2.4 Contaminant Transport Assessment and Management (CONTAM)

The CONTAM research area focuses on developing technology to observe and manage mass and energy distributions and fluxes across a range of temporal and synoptic scales. In 2009-10, the contaminant transport group continued its emphasis on integrated sensing and model-driven analysis. Projects continued to focus on closed-loop soil zone moisture, energy, and irrigation management demonstration, data assimilation approaches used to gain the maximum return on deployment investments, and high resolution river observation and modeling with respect to whole stream metabolism, groundwater-surface water exchanges, and hydrodynamic mixing.

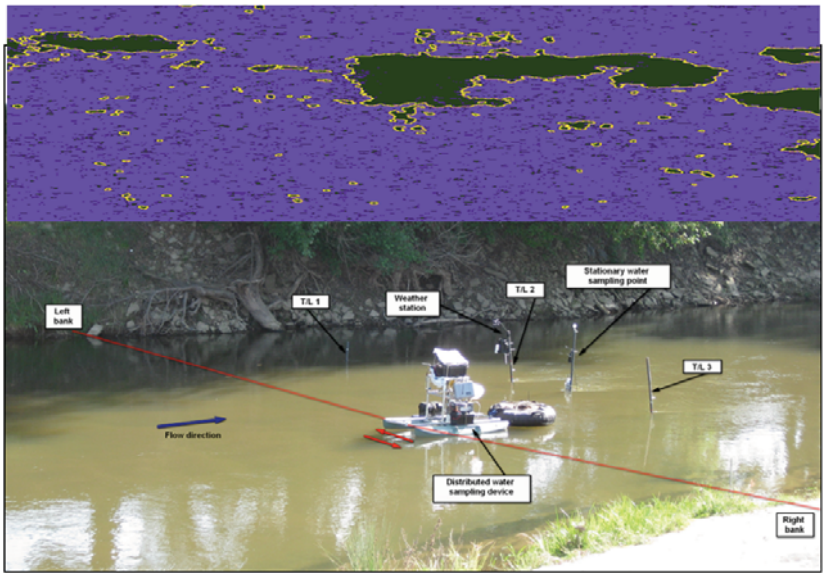

Figure 2. Stream metabolism spatial mapping experiment: (bottom) robotic and stationary water quality sensor stations on the Lower Merced River; (top) sample alteration detection algorithm results for shade/no-shade regions upstream of stations.

The major accomplishment in the CONTAM application area for 2009-10 was **the quantitative assessment of whole stream metabolism differences at unprecedented spatial resolution at the Lower Merced River test site** (see CoONTAM 02 report section). The layout of the full-scale river metabolism spatial observation test is shown in Figure 2. We are explicitly characterizing velocity, temperature, and light distributions while collecting high temporal resolution dissolved oxygen data to support metabolism calculations. The three main approaches explored over the past year are (1) high temporal resolution dissolved oxygen data collection and net daily metabolism estimation at high spatial resolution, (2) light intensity sensors and a network security camera were used at the field site to acquire the incident light data from the water surface over a river reach, and (3) the NIMS RD and AQ robotic systems were used to provide high resolution data on river flow fields, which were then used to parameterize a 2D (depth-averaged) river model.

CENS-developed sensor deployment platforms, such as the javelin, were also re-deployed during 2009-10 campaigns to begin to connect the flow path from terrestrial to the aquatic environment via groundwater-surface water exchanges. Using arrays of javelins at the same Lower Merced River test site discussed above, groundwater velocities were shown to be spatially heterogeneous about each transect with a small range (-1.82 to 4.80 cm/day) (see CONTAM 01 report section). Higher rates of groundwater discharge were found on the north side of the river in both transects. Groundwater discharge velocities were within range of previous studies at this site giving credence to the instrumentation, and method. In future field experiments, we will attempt to draw connections between these groundwater discharges, nutrient transport, and the stream metabolism observations discussed above.

In addition to these successes in the aquatic environment, CONTAM researchers continued to make substantial progress on the water resources management front, particularly in the context of stochastic data assimilation (see CONTAM 03 report). This CENS project builds off of earlier successes at the County Sanitation District in Los Angeles experimental site in Palmdale, CA, and continues to address the goal of safe wastewater reuse via irrigation. Wastewater often contains elevated solutes (e.g. sodium and/or nitrogen) and these excessive chemicals in soil could restrain crop growth and also pollute the groundwater beneath the irrigated lands. **We continued to add to the Palmdale soil moisture, temperature, and salinity data set with uninterrupted operation of this wireless sensor network since May 2008.** Over the past year, stochastic data assimilation experiments employing the Palmdale site have shown that even for a homogeneous soil, accurate estimation of soil states and fluxes requires simultaneous estimation of states and parameters. Estimation of states only can lead to significant errors in fluxes if the parameters are not specified accurately a priori. Further, **CENS researchers have shown that even in the more complicated heterogeneous case, their data assimilation approach (ensemble Kalman filter) is capable of**

providing better estimates of soil state and flux if measurement information content is sufficient. The preliminary outcomes of the assimilation of in-situ measurements also show that the filter estimates can improve the moisture estimates at different depths and also reduce the uncertainty of estimation compared to the open-loop simulation. Together, these results indicate that the data assimilation approach provides a relatively robust framework for the real-time estimation of states/fluxes in an irrigated agriculture context.

The CONTAM group's work on arsenic observation in subsurface sediments has also continued to make progress during 2009-10 (see CONTAM 04 report). Arsenic (As) in well water has led to the largest environmental poisoning in history, affecting tens of millions of people in the Ganges Delta and elsewhere. **Current CENS research has three components focused on comparing As release from mineral dissolution and Fe hydroxide respiration using Bangladeshi soils in laboratory microcosms.** Through these same experiments, we are testing the hypothesis that pond sediments are a major site of As release in Bangladesh through a comparison of As release from sediments collected from the paddy and the edge of the pond at our site.