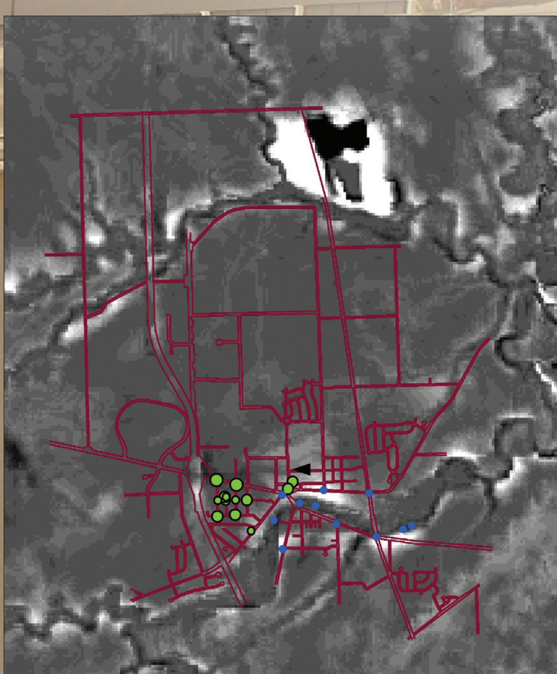
An aerial view of the flooding in the Village of Dundee. Flood levels reached the bridge leading into the downtown area, overflowing the local dam and numerous buildings.

Making More Informed Decisions

Helping small communities assess risk

By Craig A. Ries and David A. Kubiske, P.E., P.S. (Contributing Editor), David Arthur Consultants, Inc.



The digtal elevation model (here in gray scale) showing elevations in the Village's vicinity along with GPS data and GPS points marking some initial work on the CSO system shown as green dots

A small Michigan community was able to model potential flood levels and identify areas at risk by combining existing data with newly collected and highly accurate horizontal and vertical data around the floodplain.

For a community located near a sizable river, accurately predicting flooding and managing the associated risks can be a difficult and relatively expensive task. This is true for the Village of Dundee. Located in southeastern Lower Michigan, the village is bisected by a river. Like many communities in the 1970s, the village adopted a combined sewer outfall (CSO) system as a result of water quality federal regulations and statements from the Department of Environmental Quality (DEQ). CSO systems combine sewer and storm water systems to dilute outflowing sanitary effluent returning to a river.

Following changes in water pollution regulations and a better understanding of its causes, CSO systems were no longer endorsed. Under new regulations, CSO systems failed to meet the requirements of new laws. This was particularly true for the village due to overtaxing of the downriver treatment plant. Many communities replaced or modified sewer systems to meet the new regulations, and the village was no exception. It separated the storm and sewer lines it was aware of and

Continued on page 28

An aerial view of the Village of Dundee with overlays of the rights-of-way (red lines) and a number of locations of GPS shot for elevation (blue dots), which indicate partial flood levels

Making More Informed Decisions

Continued from page 27

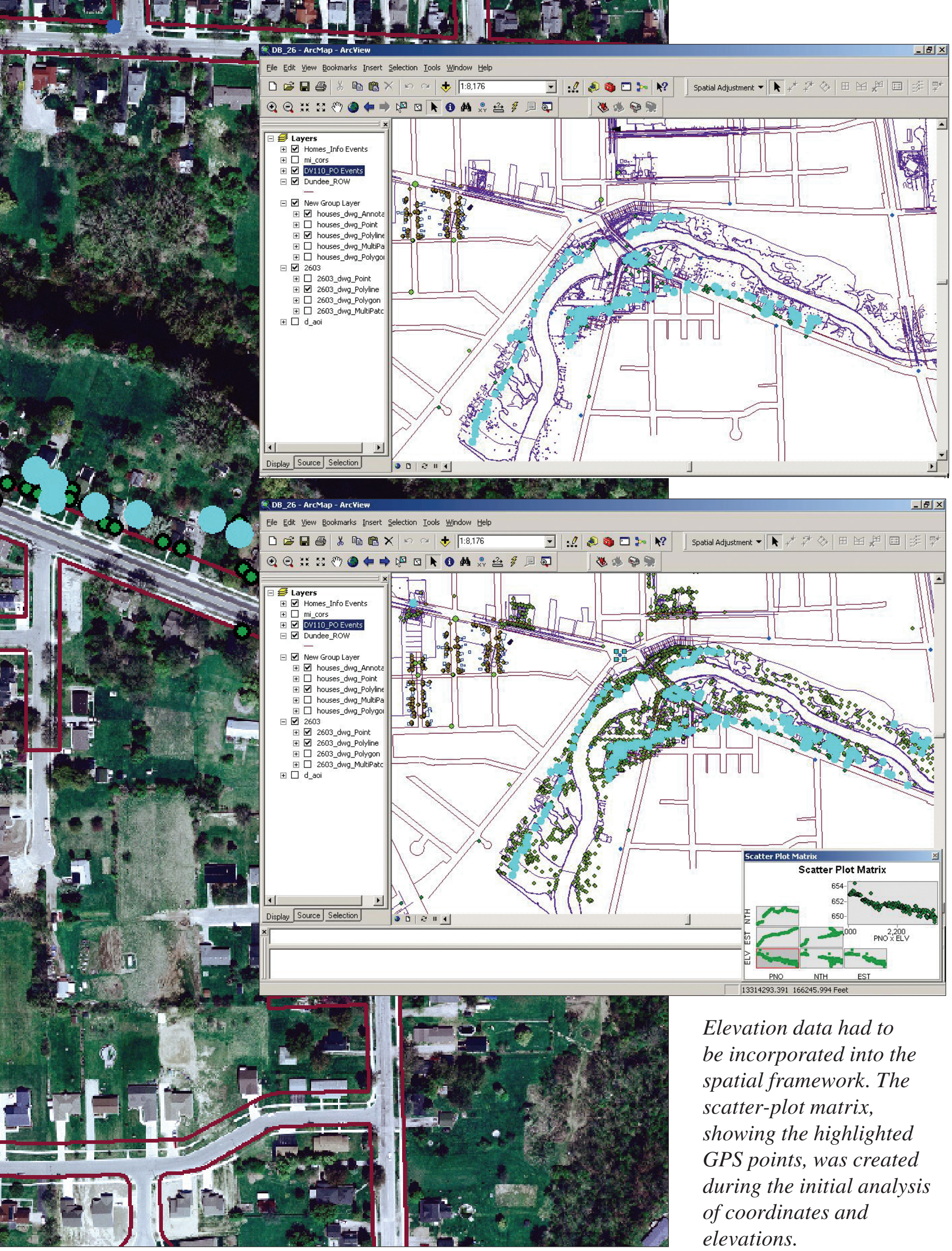
implemented better treatment measures to meet the newer requirements.

