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ESRI • Spring 2009

GIS for Water Resources

National Hydrography Dataset Provides Seamless National Coverage

By Jeff Simley, National Hydrography Dataset, U.S. Geological Survey

United States Geological Survey (USGS) director Mark Myers recently announced the completion of the National Hydrography Dataset (NHD), a five-year, $50-million project spearheaded by USGS to provide 1:24,000-scale hydrography coverage of the United States. This was made possible by a partnership of more than 30 federal, state, and local government agencies that pooled their resources into a single mapping solution for scientists studying the nation's surface water.

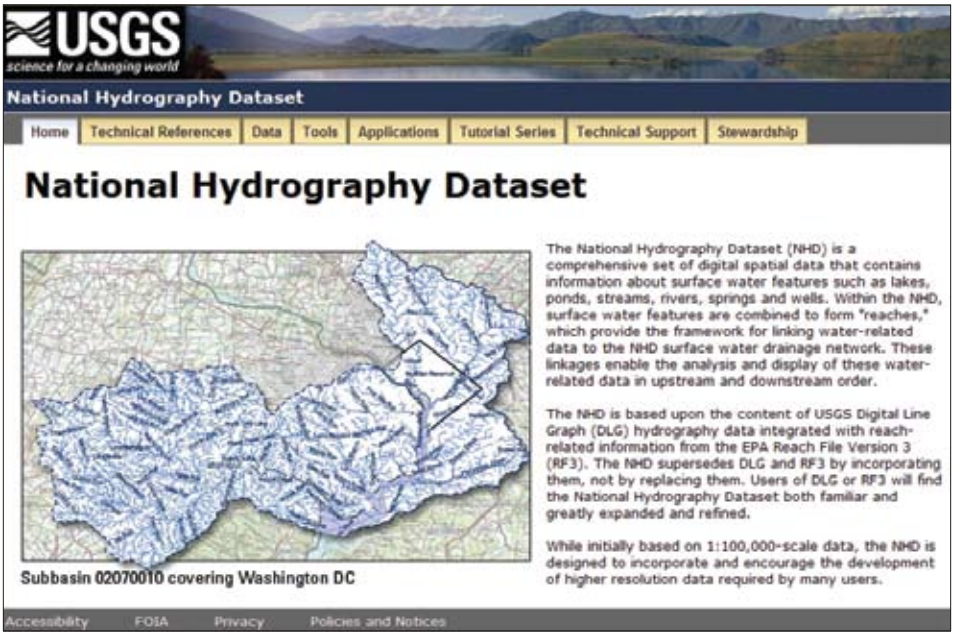
The seamless dataset is the hydrography component of the *National Map*. Content is generally based on surface water features portrayed in the 7.5-minute topographic map series and in a number of states with compilation from recent aerial photography. Efforts are now under way to begin the stewardship of the NHD in which state and federal agencies upgrade and continuously maintain the data to meet their business needs. This includes updating features; adding more feature content; naming additional features; making improvements to the flow network; and in some cases, increasing data resolution. The NHD is characterized by the use of

- Seamless nationwide coverage
- Continuous maintenance through stewardship
- A flow network
- Linear referencing of scientific data
- A change management system

The NHD is the hydrography component of the *National Map,* a USGS-sponsored program developed to provide the nation with access to basic geographic information describing the landscape of the United States and its territories through map production and data download services. The NHD is modeled utilizing the ESRI geodatabase and is available for download in personal or file-based geodatabase and shapefile formats.

The national database resides on an Oracle database, and data downloads are designed for ArcGIS 9.2. Although it is a seamless dataset, for data downloading purposes, the NHD is organized into hydrologic units covering the nation in 220 subregion units or 2,256 subbasin units.

More information and data access are available at nhd.usgs.gov.



The National Hydrography Dataset Web page gives visitors access to spatial data about surface water features and includes tools, applications, and technical support.

In This Issue

GIS Helps Reconstruct Historic Bathymetry and Morphology Changes in Lake Okeechobee

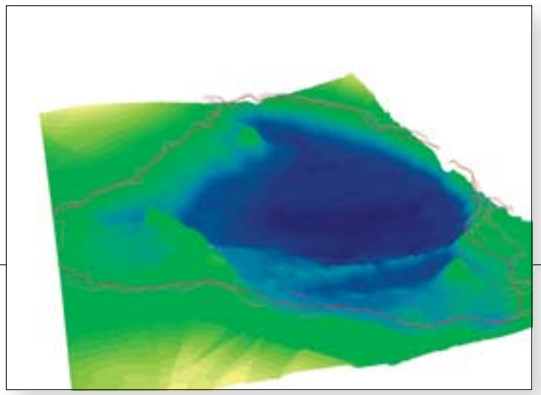
By Rosanna Rivero, Everglades Foundation, and Mehrnoosh Mahmoudi, Florida International University

Everglades restoration efforts in South Florida are supported by a broad base of public and private organizations with participation of the environmental nonprofit community and strong support at many levels. Lake Okeechobee is one of the most important ecosystems in the area, as it is the headwater of the Everglades. Lake Okeechobee is a shallow lake with an approximate extension of 730 square miles and a mean depth of 2.7 meters.

