hydro line

Esri • Spring 2011

GIS for Water Resources

# Northern Ireland's Flood Map Supported by GIS Cloud Technology

Regions of Europe have experienced significant flooding over recent years that has caused damage to businesses and homes and brought misery to thousands of people. Climate change predictions indicate increased flooding in the decades ahead. In Northern Ireland, the government is taking a proactive approach in terms of prevention, protection, and preparedness. This includes defining floodplains to avoid inappropriate development, constructing flood defenses, and raising awareness so that citizens can take measures to mitigate losses to their homes and businesses.

Traditionally, the Department of Agriculture and Rural Development's Rivers Agency has concentrated on protection. In response to significant floods and aided by advances in technology, the agency wanted to develop its ability to support prevention and preparedness. To succeed with this, it knew that information about flood risks should be made more accessible to the general public, partners, and stakeholders. The agency therefore decided to develop an online map viewer to display information about past and future flooding risks.

ESRI Ireland worked with the Rivers Agency to develop a cloud mapping service that communicates information about the potential risk of floods. The service presents maps of river and coastal floodplains and makes these publicly accessible.

A geographic information system (GIS) cloud computing environment takes advantage of capabilities maintained off premises and delivers on-demand services via the Internet. The organization providing the cloud services owns the infrastructure and applications, while the client retains ownership of the data. In addition, GIS cloud services offer data storage, end-user web applications, and focused computing services. Cloud computing is flexible, meaning that it can quickly scale up and back down to handle unpredictable traffic flow. This is very freeing to the client.

Flooding in East Belfast, Ireland

The outcome of the Rivers Agency project is the Strategic Flood Map (NI)—Rivers & Sea. The public can go to the Rivers Agency website and within the map viewer see

- Historical maps that illustrate areas that have flooded in the past
- Present-day maps that show river and coastal floodplains
- Climate change maps based on forecasts for 2030 that show predicted locations of river and coastal floodplains
- Flood defense maps that indicate the locations of existing walls, embankments, and other defenses and the areas protected by them

Developed using Esri's ArcGIS technology, the Strategic Flood Map provides simple pan and zoom tools and location search features to make it easy for people to find, view, and interpret information about a specified locality. ESRI Ireland hosts the solution from its data center in Dublin.

The Strategic Flood Map was launched jointly

*continued on page 7*

## In This Issue

## Save the Date

**American Water Resources Association**
April 18–20, 2011
Baltimore, Maryland, USA
www.awra.org/meetings/baltimore2011

**Wasser Berlin**
May 2–5, 2011
Berlin, Germany
www.wasser-berlin.de

**Ozwater '11**
May 9–11, 2011
Adelaide, Australia
www.ozwater11.com.au

**Association of State Floodplain Managers**
May 15–20, 2011
Louisville, Kentucky, USA
www.floods.org

**2011 World Environment & Water Resources Congress**
May 22–26, 2011
Palm Springs, California, USA
www.asce.org

**Aquatech China**
June 1–3, 2011
Shanghai, China
www.china.aquatechtrade.com

**American Water Works Association (AWWA) ACE Annual Conference and Exposition**
June 12–16, 2011
Washington, D.C., USA
www.awwa.org

