## H41D MCC: Level 2 Thursday 0830h

### Influence of Hydrologic and Geomorphic Processes on Surface Water Quality I Posters *(joint with T)*

***Presiding:*** **T Meixner,** University of California, Riverside**; A I Packman,** Northwestern University

#### H41D-1023 0830h POSTER

### Fluid Velocity, Particle Penetration, and Permeability Reduction in Clogging Porous Media

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Colloids depositing in porous media cause significant permeability reduction, which is relevant in groundwater remediation, aquifer storage and hydroseismicity. It is well known that permeability depends on soil chemistry, which influences deposit morphology. However, the effect of hydrodynamics on deposit morphology has received less attention; efforts to describe this relationship in constant-flow column experiments have been confounded by the fact that higher fluid velocity causes deeper particle penetration and consequentially less clogging near the filter inlet. This poster describes an attempt to quantify the influence of fluid velocity on particle penetration and deposit morphology based on O'Melia and Ali's filter clogging model. Previous applications of this model have accounted for non-uniform deposition along the flow direction by considering segments in series. We propose an alternative approach by assuming that (1) O'Melia and Ali's clogging model is locally valid, and (2) the distribution of particles along the flow direction is exponential, as predicted by the classical filtration theory for clean beds. Integrating a differential head loss equation along the flow direction results in an expression for head loss at any point along the column that depends on two empirical factors: one that describes the characteristic distance of particle penetration, and one that describes the deposit morphology. The approach was applied to published data from three sources, representing a total of 29 filtration experiments, in which head loss was measured separately in the top section of the column. The imposed approach velocity in these experiments ranged from 6 to 480 m/d. Results confirm that increasing fluid velocity results in deeper particle penetration. However, the increasing penetration depth only partially explains the increasing permeability observed for a given mass of deposited particles, suggesting that deposit morphology also plays an important role.

#### H41D-1024 0830h POSTER

### River-floodplain Hydrologic Connectivity: Impact on Temporal and Spatial Floodplain Water Quality and Productivity Patterns

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Nutrient spiraling and cycling are critical processes for floodplain systems, but these have not been well studied in western North America. Floodplain production and function relies on the integrity of river-floodplain interactions, particularly during periods of hydrologic connectivity. The purpose of this study was to: (1) determine the importance of the timing and duration of river-floodplain hydrologic connectivity, (2) link flood event water quality to subsequent primary and secondary production, and (3) identify temporal and spatial patterns of floodplain production. The Cosumnes River watershed transports surface runoff and snowmelt from the Sierra Nevadas to the Sacramento-San Joaquin Delta. It is one of the few watersheds in California that has no major water diversions or impoundments; therefore the river responds to the natural watershed hydrology. The study site in southern Sacramento County is an unmanaged experimental floodplain, one of the few remaining floodplains in California. Weekly and flood-event water quality and macroinvertebrate sampling was conducted during the flood season from January through June in 2001 and 2002. Both water years were characterized by historically low river flows. On average, volatile suspended solids in the water column increased from 5 mg/l to 10 mg/l during early season periods of hydrologic connectivity (December - February), suggesting that during watershed flushing flood events, the river acts as a source of nutrients and organic matter to the floodplain. Following a flood event, invertebrate concentrations decreased on average from 26,000 individuals/m3 to 9,000 individuals/m3 for zooplankton and from 350 individuals/m2 to 65 individuals/m2 for benthic macro-invertebrate, suggesting a net dilution of invertebrates during flood events. Chlorophyll a (chl-a) levels were also diluted during flood events, on average from 25 ppb to 5 ppb. Zooplankton densities and chl-a levels quickly rose after flood events. On average, zooplankton densities and chl-a concentrations exceeded 150,000 individulas/m3 and 30 ppb respectively. However, as hydrologic residence time increased, chl-a levels decreased and were generally lowest following periods when macroinvertebrate population densities were highest, suggesting grazing pressure on planktonic algae. Total nitrogen to total phosphorous ratios (TN:TP) tended to be greater than 10 during periods of high hydrologic residence time, suggesting P limitation during periods of hydrologic disconnection, which coincides with the highest zooplankton densities and lowest chl-a levels observed. Following a flood event, TN:TP dramatically decreased, suggesting that during periods of river-floodplain connectivity, N tends to be the limiting nutrient. These data suggest that nutrients are replenished to the floodplain during periods of hydrologic connectivity, followed by periods of resource uptake and subsequent nutrient limitation. These patterns suggests that efforts directed towards restoration of river floodplain systems should attempt to reconstruct the naturally irregular and periodic connection cycle to enhance primary and secondary production.

#### H41D-1025 0830h POSTER

### The Effect of Geomorphic Complexity on Water Temperature in a Pacific Northwest Alluvial River

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Hyporheic exchange of ground and surface water is an important physical process that contributes to the habitat template of alluvial rivers and is known to increase thermal diversity within streams by creating localized or isolated pockets where water temperature is buffered. Although the Umatilla River in northeastern Oregon, USA once supported healthy populations of salmonids (trout, salmon, and charr), summertime water temperatures in the river are now stressful or lethal to salmonids, exceeding 26°C. Using funding from NASA, the Confederated Tribes of the Umatilla Indian Reservation are coordinating the Data Rich Decision Support Environment research project to study the hydrologic and thermal regime of the river. As part of that study, we are documenting the influence of near-channel hyporheic exchange on the river's thermal regime. We instrumented a variety of stream channel units (pools, riffles, spring channels, etc.) and gravel bars with more than 70 temperature loggers. These were used to describe the thermal diversity of the channel and hyporheic zone in geomorphically complex settings where hyporheic exchange is prevalent. The loggers were deployed over a 4-week period during July and August. To monitor surface water temperatures loggers were attached to rebar that was pounded into the stream bed. For monitor hyporheic water temperatures loggers were placed in piezometers set 15 cm to 2 m into gravels . A total station was used to survey bar and streambed topography along with the locations of the temperature loggers. Resulting data suggest that complex channel patterns and bed-forms create hydraulic gradients within the near-channel aquifer that enhance hyporheic exchange. In addition to creating the expected localized patterns of thermal diversity in the stream channel near upwelling water, our data suggest that the cumulative affect of geomorphically complex nodes within the river have the ability to buffer diel temperature variation in the main flow of the river. Thus, when daily maximum temperature occurs and fish are most stressed by warm water temperatures, hyporheic exchange creates cool pockets of water and appears to reduce peak temperatures throughout the river. Our results suggest that loss of geomorphic complexity within the river due to flood-plain development, large wood removal, and channel engineering (e.g., dredging and diking) may reduce the effect of hyporheic flow as an important temperature regulation mechanism throughout the river. Restoration of geomorphic complexity and the fluvial processes that create and maintain geomorphic complexity may be an important step in restoration of habitat for now beleaguered runs of salmon within the river.

