Implementing a Wastewater Geodatabase Solution – the Midwest Way

2006 ESRI International User Conference

Tuesday, August 8, 2006; 8:30 AM; Room 29A

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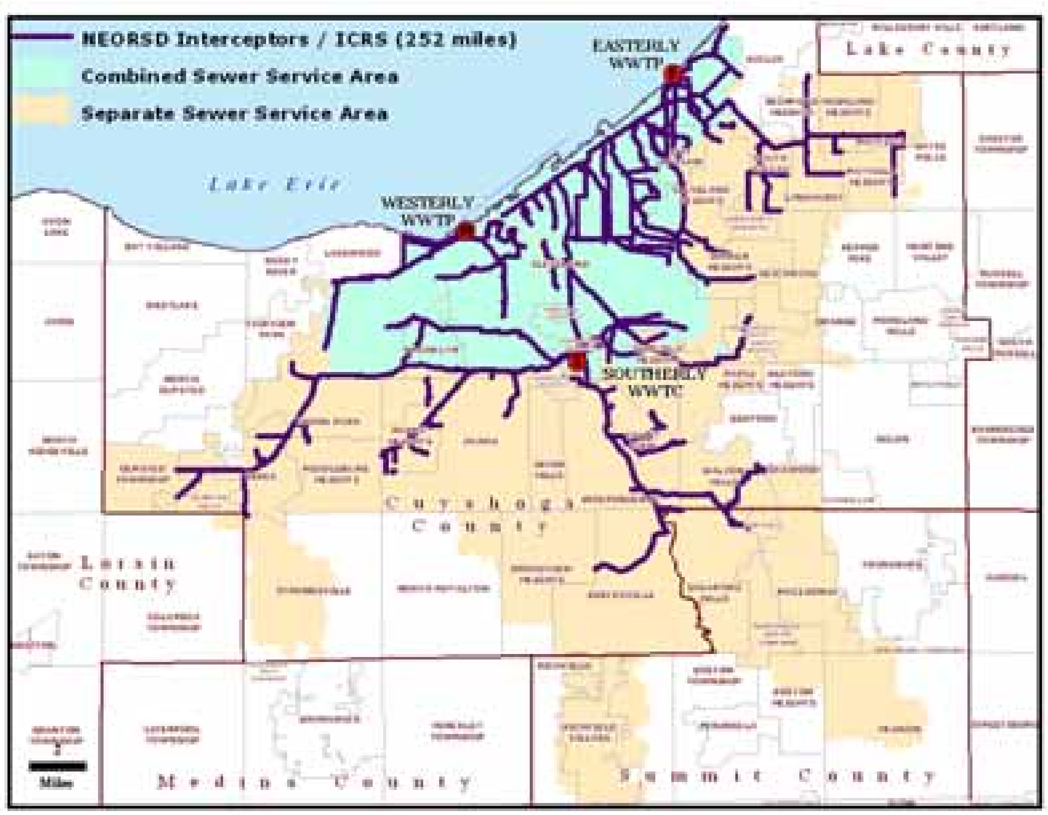
Abstract

The Northeast Ohio Regional Sewer District (NEORSD or District) is the regional agency responsible for wastewater treatment facilities and interceptor sewers in the greater Cleveland Metropolitan Area, serving more than 1.1 million customers. The system includes 4,800 miles of sewer lines and three major wastewater treatment plants. The system dates back to the early 1900s and includes many combined sewers and unique structures. In 2001, NEORSD embarked on the implementation of a multiphase, enterprise-wide GIS program to manage a comprehensive collection system database. The size, age, complexity, and uniqueness of the NEORSD infrastructure presented many data modeling challenges. The Geodatabase needed to address ways to edit, maintain, and add to the collection system data. The Geodatabase was designed as part of a multi-phase project. Each phase refined the Geodatabase to complement the District's desire to sustain the information. This paper describes the challenges and lessons learned in this endeavor.

