Equipment Developments Offer Remote Monitoring Options to Many

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Technology is converging to allow low-cost, real-time remote monitoring of a wide range of water resource parameters. The small size and low power requirements of today's electronics make possible highly sophisticated water testing equipment. Advanced license-free radio telemetry instantaneously transmits the collected data, while powerful software can make the data available in a variety of formats virtually anywhere in the world.

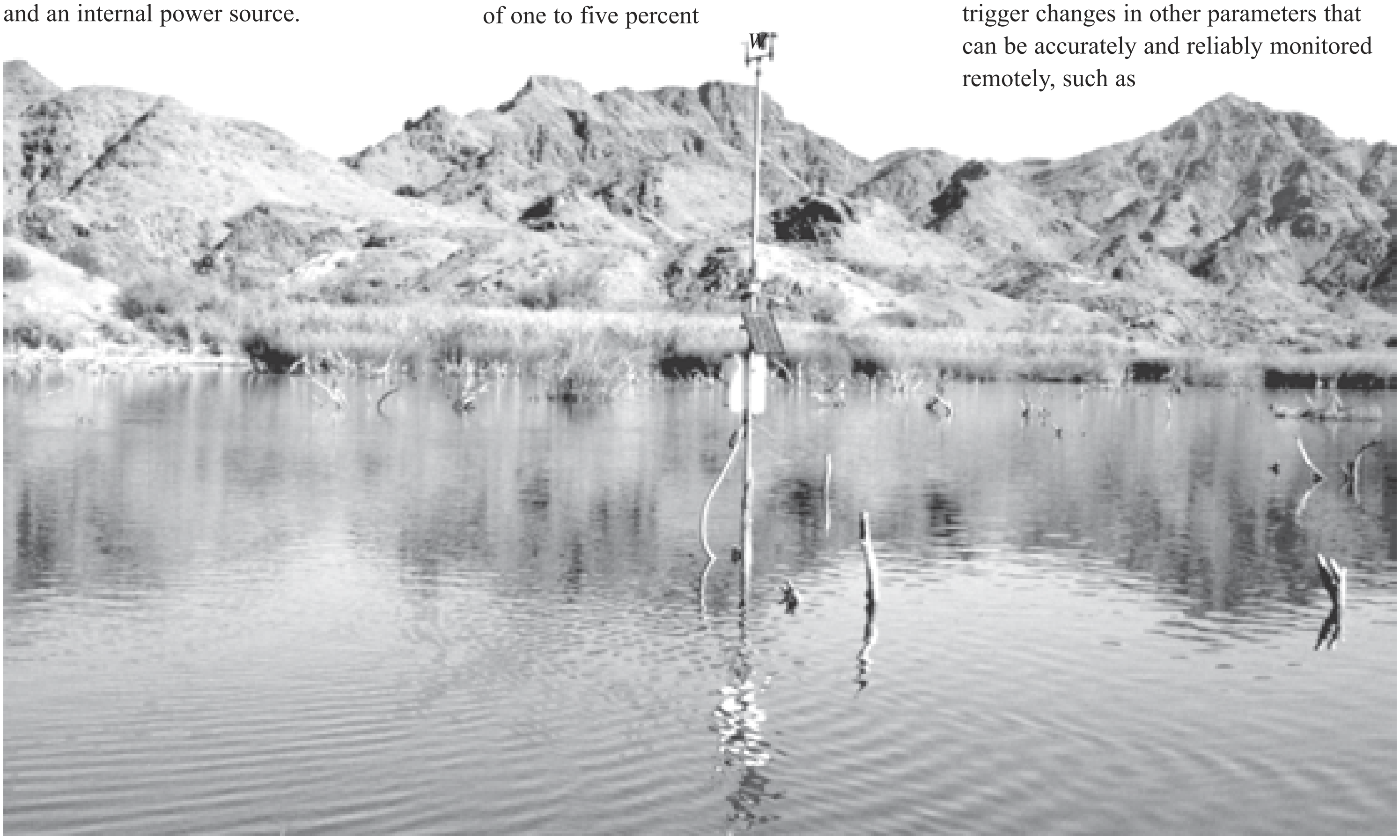
Today's advances in small, powerful electronics and computer chips are driving development of sensing equipment that can be housed in enclosures that are less than an inch in diameter and only a few inches in length. These sophisticated, self-contained sensors consist of a sensing element, a powerful on-board computer, and an internal power source.

