Credit: John Pomeroy

This solar-powered hydrometeorological station collects and report real-time data online, measuring air temperature, wind speed, soil moisture, soil temperature, precipitation and snow depth.

Managing the Ultimate Asset

Scientifically-guided decision-making.

By Tina Chu

"Thirsty cities will not grow," says Sharon Nunes, VP of IBM's Big Green Innovations, imparting wisdom she's come across at the World Council for Sustainable Development. Water and information technology (IT), she says, is "about putting together a supply chain model that will present the commodity, its availability, the multiple demands on it, and the points it moves through, to help run optimization models and manage competing demands."

When it comes to water management, smarter systems are predicated by using empirical data to generate intelligent information through combinations of sensor networks, smart meters, deep computing and analytics that will ensure the most accurate, efficient and sustainable use of water.

In other words, Nunes explains, "It's about providing time-relevant information to the people who have to make decisions—having information at your fingertips where you want it, when you want it." With growing demands and mounting pressures on this limited, global resource, all we can afford to make are data-driven decisions.

Reputed as the second largest consumers of water in the world, Canadians can use IBM's assistance to manage and understand water from end-to-end. "We still need physical infrastructure and people to move water," says Nunes, "but along with that, our whole premise with Smarter Water is that you can't manage water if you aren't monitoring it to make the system smarter."

This kind of management integrates fragmented information pillars and fills in information gaps so that a smarter system will allow timely insight to produce efficient solutions and their deployment.

Working along the same vein is Dr. Ed Sudicky, Canada Research Chair in quantitative hydrogeology and professor at the University of Waterloo.

Guided by the same objectives as Nunes, Sudicky agrees our systems must operate intelligently and our policy-makers must be scientifically guided to make rational decisions.

"Without a science-based method to forecast what would happen, it makes no sense to make a policy," says Sudicky, whose beliefs led him and collaborator Dr. Rene Therrien to develop HydroGeoSphere, an integrated surface/subsurface hydrologic modelling tool that arose out of a partnership between the University of Waterloo and Université Laval.

Dr. Sudicky began the development of the integrated modelling approach in 1995, which culminated with the release of a production version of HydroGeoSphere. The three-dimensional numerical modeling tool simulates fully-integrated surface and subsurface flow, including contaminant and thermal energy transport in water resources systems. Ideal for simulating and predicting the movement of spills and releases in the water, it can predict the flow of contaminants, how long it will take to reach a well and even play a role in forecasting the financial costs for remediation.

The model is available to researchers, professors and students globally, as well as to government agencies and specialized consulting companies; it is widely used throughout North America, Europe and Asia. As an example, HydroGeoSphere has already been used by Université de Liège in Belgium to assess the practicality of new European Union water regulations with regards to assessing the impact of agricultural inputs and climate change on groundwater quality.

Sudicky hopes the model will inform policy-makers who will then involve the community to set regulations that identify efficient but realistic business practices. He is also leading a project supported by the Canadian Water Network to forecast the possible impacts of climate change on Canadian water resources. His team is constructing a three-dimensional model of the entire Canadian land mass, based on HydroGeoSphere, with additional input from Natural Resources Canada scientists.

"Part of our duty as scientists is not to just write technical papers," says Sudicky, "but to serve the general public." Similarly, Dr. Mark Servos, Canada Research Chair in water quality protection and scientific director of the Canadian Water Network, believes that data collection should be about benefiting society and warns that one should not confuse information and knowledge.

"Information isn't good if we can't translate it into something we can use," says Servos. "It's important that we are innovative, but coming up with the right questions is just as important as having the databases."

Pre-production prototype Desktop Testing Unit instruments. The production versions will have capacity of up to 16 simultaneous tests.

Credit: Eric Marcotte

"It's about providing time-relevant information to the people who have to make decisions—having information at your fingertips where you want it, when you want it." —Sharon Nunes

The right questions

One company asking the right questions is Kingston, Ontario-based Pathogen Detection Systems (PDS), with its development of an automated, on-site, microbiological testing unit made to detect E. coli and total coliform bacteria.