Section 1 - Introduction to Northeast Ohio Regional Sewer District

In 1972, the Northeast Ohio Regional Sewer District (NEORSD) was created as a regional agency responsible for wastewater treatment facilities and interceptor sewers in the greater Cleveland Metropolitan Area. This service area encompasses the City of Cleveland and all or portions of 60 suburban municipalities in Cuyahoga, Summit, and Lorain Counties *(Figure 1).* The District owns and operates three major wastewater treatment plants: Easterly WWTP, Southerly WWTC, and Westerly WWTP. Through the operation of these plants, the District minimizes the amount of pollution entering Lake Erie and the Cuyahoga River. In addition, the District is responsible for a variety of related wastewater treatment infrastructure and projects, designed to convey wastewater from the local sewers to the treatment plants. Regionally, there are more than 4,800 miles of sewers tributary to the District. The District owns and maintains more than 200 miles of large

Figure 1 – The District's Service Area and Interceptors



interceptor sewers, the rest of the sewer are owned and maintained by local municipalities. The City of Cleveland and some nearby suburbs have combined sewers, in which one pipe conveys both stormwater and sanitary sewage. The District is responsible for controlling combined sewer overflows throughout the Greater Cleveland area. Furthermore, the District conducts investigations to identify pollutants within the sewage collection system that have the potential to be reduced through pollution prevention. NEORSD works with industrial customers to achieve pollution prevention goals. Other District activities include watershed protection, facilities planning and working with local communities to ensure that small streams and tributaries are properly maintained.

Section 2 - Geographic Information Usage at NEORSD

Prior to 2001, NEORSD managed a variety of inspection and facilities planning projects in order to access and provide recommendations for its collection system rehabilitation and develop a long term combined sewer overflow (CSO) control program to meet federal requirements. A tremendous amount of geospatial data was collected and delivered to the District in a variety of *project-based* datasets including ESRI personal geodatabases, ESRI shapefiles, and Microsoft Access tables *(Figure 2).* GIS at the NEORSD grew from these project datasets, and resulted in the deployment of an Arc-IMS GIS portal (District Infrastructure Information Management System Viewer or DIIMS Viewer) to access the data. The District's Planning Department was responsible for organizing and maintaining these data. However, due to the lack of standard processes, minimal day maintenance occurred. Subsequently, because of the increased use and success in utilizing GIS to support day-to-day activities, a District-wide GIS Program was initiated as a multi-phase process in 2001. This process included three phases of development and implementation of GIS: Phase I (2001-2003), Phase II (2004-2006), and Phase III (2007-beyond).

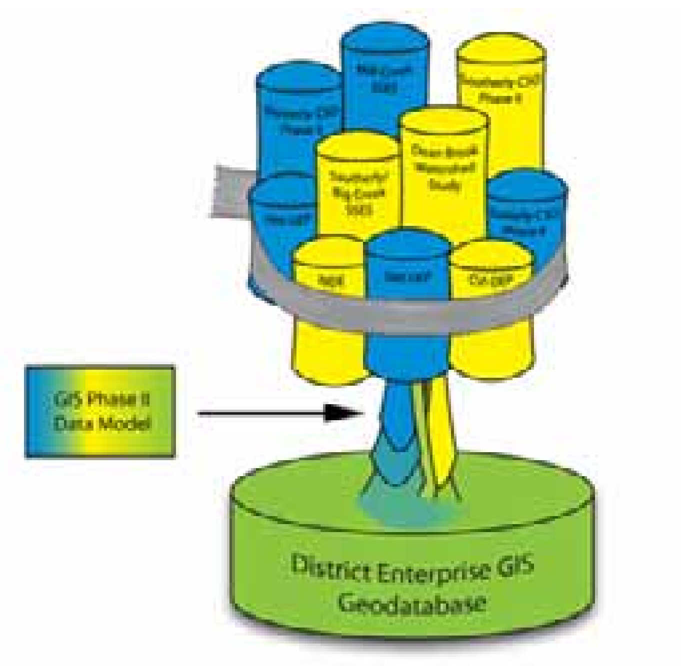


Figure 2 – Multiple Project Geodatabases into a single Enterprise Geodatabase.

GIS Phase I (2001-2003) of the District-wide GIS implementation consisted of needs assessment, conceptual design, and implementation planning tasks. For example, GIS Phase I addressed a Physical Database Design Pilot Application. Efforts in the pilot phase focused on creating the Oracle table structure for the entities currently included in the comprehensive collection system database used by DIIMS. Also, the District identified feature classes and data tables that would eventually drive the database design during GIS Phase II. Furthermore, the District's Engineering Information & Technology (EI&T) Department was established during GIS Phase I. The EI&T Department has managed and continues to manage the GIS Program. Overall, GIS Phase I developed the GIS database groundwork; however, GIS Phase II took the database to the next level.