However, while the community was expanding, many older residential areas along the river had CSO-era and earlier systems that contributed excess rainwater to the river. This water went to the treatment plant, rather than the storm water system. Recently, the village made aesthetic improvements to the riverbanks—with DEQ approval—by adding a small number of structures along the banks that altered the river's flow, direction, and magnitude. These changes, both man-made and natural, modified the river and its flow enough that the floodplain map needed to be reevaluated. The amount and flow of water are the bases for calculating the floodway and floodplains.

In early 2008, an unexpected problem developed with the storm water system. Large amounts of rainfall diverted from homes to the river brought the problem to light. Older homes were diverting more water into the sewer system than had been anticipated. This caused the treatment plant to overflow into the river and eliminated its effectiveness as a water treatment plant. These homes returned excess rainwater directly to the sewer system via house foundation drains, roof downspouts, and sump pumps. Because periods of high rainfall could overflow the treatment plant, the village began fixing the remaining portions of the storm water system. However, there was no list to indicate which houses remained partially connected to the sanitary sewer system. The problem reoccurred in early 2009 when three days of rainfall caused the village to experience approximately a 100-year flood as defined by the most recently revised hydraulic analysis for river flow by the Federal Emergency Management Agency (FEMA).

The water reached levels recorded in the village only twice before by the National Oceanic and Atmospheric Administration (NOAA). This event raised a serious question: During a severe weather event, how can the village determine which residences and businesses are in the predicted floodplain so it can warn them?

To solve this problem and more easily



A selection of CAD layers provided groundwork for later GIS development.

Elevation data had to be incorporated into the spatial framework. The scatter-plot matrix, showing the highlighted GPS points, was created during the initial analysis of coordinates and elevations.

address unforeseen complications in the future, the village turned to GIS so many aspects of hydrology could be combined. With GIS, floodplains could be overlaid to help analyze and predict events rather than simply present data. The village already had most of the information needed to predict both flood levels and the specific areas that would likely be affected by any one flood.

However, while initially the data was available to decision makers, this data was separated into many files stored on many computer systems and could not be easily gathered or studied. The maps, AutoCAD files, miscellaneous spatial information, written memoranda, and other files needed to be combined with data collected from the area and presented in a way that would allow the village government to better analyze and address not just flooding problems but also other hydrology issues.

The existing information was sufficient to predict possible floods and their locations, but due to the problem with the storm water system, the extent could not always be predicted. The additional data on, for example, which houses needed to be removed from the sewer system, once collected and combined with the existing information, would not only allow the extent of possible floods to be better predicted but also assist in dealing with certain issues with the storm water system that was being modified.

It was determined that preexisting information would be merged in ArcMap. GPS data would provide more accurate elevations, digital images around the village would help better visualize and predict flood levels, and aerial and topographical maps would be overlaid to provide context for the entire village. The aerial and topographical maps allowed an additional analysis of the watershed for areas outside the floodplain to determine their possible effects on the village's storm and sewer water systems.

A field crew used GPS equipment to collect horizontal and vertical data around the floodplain. The project was concerned with a specific aspect of hydrology. Within this limited area, a more accurate topographical representation of the floodplain and the surrounding areas was required in part to correctly identify which homes and how much water shunted into the river and sewer system would be captured by the storm water system.

GPS was used to acquire highly precise horizontal and, even more importantly, vertical benchmarks so the many other kinds of information could be accurately incorporated. Of the information to be included, a correctly projected and transformed aerial raster set for the entire village was the most challenging to obtain. With this accomplished, the rest of the project could correlate this information with the topographical data relating to the river and the storm water systems throughout the village. Both systems play a large role in the dynamics of the watershed and risk of flooding.

With a basemap and the rest of the information for the entire village in place, proper analysis could be performed at a much higher level of specificity, and these analyses could be more easily performed for future hydrological projects.

Through careful spatial analysis using ArcGIS, small and rural local governments can make more informed decisions regarding their existing infrastructure. Many of these communities already have the necessary data at their disposal but lack an effective way to leverage this disparate data. GIS can give these governments a tool to better analyze their existing knowledge base. For more information, visit the ArcGIS Resource Center for Water Utilities at resources.esri.com/WaterUtilities.

About the Author

Craig A. Ries is a GIS technician with David Arthur Consultants, Inc., and can be reached at dac@cass.net.