Report for 2004SC10B: Application of Emerging Technologies for Water Quality Monitoring and Data Transfer in the Saluda-Reedy Watershed

There are no reported publications resulting from this project.

Report Follows

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Statement of critical regional or State water problem:

Water quality in a watershed is ultimately dependent on the policy decisions made within the watershed that shape the landscape. These decisions are often made in the absence of scientific information concerning the critical resources. It is insufficient to monitor water quality and publish papers. If we are to facilitate behavioral and policy changes that result in better water quality than we must present stakeholders and policymakers with accurate, timely information upon which to base their daily decisions.

The Saluda-Reedy Watershed above Lake Greenwood (shown on the map on page 4) is the natural catchment for 1,165 square miles of the Blue Ridge foothills and upper Piedmont of northwestern South Carolina. During the past century, but especially over the last twenty-five years, the Reedy River has been seriously impacted by urban development. This development continues to move down the Reedy River corridor and is now making its way to the Saluda River. Greenwood County and especially Lake Greenwood are experiencing the adverse effects of these rapid changes.

Greenwood, South Carolina is experiencing strong manufacturing expansion, has an emerging biotech industry and will probably become the fastest growing county without a major interstate highway. Greenville's continued growth will depend on the ability to handle its waste, while Greenwood's future depends on a reliable source of drinking water and access to an equitable share of the assimilative capacity of the Saluda and Reedy Rivers. What was once an abundant resource has become the umbilical link of these two growing counties; and the capacity of that resource is finite.

We believe that the delivery of timely information to the policy makers within Greenville will take a large step toward aiding in the development of more environmentally-sound land use policy within the Saluda-Reedy watershed. Technology that reduces the cost and increases the reliability of sensor-based water quality stations will allow for proliferation of the technology in South Carolina and throughout the Nation. Increased frequency of sensor based monitoring will help researchers and stakeholders get a better understanding of how water quality varies over space and time.

Statement of results or benefits

Results of proposed research will evaluate technologies for data transfer from remote sensor locations and also evaluate a new low-cost turbidity sensor developed by the Honeywell Corporation. The most reliable data transfer technique(s) will be used to link to existing sensor sampling stations located in the Reedy River near Greenville, SC with a data warehouse server that provides policy makers with real time information on the water quality of the Reedy River and, most importantly, how this water quality changes as the river flows through Greenville. We anticipate that we will repeat this effort with county and city councils in Laurens and Greenwood counties that lie downstream from Greenville. Through related, concurrent projects we are forming working relationships with policy makers in Greenville, Laurens and Greenwood counties. These projects include Changing Land Use and the Environment (supported by the USDA-NRCS), The Saluda-Reedy Watershed Consortium: Taking Action for Water Quality Improvement and Watershed Management (supported by the V. Kann Rasmussen Foundation), and Satellite Linkages for Real Time Stakeholder Feedback in Watersheds (supported by the American Distance Education Consortium).

Nature, scope and objectives of the research, timeline

The focus of this proposal is both to develop algorithms to test two low cost techniques for data transfer from remote water quality sensor locations (meteor-burst, and cell phone data networks) and to test a promising low-cost sensor for measuring the amount of sediment in river water. Reducing the overall cost of real-time water quality monitoring will increase opportunities to monitor how human activities impact water quality on a watershed scale. Information gained through use of the data transfer techniques and turbidity sensor will be incorporated into an existing dedicated webpage and will also be available to be shared through state, county and city agency and other stakeholder websites.

This project is organized into five major objectives in order to maximize the transfer of the technology to the stakeholders:

1. Develop algorithms to use and test the reliability of Cell phone data networks for transferring sensor data over the Internet to a dedicated data warehouse.
2. Develop algorithms to use and test the reliability of meteor-burst technology for transferring sensor data over the Internet to a dedicated data warehouse. This will require the use of data minimization and compression techniques.
3. Interface and test multiple Honeywell turbidity sensors in order to statistically assess their performance as compared with other existing turbidity sensors and laboratory analyzed samples.
4. Migrate from the existing satellite data transfer technology to cell phone data network and/or meteor-burst technology for two existing sensor sample stations on the Reedy River.
5. Develop web and peer reviewed publications to assist others with using these data transfer techniques and the evaluation of the Honeywell turbidity sensor.

Methods, procedures, facilities

<u>Evaluation of Cell Phone Internet Network for Data Transfer from Sensor Sample Station</u>

High speed data networks are being developed and deployed by the major cellular phone providers and offer the opportunity to connect water quality sensor stations to the internet on a continuous basis and at a relatively low cost. These networks typically offer speeds between 40-60 kbps, with burst capability of approximately 144 kbps, while the next generation network will offer speeds between 300-500 kbps (http://www.verizonwireless.com, http://www.sprintpcs.com). In other words, the current cellular phone data networks are approximately equivalent to dialup modem speeds, while future network speeds will be equivalent to a DSL or office Ethernet connection. Current network speeds should be adequate to transfer sensor data and compressed images from sample locations over the internet to the data warehouse server located at Clemson University, but questions remain about the reliability and usability for the cellular data networks for this application. Availability of the data network varies with the number of users that access the network (SprintPCS technician, personal communication), so the ability to access the cellular phone data network can theoretically vary over time. Also, network speed can also vary with the number of users accessing the network (SprintPCS technician, personal communication). Network availability is high in urban areas and near major interstate roads, but can be limited in rural areas (http://www.verizonwireless.com, http://www.sprintpcs.com).

