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Grand Forks, N.D. Comes Back from Massive 1997 Flood With Citywide GIS from Autodesk

In early 1997, the city of Grand Forks, North Dakota, had what could be called a rough winter. The city was pounded by a brutal series of blizzards; eventually the local newspaper began to give them names. Children rarely went to school for five days in a row. After a dozen furious snowstorms, snow had piled so high on Grand Forks' flat landscape that the roads became like tunnels, walled high with white on either side. A hundred inches of snow fell - three years' worth in six months.

In April, the snow began to melt. And then the trouble really started.

As the melting snow began to pour into the Red River, the river rose steadily. Considered dangerous and flood-level at 28 feet high, the river hit that mark quickly and kept rising, creeping toward the edges of Grand Forks and its sister city across the river in Minnesota, East Grand Forks. Finally, the water crested at an unfathomable 54 feet, bursting past sandbags and dikes, engulfing the downtown business district and beyond. Forty-six thousand people - 90 percent of the city's population - were evacuated during the flood, leaving behind epic destruction: 2 million acres of farmland under water; $2 billion in property damage; 8,600 homes and 1,600 apartments destroyed or damaged. Eleven downtown buildings were gutted by a massive fire that leaped from structure to structure.

Meteorologists watching the unfolding disaster declared it a 500-year flood. Flying over the scene with President Clinton, emergency officials saw places where the Red River was five miles wide. Thousands of displaced residents slept on the floor of an air base hangar, others in whatever shelter they could find, some fleeing a hundred miles from the city. With its utilities in ruins, Grand Forks did not have drinkable water for 23 days.

When the flood waters receded, the city began to rebuild with the help of grants totaling $350 million from the Federal Emergency Management Agency (FEMA). The agency forbade the city from building anywhere within the floodplain along the river; hundreds of homes already there were purchased and demolished, replaced with green space. Outlying parts of town were developed in their place, and a long chain of temporary dikes was built until permanent flood protection systems could be built by the Army Corps of Engineers. Among the grants was $1.2 million for Grand Forks to implement a new technology that would help officials fight the next flood, and serve the city on a day-to-day basis: an Autodesk-based citywide Geographic Information System (GIS) gathering aerial photographs, land maps, utility drawings and other infrastructure features into one central, easily accessed database.

Rebuilding the City and Gathering Data

Grand Forks' move to GIS is part of the larger story of turning disaster into a moment of opportunity - how the process of reconstruction actually left the city much stronger than before the 1997 flood. Teams of engineers collaborated to redesign and bolster the city's sanitary water and stormwater systems, planning new sewer lines and water towers. Lift stations were built in undeveloped areas away from the river, to pump wastewater to treatment facilities.

Advanced Engineering, a firm involved in the water system restoration, also worked with the city to develop the GIS, ultimately winning both state and national engineering awards for its work. Working under a 20-month deadline after which federal community development grants would expire, consultants and city staff gathered and integrated different kinds of data, cleaned up existing drawings, created a giant "base map" to

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serve as the foundation of the GIS, and trained city employees to update and enhance the system themselves. The GIS runs on an Autodesk Map™ platform, and Taylor Technologies, a specialist in computer-aided design (CAD), published the map and design data online using Autodesk MapGuide®. Grand Forks' MapGuide server delivers the city's GIS maps, drawings, photos and tabular reports out to hundreds of desktop PCs via the city government's Web-based intranet.

While the GIS tools took shape, disaster recovery money enabled the city to collect new spatial data, populating the GIS with highly accurate, up-to-date information. The city's rebuilt utility network was surveyed with Global Positioning System (GPS) devices, allowing the GIS to have centimeter-accurate drawings for drinking water, sanitary water and stormwater pipes. New aerial photos were taken of the city and surrounding areas. Each of the city's half-mile-square sections was re-surveyed with GPS for accuracy, and nine new geodetic control monuments were installed at various points and registered with the U.S. Geological Service. The new survey provided a precise frame of reference when officials began to map out the city's new flood dikes and acquire the properties they crossed, and the survey helped in the creation of new topographical maps showing the city's contours and elevations. (Though in Grand Forks - as in much of pancake-flat eastern North Dakota - "elevation" is a relative term.)

"Our contractors helped establish the GIS for us, but we wanted a system that we could manage ourselves and shape into exactly what we wanted," said Adam Jonasson, the city's mapping and design coordinator. "And that's what we've done. We have been self-sufficient for more than a year, and have added several features to our GIS."

In addition to the map layers for land topography (accurate down to a foot), survey data, three different kinds of utility pipes, and 65 square miles of aerial orthophotos, the GIS has a pavement map that includes road surface maintenance reports and street-level photographs; a property parcel map used by planners and assessors; zoning information; street signs and traffic signals; and features such as valves, hydrants, catch-basins and manholes. Jonasson said the system is routinely used by eight different departments in the city government.