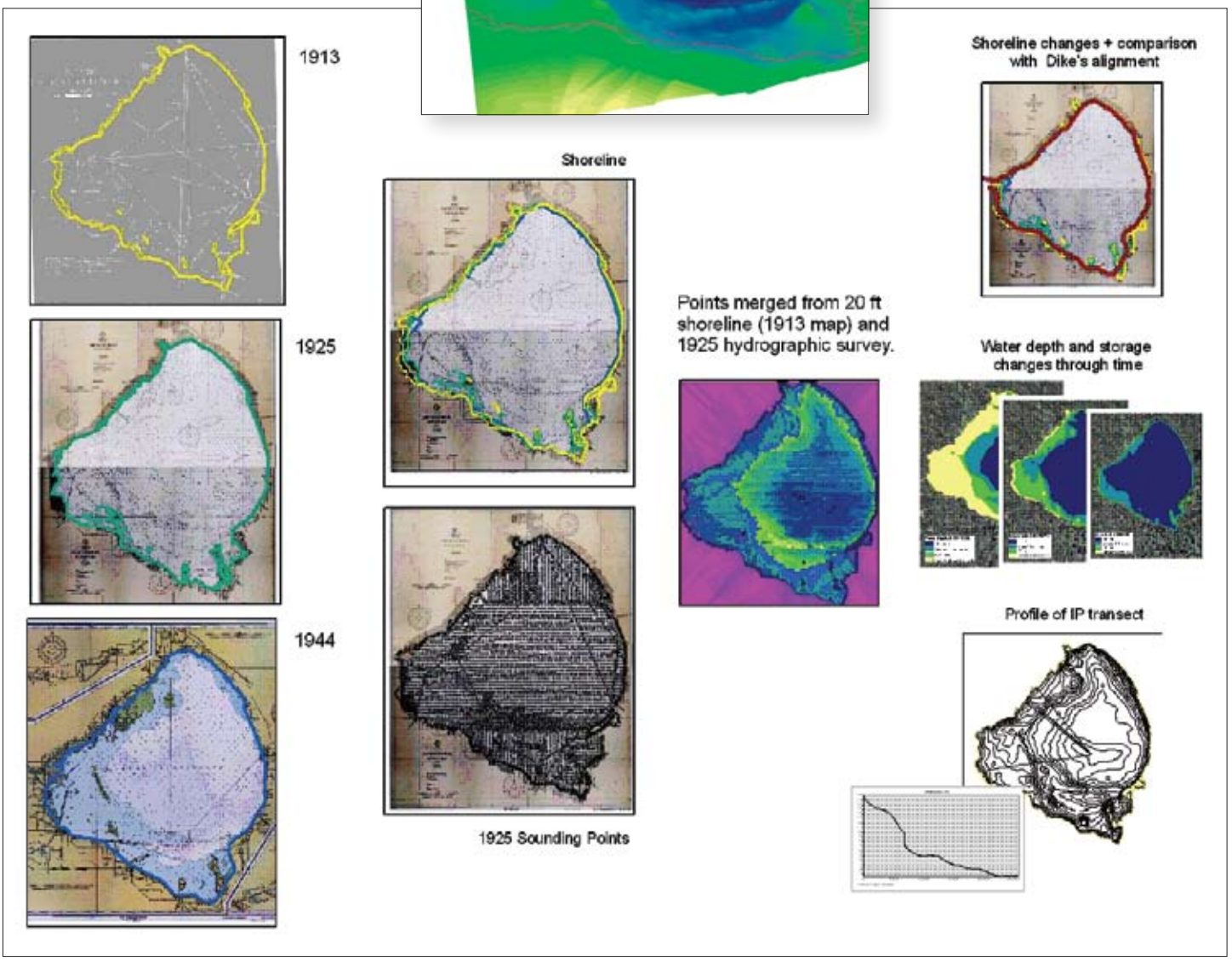
Because of its central location in the South Florida region, Lake Okeechobee represents an important hydrologic and ecological connection between the Kissimmee River watershed (extending north of the lake up to Orlando), the natural communities dominated by sawgrass (south of the lake), and the coastal estuaries (Caloosahatchee to the west, St. Lucie to the east, and Florida Bay and Biscayne Bay to the south).

Our goal was to integrate a set of historical sources (nautical charts, vegetation maps, hydrographic surveys, and written historic accounts) to reconstruct the historic bathymetry of the lake and evaluate changes over time in the lake shoreline, water levels, and lake profile. Our focus was to reconstruct time periods before and after the construction of major canals, the Herbert Hoover Dike, and other drainage works mostly from the 1913–1925 time period.

A flowchart shows all the stages of the process to be described: we were able to obtain high-resolution scanned images from navigational charts prepared by United States Coast and Geodetic



3D Visualization of Lake Okeechobee Bathymetry Using ArcScene

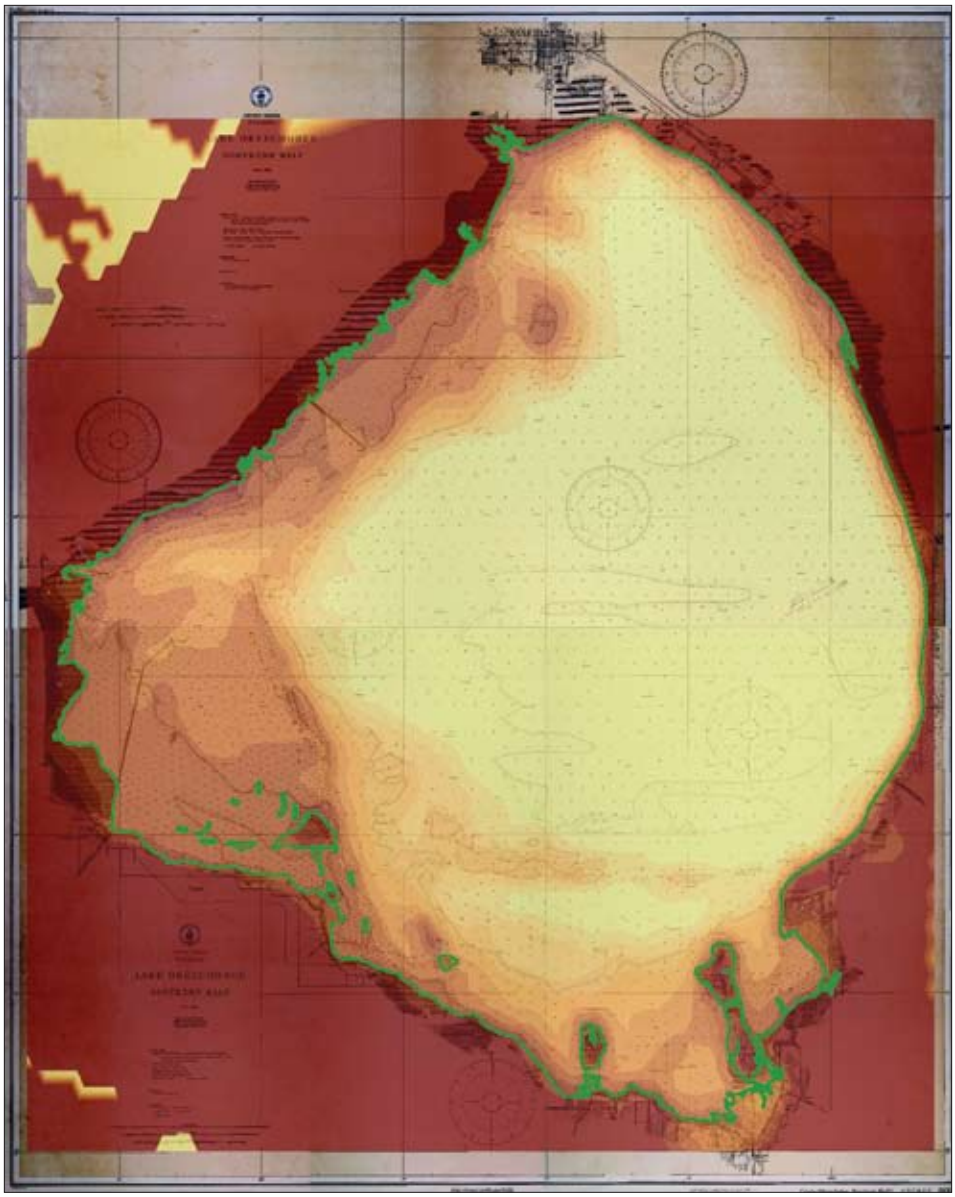


Survey (USCGS) and the National Oceanic and Atmospheric Administration (NOAA) for 1925, 1944, and 1999. These images were geometrically corrected to match existing geographic information sytem (GIS) datasets. In addition, a 1913 map (already geometrically corrected) was obtained from the South Florida Water Management District (SFWMD).

