Division of Hydrologic Sciences
Annual Technical Report
FY 2004

Introduction

Research Program

Quantifying Potential Economic Impacts of Water Quality Modeling Uncertainty for the Lower Truckee River, Nevada

Basic Information

Title:	Quantifying Potential Economic Impacts of Water Quality Modeling Uncertainty for the Lower Truckee River, Nevada
Project Number:	2003NV41B
Start Date:	3/1/2003
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	02
Research Category:	Water Quality
Focus Category:	Water Quality, Economics, Models
Descriptors:	
Principal Investigators:	Alan McKay, Alan McKay

Publication

1. Kish, S.M., J. Bartlett, J.J. Warwick, A. McKay, and C. Fritsen. Submitted. "A long-term dynamic modeling approach to quantifying impacts of non-point source pollution in the lower Truckee River, Nevada," Journal of Environmental Engineering, ASCE.
2. Warwick, J.J., S. Kish, J. Bartlett, W.A. McKay, and C. Fritsen, 2004. "Modeling Linkages between Groundwater, Surface Water and Periphyton-Driven Oxygen Dynamics in the Lower Truckee River, Nevada," Annual Conference of the American Water Resources Association, Orlando, Florida, November 1-4.

Problem and Research Objectives

Because dissolved oxygen (DO) is essential to aquatic life, it is important that DO concentrations do not drop too low. Periphyton, or algae attached to the substrate, produces oxygen via photosynthesis and uses up oxygen during cellular respiration, and the result is diel swings in dissolved oxygen concentrations. Periphyton growth is controlled largely by nutrient (nitrogen and phosphorous) availability, meaning that nutrient concentrations indirectly impact DO concentrations by influencing the amount of periphyton biomass. This study aims to refine an existing water quality model to more accurately predict the concentrations of a suite of water quality constituents, including dissolved oxygen, on the lower Truckee River, Nevada. Using this refined model, several hypothetical scenarios are modeled to determine how changes to nutrient loads impact daily minimum DO concentrations. Uncertainty analysis is then used to assess the influence of model boundary condition uncertainty on model predictions.

Methodology

All water quality modeling in this study are computer simulations using a modified version of the U.S. Environmental Protection Agency's Water Quality Analysis Simulation Program, Version 5 (WASP5). While there are too many model inputs and parameters to list, they include a flow balance derived from USGS stream gages, water quality data provided by the Truckee Meadows Water Reclamation Facility (TMWRF), and rate coefficients provided by previous studies on the Truckee River. Hypothetical scenarios are modeled by adjustment of flows and nutrient loads. Uncertainty analysis is employed to quantify the impacts of boundary condition uncertainty on model predictions. More specifically, this analysis will be done using Monte Carlo techniques, and the quantification will be achieved by developing probabilistic confidence intervals around model predictions.

Principal Findings and Significance

<u>Work Completed to Date</u>

This study began with the refinement of an existing long-term, dynamic water quality model for the lower Truckee River. Changes were made in order to reduce error between model predictions and observed data. Predictions from the refined model and observed data both show the Truckee River failing to meet the minimum dissolved oxygen standard prescribed by the Nevada Department of Environmental Protection. Hypothetical scenarios were then modeled to predict the impacts of nutrient removal on periphyton biomass and DO concentrations. A model simulating the removal of a permit discharge excursion from TMWRF and a separate model simulating removal of agriculture nutrient loads both predicted that the dissolved oxygen standard would not be met at all locations in the modeled reach at all times in the model domain. It was eventually determined that the inability of the river to meet the DO standard was a result of low flows. A final scenario set a minimum upstream flow, which was increased until the dissolved oxygen standard was met at all locations at all times. These results suggest that simply decreasing nutrient loads, be it through the removal of the discharge permit excursion or via the removal of agricultural nutrient loads, would still not cause the prescribed dissolved oxygen standard to be met at all times. Instead, these findings indicate that a minimum flow must be maintained in order for the Truckee River to continuously meet the standard.

Work Remaining

Remaining work consists of implementing a Monte Carlo approach into the existing model to perform uncertainty analysis. Calculations indicate that the upstream organic nitrogen boundary condition is the model's most important boundary condition, so uncertainty analysis will first focus on determining how uncertainty in upstream organic nitrogen concentrations affects model predictions of other constituents, particularly dissolved oxygen. Another significant source of model uncertainty is the effect of irrigation ditch returns, as nutrient loads from these largely unmonitored ditches are not well known. Additional uncertainty analysis will focus on these ditch returns to determine their influence on predicted concentrations of constituents in the river. As mentioned previously, uncertainty analysis will result in confidence intervals around model predictions. Large confidence intervals show a great deal of uncertainty in model predictions and might indicate that more data is required in order to properly model water quality in the lower Truckee River. Small confidence intervals, on the other hand, indicate more certainty in model predictions and might suggest that additional or more frequent sampling is not necessary.