The result of a multi-year research and development program in partnership with Queen's University, the PDS solution is propelled by the O'Connor Inquiry into the Walkerton water crisis and the commissioner's call for improved microbiological testing of water samples.

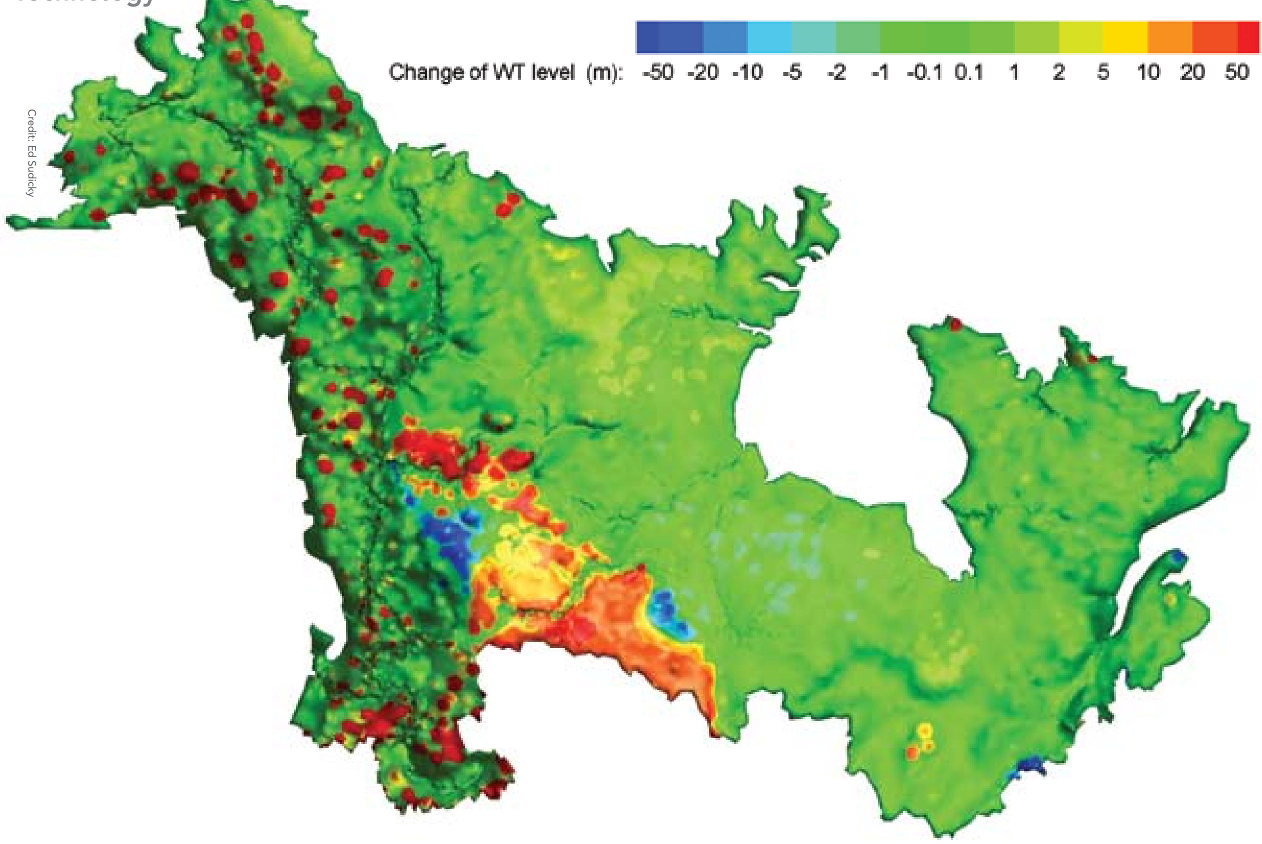
Composed of the Desktop Testing Unit (PDS-DTU), 100-millilitre pre-sterilized test cartridges (PDS-CCA-210) and test automation software, the PDS solution can be used in source and potable water testing as well as environmental, recreational and wastewater testing and is operational even for turbid samples.

PDS identifies bacteria through the detection of enzymes that are well-accepted indicators of E. coli and total coliform bacteria. Complete with all required reagents pre-loaded, the system relies on breaking down target bacteria at the molecular level, which forms fluorescent product molecules that become detectable through a polymer-based sensor.