In March 2004, the District contracted with CH2M HILL to complete the District's GIS Phase II Project. During the GIS Phase II, the District's expectation for the completed District-wide GIS Program was to provide the following:

- A District-wide system to manage GIS-related data from District projects
- Integration of GIS-related data with other District data management systems, such as the Maintenance Management System (SPL), Laboratory Information Management System (LIMS)
- General applications for accessing, analyzing, reporting, and managing GIS data
- Specific task-oriented/department-oriented applications to increase efficiency, automate work processes, and improve communication.

During GIS Phase II, the District has, or is in the process of, completing the following objectives: District-wide ESRI SDE Geodatabase, an enhanced intranet portal (DIIMS Viewer Version 2 aka DV2, utilizing ArcGIS Server technology), integrating other District database applications (SPL and Lablynx), and the overall GIS work flows and data management practices and standards. Once GIS Phase II is complete, the District will rollout the DV2 application to all staff and undertake the GIS Phase III project 12 to 18 months later.

Goals and objectives for the GIS Phase III project consist of an operational evaluation and additional application development, as driven by other District initiatives. Some of these District initiatives would include the completion of the District's Stormwater Network, integration with other District data management systems such as Operations Data Management System, and further enhancements to DV2.

The subject of this paper – the NEORSD GIS Data Repository – was created to fulfill GIS Phase II project. It is implemented as an ArcSDE Geodatabase operating on Oracle 9i. The GIS and the associated Geodatabase are to support the day–to-day operations at the District. District departments will use the GIS to manage the facilities and plan for the future.

Section 3 - Database Development Strategy

The following summarizes specific details and actions that formulated a strategy for developing an enterprise-wide data repository for the NEORSD GIS program:

1. Provide a structure supportive of the District's progressive approach for maintaining high-quality wastewater collection and treatment services. The database design needs to address capital improvements programs for updating and sustaining an aging system and for meeting National Pollutant Discharge Elimination System (NPDES) permit requirements for receiving waters. Day-to-day operations at the District support the operation and maintenance of the collection system as well as investigations and surveillance activities to monitor regulatory requirements and water quality issues. Also, the District is currently embarking on a control program for capital improvement to address CSO issues in its service area.

2. Provide a consistent knowledge base through the design and storage of existing GIS data in the District-wide GIS Repository to create the "official" version of collection system data for use within the District. For instance, the District's previous GIS portal (DIIMS) has a significant amount of collection system, planimetric, and jurisdictional data. Local, regional, and state agencies have a good deal of data directly available (in most cases, these were the source of data used in DIIMS). Data such as the state boundary, hydrography, and political jurisdictions can be acquired and loaded as time permits..

3. In concert with the above item, provide access to other significant enterprise data collection systems. For the Phase II effort, the preventative maintenance and work order data in the District's Computerized Maintenance Management System (CMMS) and the water quality sampling data for industrial dischargers, investigative surveillance activities and receiving water sampling events in Laboratory Information Management System were targeted for integration with enterprise GIS.

4. Develop a consolidated, true graphical representation of the District's sewer infrastructure. The database would need to mirror the unique features within the District's service area to support the day-to-day operations of their core mission of collecting and treating wastewater. Sewer construction dates back to the early 1900s, and is characterized by myriad inconsistent construction methods and facility types. The structure would need to match true infrastructure representations for the enterprise GIS data. In addition, the structure would need to address the inventory and management of historically collected documents, images, and videos and for day forward data. Ideally these records would be attached to an asset for easy access and viewing, providing users images of CADD drawings, as-builts, paper maps, photographs, and other static media related to the infrastructure.

5. Take full advantage of the county-wide consortium efforts underway among other utility organizations, specifically the City of Cleveland and Cuyahoga County Sanitary Engineer's (CCSE) office. The database structure would accommodate corresponding Landbase data as well as graphical representation of the integrated local infrastructure based on the available existing digital representations of these networks. The District would work with each local operator to improve the quality and completeness of their facilities inventory, and encourage these systems to use the District's data model and data compilation standards for their database development. Further, the District would work closely with these operators to ensure that timely and efficient updates are provided. As an example, in 2000, the District entered into an agreement with the City of Cleveland, Cuyahoga County Auditor, CCSE, and the Greater Cleveland Regional Transit Authority (RTA) to share the cost for developing new digital orthophotography for Cuyahoga County. The effort is expected to result in some future regional sharing of orthophotography data.

