American Water Resources Association
2009 SPRING SPECIALTY CONFERENCE
Managing Water Resources Development in a Changing Climate
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Monday, May 4
3:30 PM – 5:00 PM
Session 7: Regional Watershed Responses III

1. Analysis of the Combined Effects of Climate Change, Land Use, and Management Practices in a Chesapeake Bay Watershed - Paul Hummel, AQUA TERRA Consultants, Decatur, GA (co-authors: John L. Kittle, Jr., Tom Johnson)

Climate change presents a potential risk to the Chesapeake Bay Program's (CBP) water quality and living resources restoration goals. The CBP is interested in developing a better understanding of how climate change, together with other stressors including land use change, could impact proposed strategies for achieving nutrient and sediment reduction targets to meet water quality standards. Predictions of future climate at the local and regional scales required by water managers remain uncertain. Given this uncertainty, managers can best respond by developing management strategies responsive to the full range of plausible conditions and events. In this study we considered the integrated effects of climate and landcover change along with BMP implementations in the Monocacy River, a Chesapeake Bay subwatershed. The Monocacy is a 1,927 km^2 tributary to the Potomac River and Chesapeake Bay. Landcover is about 60% agriculture, 33% forested, and 7% urban. The assessment was conducted using new climate assessment capabilities developed for the HSPF watershed model in EPA's BASINS 4 system. We explored the general pattern of watershed response to projected climate changes for the years 2030 and 2090. For each year, model runs were made for 42 scenarios based on projected changes from 7 GCM models, 2 IPCC SRES storylines, and 3 assumptions about precipitation intensity changes. For 2030, changes in mean annual temperature ranged from 0 to 10oF and annual precipitation from -10 to +20 percent. For 2090, temperature changes ranged from 4-15 oF and annual precipitation from -15 to 15 percent. Endpoint responses showed a wide range of variability, with decreases in mean streamflow and 7Q10 low flow, increases in the 100-yr flood, and a mixed response for sediment, phosphorus, and nitrogen loads. Projected land use and management practice changes were combined with the climate change scenarios to explore the impacts of future development. Similar trends to the climate scenarios were seen in the future land use scenarios, with reductions in high impact agricultural lands leading to reduction in sediment and nutrient loads. Given the substantial number of model runs required, BASINS scripts were used to automate pre- and post-processing tasks and perform model runs.

2. Watershed Scale Response to Climate Change: Sprague River Basin, Oregon - John Risley, U.S. Geological Survey, Oregon Water Science Center, Portland, OR (co-authors: Lauren Hay, Steve Markstrom)

The U.S. Geological Survey Global Change study, "An integrated watershed scale response to climate change in selected basins across the United States," began in 2008. The long term goal of this study is to provide the foundation for hydrologically based climate-change studies across the nation. Fourteen basins for which the Precipitation Runoff Modeling System (PRMS) had been calibrated and evaluated were selected as study sites. PRMS is a deterministic, distributed-parameter, watershed model developed to evaluate the effects of various combinations of precipitation, temperature, and land use on streamflow and general basin hydrology. PRMS results for the Sprague River basin in Oregon are summarized below. Six General Circulation Models (GCMs) incorporating three climate change scenarios were used to develop an ensemble of climate change inputs to PRMS. Although, the climate change projections for 2001–2099 showed a wide range of variability between the GCMs, which would indicate a large amount of uncertainty, the central tendency lines showed an overall increase in temperature (2 to 3 degrees Fahrenheit) and a slight increase in precipitation over the 21st century. Using these data as model input, simulated streamflow output from PRMS for the Sprague River indicate increased flooding earlier in the spring and decreased summer baseflow as a consequence of increased and decreased proportions of rainfall and snowfall, respectively. Supplying approximately 25 percent of inflow to the Upper Klamath Lake, the Sprague River basin is vital to environmental and human water needs within the Klamath River basin. As water demands increase, the reliability and timing of flow from the Sprague River becomes increasingly critical in water-management decisions. Potential alterations in flows to the Upper Klamath Lake as a result of climate change could necessitate (1) modifications to the operation of the lake as a storage reservoir and (2) creation of additional storage capacity to meet water demand during the summer.

3. Assessing Climate-Change Impacts on the 2-Year Flood in Selected Basins Across the United States: A Probabilistic Approach Using Ensembles of Climate Model Predictions - John Walker, U.S. Geological Survey, Middleton, WI (co-authors: Michael D. Dettinger, Lauren E. Hay, Stephen L. Markstrom)

General circulation model (GCM) simulations of future climates represent subsamples from the universe of likely future conditions. To determine the sensitivity and variability of the freshwater resources of the United States in the face of current climate-change projections, simulated hydrologic responses in basins from 17 different hydroclimatic regions have been studied recently by the U.S. Geological Survey project "Integrated watershed scale response to climate change in selected basins across the United States." The Precipitation Runoff Modeling System (PRMS) model was applied in each of the 17 basins. Rather than attempting to choose a most likely scenario from the results of the Intergovernmental Panel on Climate Change, an ensemble of climate simulations from 6 models under 3 emissions scenarios each were used to drive the basin models. Climate change scenarios were generated for PRMS by modifying historical precipitation and temperature inputs; mean monthly climate change was derived by calculating changes in mean climates from current to various future decades in the ensemble of climate projections. Empirical orthogonal functions (EOFs) were fitted to the ensemble of climate projections, and provided a complete basis for randomly (but representatively) generating realizations of future climates. Hydrologic responses to 10,000 realizations of future climate conditions were simulated with the PRMS watershed model. For each realization, the 2-year flood was calculated to represent a flow important for sediment transport and channel geomorphology. The empirical probability density function (pdf) of the 2-year flood was estimated using the results across the realizations, for each basin. Results from the 17 basins across the United States indicate the impact of climate change on the 2-year flood is highly variable. To illustrate the utility of this approach, we used the empirical pdf of the 2-year flood to form a probabilistic characterization of potential impacts of climate change on flood flows.

4. Monitoring Headwater Streams for Landscape Response to Climate Change - Matt O'Connor, O'Connor Environmental, Inc., Healdsburg, CA

Characterization and monitoring of headwater channel systems within regions and across regions is a strategy that can be used to detect geomorphic manifestations of climate change at the hillslope scale. Headwater streams (first order streams) are closely linked to upland hillslopes and their morphology reflects hydrologic conditions and the influence of land use, vegetation and climate on runoff and erosion processes. In addition, these streams represent a very large proportion of channel networks within watershed systems, and are known to be an influential source of productivity in aquatic ecosystems. Headwater streams are likely to be more suitable monitoring subjects than larger streams because they are relatively sensitive to changes in hydrologic conditions over short time scales. Processes influencing the development of the channel head (the uppermost point in a first order stream), and the erosion, extension, enlargement and retreat of incipient channels (linear zones of concentrated water flow at or near the surface), are sensitive to the balance of erosion and deposition processes in the vicinity of the channel head. Erosion and deposition processes in the channel (e.g. channel incision) are in turn modulated by hydrologic conditions on adjacent hillslopes, with potential feedback on water table conditions and local soil/plant ecosystems. Hydrologic conditions may be altered by changes in climate or land use that affects precipitation, vegetation and soil characteristics. Such hydrologic changes have the potential to affect geomorphic processes at the channel head and in incipient channels. Characterizing and monitoring of headwater drainages requires development of innovative techniques capable of addressing high natural variability. Recent investigations in northern California addressing potential impacts of timber harvest and forest land conversion to agriculture provide case studies demonstrating available technology and analytical techniques. The use of LiDAR, GPS, high accuracy ground surveys and GIS tools are considered.