**Esri International User Conference**
July 11–15, 2011
San Diego, California, USA
esri.com/uc

**StormCon**
August 21–25, 2011
Anaheim, California, USA
www.stormcon.com

# Web Application Combines Mapping and Analysis for Australia Floods

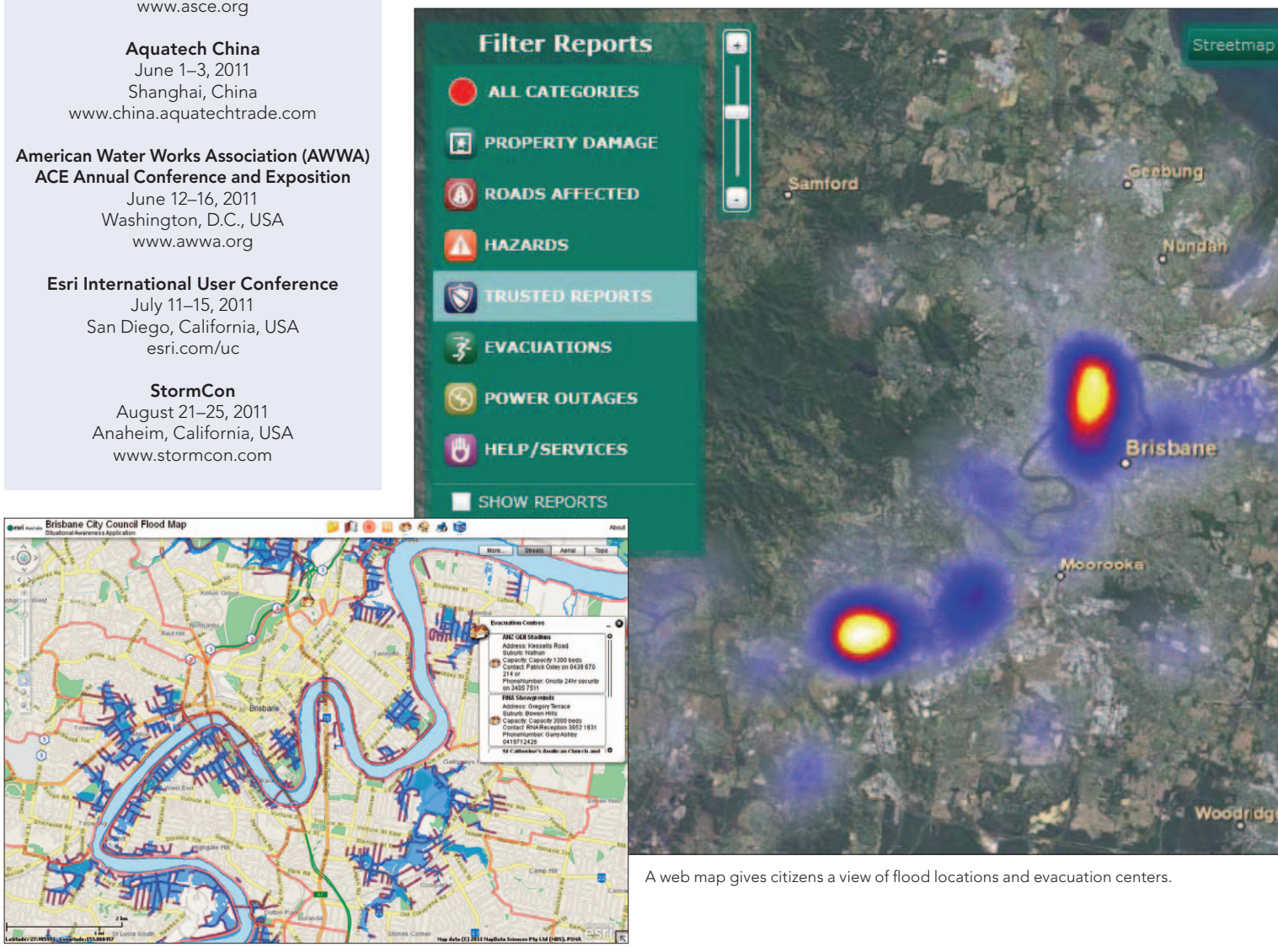
By Jesse Theodore, Esri Writer

Esri developed a newly launched web application that provides mapping and analysis to enhance Australia flood information supplied through the Ushahidi social network. The network allows people to report incidents via short message service (SMS), e-mail, or the web. The information is categorized and analyzed using GIS technology to provide hot spot visualization. By combining web GIS capabilities with Ushahidi data, anyone can view reports of flood incidents, damage, requests for help, and response requirements in a map context.

The application allows people to easily view the density or clusters of multiple events, such as property damage, roads affected, and hazards. These density color-coded hot spots illustrate geographic areas where similar requests, statements, and issues are clustered. This allows both government officials and the public to identify problems or issues reported by a number of people in a common area. They can better understand the distribution of reports by category and by time.

"Ushahidi information, combined with ArcGIS, provides a timely and relevant map-based picture," says Russ Johnson, director of public safety, Esri. "What's unique about this site is the analytics involved. It's more than just dots on a map. Esri developed this application to organize a lot of data and provide a better understanding of the data quickly."

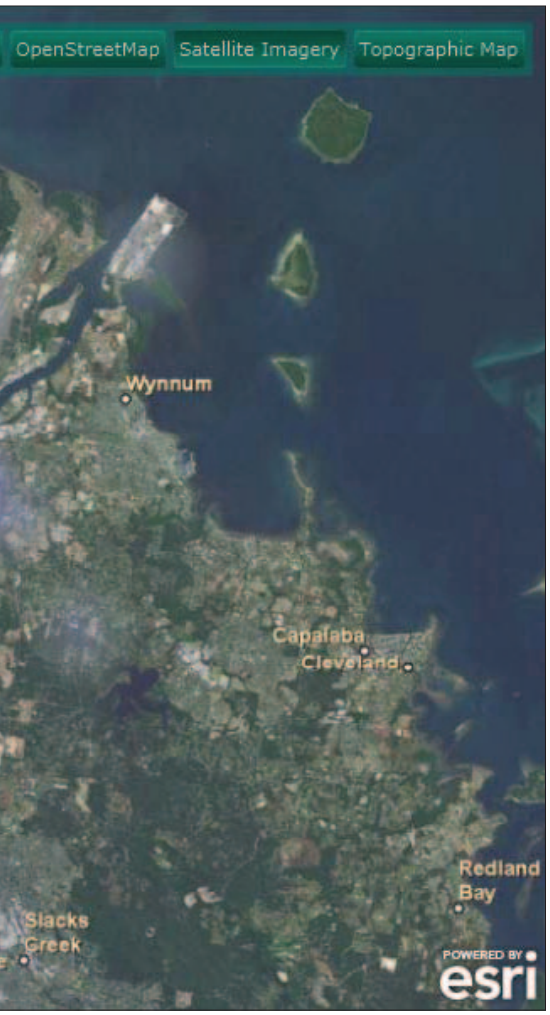
The application demonstrates how GIS can analyze and transform large volumes of data into actionable intelligence. Background map data




A web map gives citizens a view of flood locations and evacuation centers.

or basemap layer options include street maps, satellite imagery, and topographic maps. In addition, the data can be visualized over time to understand both spatial and temporal trends together. A temporal tool is available to present data for a particular day or range of days. It allows users to select multiple days on the map chronologically with the time slider tool. As dates move sequentially, the updated data is automatically displayed for the indicated time period. This provides a visual understanding of how an incident evolves over time.

