Infrastructure Management Information System Project Report

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Center for Transportation Research and Education

Iowa State University

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Introduction

A geographic information system (GIS) is a technology that combines database management with digital mapping on a computer (Korte 1994). Users are able to query the database and have the results displayed on a map or obtain detailed information about objects displayed on the map with the click of a mouse button. Relationships between different types of data can be easily understood, displayed, and analyzed with GIS. Useful maps can be printed out or saved for later use. GIS technology has been dropping in price and increasing in ease of use and is now used by many organizations.

The project documented in this report developed and pilot tested an infrastructure management information system (IMIS) for two key "traditional infrastructure" systems in Iowa—sanitary sewer and water supply and distribution systems. The main goal of this project was to develop an effective and useful infrastructure management information system for infrastructure funding organizations, economic developers, and environmental regulators. The project used GIS technology to make the management information as useful as possible for decision makers.

The project established a new partnership by combining financial resources from the U.S. Department of Commerce Economic Development Administration (EDA) 302A program, the administrative assistance of the Iowa Department of Economic Development, technological expertise of the Center for Transportation Research and Education (CTRE) at Iowa State University, and the management information of state government and regional planning/development organizations in rural Iowa.

Need for the Project

Many recent community and economic development planning documents prepared in Iowa cite the need to invest more funds in infrastructure as a critical issue. For instance, the latest Five-Year Economic Development Plan for Iowa identifies "deteriorating or inadequate infrastructure" as a key weakness that Iowa must overcome to prosper economically (Iowa Department of Economic Development 1992). "Traditional infrastructure," in addition to systems like telecommunications and information infrastructure, is a necessary enabler for community and economic development. The Iowa strategic plan suggests that additional progress must be made in developing a strategic plan for "traditional infrastructure" like sewers, water systems, and local streets and bridges. It suggests that such a plan be developed to guide investment decisions made by state government or poor quality infrastructure could hinder future economic development in Iowa.

The Iowa Rural Development Council (IRDC), a partnership organization that encompasses many federal, state, local, non-profit, and private organizations, has also identified inadequate water and sewer infrastructure as a critical Iowa rural development issue. At a special meeting several years ago, the IRDC identified the following problems associated with sewer and water infrastructure in rural Iowa:

- Aging physical plant.

- Increasing cost of physical improvements.
- Increasing costs of compliance with federal and state regulations, such as the Safe Drinking Water Act. (Recent changes in the Safe Drinking Water Act and funding for testing may have lessened this concern somewhat.)
- Need for better coordination among funding agencies (both federal and state) to reduce paperwork.
- Lack of economies of scale if small communities continue to maintain separate systems.

A considerable amount of work has been done or is now being done in Iowa to develop GIS-based management information systems for transportation infrastructure such as highways, streets, roads, and bridges. Management systems for pavements, bridges, and highway safety will be completed and maintained over the next few years. However, there has been no effort underway to create a management system for the other major portion of "traditional infrastructure": sewer and water systems. Such a management system could serve as the basis for a coordinated infrastructure strategic planning effort and would be especially helpful in dealing with the need for interagency coordination and exploring regional approaches to infrastructure.

Overview of "Traditional Infrastructure" in Iowa

Much like Iowa's highway, road, and bridge infrastructure and its telecommunications infrastructure, Iowa's sewer and water infrastructure can be characterized as being made up of a large number of very small systems. This is not uncommon nationwide. A recent report by the U.S. Environmental Protection Agency (EPA) indicates the following:

> The majority (87%) of our nation's water suppliers are small systems serving 25 to 3,300 people. Small and very small community water systems serve fewer than 26 million (11%) of the approximately 233 million customers in the country.

According to an informal 1994 study by the U.S. Department of Agriculture's Rural Development office in Iowa (USDA/RD, formerly the Farmers Home Administration), over 200 communities in Iowa have no centralized water supply system. This means that their residents rely on individual wells or other means for drinking water. Most of the communities without municipal water supplies are very small, typically an unincorporated place with fewer than 100 residents.