#### H41D-1026 0830h POSTER

### Hyporheic Exchange With Complex Channel Morphologies

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While currently available hyporheic exchange models generally consider one- or two-dimensional transport, rivers with complex channel morphologies are expected to produce three-dimensional advective hyporheic flow patterns. Experiments were conducted in a large recirculating flume to observe exchange with naturally-formed alternate bar and meandering channel morphologies. The structure of the stream flow and channel topography were measured in detail, and the sediment properties were very well characterized. Because it is so difficult to make these types of measurements in conjunction with field tracer injection experiments, this represents a unique data set for assessment of hyporheic exchange with complex channel morphologies. A standard two-dimensional advective exchange model was initially used to analyze the experimental results. The two-dimensional model significantly underpredicted the observed exchange, clearly indicating the need for consideration of three-dimensional flows. Introduction of additional length scales to better characterize the channel geometry indicated that exchange occurred by means of three-dimensional pore water flows induced by head variations over the complex channel boundaries. The three-dimensional flow coupling and resulting hyporheic exchange can be analyzed by the application of a computational fluid dynamics code for the stream flow and subsequent application of a finite element model for hyporheic transport. Both models must represent the complex three-dimensional channel morphology.

#### H41D-1027 0830h POSTER

### Reliability of Groundwater Flow Models of the Hyporheic Zone of Small Mountain Streams

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Several recent studies have used numerical groundwater flow models to simulate exchange flows of stream water through the hyporheic zone. Physically-based groundwater flow models can provide quantitative predictions of the amount of exchange flow and the residence time distribution of that water in the subsurface - both of which help determine the effect of hyporheic exchange flows on water quality. However, reliability of these predictions have not been well validated. We ask the questions: 1) How reliable are hyporheic groundwater models in typical applications examining hyporheic exchange flows? and 2) How does the reliability change with increased data availability and model sophistication? We developed groundwater models of

the hyporheic zone for two mountain streams in the HJ Andrews Experimental Forest, Oregon. The models are based on geomorphology as quantified by surveyed topography, with saturated hydraulic conductivity conditioned to in-situ measurements from slug tests and observed water levels in more than 25 wells per stream. For each stream, we developed several models using different methods to estimate two of the most uncertain parameters - hydraulic conductivity and the thickness of the saturated alluvium. We tested the reliability of each model in predicting in-well tracer breakthrough data from injections of NaCl. We found that, for the two mountain streams, increased model sophistication does not necessarily lead to improved reliability, since the model with homogeneous hydraulic conductivity functioned almost as well as the heterogeneous models. However, while general trends in solute breakthrough were correct in the model, hydraulic conductivity data from even 25 wells was insufficient to characterize detailed arrival times accurately without conditioning conductivity to concentration data itself. This suggests that geomorphic data may be sufficient to predict water fluxes through the subsurface and approximate travel times. However, for detailed analysis of solute transport pathways and breakthroughs, intensive sampling of the subsurface may be necessary.

## H41D-1028 0830h POSTER

### Channel Morphology, Bed Forms and Aquifer Heterogeneity: Roles in 2-D and 3-D Analysis of Hyporheic Exchange Flows

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The effects of channel pattern, bed forms and aquifer heterogeneity on flow interactions between stream and groundwater systems are examined in this study. Two and three-dimensional approaches were used to determine the influence of stream meandering patterns and bed forms on the characteristics of stream-subsurface exchange. A grid with 180x256x30 (x, y, z) cells was designed using the correlation scales of the heterogeneous fields generated by the Turning Bands method and the scale of the stream meanders. MODFLOW and MODPATH were applied to evaluate magnitude, direction and spatial distribution of the exchange flow. Particle tracking was performed to define hyporheic residence time distributions. Even though the main purpose of the simulations is the analysis of three-dimensional surface-groundwater interchange in heterogeneous systems, the two-dimensional approach was also adopted to allow comparisons. The model is an idealized case intended to describe how properties of the streambed and aquifer in low-gradient lowland streams contribute to hyporheic exchange. A sine curve was built to represent the meandering stream with variations on wavelength and amplitude. The bed forms were simulated assuming a sinusoidal distribution of pressure head in the bed surface. Various amplitudes and wave lengths were used to cover a range of flow velocities between 20 and 40 cm/s in the channel. The objective is to show the influence of river morphology and the role of natural bed forms on the flow exchange in the hyporheic zone. Flow variances along the wetted perimeter and along transverse cross-sections of the stream were analyzed. Simulations with four meander cycles, four amplitudes and four levels of hydraulic conductivity variance show that as the heterogeneity variance increases so does the hyporheic exchange. Flow variance decreases as the number of meander cycles and amplitudes of the meanders increase. The results for travel time in the meandering stream show a substantially increased travel time between a homogeneous field and all degrees of heterogeneity. MODPATH simulations also showed that heterogeneity increases tailing in cumulative distribution functions of hyporheic residence times. Further simulations will provide additional insights on the role of geomorphic features in controlling hyporheic exchange processes.