Since December 2010, the Esri disaster response team, as well as ESRI Australia Pty. Ltd., has been working to support response to this incident. Several applications are available through the Esri disaster response portal. For instance, there is a common operational picture (COP) for the Brisbane City Council that was developed with the assistance of ESRI Australia. People or organizations affected by the flood can request GIS support directly through the portal located at esri.com/australiaflood.




An Esri web application allows anyone to visualize Australia flood information.

## Esri News

# Join the Water Resources Group

Esri's Water Resources Group is a network of water resource managers, geologists, environmental managers, and others interested in applying ArcGIS to their projects. User groups meet throughout the year to share information, data, tips on software usage, and project news. All users of Esri software are welcome. Learn more at esri.com/waterresources.

# Esri International User Conference—A Resource for Water Resources

Esri invites you to the Esri International User Conference. At this conference, you will see how GIS helps you get the most out of your geological, environmental, and climatic data. GIS is used to develop climate change policy, create strategic flood maps, design disaster plans, and much more. Find the solution you need, from a desktop water analysis project to an enterprise-wide GIS implementation.

Join us and be inspired.

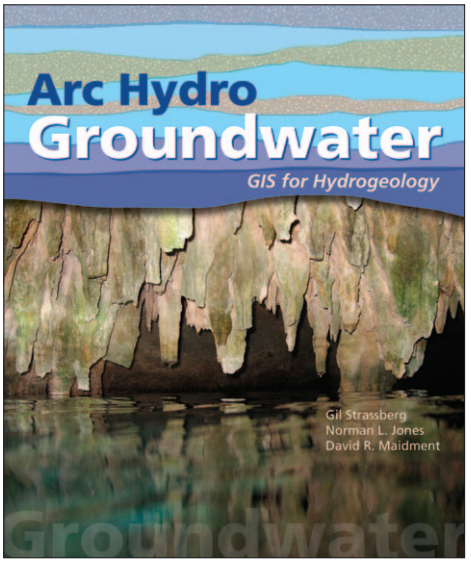
When: July 11–15, 2011

Where: San Diego Convention Center, San Diego, California, USA

Learn more and register: esri.com/uc.

# Arc Hydro Groundwater: GIS for Hydrogeology

The definitive book on the groundwater data model, *Arc Hydro Groundwater: GIS for Hydrogeology* is a resource for ArcGIS users that work with groundwater data to research and solve water resource problems. It addresses geologic mapping of aquifers, wells, and boreholes; 3D hydrogeologic models time series for hydrologic systems; groundwater simulation models; and other data model objectives.




ISBN: 978158941985
2011
176 pages
$64.95
Order online from Esri's GIS Bookstore at esripress.esri.com, or call 1-800-447-9778.

# Lidar and GIS Fast-Track Water Resource Pipeline Project

By Shane Schwarz, GWMWater

The Wimmera Mallee's historic stock and domestic water supply system, 10,800 miles of open, earthen channels, has supplied water to farms and residents of northwestern Victoria, Australia, since the early 1890s. In recent times, the region experienced a period of extended and severe drought, which dried the land and left reservoirs at less than 5 percent of their capacity. Low water levels revealed the inefficiency of the system. Of the 120,000 megaliters of water released into the channel system, only 17,000 were used by customers, and the rest—up to 80 percent—was lost due to evaporation and leakage.

To increase the efficiency of water distribution, the Commonwealth of Australia, the Victoria state government, and Grampians Wimmera Mallee Water (GWMWater) agreed to fund the Wimmera Mallee Pipeline Project (WMPP), an initiative to improve the water system with pipelines and pump stations. Although the timeline to complete the project was 10 years, the community needed the water sooner to maintain its farms and livelihood.