The same informal 1994 survey conducted by USDA/RD showed that about 375 communities in Iowa have no sewage treatment plant, meaning that households and industries located in them relied on septic field systems or private lagoons for treatment. About half of these were incorporated communities (meaning they had a municipal government). The great majority of communities without a sewer system at the time of this survey were very small, with 200 or fewer residents. Most communities in Iowa with more than 200 to 300 residents have municipal sanitary sewer systems. There are in fact about 750 municipal sanitary sewer systems in total in Iowa—a very large number considering Iowa's total population is only about 2.9 million. This makes the statewide

management of these systems difficult without some form of management information system (MIS).

A growing trend in Iowa is the provision of water systems (and to a lesser extent sewer systems) through intergovernmental sharing, regional facilities, or county-wide facilities. Regional water systems are especially prevalent in sparsely-populated southern Iowa, where they help overcome the lack of scale economies. Regionalization and sharing are now spreading north in Iowa. Having a high-quality MIS for infrastructure, particularly one based on GIS technology, makes it much easier for planners and program managers to identify the most promising opportunities for services sharing or regional facilities.

Water and Sewer System Funding Sources

The vast majority of traditional infrastructure in Iowa is financed through local funding sources: customer (ratepayer) revenues and bond issues supported by rate-generated revenues. In most cities, water and sewer systems are operated as break-even enterprises.

Although local sources (such as general obligation or revenue bonds) and enterprise revenues make up most of the infrastructure funding in Iowa, several state and federal agencies offer significant funding resources to local communities. These agencies now informally coordinate their funding activities, although each agency tends to have its own mission and goals with respect to infrastructure.

- CDBG. The Community Development Block Grant (CDBG) program is a program funded by the U.S. Department of Housing and Urban Development (HUD) and administered by the Iowa Department of Economic Development. The CDBG program is available in both rural and urban communities and for uses beyond sewer and water infrastructure, although that is what the bulk of funds are spent on. CDBG is targeted exclusively toward communities and neighborhoods made up of low- and moderate-income persons.

- SRLF. The Iowa Department of Natural Resources administers two State Revolving Loan Funds (SRLF), one for sewage treatment and a brand new one for drinking water supplies. The sewage treatment revolving loans have tended to go toward areas having trouble meeting environmental standards. Since SRLF funds are loans, they have predominantly been used by larger communities with greater ability to re-pay.

- USDA/RD. USDA's sewer and water grants are targeted toward the smallest rural communities in Iowa. A 1995 GIS analysis prepared by the Center for Transportation Research and Education (CTRE) at Iowa State University for the Iowa Rural Development Council indicated that most of the applications for funding through this program came from communities with 500 or fewer residents. The program serves mainly very small systems and especially regional rural water systems.

- EDA. The Economic Development Administration (EDA) of the U.S. Department of Commerce is the final player in sewer and water projects in Iowa. Its grant funds are directed toward projects that are involved with or required for job creation.

In general, these outside sources are shrinking in availability; however, there has been a recent upswing in attention to infrastructure issues by the federal government. A new federal infrastructure funding initiative is "Water 2000" by the U.S. Department of Agriculture's Rural Utilities Service (RUS). Water 2000 is concerned with supplying safe, dependable drinking water to the 2.4 million Americans who lack it. (This includes about one million rural residents who do not have piped water into their homes.)

Although lack of safe and dependable drinking water is not as much of a problem in Iowa as it is elsewhere, parts of Iowa do have water supply reliability problems. These include lack of water pressure, lack of adequate storage for water in times of drought, and inability to meet Safe Drinking Water Act (SDWA) requirements. One such area, rural southwestern Iowa, has been selected for attention under Water 2000. The Southern Iowa Rural Water Association (SIRWA) has been targeted for funding for the development of a $3 million, seven-county regional water system. SIRWA serves some of the lowest income counties in Iowa, and the vast majority of the small communities in the region cannot afford the capital cost of maintaining separate water treatment and supply systems. Many residents of the region rely on poor quality individual wells for drinking water. Deterioration and contamination of these wells has caused a considerable amount of water to be hauled into the region by truck in recent years.