## H41D-1029 0830h POSTER

### Geochemistry and isotope compositions of the Han River, South Korea : implications for water-rock interaction

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In order to investigate processes and factors controlling the chemical and isotopic compositions of the Han River, seasonal studies were carried out. The North Han River was much lower in the concentrations of total dissolved solids (TDS), dissolved inorganic carbon and major ions than the South Han River, but higher in SiO2 concentration, sulfur isotopic values of sulfates and Sr isotopic ratios. This indicates that the chemical and isotopic compositions of the Han River waters were strongly controlled by the geology of their drainage basins: silicate rocks in the North Han River and carbonate rocks in the South Han River. The oxygen and hydrogen isotopic values of the waters were higher in summer than in the other seasons, resulting from evaporation in the dams. The sulfur isotopic values of sulfates were relatively higher in the North Han River (5.90+/-1.46 per mil) than in the South Han River (3.48+/-0.73 per mil). This implies that dissolved sulfate in the North Han River might be derived from deposition of atmospheric sulfates, whereas in the South Han River from oxidation of sulfide minerals in the abandoned poly-metallic deposits and the sedimentary rocks distributed over the upstream as well as deposition of atmospheric sulfates. The Sr isotopic ratios in the North Han River were much higher than those in the South Han River, reflecting water-rock interaction with different rock types. This work was supported by a grant (3-2-1) from the Sustainable Water Resources Research Center of 21st Century Frontier Research Program.

## H41D-1030 0830h POSTER

### A Rock Glacier's Response to Climate and Influence on Water Quality in the Colorado Front Range

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Little research has been conducted on the chemical content of ice and runoff from rock glaciers. However, recent work has refocused efforts on the potential of rock glaciers to indicate past climate signals and reflect current changes in climate. Furthermore, rock glaciers have the potential to affect biogeochemical processes, water quality, and buffering capacity in alpine systems. In this study, we examine water quality from the Green Lake 5 Rock Glacier outlet stream in the Green Lakes Valley, Colorado Front Range. We compare the stream water quality with that of precipitation and outlet streams from the nearby Arikaree Glacier and Martinelli Snowpatch. Precipitation samples were collected year round, and stream water samples were collected roughly between May and October in the years 1998 to 2002. Water samples were analyzed for ANC, $NH_4$, Ca, Mg, Na, K, Cl, $NO_3$, $SO_4$, and Si. The water quality from all three land types was strongly controlled by chemical weathering and hydrologic flow paths, among other variables. In contrast with the other land types, solute concentrations in the rock glacier were lowest at snowmelt and then increased through summer and into early fall. Solute concentrations in snowpatch and glacial runoff were highest during snowmelt. On average, the solutes from chemical weathering products were often an order of magnitude higher in the rock glacier runoff. For example, mean Ca was 447 $\mu$eq/L at the rock glacier compared with 17 $\mu$eq/L at the Arikeree glacier and 66 $\mu$eq/L at the Martinelli snowpatch. Mean $NO_3$ concentrations were also higher at the rock glacier at 50 $\mu$eq/L compared with 8-12 $\mu$eq/L in the glacial and snowpatch runoff. The exception is that Na and Cl concentrations were not significantly different between the rock glacier and snowpatch (95 % confidence level). The high concentrations of solutes in the rock glacier, especially in late summer/early fall, suggest the melting of old ice and change of climatic conditions. The increased yield of chemical weathering products indicates that rock glaciers have the potential to alter water quality and buffering capacity locally, and this land type should be considered when modeling water quality at fine spatial scales.

## H41D-1031 0830h POSTER

### Rock glaciers as a source of nitrate to alpine streams, Green Lakes Valley, Colorado, USA.

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An ongoing concern in alpine areas of the western United States is the high concentrations of nitrate in surface waters. A number of research scientists have shown that talus areas are one source of this elevated nitrate (Williams et al., 1997; Campbell et al., 2002). Here we evaluate the potential contribution of nitrate to surface waters from a previously overlooked source: rock glaciers. Water draining from the Green Lake 5 rock glacier in the Colorado Front Range has been sampled for nitrate and ammonium since 1998 as part of the Niwot Ridge LTER program. The mean concentration of nitrate in stream waters in the Green Lakes Valley is 16.12 ueq/L, and for talus streams is 20 ueq/L. In comparison, the stream draining the rock glacier has an average nitrate concentration of 54 ueq/L. Moreover, nitrate values from the stream draining the rock glacier peak in the late summer at over 100 ueq/L. The sources of these high nitrate values from the rock glacier are unknown at this time; we evaluate several hypotheses. Increased nitrate could be a result of dry deposition on the rock glacier that is flushed during snowmelt and rain events. Another hypothesis is that microbial processes within the rock glacier have contribute to higher nitrate concentrations. Here we evaluate the sources and fate of nitrate in waters draining the Green Lake 5 rock glacier in 2003 using a combination of stable (delta O18) and radiogenic (tritium) water isotopes, fractionation of dissolved organic matter, fluorescence index of dissolved organic matter, and mineralization experiments. These site-specific results are then placed in a regional context through a synoptic sampling of streams draining rock glaciers throughout the Rocky Mountain region. Works Cited Williams, M. W., T. Davinroy, and P. D. Brooks. 1997. Organic and inorganic nitrogen pools in talus soils and water, Green Lakes Valley, Colorado Front Range, Hydrologic Processes, 11(13): 1747-1760. Campbell, Donald H., Carol Kendall, Cecily C. Y Chang, Steven R. Silva, and Kathy A. Tonnessen. 2002. Pathways for nitrate release from an alpine watershed: Determination using delta N15 and delta O18. Water Resources Research. 11 May. Doi: 10.1029/2001WR000294.

