting areas can be closed based on daily average rainfall in order to reduce the risk of shellfish borne illness, coliform levels during the sampling period were compared to rainfall for each site. Spikes in

coliform levels were typically consistent with increased rainfall. Coliform levels were also highest, as expected, in areas with large percentages of residential, commercial, and industrial land uses. Based on our findings, it was also determined that areas that had been previously categorized as restricted for shellfish harvesting by the Bureau of Aquaculture Environmental Services, actually met the National Shellfish Sanitation Program coliform standards for approved harvesting areas for extended periods. The monitoring of these sites is still taking place and is scheduled to continue with no end date set. This poster is intended to present data that will spark interest in the methods used to determine the categorization of shellfish harvesting areas, as well as question if adequate monitoring is being enforced to make these determinations.

### **Correlation of Nutrients/Salts with Animal Confinement Land Uses Within the Central Valley**

**(California) - Melissa Turner**, Michael L. Johnson, LLC, Davis, CA (co-authors: Stephanie Henderson, Michael Johnson)

The Central Valley Irrigated Lands Regulatory Program (ILRP) was established in December 2002 and required that any agricultural operation with discharge file for either an individual discharge permit or join a coalition. Coalitions were formed across the Central Valley in California in 2003 and water quality monitoring began within the various coalition regions in 2004. Water quality parameters included a small set of pesticides, pH, dissolved oxygen, electrical conductivity, temperature, physical parameters (including total dissolved solids and turbidity), bacteria (*E. coli*) and water column and sediment toxicity. In 2006, the Coalitions began monitoring for additional constituents including total metals and nutrients. Two Coalitions, the East San Joaquin Water Quality Coalition and the San Joaquin County Delta Water Quality Coalition, have many subwatersheds that are dominated by dairies, feedlots and poultry facilities. Many of the current water quality issues documented within these subwatersheds are difficult to source to either agriculture or animal confinement operations based on water quality data alone. A simple way to determine sources other than costly isotopic analysis is to utilize current GIS land use layers in association with available monitoring data. Water quality data collected from 2006 to 2008 for nitrate, nitrite, nitrate+nitrite, ammonia, total Kjeldahl nitrogen, phosphorous, orthophosphate, total dissolved solids and electrical conductivity were evaluated in comparison to GIS land use information for animal confinement facilities. Water quality and land use data were integrated to evaluate relative contributions to current water quality impairments. Results suggest an imperfect link between current land use and water quality data suggesting that multiple sources (including historical land uses that have affected groundwater) may be contributing to the current water quality impairments.

### **Focused Management Practice Outreach Based On Water Quality Monitoring and Pesticide Use**

**Data - Melissa Turner**, Michael L. Johnson, LLC, Davis, CA (co-authors: Michael L. Johnson, Francisca Johnson)

Dry Creek @ Wellsford Rd (23,339 irrigated acres) is a watershed within the northern part of the San Joaquin Valley (California). It receives runoff from a combination of field crops, deciduous nuts, and vineyards. Dry Creek originates in the Sierra foothills to the east of Modesto and drains into the Tuolumne River. This base of the watershed samples Dry Creek at the furthest downstream location that collects agricultural drainage prior to flowing through the urban areas of Modesto. Dry Creek has been monitored by the East San Joaquin Water Quality Coalition (ESJWQC) since 2005 under the Central Valley Regional Water Quality Control Board Irrigated Lands Regulatory Program (ILRP). This watershed is currently under a Management Plan for chlorpyrifos, copper, diuron, water column toxicity, sediment toxicity, dissolved oxygen, *E. coli* and pH. The ESJWQC Management Plan describes how the Coalition will source water quality exceedances, conduct outreach to Coalition members regarding water quality impairments and management practices, encourage the adoption of additional/new management practices and evaluate water quality improvements after new management practices have been implemented. To aid the Coalition's outreach efforts, an analysis was conducted evaluating water quality data (exceedances and detections), pesticide use, and proximity of parcels to the creek to determine which practices should be encouraged during outreach to members in the subwatershed. For chlorpyrifos, the regression of concentration of pounds AI applied per acre indicated a positive but non-significant relationship. There was no significant regression of chlorpyrifos concentration on total pounds of active ingredient applied. Consequently, outreach efforts have focused on contacting individual growers along Dry Creek for discussions about management practices to mitigate drift. The analyses conducted for copper suggests that management of copper should focus on providing information to specific growers

located adjacent to Dry Creek to encourage the retention of water and sediment on the fields, especially during the winter dormant season.