We digitized various features of these charts (bathymetry points, shorelines, and islands) using ArcGIS 9.1 and 9.2 software. In addition, a hydrographic survey, conducted by the USCGS between January and April 1925 was used as a more complete source of data for the bathymetry reconstruction, along with a subset of shoreline and island points from the 1913 map.

One of the challenges of the project was to standardize metrics and vertical datums. Because of the construction of canals and other features around the lake, various adjustments were made in 1933 to define the relationship of various datums. These constructions were established between 1905 and 1931 by the Everglades Drainage District for the purpose of draining and reclaiming the Everglades. The 1913 and 1925 charts were registered to a local datum known as mean low water Punta Rasa, but later maps were reported under mean sea level and a Lake Okeechobee datum. To standardize the metrics, units, and datums, all depths were converted to NGVD elevations.

We used the ArcGIS Geostatistical Analyst extension to perform ordinary kriging, which was used to interpolate data to produce bathymetry surfaces from digitized and surveyed points. We stratified the lake into two areas (above and below a six-foot depth), and these interpolated areas were merged to produce a final bathymetry surface. We also used the ArcGIS Spatial Analyst extension to perform various raster calculations between the bathymetry surface and the stage data. These results were used to quantify changes in water levels and storage. During the final stages of the project, we used the ArcGIS 3D Analyst extension to render the historic sequence of changes at various lake stages.



Screen Shot of Interpolated Surface, Based on 1925 Sounding Points, after Conversion to Elevation and Interpolated Using the ArcGIS Geostatistical Analyst Extension

This analysis was able to draw conclusions about shoreline changes through time, implications for water storage, and ecological implications for near-shore areas. As an example, an evolution of shoreline changes overlying the current alignment of the Herbert Hoover Dike showed relatively small changes in the extension of the lake.

The ArcGIS 3D Analyst extension was also used for visualization. Using the lake's reconstructed bathymetry and the lake stages during the various time periods associated with each lake stage, we were able to show the changes in 3D. We used the 1925 nautical chart as the background for our visualization.

With the use of a variety of GIS tools (ArcGIS and the Spatial Analyst, 3D Analyst, and Geostatistical Analyst extensions), we were able to provide a spatial representation of changes in lake stages from 1913 to the present, and relate these to changes in shoreline, water depths, and water storage. Further conclusions of this study are being published in a peer-reviewed journal.

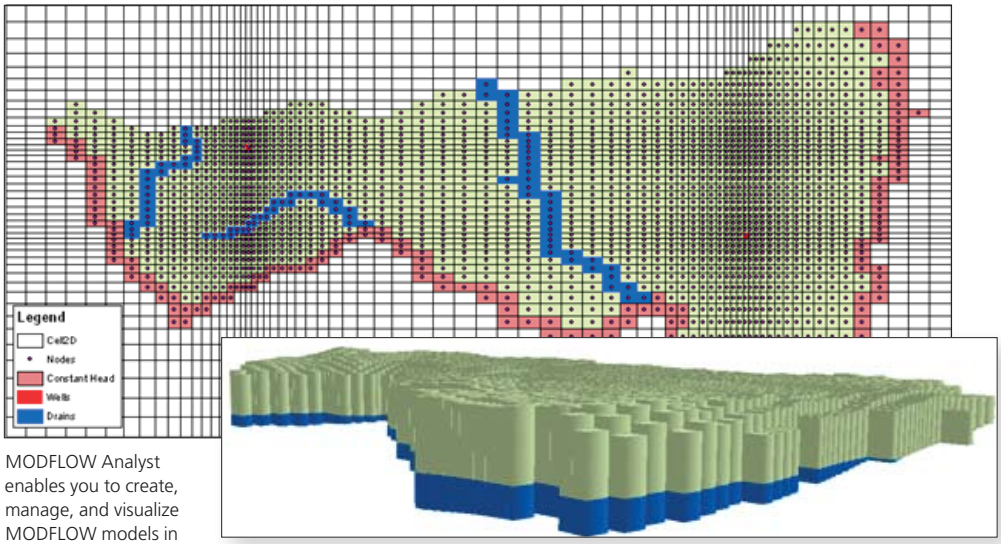
For more information, visit www.evergladesfoundation.org or contact Rosanna G. Rivero, Ph.D., by phone at 305-251-0001, extension 232, or by mail at Everglades Foundation, 18001 Old Cutler Road, Suite 625, Palmetto Bay, FL 33157.

Arc Hydro Groundwater Tools Manage Groundwater Data in ArcGIS

Arc Hydro Groundwater Tools are ArcGIS tools developed to help you better manage your groundwater data in ArcGIS. The tools are based on the Arc Hydro Groundwater Data Model, a public domain geodatabase design for representing groundwater datasets in ArcGIS.

The Arc Hydro data model started as a data model for representing surface water systems in an ArcGIS geodatabase. In 2002, the Arc Hydro data model was published as an ESRI Press book, *Arc Hydro GIS for Water Resources*. Arc Hydro has been highly successful and widely adopted in the industry. The groundwater data model was developed as a companion to the surface water data model. The data model is based on a newly designed Arc Hydro framework, which is shared by the surface water and groundwater data models. Users can add groundwater and surface water components to the framework as necessary or develop their own components. This new approach enables tailoring the geodatabase design to meet specific project needs.

The groundwater data model is being documented as an ESRI Press book, *Arc Hydro Groundwater Data Model,* which will be available soon. The data model components (as described in the book) enable the representation of different types of datasets including aquifers and wells/boreholes, 3D hydrogeologic models, temporal information, and data from simulation models.



MODFLOW Analyst enables you to create, manage, and visualize MODFLOW models in ArcGIS.

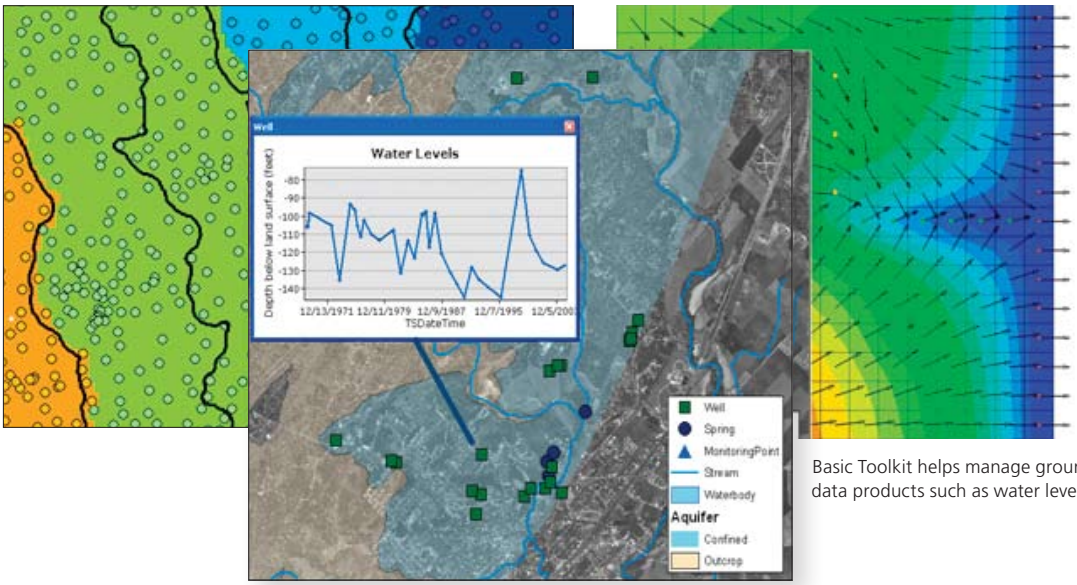
ESRI business partner Aquaveo, LLC, and ESRI partnered to develop tools that work on top of the Arc Hydro Groundwater Data Model components. Three sets of tools are being developed:

Basic Toolkit: Tools in this toolkit help you import data into your Arc Hydro geodatabase, manage key attributes, and visualize your data. With Basic Toolkit, you can import a variety of datasets (wells, time series, cross sections, and volumes) into your geodatabase; manage symbology of layers in ArcMap and ArcScene; map and plot time series; and create common products such as water level, water quality, and flow direction maps.

Subsurface Analyst: With Subsurface Analyst, you can create and visualize 3D hydrogeologic models. The tools include a borehole editor for visualizing, classifying, and editing borehole logs and tools for importing, creating, and editing 3D cross sections and volumes.

MODFLOW Analyst: MODFLOW Analyst enables you to create, archive, and visualize MODFLOW models within ArcGIS. The tools are based on the MODFLOW Data Model (a three-dimensional, finite-difference groundwater model, which is a public domain design for storing complete MODFLOW models including grid structure, inputs, and results) within an ArcGIS geodatabase. These tools enable you to import existing MODFLOW models into the geodatabase and georeference models so you can visualize and analyze model inputs and results in context with other GIS data as well as create new models from GIS features.

Arc Hydro Groundwater Tools are available now. For more information, visit www.aquaveo.com/archydro or www.archydrogw.com.

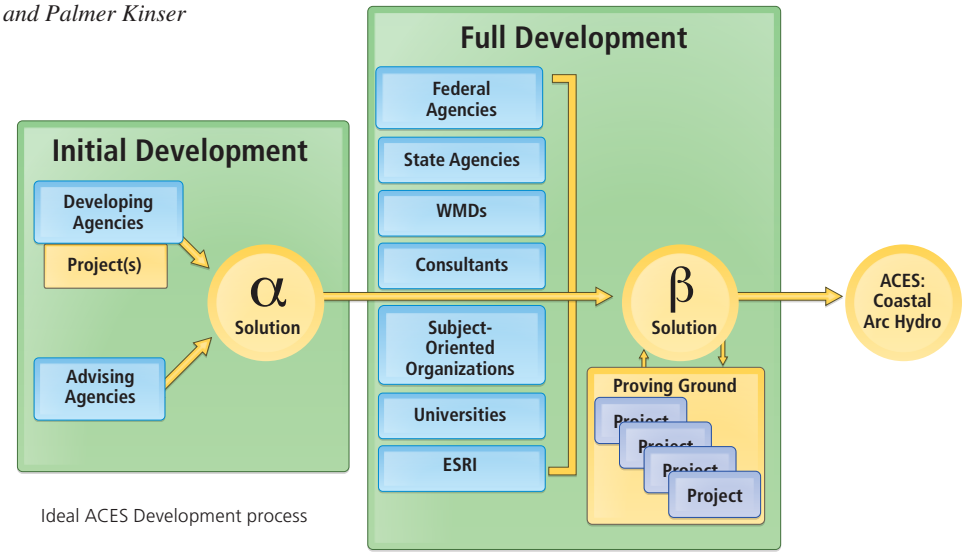


Basic Toolkit helps manage groundwater datasets and create common data products such as water level, water quality, and flow direction maps.

Using a Collaborative Approach to Develop Analytical Framework for Coastal and Estuarine Studies

By Sandra Fox, Stephen Bourne, Clay Montague, and Palmer Kinser

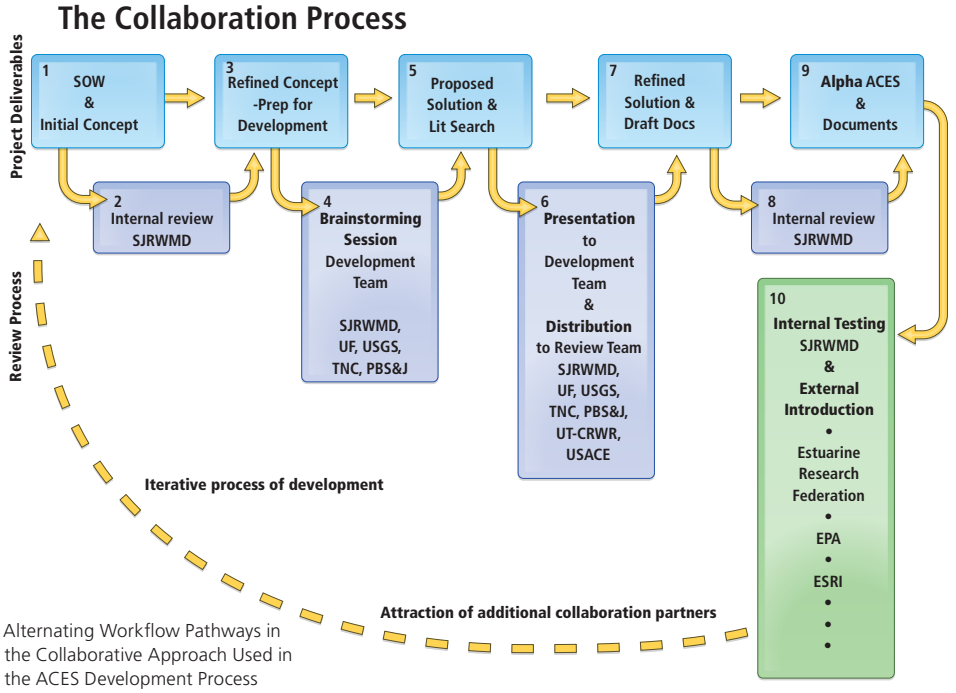
The benefits of taking a collaborative approach in science include providing a more efficient use of available knowledge, resulting in shared knowledge, enhanced learning, and consensus building as participants work toward the intersection of common goals. Arc Hydro, an evolving data model of the hydrologic environment with tools to work with the data model, is an excellent example of a collaborative approach in developing a GIS (Maidment, 2002). Professionals in the hydrologic sciences and engineering worked with ESRI and the Center for Research and Water Resources, University of Texas (UT-CRWR), to develop Arc Hydro.



Ideal ACES Development process

The development of Arc Hydro introduced two important concepts: (1) the idea that a single, modifiable, GIS-based data model can serve a community of scientists, engineers, planners, and decision makers and (2) the process of convening the community of users to design that data model. Collaboration on Arc Hydro continues as groups such as the Florida Arc Hydro Working Group share advancements in geodatabase and tool design and function (Cameron et al., 2007).