This process is fully automated from incubation to interpretation, meaning there is continuous monitoring of the test cycle because the system manages and completes the test, producing rapid detection.

For test samples that are highly contaminated, the PDS solution requires only two hours to identify the bacteria. For low levels, the system requires 12 to 14 hours and if the sample is void of E. coli and total coliform bacteria, it will be pronounced so after a period of 18 hours, an up to 80 per cent lower overall turn-around time.

"When the detection is automated, reliability is inherently higher, lowering



Forecast of the predicted change in the depth to the water table (WT in metres) over the Canadian landscape in 2099.The forecast is based on a three-dimensional HydroGeoSphere model calculation driven by a climate scenario produced by the Canadian Regional Climate Model. The simulation was performed by Jeremy Chen, a PhD student of Dr. Ed Sudicky at the University of Waterloo, in a current study supported by the Canadian Water Network, the Canada Research Chair program and the Natural Sciences and Engineering Research Council of Canada.

false positives and false negatives," says Peter Gallant, VP of business development and regulatory affairs at PDS. As well, not only is the unit self-sufficient in running the tests, it also provides alerts to mobile phones, pagers and emails to ensure that adverse samples are made known as soon as possible.

As an on-site testing unit, PDS makes it possible to move routine microbiological tests from the lab to the site, closer to the point of sampling. Thus, it not only reduces test times, but the costs of transporting and preparing samples by over 50 per cent.

Already the subject of long-term trials in several Canadian municipalities with more trials to commence in the United States late this year, PDS caught the attention of Veolia Water, and will become part of its enterprise as of January 2009. This partnership gives PDS access to resources to fully develop the product line for Canadian municipalities and expansion beyond Canada.

Broader detection

In Toronto, another venture with similar international potential is Airborne Underwater Geophysical Signals' (A.U.G. Signals) Intelligent Drinking Water Monitoring System (IDWMS).

The project that began three years ago with funding from Precarn. Dr. George Lampropoulos, president and CEO of A.U.G. Signals, and his team are now entering the demonstrative phase of the project through a grant from Sustainable Development Technology Canada (SDTC). Though there is still work to be done, A.U.G. Signals has begun discussions with Calgary, Montreal, three cities in China, Beijing, Shanghai, and Chongqing, as well as the Greek city of Trikala, to implement the system.

Where the PDS solution targets emergency scenarios and remote areas, the IDWMS is a large-scale water monitoring mechanism that targets municipal infrastructure, from the source to the tap, by detecting imbalances in the water.

The IDWMS operates through two major components. The first are sensor arrays installed throughout the water distribution network and the second, the IDWMS database and software, is the intelligent processing unit responsible for data interpretation.

The sensor arrays consist of spectroscopic and non-spectroscopic or conventional sensors. The non-spectroscopic sensors detect anomalies in the water, such as conductivity, pH and chlorine levels. The spectroscopic sensors pinpoint the contaminant and its concentration at levels ten times lower than those regulated by the World Health Organization.

Dr. Dongxin Hu, a research scientist involved with the IDWMS, explains that such meticulous identification is possible because each compound contacts light in different forms. By observing how the light changes, one is able to identify not only the chemical, but its concentration in the water.

As well, the strategic placement of the sensor arrays across the water distribution network ascertains anomalies are accurately located and treatment is immediately and efficiently deployed. Their presence in the pipes will also help regulators understand how water changes once it leaves the treatment plant. For example, how it interacts with aging infrastructure or other spontaneous water events.

Along with identifying the anomalies through sensor arrays, the IDWMS retrieves other non-sensor data, which includes anything from emergency room statistics to consumer complaints, so that even if an event goes unnoticed, operators can double check any missed information in the integrated database.

Not only is the IDWMS capable of dealing with various types of information, it can be customized to identify different contaminants in different water compositions.

According to Xia Liu, IDWMS' Intelligent Systems manager, the mineralogy of water, or its matrix, varies according to location and the IDWMS is able to adapt to different matrices if a learning period is allocated for it understand the changes.