Small Scale Variability of Soil Ped Hydraulic Properties: Potential Impact on Soil Recharge and Ecosystems

Basic Information

Title:	Small Scale Variability of Soil Ped Hydraulic Properties: Potential Impact on Soil Recharge and Ecosystems
Project Number:	2004NV65B
Start Date:	3/1/2004
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	Nevada 01
Research Category:	Climate and Hydrologic Processes
Focus Category:	Hydrology, Geomorphological Processes, Drought
Descriptors:	
Principal Investigators:	Michael Young, Eric McDonald

Publication

1. Meadows, D.G., M.H. Young, E.V. McDonald. 2005. A laboratory method for determining the unsaturated hydraulic properties of soil peds. Soil Sci. Soc. Am. J. 69:807-815.
2. Meadows, D.G., M.H. Young, E.V. McDonald. 2005. Hydraulic property determination of vesiculated soil peds in desert pavement environments. W-188 Soil Physics Research Group Meeting. Las Vegas, NV, Jan. 3-5, 2005.
3. Meadows, D.G., M.H. Young, E.V. McDonald. 2004. Hydraulic properties of individual soil peds, Mojave Desert, CA. Soil Science Society of America 68th Annual Meeting, Seattle, WA, Oct. 31-Nov. 4, 2004.
4. Young, M.H., D.G. Meadows, D. Gimenez, R.J. Heck, T.R. Elliot. 2004. Dynamic behavior of pore morphology using CT scanning preliminary results. Soil Science Society of America 68th Annual Meeting, Seattle, WA, Oct. 31-Nov. 4, 2004.
5. Prim, P.S., D.G. Meadows, M.H. Young. 2004. Determination of interped flow and surface sealing through infiltration experiments on a 100 kA desert pavement. Geological Society of America Annual Meeting, Denver, CO, Nov. 7-10, 2004.

Problem and research objectives

Spatial variability of soil properties has significant impacts on desert ecosystems that are highly water limited. Coupling that observation with the fact that the southwestern United States has been experiencing significant drought conditions for the past several years, we are left with the need to better understand how water moves through the upper soil surface and into the deeper horizons, particularly in highly structured desert pavement environments. These surfaces are common throughout the arid southwestern United States. Understanding the evolution of the hydraulic properties of these surfaces that result from the pedologic development over time has implications for the mechanisms, frequency, and depth of recharge events, and how those events could influence plant ecosystems, deeper soil recharge, and potential recharge to groundwater supplies.

Methodology

In this study, we compare the hydraulic properties derived from tension infiltrometer experiments conducted in the field with the average hydraulic properties of the individual soil peds that comprised the area of the field experiment. This approach facilitates investigation of the interped cracks that separate the individual soil peds on the soil surface. The field infiltrometer samples both ped and interped areas, and the laboratory method samples only the peds themselves. Therefore, the method provides a means to quantify the potential water flow through these preferential flow pathways. The laboratory method for determining the hydraulic properties of individual soil peds is novel and is based on traditional evaporation experiments. Experiments were conducted on three different aged desert pavement surfaces in the Mojave Desert.

Principal findings and significance

We developed a new laboratory method for determining the hydraulic properties of individual soil peds (Meadows et al., 2005). We show a large amount (2 orders of magnitude) of interped variability in the hydraulic properties over 20 cm. We also show that infiltration into the soil is dominated by the interped cracks on the older surfaces when conditions are near saturation. These interped cracks could act as preferential flow pathways, increasing deep percolation and potential recharge. A transition in the dominant mechanism of infiltration appears to vary with the age of the surface. For example, as the surface ages, the interped area becomes more defined, changing the hydraulic properties of the bulk soil. This is likely caused by an increase in the clay content (perhaps eolian deposited but also weathered from parent material), which causes an increase in shrink/swell activity. Work is continuing to more fully explain these preliminary findings.

Development of a Classification System for Natural Impervious Cover in the Lake Tahoe Basin

Basic Information

Title:	Development of a Classification System for Natural Impervious Cover in the Lake Tahoe Basin
Project Number:	2004NV67B
Start Date:	3/1/2004
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	Nevada 02
Research Category:	Water Quality
Focus Category:	Models, Water Quality, Geomorphological Processes
Descriptors:	
Principal Investigators:	Mary Cablk

Publication

No progress to report.

Information Transfer Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	1	0	0	0	1
Masters	1	0	1	0	2
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	3	0	1	0	4

Notable Awards and Achievements

Publications from Prior Projects