Common Coordinates and 'Live' Links

A large amount of legacy data was imported onto the GIS. The city had maintained its maps and utility drawings in Autodesk's AutoCAD® format for almost 20 years, and while these survived the flood, many other city records were lost or damaged when City Hall was waist-high in water. "One thing the flood did was open our eyes to the importance of digital backups for hard copies," Jonasson said. So the city decided to scan all of its maps - some dating back to the 1890s - using Autodesk CAD Overlay®, which converted the paper and vellum plans into online, multi-page online files. The city scanned 20,000 sheets and still has a cabinet full of drawings to scan.

All the city's map and photo data shares a common coordinate system, which allows employees to pinpoint same location in different layers, whether in a pipe diagram, a terrain map or an aerial photograph. "When we were choosing which system to use, we liked the precision of Autodesk Map, which is something we didn't see in other GIS formats," Jonasson said. "Our engineers were already comfortable with AutoCAD. We can also exchange data easily between the GIS and the civil engineers who use maps to design roads and other facilities, because they're using Autodesk® Land Desktop for that. It made sense to adopt a total platform for data collection, GIS and design work."

One helpful feature that Autodesk MapGuide's Web-based map platform gives the GIS is "live" hot-linking - the "clickability" that people associate with Internet sites. If a user is paging through the water layer and pauses at a particular valve, they can click on it and view the maintenance record showing the last time it was flushed, or view the as-built drawing from when the pipe was dug or replaced.

Jonasson also noted that Autodesk Map is able to import other kinds of file formats without losing accuracy: "That was important to us because our property parcel maps, zoning and pavement data are in a non-AutoCAD format."

The detail provided by the GIS is useful for breaking infrastructure down into areas or types, or for budget calculations. Employees can query the system to find concrete pipe versus plastic pipe, or all the valves of a certain kind that were installed between 1992 and 1995. "Before, we had no fast way of knowing how many pipes fed into a particular lift station; now we can total up all the feet of pipe for each area. So if the Wastewater Department is doing cleaning, they can do a cost projection - or draw up a maintenance plan."

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For example, in the property parcel map, clicking on a parcel brings up a photo of the house and the latest assessor's report - data that is brought over from a separate IBM AS/400 file server. On the traffic layer, the city's electricians will click on a particular traffic signal to link to a history of the maintenance on that specific signal and a photo of it, stored in an Access database. Behind the scenes, these links were made possible by Cold Fusion programming tools, which allow map objects to pluck things from several data sources via standard Windows ODBC (open database connectivity) interfaces.

Fighting Floods with GIS

Even if a cataclysmic flood such as the one in 1997 is only supposed to come along twice in a millennium, Grand Forks will be ready next time. The Army Corps of Engineers is building a large-scale chain of dikes around the Red River and a diversion ditch around the English Coulee stream that won't be finished until 2005; in the meantime, the city has a series of interim dikes. The plans for the permanent flood protection system are on the GIS; so is FEMA's 100-year floodplain map showing vulnerable areas. The GIS also holds a "closure document" indicating specific points where dikes would be closed across roads and railroads in the event of a flood, parts of the stormwater system feeding into the river that would be closed, and pumps that would have to be activated.

The city got a scare in March and April of 2001, when winter brought large amounts of snow to the Red River Drainage Basin and the river once again began to rise. The Grand Forks government went into its "flood fight" mode, and Jonasson was posted to the police headquarters and to the city's Emergency Operations Center, where he and other staff accessed the GIS via a PC station and took turns answering the phone.

The GIS' topographical layer, with land elevations for every part of town, showed them which areas would be impacted at different river levels. Employees also used the GIS' mail-merge function to assemble lists of property owners, so the city could ask for permission to build temporary dikes on their property.

"The GIS was only a month old at that point, but it was a great tool for us because it was information we'd never had at our fingertips before," Jonasson said. "Citizens would call in, worried

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about the risk to their house, and we could zoom right to their address, turn on the topo[graphical] elevations, tell them the elevation in their lot, then compare that to the river profile in their area. We would tell them that the river had to get to a certain height before they'd be in danger. It gives people peace of mind. We probably took 800 calls like that."

Looking Ahead

The GIS is helpful in non-crisis situations as well, such as managing routine improvements to roads, curbs and gutters. Part of Grand Forks' pavement maintenance system is a database of street-level photographs for every road in the city, taken in 1999 by a van equipped with a low-hanging camera and a GPS device. Was that curb just nicked by a snowplough, or has it been that way for years? What joint pattern did the city use for the street in that subdivision? "We incorporated those photos into the GIS," Jonasson said. "They're extremely helpful in solving problems in the office that used to require a trip out into the field."

Jonasson expects that a version of the GIS will be available to the public over the Internet within two to three years, so residents can check property elevations and other information on their home Web browsers. The city also wants to make the GIS available to field staff on wireless devices.

"Ultimately we'd like our maintenance folks to have water data on their iPac when they're out on a job," he said. "We're putting all the 'birth data' onto the GIS now, details from when water pipes were originally installed. So they'd be able to click on a valve and see that it was built in 1940 and requires 15 turns to close it." For a city that was ready to build an ark not so long ago, that's a water challenge that seems simple enough.

The City of Grand Forks' Autodesk solutions were implemented and supported by Taylor Technologies of St. Louis Park, Minnesota. Call 877.870.3737 or visit www.taylor-tech.com.

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