Section 4 - Database Development and Design

Along with the issues discussed in Section 3, the database design must also address the application functions and work flows of its users. Overall, the District and consultant embraced the implementation philosophy that the database structure must be developed to include the recommended list of features and their associated attributes, but with the understanding that database scheme changes would occur, evolving the design. The team agreed to conceptually build the database using Microsoft's Visio 2002 Professional. The DDL required to create the physical database structure would then be generated at the appropriate point using the Visio tool, allowing DDL Scripts to be created. Beyond this, point modifications to the database environment would be handled in the database environment. The GIS Repository design, both Visio diagram and data dictionary, will then be maintained and transmitted gradually to the District staff so that the District could ultimately develop a comfortable work flow for future maintenance and documentation. The District staff is currently conducting all maintenance and documentation for the enterprise repository.

Conceptual and Physical Design

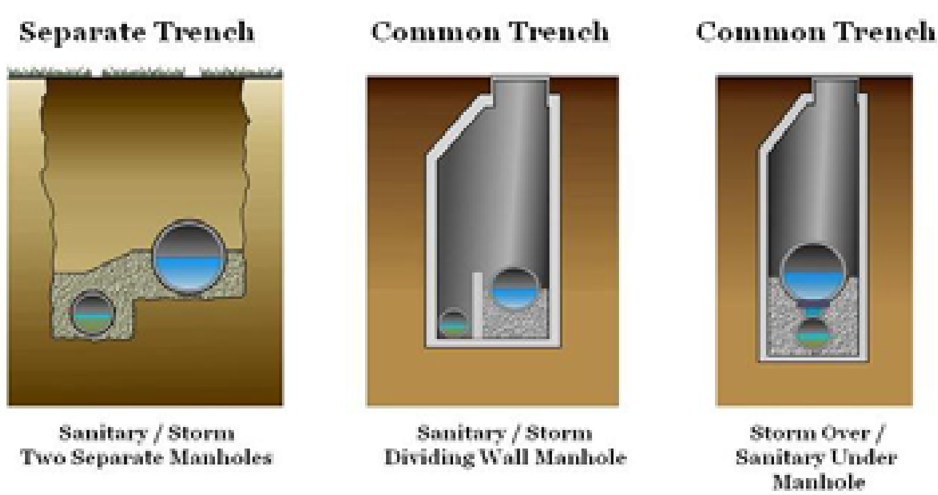
The database was modeled to allow the different departments a spatially enabled enterprise solution to manage their individual data. An extensive effort was made to include the individual departments of the District in determining the information that would be of most benefit in the enterprise GIS. Efforts were also engaged with the City of Cleveland and CCSE to determine which datasets would be shared and the resultant effect on the database design. The resulting database design reflected both the information currently being tracked and future data needs of various individual District departments and other stakeholders.

Wastewater and Stormwater Model Considerations

The standard ESRI Sewer and Stormwater Model was considered as the solution for the District's enterprise geodatabase model. However, several issues related to the unique characteristics of the District's infrastructure and business processes would not fit the standard model. The standard model does not adequately account for the need to model combined and separate sewers, unique facilities, and the specialized nature of the District's support functions. Though many aspects of the standard wastewater model were utilized, the District needed a specific, customized model for its Geodatabase. Highlights of the database design efforts include the following:

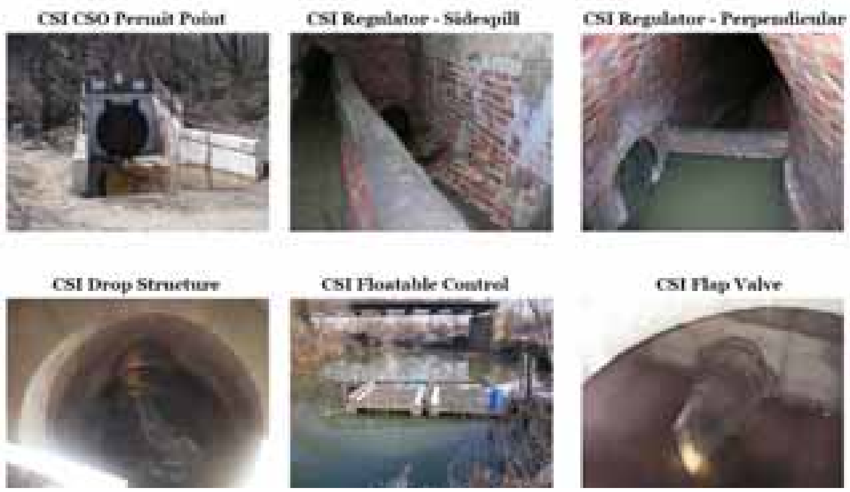
- Sewers – One of the fundamental reasons for developing a GIS was to allow the District to model its Combined and Separate Sewer infrastructure. This accounts for a substantial part of the District's facilities. To address both regulatory and internal reporting requirements, the District needed to have a model that adequately addresses the primary flow of each segment of its sanitary and combined flow network. In addition, various sewer construction types including over/under, common trench, and deep tunnels added to the complexity. Reference *Figure 3* for examples of the unique types of sewer pipe construction. Often, allowing the user to access both flow and the construction types provides the additional benefit of enabling the District's Design, Planning, and Maintenance Department staffs to better understand the system's operation. One user requirement was to network trace for dry and wet weather flowpaths.