Major Uses for an Infrastructure Management Information System

An infrastructure management information system has many potential uses in the management of Iowa's water and sewer system assets. Some of the most important uses are the following:

- Help federal and state infrastructure funding agencies to coordinate their activities more fully.
- Identify the most appropriate targets for the very limited federal and state funds that do exist.
- Identify opportunities for regional service provision of water and sewer services.
- Identify locations where lower cost treatment alternatives (such as "point of entry" water treatment, which treats drinking water closer to the consumers) might be more appropriate than traditional approaches.
- Identify locations with immediately available infrastructure capacity for economic development, particularly for intensive water-using industries such as value-added agriculture activities.
- Graphically identify and display locations and patterns of past funding of projects.
- Demonstrate GIS use for an issue related to community and economic development to demonstrate the technology's value to developers.

System Development Process and Tasks
There were eleven main work tasks for this project. They included the following:

1. Establish an Advisory Group. During this task, a small advisory group was formed to help guide the project. It consisted of representatives of funding agencies and other stakeholder groups. The final advisory group members for the project were the following people:

    - Robert Cecil, Economic Development Administration, Des Moines, Iowa
    - Lane Palmer, Iowa Department of Economic Development, Des Moines
    - Darrell McAllister and Todd Bishop, Iowa Department of Natural Resources, Des Moines
    - Dorman Otte and Jim Carroll, U.S. Department of Agriculture, Rural Development, Des Moines
    - Tim Ostroski and Jeremy Rounds, Southern Iowa Council of Governments, Creston
    - Jerry Dumke, Upper Explorerland Regional Planning Commission, Postville

Other partners that were involved in the project but not represented in the advisory group were the Iowa Rural Water Association and the Mid-West Assistance Program. The Iowa Rural Water Association (IRWA) is the major nonprofit player in the supply of water in Iowa. The IRWA is an association of the major regional water systems that serve Iowa. Mid-West Assistance Program, Inc. (MAP, a nonprofit organization) provided considerable assistance to the project by supplying a Microsoft Access database on water supply and distribution systems in Iowa. MAP was the organization that completed Iowa's most recent comprehensive water plan.

2. Select Two Pilot Regions. Two rural regions of Iowa (both EDA districts) were selected based on their interest in the project and economic, demographic, location, and physical characteristics. The two regions, although both rural in nature, have different characteristics in terms of water and sewer infrastructure.

The Southern Iowa Council of Governments (SICOG) is an eight-county planning and economic development organization located in southern Iowa adjacent to the Missouri border. It contains about 4,000 square miles of area and is very sparsely populated. Only about 66,000 persons live in the eight counties. SICOG is characterized by regional water systems; in fact, one water system (SIRWA) serves much of the eight county area.

The Upper Explorerland Regional Planning Commission (UERPC) is located in northeastern Iowa adjacent to the Minnesota and Wisconsin borders and contains five counties. It is characterized by some very environmentally sensitive land including numerous limestone sinkholes. Groundwater protection is a major concern in this region. UERPC is characterized by a large number of small water and sewer systems; regionalization is not as prevalent as in the SICOG region. It is somewhat more densely populated than SICOG with about 85,000 residents in the five counties.

Both SICOG and UERPC have incomes lower than the statewide average. The two selected pilot agencies assisted with designing the management system, collecting data where required, and applying the IMIS to some real problems.