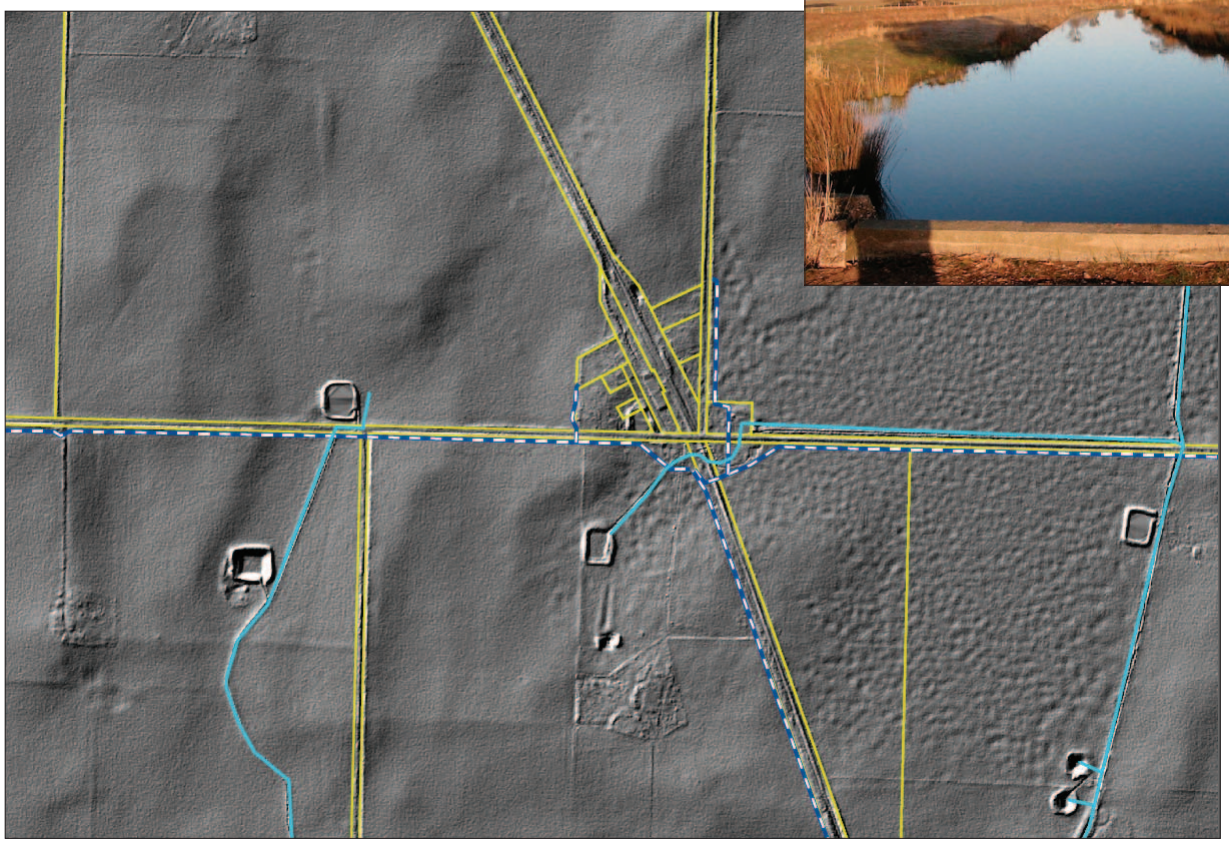
GWMWater was responsible for the project. Its engineers knew that capturing and analyzing the required amount of data over such a large and diverse area of terrain and vegetation would best be managed in a file format-friendly GIS software platform. Working with AAMHatch, an Australia-based firm specializing in geospatial services and products, GWMWater aimed to fast-track the project from a 10-year to a 5-year schedule. To do so, it used light detection and ranging (lidar)-based imagery of the entire project area, packaged in GIS spatial datasets. The enterprise GIS was put to work managing lidar, orthophotography, and other data, enabling engineers to speed up the 8,800-kilometer (5,468-mile)-long pipeline project, as well as save time, resources, and money.

Air crews captured data, surveyors processed GPS and laser scanner data, and analysts worked on data processing. Using Esri's terrain data type, which allows massive surface datasets to be stored in an ArcGIS geodatabase, AAMHatch created terrain datasets of the project area comprising 1.3 billion points. ArcGIS terrains optimized performance at multiple resolutions through the use of terrain pyramids that quickly retrieved only the data needed for the required level of detail in a given area of interest. The digital terrain model datasets had approximately 15-centimeter vertical accuracy at one sigma on open areas, with an average laser strike spacing of 1.3 meters. The terrain data was easily and quickly processed and analyzed using the ArcGIS Server 3D extension and was complemented by orthoimagery data with 60-centimeter image resolution to provide a complete picture. Stored in the GWMWater GIS, the lidar and orthoimagery data provided a continuous coverage of the land use, land cover, and terrain—all data that was essential for engineers to efficiently design, model, and construct the pipeline.

In April 2010, the Wimmera Mallee Pipeline was officially opened 5 years ahead of schedule. Since replacing the inefficient open channel system, water restrictions for farms and residents have been eased, and the region's reservoir levels have returned to 60 percent of capacity. The WMPP terrain data and orthoimagery continues to be used by GWMWater for engineering of earthworks to in-fill the 10,800 miles of redundant open channels.

For more information, contact Shane Schwarz, network coordinator, GWMWater (e-mail: shane.schwarz@gwmwater.org.au).

The Wimmera Mallee open channel system was losing drastic amounts of water due to evaporation and leakage.