**Impacts of Climate Change on Water Management in the State of Washington, USA - Julie Vano,** University of Washington, Seattle, WA (co-authors: Nathalie Voisin, Marketa Elsnier McGuire, Alan Hamlet, Dennis Lettenmaier )

Reservoir systems throughout the western U.S. depend on mountain snowpack for springtime storage and refill. Climate change is expected to result in earlier snowmelt runoff and reduced summer flows, which will impact metropolitan water supply, irrigation, and hydropower production throughout the state of Washington. To better understand future changes, the Climate Impacts Group at the University of Washington conducted a statewide climate impacts assessment, released in 2009. The project used a range of climate change scenarios, produced as part of the 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), to drive land-surface models that simulate streamflow over the Pacific Northwest for the 2020s, 2040s, and 2080s for two emission scenarios. These streamflow predictions were then coupled to existing reservoir system models. We highlight how hydrologic changes affect irrigation and economics in the agriculture-rich Yakima River basin. Historically, the basin experiences substantial water shortages in 14% of years. Without adaptations, for A1B emission scenarios, projections indicate that water shortages increase to 27% (13% to 49% range) in the 2020s, to 33% in the 2040s, and 68% in the 2080s. For B1 emissions scenarios, shortages occur in 24% (7% to 54%) of years in the 2020s, 31% in the 2040s and 43% in the 2080s. From this work, we summarize both the advantages and challenges of the ensemble methods in representing uncertainty in future climate as it affects water resources planning and how, since the release of the report, this information is being used by water managers to adapt reservoir operations for future change. We specifically focus on what research tools might be further developed to better use climate change assessments in water resource planning.

**Induced Complexity: Early Results from a Floodplain Connection Project in Meacham Creek, Oregon - James Webster,** Umatilla Tribes, Pendleton, OR (co-authors: Scott O'Daniel, Michael Lambert, Eric Hoverson)

River channels and floodplains are linked elements of river ecosystems, and hydrologic inter-connections sustain geomorphic and ecological processes. However, many river channels and floodplains have been disconnected throughout the Columbia River watershed, prompting fisheries managers to consider floodplain reconnection to restore degraded aquatic habitats. Meacham Creek, a 400 km<sup>2</sup> tributary to the Umatilla River currently supports native bull trout and steelhead, along with restored spring chinook salmon. However, its lower alluvial reaches were channelized, cleared, and partially leveed beginning in the early 1900's for railroad construction. The hydrologic processes of Meacham Creek watershed are largely undisturbed, so its flow regime and sediment load are largely unimpaired. Thus the potential exists to restore lower Meacham Creek to a more complex, ecologically-productive condition if artificial constraints are removed. Toward this end, several levee setbacks and removals have been proposed along Meacham Creek to open access to adjacent floodplain areas and reduce concentration of flows in the main channel and allow geomorphically stable channel formation. Additionally, 175 whole conifer trees were added to the lower portion of the Meacham floodplain during the past several years in logjam complexes. We obtained detailed measurements of pre- disturbance channel conditions from 1938 aerial photographs and anticipate comparing those measurements with recent aerial photographs to document the project-induced changes. We anticipate a decrease in riffle habitat and low flow channel width. Alternatively, we anticipate increases in pool habitat, cumulative channel length, seasonal aquatic habitat and riparian vegetation. We expect results to suggest that significant and persistent reductions in river corridor complexity can be associated with floodplain disconnection, and provide an estimate of restoration potential for floodplain reconnection on streams like Meacham Creek.

**Statistical Downscaling Approaches in Analyzing Future Climate Change Impacts on Columbia River Basin - Susan Wherry,** Portland State University, Portland, OR (co-authors: Mohammad Reza Najafi, Hamid Moradkhani)

Climate change is now one of the most serious threats to our communities which may result in various economical, social and environmental problems. Water circulation pattern change is shown to be the result of climate change which results in higher intensity precipitation in some areas and drought in

others. Therefore the analysis of hydrological impacts of climate change is necessary. These studies are based on general circulation models' (GCMs) coarse scale results. Downscaling of GCM scenarios to assess future regional hydrological impacts are done utilizing regional climate models (RCM) or statistical approaches. Statistical downscaling methods are shown to be effective techniques in various regional hydrological studies; however more investigation is needed to improve their accuracy and efficiency to reduce uncertainty related to future predictions and better plan for water resource systems. In this study a procedure has been developed to statistically downscale GCM output to observed precipitation data (predictand) over some river basins in the Pacific Northwest (PNW). GCM data is retrieved from the HadCM3 model ( $2.5^{\circ} \times 3.75^{\circ}$ ) derived under IPCC climate change scenario A1 over the 1971-2000 time period. Potentially effective GCM predictors for the PNW's wet months of December, January and February are determined as those having high correlation with measured precipitation within the river basin. Principal Component Analysis (PCA) and Independent Component Analysis (ICA) are then used to determine the independent and uncorrelated signals within the GCM data. The independent components of the GCM data predictors are related to measured precipitation through support vector machine (SVM) modeling. Results show the usefulness and capability of ICA in input variable selection and also a good performance of SVM in downscaling precipitation.