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Executive Summary
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Monitoring the Impact of Climate Change on Water Resources in the Northern Highland American Legion State Forest in Wisconsin (NHAL) -- Phase II

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Monitoring the impact of climate change on water resources in the Northern Highland/American Legion (NHAL) state forest in Wisconsin: Phase II.

Executive Summary

This broad objective of this project was to design and deploy a wireless, remote sensor network that could monitor the hydrochemical impact of greenhouse gas emissions and global warming on remote lakes and wetlands within the Northern Highland American Legion State Forest (NHAL) of Vilas and Oneida counties. With over 900 lakes and 120 streams, the NHAL contains the largest group of undeveloped and nearly pristine waters in Wisconsin. Predicted changes in Wisconsin's climate have several implications for these valuable water resources. More intense summer storms and longer periods of evaporation are expected to alter water budgets and impact the exchange of solutes with terrestrial watersheds. These changes may have profound biogeochemical and ecological implications.

The design envisioned integrated sensor nodes to monitor water levels, water chemistry, rainfall and evaporation in a small subcatchment of the Trout Lake watershed. Our goal was an automated array of sensors that could function semi-autonomously for months at a time and allow data display in near-real time at a distant base station. Low power consumption, low cost, high precision, high accuracy and high reliability were our main performance criteria. After successful deployment, the prototype sensor network would then serve as a model for additional monitoring efforts across a wider variety of NHAL catchments.

This report summarizes the results of Phase II of a multi-year effort. During Phase I, we evaluated several remote sensing technologies, and then we deployed a prototype network of radio-controlled sensors within a wetland-dominated NHAL subcatchment. The hardware platform for PI (the first prototype) was the MICA2 mote from CrossBow Technology, Inc of Milpitas, CA. The CrossBow® mote consists of a miniature microprocessor and radio that can be connected to sensors embedded at the field site. When deployed, the motes form a self-healing, mesh network that can compensate for certain environmental interferences. We interfaced the PI mote network with an existing high-power radio network operated by the University of Wisconsin (www.gleon.org). This "piggy-back" approach minimized costs, conserved power and allowed the transmission of data from the catchment directly to The UW-Madison's Trout Lake research station in near-real time.

The PI network was deployed in the CB catchment at the end of summer 2007, and we began field testing. There were four sensor nodes. One node monitored precipitation; one node monitored lake-water; and two nodes monitored ground-water in the surrounding wetland. The initial deployment was promising but not all of our performance criteria were met. Power consumption was higher than expected, and data from some nodes frequently had erroneous values.

During this second phase (2008-09), we improved the electrical circuitry at the heart of each CrossBow node, and we re-deployed network in Crystal Bog. The result was enhanced performance: i.e. lower power consumption and higher reliability. We worked closely with Professors Yu Hen Hu and Michael Morrow, Department of Electrical and Computer Engineering, UW-Madison to make these improvements. Mr. Steven Yazicioglu, an ECE undergraduate, worked as a summer student on the project. In addition to the instrumentation that we designed and constructed, we also deployed a small array of commercial radio-sensors obtained from Instrumentation Northwest, Inc. of Kirkland, WA. Our purpose was to compare "build or buy" network options.

This report summarizes the project status as of October 1, 2009, when Phase II was completed. The technology is described in detail, and the results of field deployments in Crystal Bog and Trout Bog are presented. We also describe progress made in cooperation with a local non-profit organization to establish a citizen-based environmental monitoring network with broader coverage across Vilas County.