A two-meter hillshade elevation grid created using ArcGIS data processing tools displays features including redundant on-farm storage dams, as well as the open channel network.

# Africa Drought Impact Scenarios Modeled in Spatial Decision Support System

By Dr. Rainer Laudien, ESRI Deutschland GmbH

Parts of West and North Africa have experienced 30 years of drought. The shortage of fresh water is expected to be the dominant water problem of the twenty-first century and one that, along with water quality, may well jeopardize all other efforts to secure sustainable development and in some cases lead to social and political instability. The current situation north and south of the Sahara Desert is characterized by increasing population (the population growth rate is more than 3 percent per year), degradation of the natural vegetation due to overgrazing (in Morocco), and demands for firewood as well as shifting cultivation (in Benin). Consequently, soils quickly erode, and salt content rises due to the irrigation practices. These problems are likely to accelerate the degradation and desertification processes of the region during the coming decades.

Impetus is an interdisciplinary research project that uses an integrated approach for managing scarce water resources in West Africa (impetus.uni-koeln.de). Understanding ways drought and human impact will affect the region in the future requires managing large amounts of data, anticipating variables, and identifying decision options. Impetus uses a spatial decision support system (SDSS) that integrates GIS into decision processes.

Developers at the University of Cologne, Germany, used the Esri developer library ArcGIS Engine to implement spatial analysis functions with computer-based spatial decision tools. The outcome is software that provides spatial analysis functions within computer-based decision tools that are accessible from different platforms. Geodata and single SDSS models are stored in the ArcGIS file-based geodatabase, making them accessible for analysis using GIS.

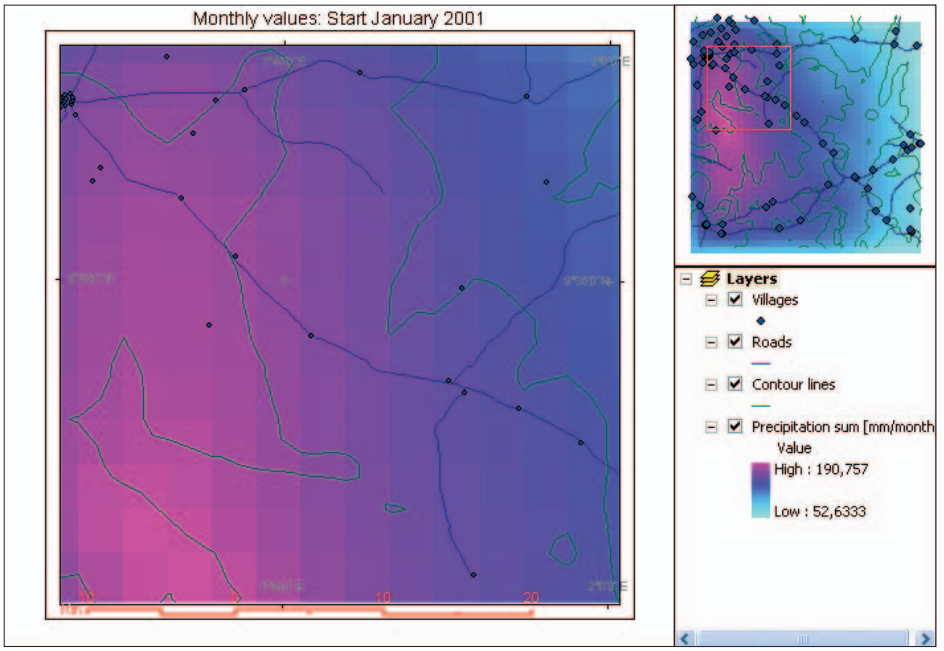
The developers created several GIS water management tools for Impetus that incorporate a specific ArcGIS map panel and its functionalities, enabling users to select from the geodatabase specific data, models, and locations, then visualize them in a map panel and save the selection to a file. Three of these tools are briefly described below.

A land-use change and precipitation tool answers questions on the possible developments of evaporation and precipitation until the middle of the twenty-first century for the Ouémé catchment in central Benin, Africa. GIS depicts Intergovernmental Panel on Climate Change (IPCC) scenarios by calculating precipitation amounts resulting from various land-use and meteorological variables. These are by month and year. Users view these scenarios on maps or as time series graphs, such as bar charts, to help them identify years with a potential of water shortages.