Sensor Capabilities

The sensing element is the external window to the environment. It might measure pressure or temperature, detect dissolved oxygen, assess conductivity or turbidity, or determine pH. Basic temperature and pressure (water level) sensors that include a data logger can be purchased for around $600. Sophisticated multiparameter water quality sensors, which measure dissolved oxygen, pH, conductivity, turbidity, and oxidation/reduction potential, can run as high as $10,000, although single-parameter units are available for under $1,000.

Temperature and pressure sensors normally maintain an accuracy of 0.2 percent of full scale for six months to a year without recalibration. Water quality sensors typically maintain an accuracy of one to five percent of full scale for one to three months without recalibration.

Additional sensors are available that directly detect nitrate, chlorophyll, and chloride, but they are susceptible to interference, are only accurate to about eight percent of full scale, and need to be recalibrated weekly. Instrumentation also has been developed for measuring volatile organic compounds (VOCs) and a few other specific parameters. Such instruments can be set up to monitor remotely, but they generally consume a lot of power, are expensive, and require regular site maintenance. However, these limitations do not completely exclude remote monitoring for such compounds as pesticides, organics, and VOCs from all but high-budget operations. Changes in the concentrations of such contaminants trigger changes in other parameters that can be accurately and reliably monitored remotely, such as



Water quality and weather monitoring at Lake Havasu National Wildlife Refuge near Needles, California. Photo courtesy of Intermountain Environmental, Inc.

dissolved oxygen, pH, and turbidity. While those measurements may not tell the person doing the monitoring exactly what is wrong, it does sound an alert that there is a problem, whereupon a field technician can be dispatched for further testing at the site, or an auto-sampler can be triggered.

Very low-power electronic components now available make it possible for a sensor to draw only tiny amounts of power. A number of sensors now on the market can run for more than a year on small internal batteries. The addition of inexpensive solar panels can allow a sensor to run virtually forever.

On-Board Computers

Output from the sensing element is fed into an on-board computer and data logger that reside in the field with the sensor. The on-board computer is the brain of the sensor and serves several functions. First, it can initiate complex, multiphased test sequences, allowing a wide variety of tests to be run. It can also respond to input from the sensor, either increasing or decreasing the sampling intervals based on gathered data, triggering alarms, or controlling external fixtures such as pumps or valves. In addition, the on-board computer can monitor the sensor's activity and go into a "sleep" mode when not taking readings or actively communicating with other equipment, thus conserving power.

The on-board computer can also run sophisticated algorithms. For example, digital temperature information can be combined with pressure data to produce highly accurate pressure information. Complex calibration values, stored in the sensor, can also be applied to compensate for individual sensor drift.

Finally, the computer's nonvolatile memory stores gathered data and protects it in the event of a power failure on the sensor. Although the sensor cannot collect data without power, when power is restored, the data again become available.

License-Free Radio Telemetry

Once data have been collected, the next step is to transfer them to a central computer for examination and analysis. In the past, this typically required a technician to go into the field, connect to the sensor or data logger, and upload data into a laptop, handheld, or special data-collection device. The data were then carried back to a central location for further study. Although today's smart sensors still allow for data transfer using laptops and handhelds, the use of low-cost, license-free radio telemetry can instantaneously transmit data from the collection site to a base station computer, without the need to send personnel into the field.

Using the 900 MHz or the 1.2 GHz radio bands avoids costly government licensing fees. Radios using these frequencies can transmit up to five miles using simple dipole antennas or up to 25 miles with more sophisticated Yagi antennas. These distances can be increased considerably through the use of repeater stations – each repeater station a low-cost, license-free transmitter. These small transmitters have data throughputs up to 19,200 bits per second and operate on small, rechargeable batteries and/or solar panels. A complete low-power transmitter unit, including radio, antenna, and power supply, costs in the neighborhood of $900. Add to that a $600 sensor that contains its own data logger and you have a complete testing and transmission site for $1,500.

Powerful Base Station Software

Once the data have been transmitted to the base station computer, powerful software can format and analyze them in a variety of ways. The data can then be accessed from or transmitted to other systems worldwide via cellular phones, wired phone lines, satellite transmission, or the Internet.

Imagine a water resources director sitting at headquarters in Sacramento, watching the ebb and flow of irrigation water over thousands of acres of farmland along California's central valley. Envision a public health official at an office in Phoenix, monitoring the water quality in the state's drinking water reservoirs, able to know the moment a potential health hazard appears. The currently available sensors can instantly signal a change in the environment, sending immediate notice or even triggering automatic water sampling for further testing in a laboratory. Environmental sensor manufacturers are committed to continuing research and development of state-of-the-art equipment and methodologies for better and lower-cost water monitoring.

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