Figure 3 - Unique Types of CSI Sewer Pipe Construction



- Facilities *(Figure 4)* – The District also has a variety of facilities that are maintained and contribute to the operation of the collection system. Visually identifying these and accessing specific details enhance the user's understanding of the system operation. A good example of the complexity involves modeling CSOs. In the District model, the feature class (CSICSOPermitPoint) attributes have been inherited from other District databases that are used for regulatory compliance. The information inherited here would not be applicable to other possible discharge points such as Sanitary Sewer Outfalls (CSISSOs) and the Discharge Point subtype of CSINode. Where applicable, a separate stand-alone feature class was developed to hold each of these features and its associated attributes.

Figure 4 – Examples of District Facilities



- Service Providers – The District does not maintain all of the sewer facilities that are tributary to the District's wastewater treatment plants. The District only maintains the interceptor (trunk) pipes and their associated facilities, as well as other critical facilities within the collection system. One can compare this to a transportation network. The District maintains the highways while the streets are maintained by the local communities (satellite systems). The collection system network tributary to the District's three treatment plants is large, but only a fraction of all the facilities (about 5%) is directly maintained by the District. Because the District does not maintain the local satellite systems or residential connections, many of the network feature classes represented in the standard Sewer Model are not of concern for the NEORSD Geodatabase. Issues to address were that both satellite systems (not owned by the District) and the interceptors (owned by the District) needed to be included in the geometric network to provide a full understanding of the flow network. The previous datasets often included both the satellite facilities and the interceptors compiled into a single feature class. The team considered separating the satellite systems and the District interceptors into separate feature classes or subtypes. Overall, this proved to be problematic – each facility in the system has ownership, maintenance, and responsibility assignments, and these become ambiguous where systems join. By separating the facilities into separate feature classes, or subtypes within a feature class based on any of these attributes, would represent a definite indication that a particular item had a definitive assignment in one of these areas. If the feature exists in the same feature class, its attributes can be changed easily and no claim of ownership or responsibility would be clear. This contradicts a system requirement to maintain a clear, definitive inventory of District and non-District facilities. Therefore, the implemented Geodatabase included both District and satellite facilities as one feature class (CSISewerPipe) in its geometric network.

- Industrial Users – The District regulates and monitors industries discharging into the system. These industry connections are mainly located on local sewer tributaries, but need to be included in the geometric network to enable upstream tracing to the industries to monitor potential contaminant discharges. Secondly, for system modeling and analysis, the team determined that a representation of all tributaries to the treatment plants and possible discharge points included in the geometric network was a valid user requirement.

- Feature Consistency – Many of the problems encountered when attempting to conform to the ESRI standard model arose from the simple issue that the existing and required District data would not fit into the standard model's feature classes. The standard model groups many facilities into single feature classes via subtypes. The District has specific and separate attributes for many of these features. Also, many of the feature classes in the standard model are not representative of how the District would define their facilities – more detail was needed both for data viewing purposes and for application functionality purposes. Though many items from the standard model were used, many more were created.

- Data Migration – Another challenge in the Geodatabase design was the daunting task of populating the end data model from a combination of data elements. Though many of the feature classes from previous datasets were already created and populated with data, many attributes had to be pulled from other datasets or may need to reside in a separate table or object class to maintain integrity or be used by other systems. Examples included construction project datasets, interceptor and evaluation reports, CSO facility planning projects, watershed studies, stormwater studies, and others. Because the project-specific data varied greatly in format and consistency, attribution for many of the individual feature classes had to be re-examined, interpreted, and strategies developed to include all important data while removing redundant and unnecessary information.

