SIERRA NEVADA CLIMATE CHANGE AND WATER RESOURCES WORKSHOP

JUNE 3, 2009 8:00AM – 3:00PM

UC DAVIS ALUMNI CENTER – FOUNDERS BOARD ROOM

HTTP://HYDRA.UCDAVIS.EDU/WORKSHOP

Agenda

Introductions:	8:00 – 8:20
Introductory Talk – Jeff Mount	8:20 – 8:40
Hydrologic Modeling – David Purkey and Chuck Young	8:40 – 9:10
Alteration and Vulnerability – Josh Viers	9:10 – 9:40
Review and Critique of IFIM/PHABSIM – John Williams	9:40 – 10:10
Break	*10:10 – 10:30*
Temperature Modeling – Mike Deas and Stacy Tanaka	10:30 – 11:00
Temperature Impacts – Sarah Null	11:00 – 11:30
Ecological Conceptual Model – Sarah Yarnell	11:30 – 12:00
Hydropower Operations – David Rheinheimer	12:00 – 12:30
Working Lunch with short film	*12:30 – 1:15*
State of Relicensing – Richard Roos-Collins	1:15 – 1:45
Climate Change Management – Steve Rothert	1:45 – 2:15
Concluding Statements – Dave Steindorf	2:15 – 2:45
General Discussion and time for questions	2:45 – 3:00

Abstracts

INTRODUCTION

PROFESSOR JEFF MOUNT

Climate warming is occurring on a global scale, and regional climate models are now beginning to demonstrate precipitation and air temperature changes which are likely to occur in specific regions. However, the potential consequences of climate change for current water uses are not well understood. There is little synthesis relating how regulated systems might be impacted, and what these changes mean for current resource use. For this reason, climate change is often excluded from future planning scenarios at the regional level. This research seeks to bridge the gap between regional climate change modeling and regional management planning, particularly as it relates to hydropower generation.

For this project, climate warming alternatives (air temperature increases of 2º, 4º, and 6ºC) were modeled for 15 west-slope watersheds in the Sierra Nevada Mountains under unimpaired conditions and with current infrastructure to increase understanding of potential changes regarding precipitation, hydrology, water temperature, and aquatic ecology. Results highlight which watersheds are most resilient to climate change, as well as possible operational and infrastructure changes to maximize human and environmental benefits, such as hydropower generation, water supply, flood control, recreation, ecosystem services, and ecosystem functioning. This research will help the Sierra Nevada region plan for likely climate changes occurring in coming decades.

REGIONAL PROCESSES

HYDROLOGIC MODELING

DRS. DAVID PURKEY AND CHUCK YOUNG

Using the Water Evaluation Assessment Planning software (WEAP21), subcontractor Stockholm Environment Institute (SEI) developed calibrated, functioning rainfall-runoff models for each Sierra Nevada watershed, wherein specific “management points” or locations within watersheds can be queried to determine flow for a given time under specific climate conditions. Models were calibrated using existing hydrological data for the 1981-2000 period, and scenarios were developed for air temperature increases of 2°, 4°, and 6° C. No other climatic variables were changed from observed values.

Initially developed in previous efforts, the WEAP21 implementation was improved with an explicit Quality Assurance / Quality Control procedure. Models were checked for internal consistency, and evaluated for key parameter sensitivity. Each modeled basin was independently calibrated, and analysis focused on the relationship between modeled weekly and observed daily hydrographs to determine which critical hydrological components were affected. This expanded exercise resulted in improved and finalized hydrological models for the major basins. The results of the calibration process are currently in review as submitted to *Journal of the American Water Resources Association*, and reflect model fits to unimpaired stream gages.

ALTERATION AND VULNERABILITY

DR. JOSH VIERS

An Index of Hydrologic Vulnerability (IHV) was developed using hydrographic output from the WEAP21 models to gauge vulnerability of streams to climate warming. This index readily identifies rivers and streams at greatest risk from climate warming using ecologically meaningful metrics such as changes in peak flows and duration of low flow, and also allows identification of general trends across the Sierra Nevada, such differential impacts by elevation or latitude. Vulnerability was defined as a measured negative departure from existing conditions using five key metrics. The overall IHV score is comprised of low flow duration, mean annual flow, slope of recession limb, centroid timing, and ratio of annual maximum to minimum flows. These metrics are ecologically meaningful, broadly representative of flow conditions, easily calculated, and largely independent of one another. The vulnerability to hydrologic alteration was calculated for each location and each year of the model domain. Using a 20-year mean, each metric value was standardized and then averaged to single score.

A preliminary analysis of IHV shows that vulnerability of Sierra Nevada streams to climate warming generally increased with greater elevation and latitude. Under 2^{o} C warming, accentuation in vulnerability scores was observed at mid-elevation areas where current snowpack was greatly reduced or absent. Surprisingly, this relationship was not seen in the scenarios with greater warming. In fact with 6^{o} warming, there was significant variability in the results of mid-elevation areas, although high elevations showed greatest vulnerability. As expected, results consistently showed northern Sierra Nevada watersheds were more vulnerable than southern under all climate warming scenarios, although this relationship diminished with greater warming.

