

2.4 Contaminant Transport 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 2008-09, the contaminant transport group emphasized data assimilation and model-driven analysis. In one case, soil zone moisture, energy, and contaminant propagation models were calibrated and then employed to manage an irrigation system in real time. In another, data assimilation approaches were used to gain the maximum return on deployment investments in the soil irrigation domain, and high resolution river data are being modeled in terms of primary production and hydrodynamic mixing.

A major accomplishment in the ConTAM application area was the **demonstration of a closed-loop system for managing moisture and salinity levels at the full-scale Palmdale experimental irrigation site**. The capacity to adaptively manage irrigation and associated contaminant transport is desirable from the perspectives of water conservation, groundwater quality protection, and other concerns. In the previous annual report, we introduced the application of a feedback-control strategy known as Receding Horizon Control (RHC) to the problem of irrigation management. The RHC method incorporates sensor measurements, predictive models, and optimization algorithms to maintain soil moisture at certain levels or prevent contaminant propagation beyond desirable thresholds. With last year's development of a closed-loop soil pylon sensor system for controlling contaminant

transport in soils, emphasis this year turned to pilot-testing the system at the Palmdale field site. Key tasks included installation of long-term sensor system at the Palmdale site and execution of an intensive field campaign aimed at testing the closed-loop system. The long-term sensor system was installed and has been successfully monitoring conditions at Palmdale since July 2008, and the closed-loop system was successfully demonstrated at the Palmdale site. A sample of the results from the full-scale test is shown in Figure 1.

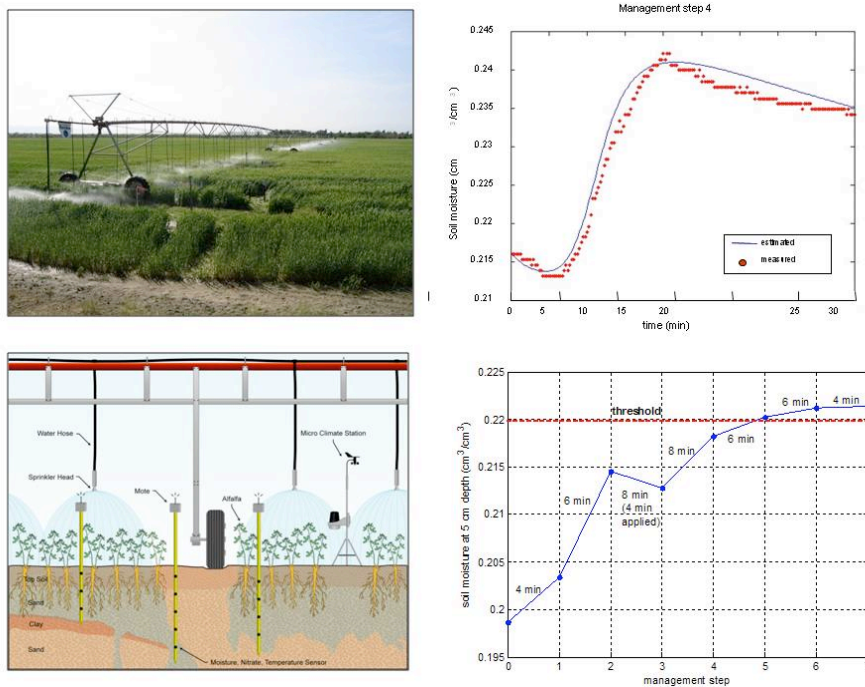


Figure 1. Full scale real-time irrigation management field test at the Palmdale, CA center pivot test facilities (left); model parameterization (upper right), and progressive management results (lower right).

Past reports have summarized the results from high resolution characterization efforts on the San Joaquin and Merced Rivers in Central California. In the past year, with the analysis of additional high resolution data sets obtained from within the Merced and San Joaquin Rivers and their confluence, the ConTAM group was able to **demonstrate the presence of relatively large temporal and spatial variations in river metabolism**. The variation appears to be caused by local factors determining metabolism, potentially including differences in biological communities, water temperature, incident light, and nutrient levels in moving from part of the mixing zone to the other. In streams and

rivers, primary production and community respiration are important determinants of ecosystem biomass and trophic structure as well as important drivers of nutrient cycling and other ecosystem processes.

The ConTAM group also made significant progress in its ongoing data assimilation (DA) research effort aimed at achieving more robust irrigation management tools. DA provides a framework to estimate the true states of an environmental system by systematically merging multiple sources of information concerning the system (e.g. embedded measurements, remote sensing observations, physically based process models, etc.) and has been widely used in many fields, such as atmospheric science and hydrology. In this project, the main goal is using an ensemble DA scheme (i.e. the ensemble Kalman filter (EnKF)) to merge soil state observations from embedded sensor networks deployed in the Palmdale wastewater reuse testbed site into a coupled unsaturated water flow and solute transport model to provide sufficient, reliable soil state (moisture, temperature and nitrate concentration) and flux estimates for maximizing irrigation rates while preventing groundwater pollution. Based on previous results, the EnKF can provide a significant improvement in soil state estimates while assimilating measurements into the coupled model. However, the estimates of water and nitrate fluxes are not well characterized when uncertain (and erroneous) soil hydraulic parameters are involved. This implies that parameter estimates are necessary to obtain reliable flux estimations. In the current year, we successfully estimated these time-invariant parameters through the EnKF scheme for a homogeneous soil profile and found that flux estimates are subsequently improved by this strategy. We then applied the DA framework to the stratified soil system at the Palmdale study site.

In another project the ConTAM group continued its ongoing investigation of Arsenic (As) in well water. The presence of elevated As levels in drinking water has led to the largest environmental poisoning in history, affecting tens of millions of people in the Ganges Delta and elsewhere. Data obtained through previous CENS deployments suggests that diurnal trends in oxidation-reduction (redox) conditions may also be important in As mobilization. Over the past year, the group continued to study these cycles at field sites in Bangladesh rice paddies and at Madrona Marsh (California). In addition, we instituted a battery of hydroponic rice plant studies at the UCLA labs **in which pronounced cycles of organic carbon, pH and alkalinity were observed which we think will add to our understanding of As-cycling and eventually aid in the development of mitigation strategies for this large-scale problem.**

Lastly, the ConTAM group continued to transfer their new-found tools and methods **internationally** in the form of targeted deployments, conference presentations, and particularly through the organization and delivery of an **NSF-funded Pan-American Advanced Studies Institute (PASI)**, which was held in Argentina in March 2009 (for more information, see: <https://eng.ucmerced.edu/paseo/>).