Arc Hydro was adopted by the St. Johns River Water Management District (SJRWMD) in northeastern Florida primarily as a means to integrate monitoring station information, including surface water, groundwater, and hydrometeorological stations (Mundy, 2008); and to better define drainage areas for surface water quality monitoring sites (Fox et al., 2005). In the drainage area application, specifically with regard to coastal areas, a shortcoming of Arc Hydro became apparent—due to the complex nature of estuarine and coastal systems, the concept of a drainage area based on unidirectional flow to the monitoring site (fundamental to Arc Hydro) is insufficient for coastal systems.



Alternating Workflow Pathways in the Collaborative Approach Used in the ACES Development Process

Assessment of coastal environments is traditionally tackled with complex supercomputer-based modeling techniques due to the complex geomorphology, hydrodynamics, and biogeochemistry of these systems. While these technologies provide useful results, they are unavailable to most coastal professionals. In a pioneering effort, Analytical Framework for Coastal and Estuarine Studies (ACES) was developed to support coastal assessments for SJRWMD by a team of academic, government, and industry experts. ACES is a GIS-based database of spatial and temporal data that describes the environment and an accompanying ESRI ArcGIS Desktop software-based toolset designed to work with Arc Hydro; a more detailed description can be found in the papers by Fox et al. (2008) and Fox and Bourne (2008).

For the development of a coastal enhancement to Arc Hydro that would enable a better understanding of the factors affecting water quality in estuarine systems and thereby assist in defining the area influencing water quality at monitoring sites, the overarching (multiyear, multiproject) plan was proposed by Steve Bourne of PBS&J. This plan is characterized by multiple collaborative efforts and ideally encompasses several

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Using a Collaborative Approach to Develop Analytical Framework for Coastal and Estuarine Studies

alpha projects in the initial development phase, each focusing on coastal or estuarine problems or management issues relevant to the developing agencies' mandates such as water quality to the SJRWMD. Each project is a collaborative effort, drawing on experts from multiple disciplines and a variety of agencies. Collaboration provides diverse viewpoints of estuarine systems to each project as well as potential additional applications that are taken into consideration as the new data model is designed.

A simplified project workflow can be described as alternating between the project deliverable pathway and the review process, with project team members remaining more or less constant. Because of the complexity of the task of building a GIS-based tool to better understand the processes that influence water quality along the coast, it was determined that the project would benefit from a wider source of input and evaluation and was, therefore, an excellent candidate for the collaborative approach.

Augmenting the development and review processes during the main development period are brainstorming sessions; experts in estuarine science and engineering from academic institutions (University of Florida and University of Texas), a nonprofit environmental agency (The Nature Conservancy), and federal agencies (U.S. Geological Survey [USGS] and U.S. Army Corps of Engineering [USACE]), as well as from SJRWMD and PBS&J, were invited to participate in the development and review of ACES. The experts were divided into two groups—those that would assist with both development and review and those that were involved with the review process only, thus providing objectivity to the review process.

Critical to the success of these brainstorming sessions is the establishment of specific goals to be accomplished during each session. The first brainstorming session provided the background for problem definition and helped set the direction for project development. During this session, the estuary physical model was used to fuel discussion. Additionally, available data for analysis was inventoried, the major direction for a literature search was determined, a realistic plan for tool development was created, and the pilot area was chosen.

From this brainstorming session and subsequent literature review, it was clear that the first step in approaching the study of estuaries with GIS was the creation of a GIS-based workbench tool that would be able to

- Integrate data from multiple sources.
- Allow creation of virtual estuaries in GIS.
- Estimate estuarine bulk parameters such as volume and flushing time.
- Facilitate development and integration of other models into the same framework.

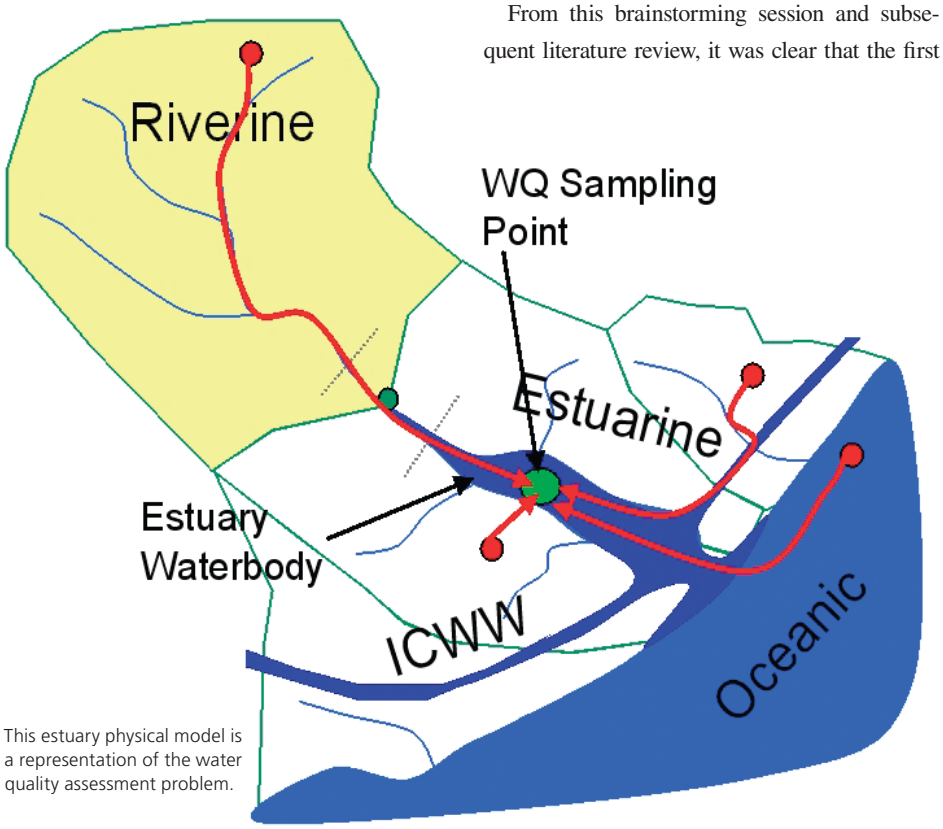
A prototype solution was developed, quickly bringing into reality an illustration of the envisioned solution, thus enabling demonstration during the next brainstorming session. The availability of the prototype was a key factor in the success of the second brainstorming session, providing a tangible element to fuel discussions. The participants had something to view rather than just a description or a blueprint. The second brainstorming session brought consensus on several important fronts (including method of estuary polygon delineation and bulk parameter calculations) and furthered the discussion, failing to reach accord on only one major issue (the water quality modeling approach). The lack of agreement on the issue of water quality modeling underscored the requirement that the tool be designed to facilitate a wide variety of modeling approaches. However, it was accepted that only a single modeling approach (multiple linear regression) could be facilitated for this alpha development phase.