REVIEW AND CRITIQUE OF IFIM / PHABSIM

DR. JOHN WILLIAMS

Examine various methods for assessing environmental flows in relation to their applicability to FERC relicensing in California. Specifically seek to provide insight to environmental flow assessments, such as IFIM (i.e., PHABSIM). This includes discussion of the need for field-based evaluation of select methods to evaluate flow assessment techniques and their efficacy in the unique hydrologic and ecologic conditions of California. The goal of this segment is to initiate a discussion on the effectiveness of instream flow methodologies.

WATER TEMPERATURE MODELING AND IMPACTS

TEMPERATURE MODELING

DRS. MIKE DEAS AND STACY TANAKA

Watercourse Engineering, Inc. developed RTEMP, a numerical model representing equilibrium water temperature conditions for streams and reservoirs in Sierra Nevada watersheds to assess possible impacts of climate change on water temperature. This modeling tool includes elevational differences and current water infrastructure and facilities, so that the impacts on water temperature from these facilities can be assessed. RTEMP works in conjunction with WEAP21 to evaluate the feasibility of grouped hydropower re-licensing, as well as other measures to mitigate or adapt to climate change conditions. The water temperature theory and modeling work presented represents an initial foray into a challenging arena of thermal assessment: large scale impacts related to large scale processes, such as climate change, over the Sierra Nevada Mountains region.

TEMPERATURE IMPACTS

DR. SARAH NULL

River water temperatures may be affected by increasing levels of climate warming in west-slope Sierra Nevada watersheds. Climate warming alternatives examined include baseline meteorological conditions, and increases of 2ºC, 4ºC, and 6ºC to air temperature. Water temperature predictions for unimpaired and climate warming alternatives were estimated using a weekly one-dimensional hydrologic model (WEAP21) and an equilibrium water temperature model (RTEMP) for fifteen major watersheds of the western Sierra Nevada. Watersheds and stream reaches where water temperature was most impacted by climate warming were identified, as well as thermal variability within watersheds. Model results were also analyzed to highlight water temperature resiliency, including contributing factors such as elevation, latitude, baseflow, drainage area, and stream order.

LOCAL PROCESSES

ECOLOGICAL CONCEPTUAL MODEL ON RECESSION LIMBS

DR. SARAH YARNELL

The snowmelt hydrograph spring recession limb is likely instrumental to general stream ecology; however little literature exists on this topic. The general ecology of the snowmelt hydrograph spring recession limb is first described and explained. Discussion then includes a conceptual model showing the relationships between a stream ecosystem and the flow regime, how shifts in the dimensions of the recession limb impact various aspects of the stream ecosystem, and examples specific to species of concern in the Sierra Nevada. General recommendations for restoring recession limb dynamics to regulated systems are also provided.

HYDROPOWER OPERATIONS AND SIMULATION

DAVID RHEINHEIMER

Efforts are currently underway to simulate hydropower-related infrastructure operations in 15 watersheds of the western Sierra Nevada under different climate warming scenarios. Current efforts and progress are presented, including models for the Feather, Stanislaus, and Tuolumne Rivers, as well as previously-developed models of the Cosumnes, American, Bear and Yuba Rivers (CABY). The models simulate reservoir releases and hydropower production operations to determine water flow rates with increasing climate warming. This presentation includes a review of the models, their development, and an optional hands-on computer exercise to demonstrate how to make changes to the infrastructure operations.

POLICY

The recent decision by the U. S. Federal Energy Regulatory Commission to reject studies of climate change in its consideration of reoperation of the Yuba-Bear Drum-Spaulding hydroelectric facilities in northern California poses a unique opportunity to explore a range of legal and political issues related to FERC and Integrated Licensing Process (ILP). Foremost, we now know that the impacts of global climate warming to the Earth's hydrological regime include changes in the spatial and temporal distribution of precipitation patterns, and its intensity and extremes; widespread melting of snow and ice; increased rates of evaporation and transpiration; and changes to soil moisture and runoff fluxes. Within the regional context of western North America, we have observed a shift in the seasonality of snow-melt runoff, as well as long-term trends to California's larger rivers. Further, California's climate is expected to warm by 2 to 6^{o}C over the next 50 to 100 years, with reduced snowpack, earlier runoff, and diminished spring and summer flows. Recent studies of Sierra Nevada water resources under climate warming suggest that these general climatic and hydrologic changes will result in substantial changes in the timing, magnitude, duration, and frequency of flows, posing significant challenges to hydropower operations. Thus, we ask the question, "if not now, then when?" Moreover, we ask what are the other approaches and avenues to addressing this and other shortcomings of the ILP.

STATE-OF-RELICENSING

RICHARD ROOS-COLLINS

HOW TO GET CLIMATE CHANGE INTO REGIONAL MANAGEMENT MODELS

STEVE ROTHERT

CONCLUDING STATEMENTS

DAVE STEINDORF

Perspective of American Whitewater Association (California Hydropower Reform Coalition)

POSTERS

UNIMPAIRED RECESSION LIMB DYNAMICS – GERHARD EPKE

SIERRA NEVADA MONTANE MEADOWS – CLAIRE STOUTHAMER

FERC ILP SURVEY – NATHAN WEAVER

HYDRA WEBSITE – SHANNON BROWN