## H41D-1032 0830h POSTER

### Characterization of Acid Mine Drainage Sources Using Stable and Radiogenic Isotopes, Chalk Creek, Colorado

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Acid mine drainage (AMD) affects many streams throughout the western United States. Understanding flow dynamics and sources within a fractured rock setting is necessary in outlining a potential remediation strategy for AMD. Radiogenic and stable isotopes of water were used in the Mary Murphy Mine, Chalk Creek, Colorado, in order to characterize flowpaths and sourcewaters. By delineating the sources of the mine water, groundwater, and event water, we may be able to target remediation techniques for individual contamination sources. Moreover, results from this research provide insights into groundwater flow systems in mountain environments of the Colorado Rockies. Tritium, a cosmogenic isotope of hydrogen, has a half-life 12.43y and is useful for studying hydrologic processes at the decadal time scale and can be

used as an effective tracer when traditional chemical tracers are non-conservative. Hydrometric information showed that discharge from the mine adit exhibited a hydrograph characteristic of snowmelt runoff. However, mixing models using stable water isotopes (D and $^{18}O$) found less than 7% of the mine's peak discharge was from snowmelt, suggesting a regional groundwater dominated system. Mine interior samples fell into two characteristic groupings: either from the extreme north side of the drift which contained most of the zinc contamination, and all other locations. The waters from the north drift, MVN-3 and MVN-4, had lower $^{18}O$ values, -17.62 per mil and -17.17 per mil, respectively, than did any of the other locations, suggesting a seasonal snowmelt input. However, the tritium values associated with MVN-3 and MVN-4 suggest at least some mixing, with values of 13.4 TU and 12.5 TU, respectively. Surface water samples from Chalk Creek show average tritium values of 11.1 TU, and $^{18}O$ values of -14.87 per mil. Groundwater samples were captured using monitoring wells, and plotted according to the depth of screening. Alluvial wells carried a seasonal signal similar to the surface water as expected; 11.6 TU and -15.15 per mil averages for tritium and $^{18}O$. In contrast, bedrock wells showed a longer residence time and snowmelt recharge. The combination of radiogenic and stable isotopes within and near the Mary Murphy Mine may provide a useful tool for studying interactions between groundwaters and surfacewaters in a fractured rock setting. Remediation techniques can be directed more appropriately, and cost effectively, by the characterization of flowpaths within the mine as well.

## H41D-1033 0830h POSTER

### Barium and High Explosives in a Semiarid Alluvial System, Cañon de Valle, New Mexico.

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Barium and RDX (a military high explosive compound) were evaluated from 1998 to 2002 within a semiarid alluvial system, Cañon de Valle (CdV), New Mexico. A high explosive (HE) machining facility discharged effluent containing these analytes to the canyon from 1951 to 1996. Surface water, alluvial groundwater, active channel sediments, and floodplain sediments were characterized along a 2 km long reach of canyon. Barium concentrations were higher in the alluvial groundwater than the surface water with the highest concentration centered approximately 500 m downgradient from the HE facility. Of the 21,000 kg of Ba estimated to be in CdV sediment in 1999, about 65% is estimated to have been contained in fine-grained floodplain deposits, 10% in the active channel, and 25% in coarse-grained deposits below the floodplains. The ratio of Ba concentration in fine grained deposits to the active channel increases downstream and increased over time. These data indicate that Ba from the effluent was first stored in the active channel where it could preferentially bind to fine sediment particles, and then was redistributed onto floodplains following scour and suspension during floods. The Ba residing within the floodplain sediments appears relatively stable, and remains isolated from surface water and alluvial groundwater. Approximately 5 kg of RDX was estimated to reside in CdV sediment, also preferentially in fine-grained sediment. RDX concentrations in groundwater were highest (up to 759 ug/L) during high flow snowmelt runoff. The highest average RDX concentration was from an alluvial well approximately 1000 m down gradient. There was a positive correlation between saturated thickness in CdV alluvial wells and RDX concentration. The strong correlation between RDX concentration and saturated thickness suggests that RDX resides in the vadose zone and mobilizes during wet periods when the effective saturated area increases. RDX and Ba show markedly different transport pathways through the alluvial system. Barium is readily sorbed and transported with the sediment fraction. In contrast, RDX is unbuffered and conservative. Thus as the alluvial system wets up, the RDX mobilizes. Knowledge of the distribution of Ba and RDX is critical to design and implementation of corrective measures for this system.

## H41D-1034 0830h POSTER

### Stream-Upland Connections and the Effects of Stream Discharge on Transient Storage Processes

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Stream-upland connections and the linkages between stream discharge and transient storage processes remain poorly understood. Previous studies of transient storage in streams have suggested that hyporheic exchange should dominate transient storage as discharge decreases because of reduced stream cross-sectional area relative to the cross-sectional area of the hyporheic zone. However, no direct relationships have been developed between stream discharge and transient storage influences on solute transport. We tested the hypothesis that the influence of transient storage on solute transport increases with decreasing stream discharge. We performed three separate conservative tracer stream additions with LiBr during baseflow recession (over 12 days) in a 16.9 ha headwater catchment, at Maimai New Zealand. Breakthrough of bromide was measured and simulated with OTIS for four sub-reaches within the 580 m study reach (145 m, 290 m, 425 m, and 580 m from the injection point). Discharge decreased from 1.11 to 0.14 l s-1 at the injection point, and from 4.5 to 1.5 l s-1 at 580 m over the course of the three tracer tests. The storage zone area to stream area ratio (AS/A) increased with decreasing stream discharge and average lateral inflows to the stream decreased as stream discharge decreased. This effect was more pronounced in the headwaters where baseflow decreased at a higher rate than in reaches closer to the catchment outlet. We also tested the linkage between local subsurface water inflow to the stream channel and lateral upland accumulated area. We synoptically sampled tracer concentrations at steady state during the first and third tracer test. We compare calculated lateral water inflows to upland area inputs computed with terrain analysis of a digital elevation model of the catchment. We suggest that improved understanding of transient storage within particular reaches is possible with improved understanding of stream-upland connections and repeated solute tracer experiments at varying discharge. A single tracer test at one discharge does not provide a representative measure of transient storage for the same reach at another discharge, and is insufficient for comparison among streams.