Additionally, the draft documents were sent to all participants for comments. The input received from the development and review teams helped further refine the final project solution.

The ACES project produced the following:

- Physical estuary model
- Conceptual model (Fox et al., 2008)
- Coastal feature dataset that works with the Arc Hydro schema
- ACES workbench (an extension to ArcMap)
- Concept of creating a virtual estuary in GIS
- Thorough literature review
- Set of documentation

Additionally, ACES creates an environment where data from diverse sources can be synthesized. At present, ACES is undergoing internal testing at SJRWMD and has been presented at



This estuary physical model is a representation of the water quality assessment problem.

several national meetings to attract additional participants for future collaboration.

The potential disadvantages to taking a collaborative approach to developing a GIS are

- The project may take more time.
- The old adage "too many cooks spoil the broth" might be expressed as scope creep, with the project diverging when it needs to be focused.
- A possible dilution of expertise may occur if the team has not been carefully selected.
- Team members must be adequately familiar with the process of development so that appropriate expectations for tool maturity are held at each development stage.

There are many advantages to using the collaborative approach in the development of GIS. First, the process of integrating expert opinion creates the potential to produce a maximally useful tool. The committee assists in the design of the data model and associated tools, each member focusing on the applications for which the new tool is needed. The resulting product can ultimately serve a variety of applications from the outset or at least be general enough to easily expand. Second, because the tool is the result of committee interaction, committee members are motivated to use the tool for their own analysis and sharing analyses. A third advantage to the collaborative design approach is that including experts in a broad variety of areas of estuarine science and management results in multidisciplinary synergies that often reveal simple and powerful new techniques for study. Additionally, communication and the sharing of data, analytic approaches, and results reduce duplication of effort, a great benefit in times of reduced funding. Finally, a collaborative approach results in communication and a collegial spirit among colleagues, thus creating a community of users providing a support network for continued development.

Acknowledgments

The Surface Water Quality Monitoring program of SJRWMD (with Aisa Ceric, program manager) provided funding for the development of the ACES project. The ACES project would not have been possible without the participation of Dr. Ashish Mehta, University of Florida; Pete Sucsy, SJRWMD; Dr. Michael McManus, The Nature Conservancy; and Mike Turtora, United States Geological Survey. We are also indebted to the review team: Dr. Rob Wallace, U.S. Army Corps of Engineers; Drs. Tim Whiteaker and David Maidment of CRWR-UT; Steve Winkler, Joel Steward, Whit Green, Nathan Martin, and Adrian Lin, SJRWMD; and Jack Hampson, PBS&J. Development of GIS-based projects at SJRWMD would not be possible without the support of the Information Resources Department.

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ESRI on the road

World Environmental & Water Resources Congress Environmental & Water Resources Institute (EWRI)
May 17–21, 2009, Kansas City, MO
content.asce.org/conferences/ewri2009/

Association of State Floodplain Managers 33rd Annual National Conference
June 7–12, 2009, Orlando, FL
www.floods.org/Conferences,%20Calendar/Orlando.asp

American Water Works Association 2009 Annual Conference and Exposition
June 14–18, 2009, San Diego, CA
www.awwa.org/ace09/

2009 ESRI Survey & Engineering GIS Summit
July 11–14, 2009, San Diego, CA
www.esri.com/segsummit

2009 ESRI International User Conference
July 13–17, 2009, San Diego, CA
www.esri.com/uc

StormCon North American Surface Water Quality Conference and Exposition
August 16–20, 2009, Anaheim, CA
www.stormcon.com

American Geophysical Union 2009 Meeting
December 14–18, 2009, San Francisco, CA
www.agu.org/meetings

Water Management Improves Field Data Collection Speed, Accuracy, and Productivity with Capturx

The Surface Water Management Division (SWMD) of Public Works in Snohomish County, Washington, takes a comprehensive approach to managing surface water. In addition to maintaining public infrastructure investments, the agency also works to minimize flooding while protecting and restoring important natural water resources. Half of the agency's 80 employees work in the field to manage vast amounts of constantly changing data. To gather information quickly and keep their central GIS data up-to-date, the agency launched a pilot program using Capturx for ArcGIS digital pen and paper software.

SWMD has a broad mandate and serves a range of constituents. The agency dedicates half of its workforce to the job of measuring and analyzing the current state of both constructed and natural drainage systems. Management of volumes of data over long periods of time is a necessary part of the work.

Map of the Stillaguamish Clean Water District in Snohomish County

The SWMD team also works closely with the citizens of Snohomish County to focus on long-term community building including providing technical assistance for property owners with drainage challenges or water quality issues and encouraging property owner actions that promote aquatic health. The team is very hands-on, building partnerships with landowners, businesses, and groups in the community to help regain and preserve the vitality of Snohomish County's network of natural streams.

Tracking and coordinating such an extensive set of mandates, data, and field personnel are major challenges. Information changes frequently. In order for team members to make the best decisions for the community, they need access to the most current data.

Other challenges are in the very nature of working with wet field environments and variable conditions. Collecting data on storm drainage patterns often involves floating down rivers; wading through streams; or trudging into wetlands that are exposed, wet, and muddy. Laptops and rugged PCs are heavy, cumbersome, and expensive.

To improve information flow from the field, SWMD selected Capturx for ArcGIS and Capturx for Microsoft OneNote to test new field data collection and management techniques. "We evaluated several field data management solutions and opted to use Adapx because its solutions digitally enable the tried-and-true business process of taking notes with pen and paper," said Deb Haynes, SWMD senior GIS analyst. "Virtually anyone can begin using it right away, and we have greater flexibility in a variety of weather conditions. There is no need to learn a new technology or do any data entry."

Capturx combines a digital pen with digitally enabled paper and Capturx for ArcGIS extension software. Field maps and layouts are created within ArcGIS the same way that the team previously prepared and printed maps. The maps are printed on normal paper but are digitally enabled with a unique background pattern that the digital pen senses as it writes. Each stroke of the pen on the paper map creates a new feature or a redline annotation that is geospatially referenced and added to the geodatabase. Once the pen is docked in its USB port on a PC or laptop, the field data automatically appears in ArcGIS. There is no new technology to learn or data to reenter.

The team also uses Capturx for Microsoft OneNote, which utilizes a Rite in the Rain all-weather journal. Notes that would normally be written on paper and remain inaccessible in notebooks kept in a desk now become digitized and easily accessible. The notes and draw-

"Our field staff has been really excited about the pilot of Capturx. They see firsthand how it makes their jobs easier, and our management appreciates the speed and accuracy with which data is delivered from the field to their e-mail in-box."

Deb Haynes, senior GIS analyst, Surface Water Management

ings are sent directly into Microsoft OneNote, leaving a paper copy in the notebook. The all-weather journal is perfect for the surface water management task.

Capturx integrates with ArcGIS and OneNote, making data uploads and management very easy. Once Capturx has data, it can be immediately uploaded and shared among team members. Elimination of the need for support staff to decipher and transcribe field notes increases data accuracy and integration speed. The agency can more quickly review important information with key personnel, enabling better data analysis to serve customers more efficiently.