With all of these features, it's a wonder a specialist isn't required to operate the system. In fact, Hu is confident most water facility operators are qualified to run it after minimal training. Aside from its ease of use, the system does not require many technical prerequisites. To operate the system, one only requires an ample supply of power and a flowing source of tap water. In the event that a problem does arise, A.U.G. Signals provides online troubleshooting and will be able to assist technicians with any questions they may have.

"It's essential that people know their drinking water is safe," says Lampropoulos, "and I think the dominant effect [of the IDWMS] across the country will be peace of mind."

The whole picture

Dr. Monique Dubé, Canada Research Chair of aquatic ecosystem health diagnosis at the University of Saskatchewan, is someone else who seeks peace of mind, but at the watershed level. Currently working for the Saskatchewan Research Council, she is perfecting an information management system called The Healthy River Ecosystem Assessment System (THREATS).

Estimated to be completed in the spring of 2013, THREATS draws from hydrology, toxicology, computer science, civil engineering, and aquatic ecology with the objective of assessing the cumulative effect of multiple stresses on any given watershed, as they interact and accumulate over time.

The system gathers and integrates data such as water quality, insect, fish and sediment health, in addition to factors that impact these elements, like the pulp, mining, forestry, agricultural industries, and sewage. After the information is collected, THREATS present changes in the watershed and the magnitude of these changes, in hopes that this information will be used to establish thresholds for regulating water usage.

> "Water is a public good. Everybody owns it and to try and manage water regionally is like the blind men and the elephant, where each person is only looking at a little piece of what's going on." —Dr. John Pomeroy

In effect, THREATS will offer holistic and improved understanding of watersheds through its comprehensive monitoring and integration of biophysical and human impact data. "THREATS is about transparency—recognizing that everybody has made a contribution," says Dubé, adding, "Pointing fingers has got to go. We need to look at whole picture and take responsibility."

Dubé identifies a holistic approach as one of the main challenges in water governance today. "Water transcends political boundaries," says Dubé. "The problem with water management in Canada is that everyone looks at a little piece."

Echoing the same sentiment is Dr. John Pomeroy, Canada Research Chair in water resource and climate change. "Water is a public good," he says. "Everybody owns it and to try and manage water regionally is like the blind men and the elephant, where each person is only looking at a little piece of what's going on."

Pomeroy cites the Saskatchewan Nelson River Basin as an example. It begins in federal jurisdiction in a national park and crosses three provinces, becoming anything but simple for any one governing body to deal with.

One of Pomeroy's research projects at the University of Saskatchewan may help face this challenge. Hydrometeorological stations that collect and report real-time data online are presently working in Smith Creek and five points within the Marmot Basin in Kananaskis.

Consisting of approximately 300 solar-powered sensors, the stations measure air temperature, wind speed, soil moisture, soil temperature, precipitation and snow depth. They're controlled by data loggers—rugged, portable computers perfectly functional in minus 50 degree weather. The loggers control the instruments of each station by directing the voltage to them and transmitting the collected data via wireless networks or radio waves.

These stations help Pomeroy gain integrated understanding into factors altering hydrology in these watersheds, like warmer winters that proliferate pine beetle populations, the devastation of forestry and canopy to capture and evaporate snow, and consequently increases in runoff. Ultimately, Pomeroy is interested in seeing the development of technology similar to Google Earth targeting watersheds around the world.

While IT can help us save every drop to create abundance out of scarcity, it will also need the financial and political support of citizens and governments to become robust and viable solutions, says author Vandana Shiva in her book *Water Wars*.

Pomeroy says, "Integrated watershed management has been accepted internationally. What we [Canada] need now is the political will. We don't have the same pressures as Europe and we haven't been as brave as they've been."

One can only hope Canadians find courage fast and soon to match its exciting homegrown technological developments. After all, according to Dr. Servos, time needs to be spent both in data collection and in thinking about the data collected.

Nunes says, "Water is a huge problem—and I can't emphasize 'huge' enough. It's not a problem IBM can solve by itself." And when speaking about importance of understanding water from end-to-end, she adds, "Not every problem has an IT answer." W

Tina Chu is a freelance writer based in Toronto.