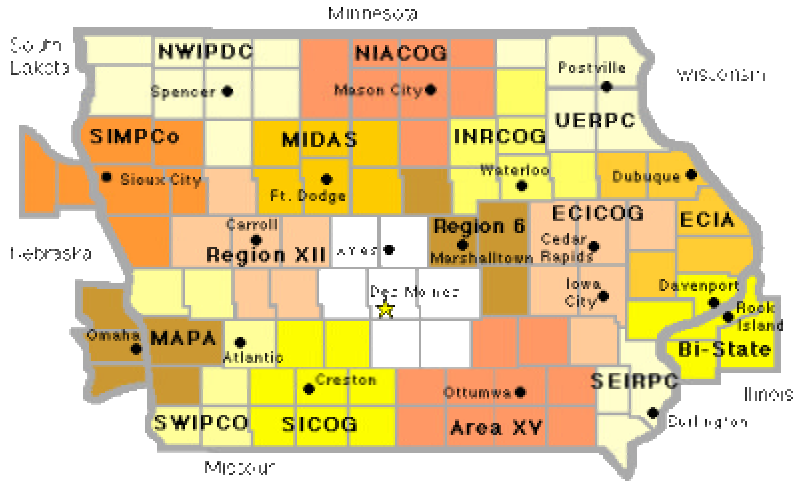

Figure 1: Regional Planning Commissions in Iowa

3. Specify Requirements for IMIS. During this task, the research team worked with the pilot regions and the advisory group to specify the things the management system needed to be able to do. This was done mainly through a brainstorming session conducted by CTRE with the advisory group members.

4. Select a Suitable Platform (software and hardware) for IMIS. The GIS software to be used and computer type to be used were selected based on the results of Task 3. The selection was also based on compatibility with local (e.g., EDA districts) needs and computer systems. A popular desktop GIS software package, MapInfo Pro, was used as the basis of the IMIS. It can be run on Windows 95, Windows 98, or Windows NT personal computer.

5. Identify Data Elements and Map Layers to be Included. To have an effective IMIS, a variety of data must be collected and then related to locations such as cities, counties, zip codes, townships, and street addresses so that they become useful spatial information. During this task, the specific data elements to be included in the information system and their configuration by layer in the GIS will be specified. Some key types of information

identified by the advisory group as needed for the pilot project are shown in the following table:

Types of Information Required for Pilot Project

Basic Information	Physical Information	Service and Environmental Information	Investment Information	Capacity Information
Base map	Water supply sources (e.g., wells or surface)	Water and sewer rate data	Federal investments (e.g., USDA or EDA)	Available water supply and storage capacity
Basic community information (e.g., demographics)	Water treatment, major storage and sewage treatment facilities	Service territories for water supply and sewage treatment	State investments (e.g., CDBG or SRF)	Available sewage treatment capacity
Community economic information (e.g., incomes)	Major water distribution facilities (mains) and sewer mains, trunks, and interceptors	Environmental protection non-attainment locations	Local budgets and investments (e.g., bond issues)	Water supply inadequacies or unreliability (e.g., % loss of water in distribution system)

Many of these data items had already been collected in a format useful for GIS purposes and are publicly available or were made available by the funding agencies. The goal of the project was not to collect information at the micro level (e.g., individual homes served or individual sewer and water lines) but at the macro/system level for management information purposes.

6. Inventory Existing Data and Data Gaps/Obtain Existing Data. During this task, existing data relevant to the project held by the pilot regions, the funding agencies, and other sources were identified, catalogued, and gathered. Data gaps were identified and decisions about whether or not to collect missing data were made.

7. Collect Data Needed to Fill Data Gaps. During this phase, needed data that were found to be missing in the previous task and necessary to the project were collected.

8. Construct GIS Map Layers, Databases, and Custom Programming for the User Interface.

9. Test IMIS. This task will involve testing the system to ensure that it functions properly and produces desired output.

10. Develop Reports and Maps for Pilot Regions Using IMIS. This task demonstrated potential uses of the system through the development of maps and reports. Uses for the two participating EDA districts, for the funding agencies, and for economic developers were all explored.

11. Evaluate IMIS Prior to Possible Statewide Development. This final task will involve evaluating the feasibility of statewide system development. It will include participation by the two EDA districts and other members of the advisory group.

Project Timeline

The IMIS pilot project involving the Upper Explorerland and Southern Iowa areas began in August 1997 and was completed during October 1998. A short time extension was needed to complete the project because critical databases supplied by MAP could not initially be provided in an electronic format that could be incorporated into a GIS format. Once the data could be provided in Microsoft Access database format, the project proceeded quickly.