With the natural pen interface and direct integration into ArcGIS, virtually any team member can begin using Capturx right away. The pen also lets field personnel work with greater flexibility in a variety of weather conditions. The agency is able to easily deploy digital pens to field staff with virtually no training.

SWMD expects meaningful cost savings from using the Capturx platform and digital pens. Compared with traditional pen-and-paper markups or other technology solutions, key gains are anticipated from the impact of time savings, more efficient decision making, and cost of ownership.

"Our field staff has been really excited about the pilot of Capturx. They see firsthand how it makes their jobs easier, and our management appreciates the speed and accuracy with which data is delivered from the field to their e-mail in-box," said Haynes.

For the future, the team also foresees expanding the scenarios for Capturx for ArcGIS to include satellite image classification, vegetation monitoring and identification, locating existing utilities, and note taking at public meetings. SWMD is also interested in exploring the use of Capturx with forms to speed up current pen-and-paper processes.

For more information on the Capturx for ArcGIS extension, visit www.esri.com/adapx.

Go Digital without Giving Up Your Paper and Pen

ADAPX™
TURNING INK INTO ACTION

Field data collection is vital to the work of water resources agencies in their efforts to understand and maintain diverse and dispersed natural features. Many methods and technologies are inconvenient, error prone, and time consuming. In any industry with a substantial mobile field force, there is great demand for reliable systems that quickly bridge the realities of the field to the desks of decision makers. Faced with harsh environments and weather, pen and paper often make more sense than laptops and PDAs for data collection.

Capturx for ArcGIS is a powerful, simple, digital data collection solution that empowers ArcGIS users to collect GIS data with pen and paper. Made by ESRI corporate hardware partner Adapx, Capturx for ArcGIS digitally enables paper-based field mapping with a digital pen and standard paper.

Here's how it works: Documents are printed on ordinary paper using Capturx software. The software converts the paper to digital paper by imprinting a pattern of tiny black dots. The Adapx digital pen captures information from paper and later uploads data to a computer through a USB port. The digital pen uses infrared light to illuminate the dot pattern, picked up by a tiny infrared camera, and thereby record location coordinates. Field maps and layouts are created with ESRI ArcGIS technology. Once the pen is docked in its USB port on a PC or laptop, the field data automatically appears in the GIS. There is no new technology to learn or data to reenter for field data collection.

As a result, data is shared more frequently and at a faster pace, resulting in more effective use of time and resources as well as significant return on investment.

Digital paper and pen technology reflects a growing trend in information technology: the incorporation of natural interfaces into the workplace. Behind this school of thought is the bold idea that users don't need to change; rather, existing communication modalities, such as writing and speech, can be adapted to proven systems. The successful integration of digital pen and paper technology into mobile operations is a clear example of this trend.

As mobile computing increasingly becomes the standard and, specifically, as more and more industries discover how to apply the efficiencies that mobile GIS provides, there will be increasing growth in how these applications evolve to meet situation-specific needs.

A digital pen records location coordinates as it scrolls over specially printed paper.

Rugged field conditions create the need for reliable, easy-to-use data collection tools.

PBS&J and Arc Hydro

By Jack Hampson, PBS&J

For the past five years, PBS&J, a multidisciplinary consulting firm based in Orlando, Florida, has implemented Arc Hydro with enterprise information systems for our clients across the country. PBS&J has water-related projects in Nevada, Texas, Georgia, and Florida.

The basic concept of Arc Hydro is an industry-standard database and a shared set of GIS tools for building and managing information. At first, this does not excite the imagination of engineers and scientists; however, when you convey a vision of what can be done with the Arc Hydro foundation, you tap into a well of enthusiasm.

That vision is conveyed in a concept called the digital watershed. In water resources, there typically is a fundamental disconnect between the geographic representation of a watershed and what is truly of interest—the water. The catchment areas and water conveyance system in a watershed are relatively easy to map, but the water data is massive and difficult to wrangle. Water data may include years of information—sometimes collected as frequently as every 15 minutes—from rain gauges, radar rainfall, evapotranspiration estimates, water levels, flows, and water quality samples with scores of water quality variables. When you add to that the data from hundreds of studies and simulation models created by dozens of agencies, you have an embarrassment of riches that must be sifted and organized to understand a given watershed.

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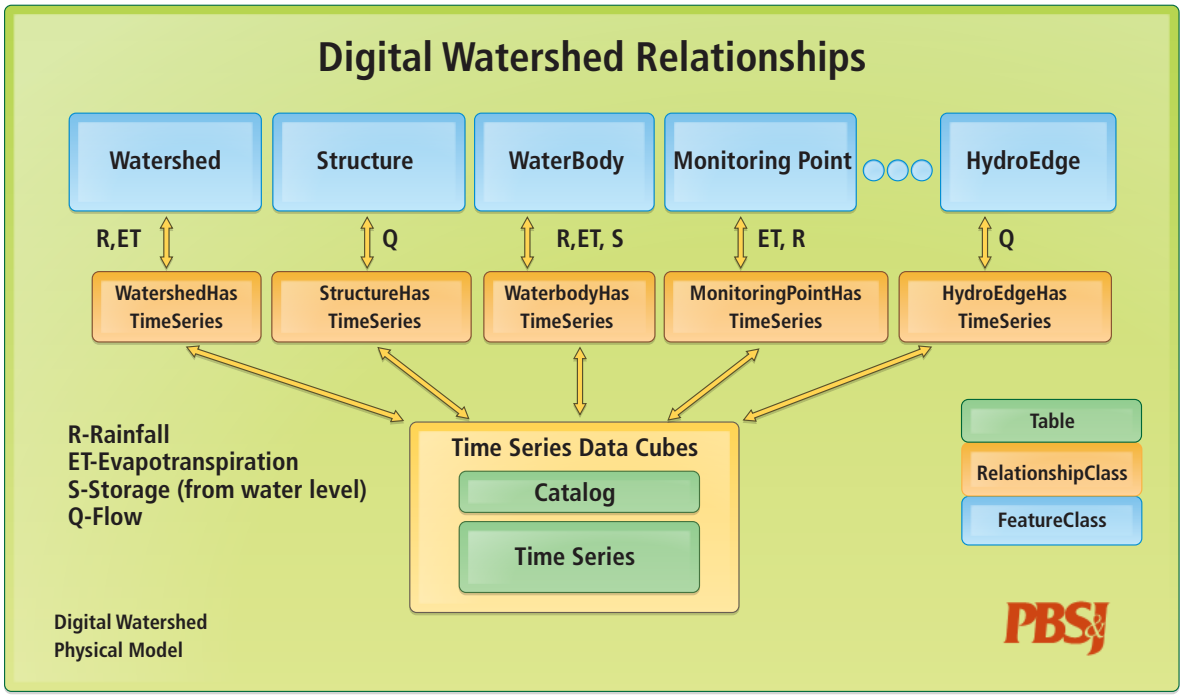
The digital watershed, in a nutshell, is a realistic database representation of the watershed and the water. With the digital watershed as a foundation, it is possible to estimate the volume of water falling on, evaporating from, sinking into, and flowing out of a watershed based on actual measurements. This foundation, known as a mass balance (or water budget), becomes an extremely powerful tool for validating water measurements, understanding the movement of water in the watershed, calibrating simulation models, and anticipating watershed responses. These capabilities are the foundation to support dynamic simulation model updates, real-time operations decision support, emergency response planning, environmental restoration, watershed management, water supply planning, and decision support. New data can be gathered and added to existing data to maintain currency. Simulation models can be loaded and updated with new parameters based on incremental updates to the watershed database.

