

Annual Report

**2010 Annual Report on Performance of
Iowa CREP Wetlands:
Monitoring and Evaluation of
Wetland Performance**

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Monitoring and Evaluation

A unique aspect of the Iowa CREP is that nitrate reduction is not simply assumed based on wetland acres enrolled, but is calculated based on the measured performance of CREP wetlands. As an integral part of the Iowa CREP, a representative subset of wetlands is monitored and mass balance analyses performed to document nitrate reduction. In addition to documenting wetland performance, this will allow continued refinement of modeling and analytical tools used in site selection, design, and management of CREP wetlands.

Summary of 2010 Monitoring

Six wetlands were monitored for the Iowa CREP during 2010 (Figure 1). These include AA, AL, HS (north wetland), JM, KS, and LICA wetlands. Wetland monitoring included wetland inflow and/or outflow measurements, wetland pool elevation measurements, and collection of weekly grab samples and automated daily samples. Automated samplers were programmed to collect daily composite water samples composed of four six-hour subsamples collected at wetland inflows and outflows when temperatures were sufficiently above freezing to allow water to be pumped through tubing by the automated equipment. At AL, HS North and KS wetlands, grab samples were collected throughout the year during approximately weekly site visits at inflow and outflow locations and daily auto-samples were collected from about mid March to mid November. Monitoring was initiated at the JM wetland on May 6, at the LICA wetland (grab sampling only) on June 20, and at the AA wetland on August 5. All water samples were assayed for nitrate-N concentration.

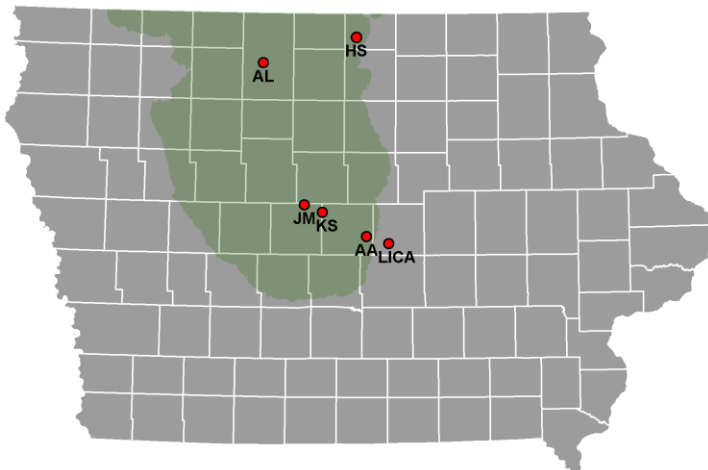


Figure 1. Wetlands monitored during 2010.

Wetland inflow and/or outflow stations were instrumented with submerged area velocity (SAV) Doppler flow meters for continuous measurement of flow velocity. The SAV measurements were combined with cross-sectional channel profiles and stream depth to calculate discharge as the product of velocity and wetted area. Wetland water levels were monitored continuously using stage recorders in order to calculate pool volume, wetland area, and discharge at outflow structures. The pool discharge equations and SAV based discharge measurements were

calibrated using manual velocity-area based discharge measurements collected during weekly site visits. Manual velocity-area discharge measurements were determined using the mid-section method whereby the stream depth is determined at 10 cm intervals across the stream and the water velocity is measured at the midpoint of each interval. Velocity was measured with a hand held Sontek Doppler water velocity probe using the 0.6 depth method where the velocity at 0.6 of the depth from the surface is taken as the mean velocity for the interval. The product of the interval velocity and area is summed over intervals to give the discharge. Depending on the stream width and depth, one manual discharge measurement takes about five to forty minutes to complete and provides an accurate measure of discharge at a known stream depth and time.

Wetland bathymetric surveys were conducted at the KS and AL sites during 2010. These compliment and add to prior bathymetry evaluations compiled during 2007. The bathymetry data are used to characterize wetland volume and area as functions of wetland depth. These relationships are used in numeric modeling of water budgets and nitrate mass balances to estimate nitrate loss. Wetland water temperatures were recorded continuously for numerical modeling of nitrate loss.