## H41D-1035 0830h POSTER

### Estimating catchment residence time using environmental tracers: modeling recharge and input uncertainty

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The residence time of subsurface water in a catchment is an important control on stream water quality. The residence time reflects the various flow pathways, storage volumes, and chemical interaction times of water transported through the catchment to the stream. Residence time estimates therefore provide a primary description of the hydrological system and catchment sensitivity to anthropogenic inputs and land-use change. Residence time is estimated typically with environmental tracers (e.g., $^{18}O$ and $^{2}H$) using simple lumped-parameter models that define the transfer of input (rainfall) to output (baseflow) tracer composition. However, the estimation of recharge and spatial input variability can introduce considerable uncertainty in modeled residence time distributions. This paper presents a new approach to modeling residence time that combines a transfer function model with a non-linear wetness index model to estimate catchment-average recharge. Using this model, the effects of input uncertainty are explored for several catchments in the H.J. Andrews Experimental Forest (basin scales range from 0.09-62 $km^2$). Our results show that these catchments produce heavy-tailed residence time distributions signifying a long memory to past inputs. Catchments with steeper and shorter hillslopes had distributions with more mass at short residence time indicating a contribution from rapid flow pathways. Uncertainty derived from measured spatial variability of tracer input affected the mean more than the shape of the residence time distribution. Thus, the mean residence time appears to be a robust estimator of the residence time distribution given input uncertainty.

## H41D-1036 0830h POSTER

### Controls of riparian areas, hillslopes, and hollows on storm-event evolution of stream water and chemistry

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The controls of variable source areas (VSAs) and/or riparian areas on storm-event exports of water and solute from watersheds is widely recognized. However, our understanding of the areal expansion (wetting-up) and contraction (drying-down) of VSAs and its impacts on the temporal evolution of solutes during storm events is limited. There is also considerable interest in determining the relative contributions of hillslopes, hollows, and riparian areas (VSAs) to the temporal pattern of stream water and chemistry during storm events. We explored these questions at two different spatial scales for a 710 ha forested watershed located in southwestern NY, USA. Stream flow and chemistry is being monitored at the main outlet (710 ha) and at the outlet of a 5 ha subwatershed. The response of hillslopes, hollows, and riparian areas (VSAs) is being monitored using an extensive network of groundwater wells and surface runoff weirs which record data at 15 minute intervals. The areal expansion and contraction of VSAs is being monitored using a network of surface moisture sensors recording data at every 15 minutes. ISCO samplers have provided stream chemistry data for more than 15 storm events at the two catchment scales. The collected samples are being analyzed for - nitrate, DOC, calcium, sodium, magnesium, potassium, silica, ammonium, sulfate, and DON. A 1m DEM of the watershed has been used to generate a ln[a/tanB] distribution for the watershed. Riparian groundwater elevations peaked early on during storm events whereas the response of hollow groundwater was delayed. Hollow groundwater continued to rise while riparian groundwater elevations dropped during the event. These results suggest that riparian areas (VSAs) have a greater influence on the early portion of the streamflow hydrograph whereas hillslopes and hollows dominate the receding portion of the stream discharge. Further analysis is in progress to discriminate between the contributions of riparian areas and hillslope/hollows to stream chemistry.

URL: http://www.buffalostate.edu/orgs/glc/gowanda/overview.htm

## H41D-1037 0830h POSTER

### Monsoon Season Surface Water Chemistry Response Following Wildfire: 2003 Aspen Fire in Sabino Canyon, Arizona

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The Aspen Fire in the Coronado National Forest north of Tucson burned in excess of 80,000 acres and destroyed more than 300 structures. Exposed, burned soils are highly vulnerable to intense monsoon rains, leading to increases in surface runoff, peak flows, and erosion rates. As part of an integrated investigation of the hydrologic impacts of this fire, we rapidly mobilized a field sampling campaign during the 2003 monsoon season that began immediately following the resolution of the fire. Stream water chemistry serves as an integrated signal of many watershed processes: precipitation, runoff, infiltration, soil hydrophobic layers, ash deposition in the stream, debris flows, and subsequent water/ash chemical equilibrium reactions. The portion of the watershed that has been burned by the Aspen fire covers a wide range of elevation and vegetation zones of the Santa Catalina Mountains. Many biogeochemical and hydrological processes within this area were altered by a sudden lack of vegetation and changes in soil properties following a fire: evapotranspiration, litter volume, organic decomposition, leaching, cation exchange, anion sorption, nutrient uptake, and soil hydrophobic layers. Surface water and precipitation samples were collected following an event-based sampling strategy, while soil samples were collected in each vegetation and burn severity regime. Precipitation samples were collected to characterize temperature and elevation effects on precipitation chemistry, in particular stable isotopes. The surface water chemistry changes measured throughout each hydrograph event can be linked to air permeameter results, a rapid measurement for soil hydraulic conductivity, for the different burn severity and vegetation zone regimes. Both nutrient and suspended sediment loads greatly increased following the fire. A debris flow mobilized large diameter boulders. Stream gauge flow event peaks were larger than expected given concurrent extensive precipitation gauge network recordings compared with flow history of this watershed before the fire.