Pilot System Description

System Description

The IMIS was designed to answer questions about public water supplies, wastewater treatment facilities, and related information, such as socioeconomic characteristics of communities and other geographic areas of interest.

User and System Requirements

IMIS was designed to be simple to use. A number of button pads provide a simple user interface. The user need not have had any experience using GIS software to effectively use the IMIS. However, an experienced user of MapInfo or other GIS software may also use the advanced analytical features of MapInfo in conjunction with the databases and map layers contained in IMIS.

IMIS requires that MapInfo 4.0 or higher be first installed on the user's Windows 95, Windows 98, or Windows NT personal computer. (The latest version of MapInfo available is 5.0.) A recent Pentium, Pentium II, or Pentium Pro machine with at least 32 megabytes of random access memory (RAM) is highly recommended. The personal computer must also have a large amount of available hard disk drive space (40 megabytes) prior to loading IMIS. The IMIS is installed from a CD-ROM.

Functionality

IMIS, when combined with MapInfo 4.0 or higher, allows the novice user to perform a variety of functions using only simple-to-understand button pads. These functions include making simple maps, visualizing some data using graphs, making thematic maps using census data, performing queries against data, and printing maps.

More advanced users can take advantage of the full functionality of MapInfo to perform functions such as complex queries on the databases included in IMIS. In addition, more advanced users can import or develop and use additional databases and map layers with those originally included in IMIS. For example, an advanced user might want to include additional environmental or natural resources data or data about cities and counties.

For a complete overview of the capabilities of IMIS, see the separate User Manual.

Examples of Users
It is anticipated that IMIS will be used by infrastructure finance agencies (both federal and state), regional planning organizations, and economic developers.

Benefits and Impacts
Benefits from this project will accrue to a number of parties: funding agencies, economic developers and their clients, water and sewer customers, and the general public though improvements to environmental quality. Each of these categories of beneficiaries is discussed below:

- **Funding agencies** of traditional infrastructure in Iowa all face one fundamental issue: the need for funding is many times greater than available funding. This results in a need to carefully target funding so that it best meets program objectives. This project has resulted in a shared base of information that will enable better coordinating, funds targeting, and leveraging of limited federal and state funds.

- **Economic developers** are often interested in quickly knowing a location where their customers' needs for water supply and sewage treatment can be met quickly and without a great deal of additional investment. The proposed IMIS provides that ability through the ability to query its database. Since it also contains highway data, questions involving water, sewer, and transportation characteristics of sites can be addressed.

- If the IMIS can be used successfully to identify locations where there are opportunities for services sharing or regional provision or to identify places where low cost alternatives make sense, **water and sewer customers** should benefit in terms of lower rates and improved services.

- The quality of both drinking water and surface and groundwater in Iowa should improve over time. This is because the IMIS can be used to better target funds toward **communities in greatest need in terms of environmental compliance or financial need and distress**.

The two pilot regions for the IMIS were selected based partly on measures of economic distress. In Iowa, distressed areas tend to experience problems with lack of growth, low

incomes, and out migration of young people rather than with high unemployment. This project was designed to initially benefit two of the most distressed regions of Iowa.

Pilot Project Preliminary Evaluation

Performance measures selected for the IMIS pilot project by the Iowa Department of Economic Development, CTRE, and EDA were as follows:

1. Fully involve two Iowa councils of governments/EDA districts in development of a pilot infrastructure management information system for their region.

2. Successfully develop pilot infrastructure management information systems in two regions of Iowa using geographic information system (GIS) technology.

3. Successfully use the pilot management information systems to help guide decisions by federal, state, and regional agencies regarding funding and economic development in the two pilot regions.

Performance measures 1 and 2 have been fully realized as of the end of the development of the pilot system. Members of the advisory group had an opportunity to view a demonstration version of the IMIS several times during the spring and summer of 1998. They expressed great support for and interest in its development and in testing it "hands on."