By design, the wetlands selected for monitoring span the 0.5% - 2.0% wetland/watershed area ratio range approved for Iowa CREP wetlands. The wetlands also span a 2-3 fold range in average nitrate concentration. The wetlands thus provide a broad spectrum of those factors most affecting wetland performance: hydraulic loading rate, residence time, nitrate concentration, and nitrate loading rate. Despite significant variation with respect to average nitrate concentration and loading rates, the wetlands display similar seasonal patterns. Nitrate concentrations are generally moderate to high during the winter, but flow is generally low so that mass loading is typically low during the winter (Figure 2). The spring melt often results in a high flow event during February or March but nitrate concentrations in the melt water and associated surface runoff are low (see AL, HS north, and KS wetlands in Figure 2). Nitrate concentrations increase to their highest levels during high flow periods in spring and early summer, may decline with declining flow in mid to late summer, and generally increase again if there is increased flow during late summer or fall. A nitrate concentration decline is often observed during high summer flow events and is thought to be associated with low concentration surface runoff. These nitrate concentration and flow patterns are representative of the patterns that are expected for future wetlands restored as part of the Iowa CREP.

Nitrate Loss from Wetlands

Mass balance analysis and modeling were used to calculate observed and predicted nitrate removal for each wetland. Inflow and outflow nitrate concentrations for the wetlands are illustrated in Figure 2. In addition, Figure 2 shows the range of outflow concentrations predicted for these wetlands by mass balance modeling with 2010 water budget, temperature, and nitrate concentration inputs and forcing functions.

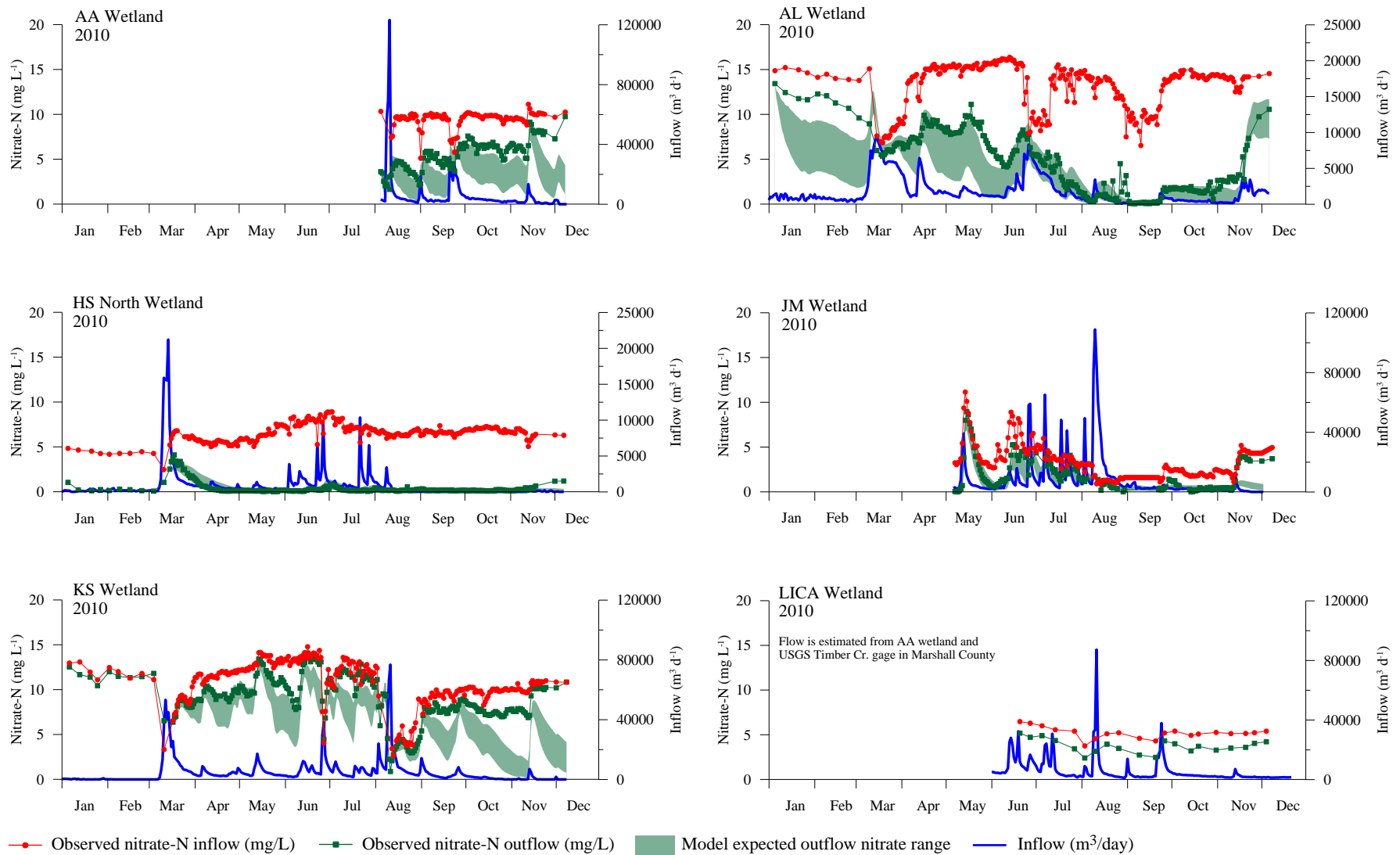


Figure 2. Measured and modeled nitrate concentrations and flows for wetlands monitored during 2010.