## H41D-1038 0830h POSTER

### Water quality and geochemistry of the mountain fynbos ecosystem in the vicinity of Citrusdal, South Africa

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The water chemistry along the path of the hydrologic cycle gives clues to the complex interactions among water and the bedrock, soil, vegetation and atmosphere. This study gives a first-order estimation of the chemical composition of the recharge, discharge, and ground waters, along with the bedrock, soil, and vegetation of the Olifants River Valley around Citrusdal, South Africa. The valley occurs in a synclinal fold with the main aquifers, the Table Mountain Group (TMG) sandstones of the Peninsula Formation and the Nardouw Subgroup, folded beneath the central valley. The Peninsula aquifer is recharged in the east towards the Cedarberg Mountains and discharged at up to 43$^{o}$C in the west. The headwater catchments support mountain fynbos vegetation communities, part of the Cape Floral Kingdom, which is globally significant as one of 6 floral kingdoms in the world and a biodiversity hotspot. Groundwater data for this study comes from two boreholes, one cold spring, and one warm spring. Ten surface water samples were taken to study discharge, and 14 rainwater samples for recharge (3 from Citrusdal, 11 from Cape Town). Alkalinity and acidity titrations were performed in the field to complement pH values in characterizing the acid-base status of the waters. Major ions were determined by ion chromatography, and trace elements by ICP-MS. The recharge (pH 4.8-5.8) carries roughly a seawater signature, with some deviation from rainout and washout of wind-blown dust. Rainwater composition in the study area is similar to that sampled within 5 km of the coast in Cape Town, located 170 km south of the study area. Discharge is acidic in the study area (pH 4.9-5.8) and varies from clear to light brown (DOC <3 mg/l). TMG discharge is commonly acidic, particularly from the Peninsula Formation, where there is minimal buffering from weathering of the quartz arenite sandstones. In addition, organic acids tend to pass through with the discharge in these clay-poor sandy soils (<7 wt% clay). TMG ground waters studied have low ionic strength (0.2-1 mM) and electrical conductivity (2.5-12 mS/m). The low pH helps to keep trace metals in solution, particularly iron and manganese, which tend to precipitate in the presence of oxygen near the surface. The presence of metals in solution contributes to the ability of the ground waters studied to buffer the addition of hydroxyl ion (Base Neutralizing Capacity) in the acidity titration. The Acid Neutralizing Capacity, or the ability to buffer acid, increases downstream along the main valley as agricultural runoff increases. The size of the major elemental reservoirs and the fluxes among them are approximated from chemical analyses of the bedrock, soil, vegetation, and waters of the ecosystem. These estimates are used in a simplified box model to discuss the element dynamics within the fynbos ecosystem of a headwater catchment underlain by the Peninsula Formation. The data support the idea that soil and vegetation act as a filter, selectively retaining elements from the water, particularly K and Mn, but also including Ca, Mg, Fe, and Al. The properties of the ecosystem that allow for this retention of elements could be disrupted by human activities.

## H41D-1039 0830h POSTER

### Hydrological Controls on Nutrient Concentrations and Fluxes in California Park Lakes, Butte County, California

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Storm drains, groundwater wells, and an ephemeral stream network, Dead Horse Slough, supply nutrients to California Park Lakes, three interconnected reservoirs east of Chico, California. The 11 km$^2$ watershed above the lakes traverses the Tuscan Formation, which consists of volcanic/sedimentary rocks with thin soil and suburban housing developments. The relatively impermeable Tuscan Formation strata and developed surfaces are consistent with surface flow strongly exceeding subsurface flow. During the winter months, storms supply both forks of the Sloughs, outflow occurs by flow over the terminal dam, and lake water is repeatedly flushed. During summer months little to no water flows in the slough, so water levels in the lakes are maintained by pumping groundwater into the system from the underlying aquifer and from storm drain runoff, which is derived from about 20 suburban microwatersheds surrounding the lakes. Water mass balance analyses (Murphy and Sundermann, 2002) indicated that evaporative losses from the lakes during summer are comparable to water supply from wells and surface runoff. Drainage areas and land use patterns have been mapped to examine relations between flow and nutrient supply. Data have been collected for over two years on runoff volumes and nutrient concentrations from microwatersheds surrounding the lakes. The analyses indicate that most nutrients in inflow during the summer time are supplied from groundwater wells. Microwatershed land use has a greater effect on nutrient supply than the catchment area because of both higher runoff (mostly from lawn watering) and higher nutrient concentrations in developed microwatersheds.