This proposal will test the network of two major cellular phone providers: Verizon Wireless and Sprint PCS at multiple locations within the Saluda-Reedy Watershed near Greenville, SC. Initial testing will be centered at our real-time sensor locations, one located in the headwaters of the Reedy River above Greenville, SC and one located at the Western Carolina water treatment facility on the Reedy River, south of Greenville, SC. Further testing at other permanent sample sites within the watershed will provide a picture of the applicability of this technology for long-term data transfer. Computer programs will be developed, in JAVA and C++, that both test the quality of the cellular phone network link and optimize the data transmission from the dedicated watershed-based computers that are connected to the sensors to the Clemson University based data warehouse computer. Both dedicated cellular network data cards and connections through cellular phones will be evaluated. The information developed will be useful to a wide range of agencies and individuals as use of Internet-linked sensors and sensor networks become ubiquitous.

<u>Evaluation of Meteor-Burst for Data Transfer from Sensor Sample Station</u>

Meteor-burst technology was developed by the U.S. military in the 1950's and is based on bouncing radio waves off of small meteor particles in the upper atmosphere which are subsequently received by a base station (NRCS, 2003). This technique is a reliable and inexpensive way for remote two-way communication and has a range of approximately 1200 miles (NRCS, 2003). Limitations of this technique include slow data transfer speeds 1-2 kbps and the lack of continuous communication; however communication is usually possible every few minutes when a meteor trail is created in the upper atmosphere (Fukuda, 1996). Computer programs will be developed, in JAVA and C++, to test the use of the meteor burst technology to transfer sensor data to the Internet. NRCS data centers will be used for relay of the sensor information to the internet and subsequently to the Clemson based data warehouse computer (at no cost to this project). This technique will be tested at multiple locations in the Saluda-Reedy watershed and will be compared with the above mentioned cellular data network data transfer technique. Limited bandwidth availability will require the use of data compression techniques and may not allow the transfer of images from dedicated watershed cameras.

Dedicated Use of Cell Phone Data Networks/ and or Meteor-Burst Technology for Existing Sensor Sample Locations on the Reedy River

After the cell phone network and meteor-burst technology has been evaluated either or both technologies will by employed to replace an existing satellite data network for two sensor sample sites, one located in the headwaters of the Reedy River above Greenville, SC and one located at the Western Carolina water treatment facility on the Reedy River, south of Greenville, SC. The satellite system was funded for one year through the American Distance Education Consortium (ADEC). It is cost prohibitive to continue the satellite Internet connection and funding of this proposal will allow for the long-term continued use of the sensor sample stations for scientific monitoring and stakeholder education.

Verification and Calibration of a Honeywell Turbidity Sensor

Use of multiple water quality sensors in a watershed is often limited by the cost of the sensors themselves. Honeywell created the first turbidity sensor for incorporation in dishwashers in 1997 and has recently developed a new high sensitivity turbidity sensor (0 to 100 NTUs, nephelometric turbidity units) that uses a laser diode to estimate the amount of soil particles present in water solution (Ottens and Engler, 2003). Earlier versions of the Honeywell turbidity sensor were not sensitive enough for river water quality use (Personal Communication with K. Engler, December, 2003). This sensor has an approximate cost of $100-$150, which is 10% of the cost of other commercially available turbidity sensors. If this sensor performs well in river water quality monitoring, it could multiply the opportunities for in-situ turbidity sensing because of its low cost. Since this sensor has only been available since December 2003, there is no independent assessment available of the reliability and repeatability of this sensor in a river setting.

This project proposes to test this Honeywell turbidity sensor at an established sensor station in the Reedy River. The established sensor station, located on Western Carolina water treatment facility property, contains a turbidity sensor as well as a LISST-25 laser diffraction sediment load analyzer (from Sequoia Scientific). In addition this location is regularly sampled with an automatic sensor for laboratory analysis of sediment concentration. The combination of established turbidity/sediment sensors and a sampling regime offers an excellent opportunity to test this new sensor.

Related research:

The Changing land Use and the Environment project, supported by USDA-NRCS, focuses on developing cause and effect relationships between land use and water quality in the Saluada-Reedy watershed. As such, this project has established 12 automated water sampling sites within the watershed. These sites automatically sample water from the river during a storm event. Samples are collected manually and taken back to the laboratory for analyses. The Satellite Linkages for Real Time Stakeholder Feedback in Watersheds project, supported by the American Distance Education Consortium, focuses on the equipment and satellite linkages necessary to fully automate two of these sites (one above and one below the City of Greenville on the Reedy River). This automation goes beyond the water sampling to the use of in-stream probes that continuously monitor dissolved oxygen, pH, turbidity, and conductivity.

References

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