Following the completion of documentation for IMIS in October 1998, copies of MapInfo 5.0 (if required) and the IMIS system will be delivered to each of the participating pilot region agencies plus the state and federal agency partners. Assistance will be provided by CTRE in loading the programs and getting started with IMIS. This will allow each of the partners involved in developing the system to evaluate its usefulness, actually use the system to help guide investment and economic development decisions, determine needs for future system refinement, and consider whether statewide deployment is warranted.

Transferability to Other States

Because many other states are characterized by a large number of very small water and sewer infrastructure systems, the lessons learned through this project and some of the systems development work will be very transferable to other states, particularly those in the Upper Great Plains and Midwest.

Iowa is very reflective of the nation as a whole in terms of sewer and water infrastructure, as the table below indicates. Iowa has a slightly higher percentage of housing units with complete indoor plumbing and connected to sewage treatment systems, but a slightly lower percentage of units connected to a water supply system. Private water wells are more common in Iowa than in the rest of the country, mainly because Iowa has such a large rural population.

Percentage of Housing Units In 1990

Region	Lacking Complete Indoor Plumbing	Connected to a Water Supply System *	Connected to a Sewage Treatment System **
United States	1.1%	84.2%	74.8%
Iowa	0.9%	81.1%	76.0%

Source: 1990 Census of Population and Housing.

* Others are dependent on wells or other means for water supply.

** Others use a septic system, cesspool, lagoon, or other means for sewage disposal.

Proposed Plan for Statewide Expansion

The initial phase of this project developed and pilot tested the infrastructure MIS in two rural regions of Iowa. A future phase would involve further development into a statewide system. Since GIS technology is so flexible, the future phase could also involve building a comprehensive GIS for economic and community development containing sewer and water infrastructure plus other economic development layers (e.g., available buildings, community facilities, transportation facilities, support industries and services, and available workforce). Because of the "learning curve" involved, the cost per region of statewide deployment would be significantly lower than in the pilot test.

Institutional Considerations: Project Champion

In order for IMIS to be expanded and used on a statewide basis, an agency-based project champion will be needed. This champion would help organize the funding and collaborative partnership needed to take the system statewide. This champion may emerge as a result of the pilot system being made available for testing during late 1998 and early 1999.

Preliminary Cost Estimate for Expansion and Update

The initial phase of this project cost approximately $65,000 including all hard and soft matching funds. This amounts to $32,500 per pilot region. Expansion of the system statewide would cost far less per region—an estimated $6,500 per additional region. With 14 additional planning regions in Iowa, this would amount to a total of $91,000. This money would also allow for some expansions in the data and map layers contained in the IMIS. Both ESRI ArcView and MapInfo versions of the system would be produced, since these are the two most widely-used GIS platforms in Iowa. The second phase project would also include training for all the funding agencies and all of the councils of governments in Iowa.

The cost to periodically update the IMIS would be fairly small, perhaps only $10,000 per major update. This is because nearly all of the available data are available from secondary sources data (e.g., the Iowa DNR or the U.S. Census).

Data Update Considerations

Most elements of the IMIS could be updated on an “as available basis” as new census data or administrative data become ready. The only notable exception to this appears to

be a few fields of the MAP database, which might have to be updated through surveys of cities and regional water systems.

Data Expansion Possibilities

Any database that can be georeferenced can conceivably be included in a system such as IMIS. The most useful expansions to the existing system would appear to be muncipal finance data (e.g., data about Iowa municipalities' bonded indebtedness and bonding capabilities). Other categories of data that could be added would include housing data, economic development available site and building data, and additional wastewater treatment information.

Platform Considerations

Agencies involved in the development of the pilot project indicated their preferred GIS platforms to be either ESRI's ArcView or MapInfo Corporation's MapInfo. These are both good choices since they are both entry-level, desktop GIS systems. The Iowa DNR is a large user of Arc Info/ArcView, while a number of the councils of governments are now using MapInfo. The pilot application was developed using MapInfo because of the existence of much of the needed data in that format and because of the ability to customize its interface to add button pads using the Map Basic programming language. This ability to customize makes the IMIS pilot system very easy to use for novice users.

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