## H41D-1040 0830h POSTER

### Effects of Benthic Flux on Dissolved-Mercury Distributions in Camp Far West Reservoir, California

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Benthic flux measurements of dissolved mercury species were made on sediment cores from Camp Far West Reservoir, a reservoir in which elevated mercury levels in sport fish had previously been documented. The reservoir is located downstream of historic hydraulic placer-gold mining and ore processing activities in the Bear River watershed of the northern Sierra Nevada. Field and laboratory studies were conducted in April and November of 2002 (one of the driest years on record for the area) to provide the first direct measurements of the benthic flux of dissolved mercury species between bottom sediment and the water column at three locations within the reservoir. Ancillary data, including nutrient and ligand fluxes, and benthic biological characterizations, were also gathered to provide a water-quality framework with which to interpret the mercury results. The following are the major observations made from interdependent physical, biological, and chemical data. Bottom water total mercury ($Hg_T$) concentrations ranged from 2.94 to 18.3 pM. Dissolved $Hg_T$ benthic fluxes were generally higher in April than in November 2002 (based on site averages from replicate cores). $Hg_T$ fluxes of 36.3 and -28.4 pmoles-m$^{-2}$-h$^{-1}$ were measured in cores from the deep site which was suboxic in November, contrasting with positive fluxes of 306 and 272 pmoles-m$^{-2}$-h$^{-1}$ at that site in April 2002 when the bottom water was oxic. All six measurements of $Hg_T$ flux in April 2002 and five of six in November 2002 resulted in positive values (i.e., out of the sediment into the overlying water column). Consistent with benthic fluxes for $Hg_T$, dissolved MeHg fluxes were: (a) generally positive in April 2002, (b) negligible at all sites in November 2002, and (c) at least two orders of magnitude lower than total-mercury fluxes, roughly consistent with concentration differences between species. Observed concentration ranges for MeHg in bottom water ranged from less than the detection limit (0.20 pM) at the two shallower, up-gradient sites to 0.48 $\pm$ 0.03 pM (n=3) at the deepest sampling site in November 2002. Dissolved MeHg concentrations in the bottom waters were significantly lower under the low-flow conditions of November 2002 relative to high flow in April 2002, but spatial trends were not temporally consistent. The reservoir was highly phosphate-limited with molar N:P ratios in water column samples ranging from 136 to >5,000 (compared to the Redfield N:P molar ratio of 16). Sulfide benthic fluxes were highest (1,180 $\pm$ 50 nmoles-m-2-h-1) at the deepest site in November 2002 following at least 2 weeks of hypolimnetic anoxia (based on prior water-column monitoring), and lowest at the same site in April 2002 (290 $\pm$ 30 nmoles-m-2-h-1) under oxic, high-flow conditions. Sparse benthic macroinvertebrate distributions, mirrored by low benthic-chlorophyll concentrations, were considered to be inconsequential factors mediating benthic flux. Despite their seasonal variability, the magnitude of benthic flux estimates for $Hg_T$ were consistently comparable to or greater than riverine sources during a relatively dry year. Diffusive transport of dissolved, bioavailable mercury species between the reservoir bed and water column may therefore be an important process regulating the concentration of mercury species in the reservoir water column.

URL: http://wwwrcamnl.wr.usgs.gov/solute_transport/index.html

## H41D-1041 0830h POSTER

### Factors controlling net advection and longitudinal dispersion in the tidal Hudson River: Results from $SF_6$ tracer release experiments

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Two large-scale tracer release experiments were conducted in the tidal Hudson River in the summers of 2001 and 2003 to determine net advection and longitudinal dispersion. During the experiments, ca. 4.3 moles of the inert gas $SF_6$ were injected into the Hudson River, several m above the bottom, near Newburgh, NY in 2001, and Hyde Park, NY, in 2003. After injection, the $SF_6$ was monitored from a boat using an automated measurement system for periods of 14 and 11 days, for 2001 and 2003, respectively. Longitudinal dispersion was more rapid in 2001 (70.1 $\pm$ 4.3 m$^2$ s$^{-1}$) than in 2003 (34.8 $\pm$ 2.1 m$^2$ s$^{-1}$), whereas mean advection was faster in 2003 (1.5 km d$^{-1}$) than in 2001 (0.5 km d$^{-1}$). At the end of the experiments, the $SF_6$ had spread to stretches of the river 100 and 60 km in length, in 2001 and 2003, respectively. Also, in 2001, the tracer moved further up river from the injection point, and asymmetry in tracer distribution was more pronounced. A numerical model of the Hudson River is used to simulate the tracer release experiments, and to determine the relative importance of various factors that contribute to the differences in the two experiments. The major external factors (e.g., river geometry, freshwater flow rate, tracer injection time with respect to the tidal cycle, and salinity distribution) that contribute to determining the tracer distributions will be discussed.

## H41D-1042 0830h POSTER

### Measurements of Sediment Erosion and Transport with the *ASSET* Flume

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Soil and sediments play an important role in water management and water quality. Issues such as water turbidity, associated contaminants, reservoir sedimentation, undesirable erosion and scour, and aquatic habitat are all linked to sediment properties and behaviors. *In situ* analysis is necessary to develop an understanding of the erosion and transport of sediments. Sandia National Laboratories has recently patented the ASSET Flume that quantifies in situ erosion of a sediment core with depth while affording simultaneous examination of transport modes (bedload vs. suspended load) of the eroded material. Core erosion rates and ratios of bedload to suspended load transport of quartz sediments were studied with the ASSET Flume. The erosion and transport of a fine-grained natural cohesive sediment were also observed. Experiments using quartz sands revealed that the ratio of suspended load to bedload sediment transport is a function of grain diameter and shear stress at the sediment surface. Data collected from the ASSET Flume were used to formulate a novel empirical relation for predicting the ratio of bedload to suspended load as a function of shear stress and grain diameter for non-cohesive sediments.

## H41E MCC: Level 2 Thursday 0830h

### The Effects of Best Management Practices on Water Quality, Runoff Processes, and Sediment Transport II Posters *(joint with B, PA)*

***Presiding:*** **D A Burns,** U.S. Geological Survey**; B McGlynn,** Montana State University

#### H41E-1043 0830h POSTER

### Effectiveness of Vegetated Buffer Strips in Reducing Dormant Season Orthophosphate Pesticide Loading to Surface Waters in Glenn County, Northern California

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Riparian buffer strips are used in preventing nonpoint source contamination of agricultural runoff. The design and effectiveness of buffers varies widely under differing environmental conditions. Over the past two years, a project was implemented to evaluate the effectiveness of certain Best Management Practices in reducing organophosphate (OP) pesticide transport from almond orchards to local surface waters in Glenn County, northern California. Diazinon is a commonly-used OP pesticide applied during the dormant season in almond and stone-fruit orchards throughout the California Central Valley. Dormant season diazinon application coincides with the months of greatest rainfall and surface runoff in California. Three filter strip treatments were established: one planted with native vegetation, one with weedy resident vegetation, and the third with a bare soil surface. As a demonstration and reconnaissance project, replication of the treatments in this study was lacking (one plot of each vegetation type and two bare ground plots). Diazinon was applied in test orchard cells in January 2003. Surface runoff, shallow groundwater in the root zone, and deeper groundwater were monitored for the transport of diazinon during the three subsequent storm events. Composite surface water samples and flow volumes were obtained for each storm event using automated surface water collectors. Runoff and infiltration results indicate greater infiltration occurred in the vegetated plots as would be expected. Infiltration on bare ground plots was approximately 25%-50% less than on the vegetated plots. However, differences between the two vegetated plot treatments were less than 5%. Diazinon concentrations were reduced as surface runoff crossed the buffer strips for all three treatments. Detectable levels of diazinon were still present in runoff following the third storm, seven weeks after the pesticide application. Further replicated studies are currently being prepared for the coming dormant season and this study will continue over the next three years.