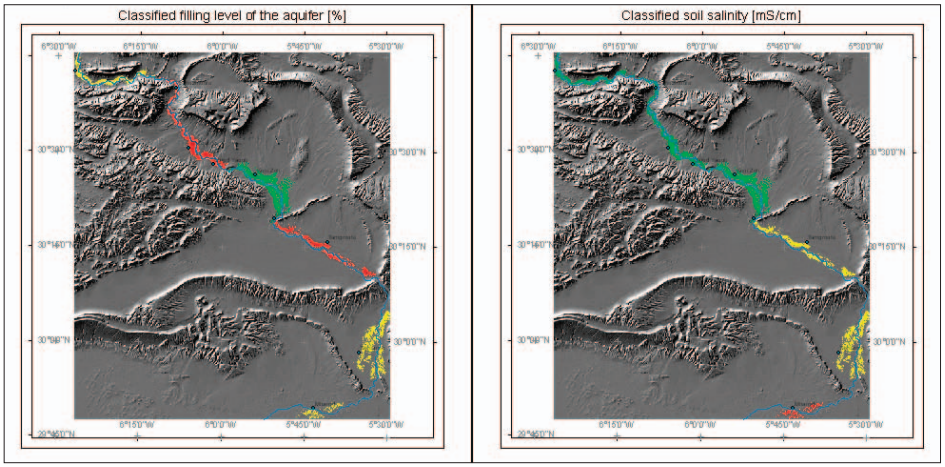
Another tool models the impact of water exploitation on groundwater and soil. Impetus researchers used this tool to study six oases in Morocco. The model approximates the groundwater stock and soil salinity results and generates classified multitemporal thematic maps. Users may also see time series in terms of histograms of a selected oasis.

A water quality tool provides information about the drinking water status of more than 2,000 wells that were digitized in the area of the upper Ouémé catchment in Benin. It accesses multitemporal water quality data, digital photographs, emergency addresses, and other pertinent information.

For more information concerning the use of ArcGIS Engine for spatial decision support, contact Dr. Rainer Laudien (r.laudien@esri.de) or ESRI Deutschland GmbH (esri.de).




The GIS tool calculates precipitation values based on various land-use and meteorological variables.




Estimate of Water Exploitation of an Aquifer for the Year 2016 as Well as Soil Salinity

# Groundwater Resource Vulnerability Revealed

By Brian Gedlinske and David May, University of Northern Iowa

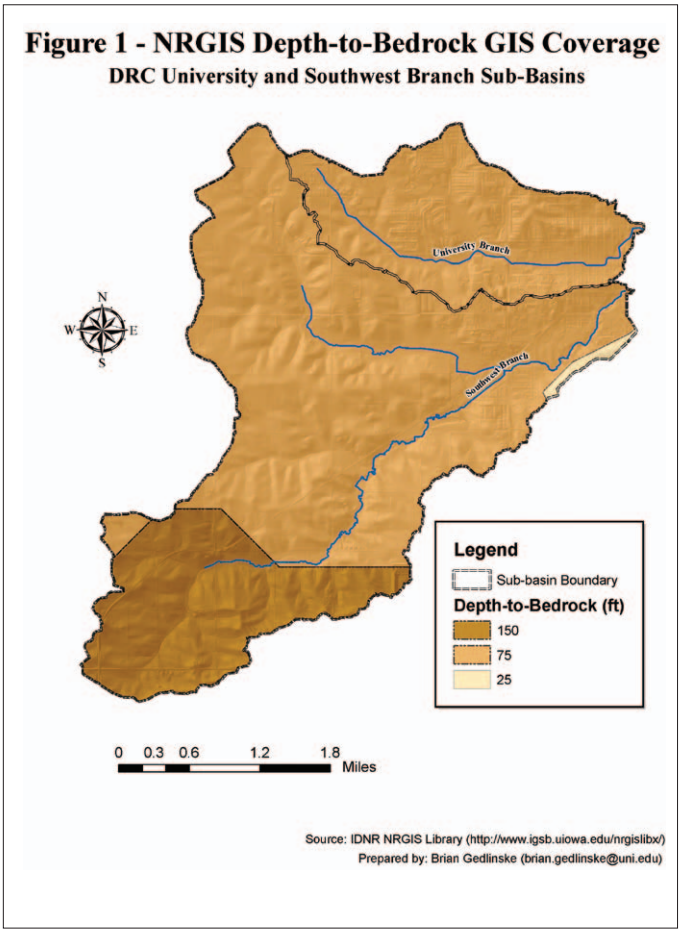
The University of Northern Iowa (UNI) and the city of Cedar Falls, Iowa, rely heavily on groundwater from the Devonian aquifer underlying northeast Iowa. UNI extraction wells tap the aquifer largely as a source of once-through cooling water for its campus buildings. Cedar Falls uses the aquifer as its municipal water source. Collectively, UNI and Cedar Falls withdraw over 4.5 billion gallons of groundwater from this aquifer each year.

The carbonate bedrock comprising the aquifer has typically been characterized as a highly productive groundwater resource protected or confined by overlying clay-rich till. This stratigraphic generality has led to an impression that the aquifer is not susceptible to most contaminant sources. Recent fieldwork, analyses of well logs, and representation of the new data in a geographic information system, however, clearly illustrate that the aquifer is much more vulnerable to contamination than previously thought.