The monitored wetlands generally performed as expected with respect to nitrate removal efficiency (percent removal) and mass nitrate removal (expressed as $\text{Kg N ha}^{-1} \text{ year}^{-1}$). Wetland performance is a function of hydraulic loading rate, hydraulic efficiency, nitrate concentration, temperature, and wetland condition. Of these, hydraulic loading rate and nitrate concentration are especially important for CREP wetlands. The range in hydraulic loading rates expected for CREP wetlands is significantly greater than would be expected based on just the four fold range in wetland/watershed area ratio approved for the Iowa CREP. In addition to spatial variation in precipitation (average precipitation declines from southeast to northwest across Iowa), there is tremendous annual variation in precipitation. The combined effect of these factors means that annual loading rates to CREP wetlands can be expected to vary by more than an order of magnitude, and will to a large extent determine nitrate loss rates for individual wetlands.

Mass balance modeling was used to estimate the variability in performance of CREP wetlands that would be expected due to spatial and temporal variability in temperature and precipitation patterns. The percent nitrate removal expected for CREP wetlands was estimated based on hindcast modeling over the 10 year period from 1996 through 2005 (Figure 3). For comparison, percent nitrate removal measured for wetlands monitored during 2004 to 2010 is also presented and illustrates reasonably good correspondence between observed and modeled performance. Because only weekly grab samples were collected at the LICA wetland, the percent removal could not be reliably estimated and is not shown in Figure 3; however, this wetland appears to have about a 30% nitrate removal efficiency. Percent nitrate removal is clearly a function of hydraulic loading rate (Figure 3).

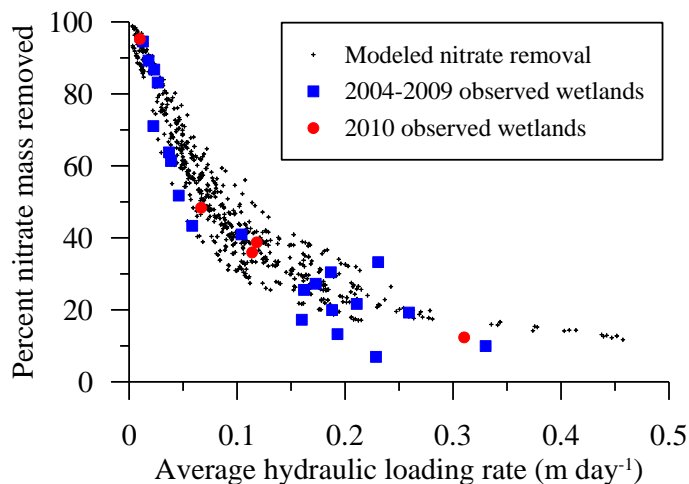


Figure 3. Modeled nitrate removal efficiencies for CREP wetlands based on 1980 to 2005 input conditions and measured nitrate removal efficiencies for CREP wetlands during 2004 to 2010.

Mass nitrate removal rates can vary considerably more than percent nitrate removal among wetlands receiving similar hydraulic loading rates. However, mass removal rates are predictable using models that integrate the effects of hydraulic loading rates, nitrate concentration, temperature, and wetland condition. Crumpton et al. (2006) developed and applied a model that

explicitly incorporates hydraulic loading rate, nitrate concentration, and temperature to predict performance of US Corn Belt wetlands receiving nonpoint source nitrate loads. This analysis included comparisons for 38 “wetland years” of available data (12 wetlands with 1-9 years of data each) for sites in Ohio, Illinois, and Iowa, including four IA CREP wetlands (2 low load and 2 high load sites). The analysis demonstrated that the performance of wetlands representing a broad range of loading and loss rates can be reconciled by models explicitly incorporating hydraulic loading rates and nitrate concentrations (Crumpton et al. 2006). This model will be updated to include the 2004 to 2010 Iowa CREP wetlands and exclude wetlands smaller than the 2.5 acre minimum size required by Iowa CREP criteria.

References

Crumpton, W.G., G.A Stenback, B.A. Miller, and M.J. Helmers. 2006. Potential benefits of wetland filters for tile drainage systems: Impact on nitrate loads to Mississippi River subbasins. US Department of Agriculture, CSREES project completion report. Washington, D.C. USDA CSREES.