#### H41E-1044 0830h POSTER

### Erosion Management of Construction Sites

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Improvements in medical technology and improved lifestyles around the globe have resulted in the population growth trend we see today. The outcome is an ever-increasing demand in construction activities, be it for housing purposes or to provide for additional infrastructures to sustain the population growth and improved lifestyles. Indirect impact of this increase in construction activities is an increase in soil erosion from these (construction sites) activities, accelerating the global threat posed by massive soil erosion from human induced activities. While little, if any, can be done to stop the natural erosion process, timely actions can be taken to reduce erosion resulting from construction activities. The constraint, however, is to strike a balance between adverse economic impacts and associated environmental hazards. This is where effective use can be made of mathematical models specifically developed with aims of predicting soil erosion. For construction activities, these mathematical models can be used to compare adverse impacts of different management practices, with the objective of choosing the most appropriate (i.e. Best) Management Practice (BMP) for minimizing adverse environmental effects. With a plethora of erosion models available, with varied degree of data requirements and associated reliabilities, the dilemma planners and managers face in selecting a set of BMPs for reducing soil erosion from construction activities is the selection of a suitable model itself. This paper addresses this dilemma through selection of a simple yet reliable model that will assist the planners, developers and decision makers in comparing impacts of a range of management practices. The result is the selection of management practices that will meet the economic requirements without causing adverse environmental impacts.

#### H41E-1045 0830h POSTER

### Managing Salinity of Seasonal Wetlands in the San Joaquin River Basin

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Management of seasonal wetlands (Refuges) for waterfowl in the San Joaquin Basin of California has been complicated by water quality requirements in the San Joaquin River, into which the wetlands drain. In particular, releases of salt and boron to the river are bound by a Total Maximum Daily Load requirement. At the same time, the US Bureau of Reclamation is exploring opportunities for conjunctive use of groundwater from beneath these wetland areas, which will likely yield pumped water of higher salinity than the surface water currently supplied to the Refuges. This study uses real-time data collection and adaptive management to encourage releases of saline water to coincide with periods of increased assimilative capacity in the river (i.e. elevated rainfall/runoff levels and timed releases from reservoirs upriver.) The wetland system is modeled using the Mike She and Mike 11 software packages, developed by the Danish Hydrologic Institute. The purpose of the model is the forecasting of assimilative capacity, estimation of response to wetland drainage, and simulation of migration of salinity in groundwater.

#### H41E-1046 0830h POSTER

### Telluride, Tom Cruise, and Land Use Codes: Science, Policy, and Community Response

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Mountain areas throughout the western US have experienced a surge in popularity in the last decade, resulting in degradation of the resources that drew people to the area in the first place. Traditional economic interests, recreational users, and environmentalists all have opposing priorities. Thus, resource managers and planners face increasingly critical and controversial decisions regarding development and protection of watersheds. Best Management Practices (BMPs) are generally an attempt to improve land and water quality after degradation. Here we report on our work with local stakeholders in the San Miguel River drainagehome of Telluride Ski Area and Hollywood moguls such as Tom Cruiseto prevent degradation of headwater catchments while providing for reasonable economic and recreational activities. We developed new tools for resource managers by mapping landscape types and associated water quality parameters so as to develop sensitivity criteria that are displayed visually using GIS maps. Using these results, San Miguel County Commissioners adopted land use codes to restrict development, including an 800-sqft building footprint, and bans on septic systems and winter plowing. This case study lays the foundation for science-based policy at the catchment scale, but is dependent on local culture and politics. Preliminary fieldwork was conducted in the summer of 2003 as the first steps toward similar work in adjacent San Juan County, which has a strong mining heritage. The San Juan County Planning Commission identified priority basins for study, and extensive physical field surveys were conducted in these drainages to map spatial distribution and aerial extent of numerous landscape types. Again, water quality parameters will be associated with different land covers to enable alpine sensitivity analysis at the landscape unit scale. Results will be provided to the San Juan Planning Commission to augment current planning tools. However, because of the different political and cultural climates of the two counties, we show that policy outcomes that ensue in San Juan County will likely differ from those achieved in San Miguel County.

#### H41E-1047 0830h POSTER

### Sediment Yield From First Order Streams in Managed Redwood Forests: Effects of Recent Harvests and Legacy Management Practices

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First order streams in the Van Duzen River and lower Eel River watersheds owned by Pacific Lumber Company (Palco) in Humboldt County, California, were surveyed and small sedimentation basins were installed to develop quantitative estimates of sediment yield. A random study design was developed to investigate the potential effects of different geologic substrates and forest management on sediment yield. The drainage area for these streams was about 5 to 10 ha where fluvial characteristics were expressed. The erosion processes within the scope of this investigation included surface erosion from hillslopes and harvest units, rill and gully erosion that may occur in relation to skid trails (recently used or abandoned), and stream channel erosion, including bank erosion and small-scale mass wasting. Temporary sedimentation basins were installed in 30 randomly chosen channels to quantify relative amounts of sediment yield from watersheds with different management conditions (treatment sites) and second-growth stands not recently entered (control sites). Most treatment sites were clearcut harvests. Two classes of treated sites were sampled: sites harvested under stricter regulations of a Habitat Conservation Plan (HCP) and sites harvested prior to implementation of the HCP. Channel surveys were also conducted to characterize conditions and identify existing evidence of channel erosion and surface erosion