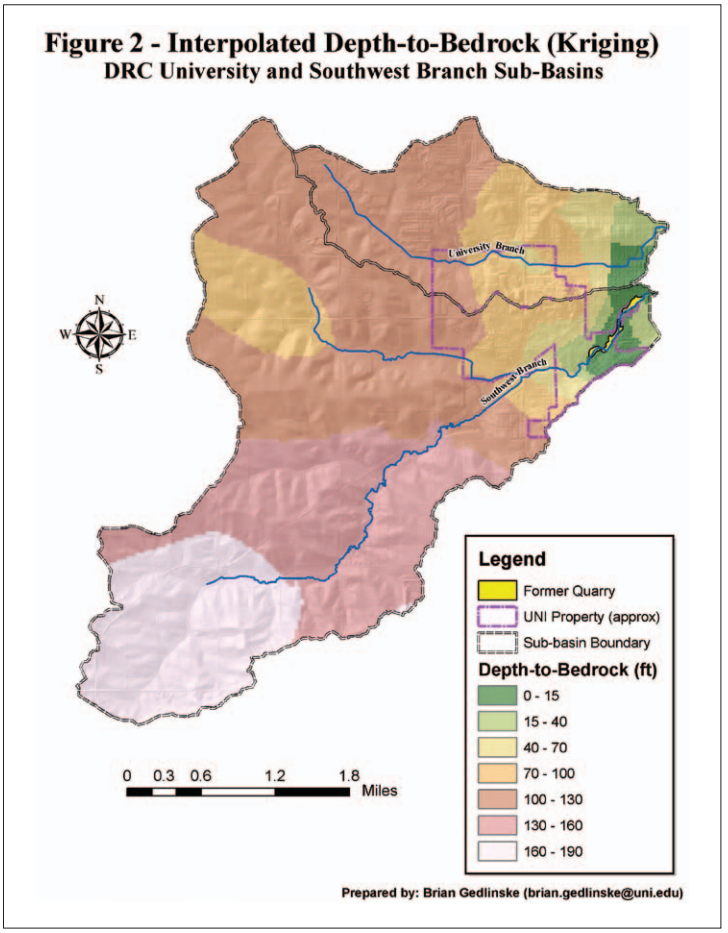
Two adjacent subbasins within the Dry Run Creek (DRC) watershed (the University and Southwest Branch subbasins) constituted a study area in which detailed GIS work was performed to better characterize the hydrogeology of the area. Since its designation as an impaired water body in 2002, the DRC watershed has been the subject of numerous water quality studies. At best, these efforts provide only cursory descriptions of the area's hydrogeology. As a result, readily observable and significant aspects of the area's hydrogeology were omitted or misrepresented.

As the thickness of an overlying confining layer (in this case, till) is often the most critical indicator of aquifer susceptibility to surface contamination, the GIS effort focused on developing a detailed depth-to-bedrock map of the study area. For comparison purposes in demonstrating how generalized data can be improved, a depth-to-bedrock map was also developed for the area using existing digital, geographically referenced data obtained from the Iowa Department of Natural Resources (IDNR) Natural Resources Geographic Information Systems Library. As shown in figure 1, this generalized GIS data suggests that bedrock depth ranges from 25 to 150 feet across the study site, with 99 percent of the area overlain by at least 75 feet of quaternary deposits.

To develop an accurate depth-to-bedrock portrayal of the study area, a more detailed dataset was compiled for the area. Water-well drilling logs and boring logs associated with monitoring well installations that have been completed as part of environmental investigations were mined for pertinent data on the area's stratigraphy, hydrogeological characteristics, and specific yield information. A thorough review of historical literature was also performed. This review revealed significant but apparently forgotten or unrealized characteristics of the area including the




An aquifer depth-to-bedrock analysis based on generalized data indicates depth ranges from 25 to 150 feet as well as its overlay of quaternary deposits.




A more detailed dataset from the Iowa Department of Natural Resources includes drilling and boring log data for this depth-to-bedrock map that shows a strong hydraulic connection between two aquifers suggesting an aquifer is more susceptible to surface contamination than previously thought.

presence of karst swallow holes and bedrock quarry sites along the DRC channel. Finally, secondary data sources were complemented with GPS field mapping of significant features (i.e., well locations and bedrock exposures) found within the study area.

The effort to construct a more accurate depth-to-bedrock representation of the area relied extensively on Esri's ArcGIS to compile information, interpolate data, and illustrate the findings. Figure 2 illustrates the depth-to-bedrock map subsequently generated for the area. As shown, it conveys a dramatically different message with regard to aquifer susceptibility. Data interpolation identifies a broad ridge of shallow bedrock along the DRC's Southwest Branch, a representation consistent with the bedrock exposures observed along the stream channel southeast of UNI's campus. Shallow bedrock, historical descriptions of the DRC as an ephemeral stream (caused by karst swallow holes), and groundwater-surface water elevation comparisons indicate a strong hydraulic connection between the DRC and the Devonian aquifer. Although a century of hydrologic alterations to the watershed (e.g., urban runoff, agricultural practices, cooling water discharge, and anthropogenic stream channel modifications) have transformed the DRC from a disappearing stream to a perennial tributary of the Cedar River, the aquifer undoubtedly remains more susceptible to surface contamination than typically alluded to in existing literature and generalized GIS datasets.