The key enhancements to Arc Hydro needed to implement the digital watershed are the time series catalog and many-to-many relationships. Don't glaze over yet; all this means is that sets of measurements, such as rainfall at one location or water levels at one gauge (time series), can be described in a catalog. Then the catalog entries can be associated with multiple features—not just where they are measured but where they can be applied in a water budget—for instance, the rainfall on a basin or the water level in a lake. The figure below shows an example of a digital watershed physical model, where watersheds have rainfall, streams have flow, and water bodies have water levels. The traditional disconnect is being overcome thanks to the next generation of GIS and Arc Hydro. Visit www.esri.com/archydro.

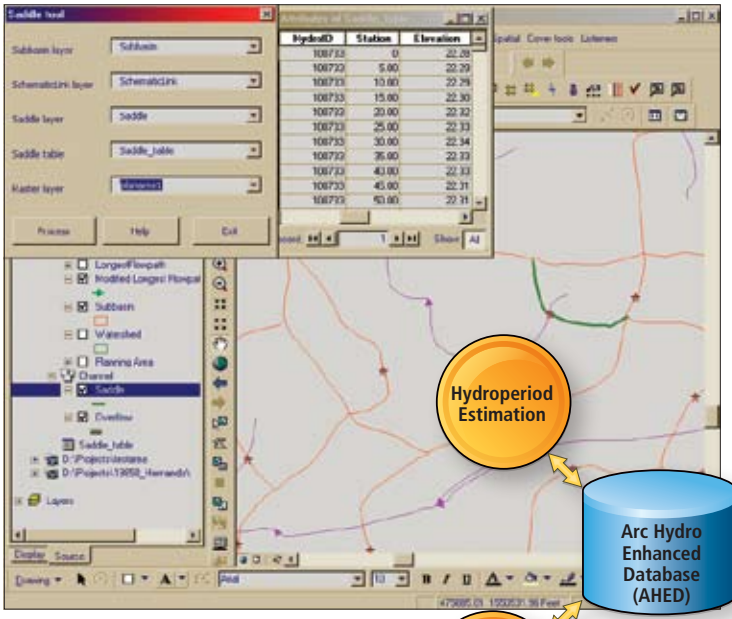


Many-to-many time series relationships must be built into the geodatabase to create a digital watershed model.

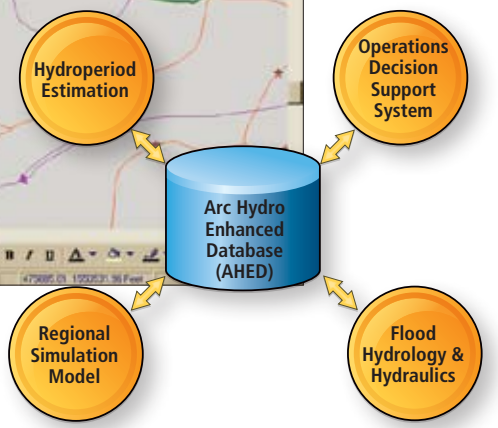
Jones Edmunds

Jones Edmunds is a Florida-based consulting firm providing professional services in engineering, architecture, and environmental sciences. Jones Edmunds consists of more than 300 employees and is considered by *Engineering News-Record* to be a top 500 design firm and a top 200 environmental firm. The company is also ranked as one of the top 25 design firms in the southeastern United States by Southeast Construction. Jones Edmunds delivers quality services in a broad range of disciplines including GIS technology.

The importance of using technology that properly stores and maintains data is an indispensable part of resource planning when considering Florida's continually expanding population. Throughout Florida, this expanding population creates a need for new infrastructure and water supplies that is complicated by floodplain management and the need for ecological restoration and preservation.



Specialized tools for Arc Hydro permit data integration.



Schema of a central source of hydrologic and hydrographic GIS data supports a variety of water management business functions.

As a leader in GIS and water resources, Jones Edmunds is helping clients integrate data at the core of their water resources work by streamlining their workflow through a geodatabase approach. The company's innovative approaches to GIS and water are targeted at facilities/asset management and engineering. Finding common ground between these two unique activities helps clients do more with less.

At the center of this integration is the Arc Hydro geodatabase. Jones Edmunds is customizing the design of the geodatabase and the associated Arc Hydro tools to suit the specific asset management and engineering modeling needs of a number of clients including the South Florida Water Management District (SFWMD), Southwest Florida Water Management District (SWFWMD), and Sarasota County. All have critical data and modeling needs and have developed unique ways to manage water through innovative and efficient uses of technology.

Jones Edmunds is supporting SFWMD in development of an Arc Hydro enhanced database (AHED). The AHED will serve as a central source of hydrologic and hydrographic GIS data, supporting a variety of water management business functions. Leveraging the AHED data model as a hydrologic system framework will enable connectivity to facilitate spatial analysis of attribute and time series data. This will greatly reduce data redundancy and ensure that multiple business groups are using a common source of information throughout 16 counties in South Florida.

As part of efforts to support SWFWMD's Watershed Management Program and Federal Emergency Management Agency (FEMA) work, Jones Edmunds developed a custom set of ArcGIS software-based tools to augment ESRI's Arc Hydro tools. These tools addressed unresolved issues with creating large models. SWFWMD recognized the efficiencies gained by the new tools and contracted with Jones Edmunds and ESRI to further develop and deploy these tools as part of the core ESRI Arc Hydro tools. As part of this effort, Jones Edmunds is optimizing the district's geodatabase design to support GIS tools and will standardize the import/export of data between the geodatabase and storm water models.

Jones Edmunds helped Sarasota County with a storm water data development plan. In performing this service, Jones Edmunds developed an asset-based storm water geodatabase that supports elements of the county's FEMA map modernization efforts. Existing and new storm water data is being collected to populate the geodatabase that will ultimately support the county's asset management implementation as well as its ongoing storm water modeling efforts. Related to this effort, Jones Edmunds helped the county develop its storm water manual as part of its land development regulations updates. The county will now have updated models that can be readily used on a daily basis.

Jones Edmunds continues to utilize the best of GIS technologies to help its clients plan for Florida's future.

Hydro Line is a publication of
the Water Resources Group of ESRI.

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Lori Armstrong, Water Resources
Industry Solutions Manager
larmstrong@esri.com

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