Results of this study clearly demonstrate why generalized depth-to-bedrock data and stratigraphic descriptions must be scrutinized and verified before being incorporated into local hydrogeological studies, aquifer vulnerability determinations, environmental sustainability assessments, or contemporary watershed water quality work. Assumptions based on generalized descriptions or GIS data may run the risk of causing and perpetuating mischaracterizations of specific sites. In turn, this may lead to false environmental conclusions, poor decision making and planning, and application of inappropriate water-quality regulations. The findings of this project demonstrate how readily available data resources may be used in a GIS to develop a more detailed and representative portrayal of the hydrogeology of an area and provide a more reliable basis for sound decision making and environmental planning, particularly with regard to source water protection, hydrogeology, and watershed assessment.

For more information, contact Brian Gedlinske (brian.gedlinske@uni.edu), environmental specialist, or David May (Dave.May@uni.edu), professor of geography, Department of Geography, University of Northern Iowa.

*continued from page 1*

## Northern Ireland's Flood Map Supported by GIS Cloud Technology

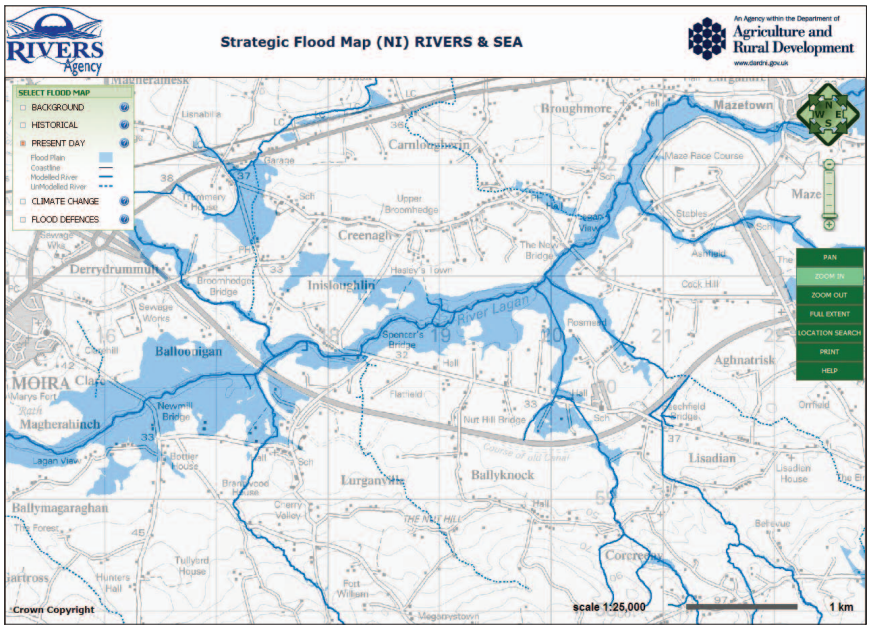
by the Northern Ireland Assembly ministers with responsibility for flood risk management and land-use planning. The launch generated a lot of media interest, and in the first few days alone, more than 15,000 users visited the website to use the map viewer. As the cloud map service host, ESRI Ireland responded quickly to this massive spike in web traffic and worked with its Internet service provider (ISP) to accommodate demand.

The Rivers Agency is delighted with its Strategic Flood Map, which helps it comply with European Union legislation and improves the availability of flood risk information to key stakeholders.

The map viewer has proved to be reliable, and the agency has received very few calls from customers reporting difficulties in using it. The agency wants to grow its services by adding data layers so that users can drill down to get more detailed information. It will also incorporate information about flood risk, such as surface water and overland flow, from other sources. Esri's cloud map service solutions will make these changes achievable and affordable.

Visit, www.dardni.gov.uk/riversagency/index/stategic-flood-maps.htm to view the Strategic Flood Map.

Ireland floodwaters




Flood Map Built on Esri's Cloud Map Service Solutions

*Hydro Line* is a publication of the Water Resources Group of Esri.

To contact the Esri Desktop Order Center, call
**1-800-447-9778**
within the United States
or
909-793-2853, ext. 1-1235,
outside the United States.

Visit the Esri website at **esri.com**.

View *Hydro Line* online at **esri.com/hydroline**.

**Advertise with Us**
E-mail ads@esri.com.

**Submit Content**
To submit articles for publication in *Hydro Line*, contact Lori Armstrong at larmstrong@esri.com or Barbara Shields, editor, at bshields@esri.com.

**Manage Your Subscription**
To update your mailing address or subscribe or unsubscribe to Esri publications, visit esri.com/manageyoursubscription.

International customers should contact an Esri distributor to manage their subscriptions. For a directory of distributors, visit esri.com/distributors.

**Circulation Services**
For back issues, missed issues, and other circulation services, e-mail requests@esri.com; call 909-793-2853, extension 2778; or fax 909-798-0560.

**The Water Resources Group**
Lori Armstrong, Industry Solutions Manager
E-mail: larmstrong@esri.com

Christa Campbell, Water Resources Coordinator
E-mail: ccampbell@esri.com



125486
QUAD16.6M4/11tk



380 New York Street
Redlands, California 92373-8100 USA