- Unique Identification – During the project, the apparent combination of differing datasets created a problem with what are the unique identifiers. Different projects may have different identifiers for the same entity. With manholes, the District had a standard intelligent 15-character naming convention. The original implementation path was to use this as the unique key for all manholes. When considering the non-District facilities, this identifier field was null. Also, in some cases, manholes were encountered where junk identifiers were created to fill in the key. Overall, only 4,950 manholes of 80,484 had a valid unique identifier and, eventually, it became important to find a solution to the identifier problem. The original intelligent 15-digit manhole key was reduced to a 9-digit intelligent manhole name. A unique identifier was created for each manhole, and a table was created to save all possible identifiers for a manhole and store all obsolete identifiers. This table is linked to the manholes via the unique identifier and allows multiple records for each manhole. This table was populated with the original manhole key and any other identifiers encountered. A similar solution was devised for pipes.

Resulting Geodatabase

The resulting effort of the database work was to divide the enterprise into four data models or feature data sets. These included Administrative, Collection System Infrastructure (CSI), Land base, and SDI (Storm Drainage Infrastructure), described as follows.

- Administrative – Data model of administrative-related fields, such as service areas, contacts, political boundaries, and Community Discharge Permit (CDP) program tables. The CDP program is the District's program for regulating discharges to its system from its member communities.

- CSI – This is the core data model of the District. The CSI category includes wastewater collection system infrastructure that conveys sanitary sewer flow including the combined system. It includes all NEORSD facilities as well as pipes, manholes, diversion structures, pump stations, and outfalls from satellite systems.

- Landbase – Varied collection of feature and object classes that relate directly to the geography of the area of operation. This collection includes U.S. Census data and Landbase records such as parcels and buildings, topographic data, and transportation data. Most of the items in this category are not directly maintained by the District. They are imported directly into the Geodatabase as read-only data. The exceptions are tables and features to store District properties, easements, and interests. These tables are included here because they directly relate to other tables in the model.

- Storm Drainage Infrastructure (SDI) - Feature and object classes of concern for stormwater collection and conveyance. This is still in development and is currently a repository for all infrastructure classified as having only stormwater flow.

Features included in each dataset are presented in Table 1. Each feature class or object class named in the geodatabase is given a prefix to distinguish its data model. In addition, each feature class is placed in a feature dataset named for each category.

TABLE 1
Geodatabase Features Overview

Administrative-related Data:	Collection System-related Data:	Land-related Data:	Stormwater Data:
• District Service Area including Combined Sewer Boundaries • City of Cleveland Wards • Jurisdictional Boundaries – County, City, Community, etc. • Project-related Boundaries • Administrative Districts • Agency, Community, and Contractor Contact Lists • Community Discharge Permit Database • Geotechnical Borings Locations and Images • Local Collection System Areas and Service Providers • Local Political Districts • Ownership Data • Sewer Plan Database • State Political Districts	• Industries Feature • Manholes • Manhole Inspection Data • WWTP Feature • Sewer Pipes • Sewer Pipes Inspection Data • Automated Regulator • Flow Monitor • Hydrobrake • Level Monitor • Odor Control Facility • Rain Gauge • Regulator • Outfalls • Pump Stations • Access Shafts • Diversion Structures • Drop Shafts • Facility Boundaries • Flap Valves • Floatable Control Facilities • Force Main Appurtenances • Debris Traps • Vaults • Proposed Pipes • Proposed Structures	• Bridges Feature • Buildings Feature • Roads or Edge of Pavement • General Sewer Map Grid • Orthophotos • Parcel • Railroad • Street Centerline • County (Cuyahoga, Summit, etc.) Parcel Information • Census Geography and Data • Control Monuments • Public Land Survey System • District Property information, including: — Buildings — District Parcels — Easements Granted/Owned • Flood Data • Imperviousness Data • Landmarks • Land Use • Rights of Way • Soils • Topography	• Manholes • SewerPipes • Streams • Water Bodies Feature • Others to be developed.

Post-Geodatabase Implementation

Following the geodatabase creation, some specific elements presented special problems during data migration. The following represent the more interesting and unique data modeling challenges.

- CSINodes – The CSINodes feature class was implemented as a combination of Manholes and Connections features on the sewer network. Connections had originally been imported from the ssFitting feature class on the standard model. Most of the subtypes in the standard model are not used by the District, but many were added to the model to accommodate future additions. These features operate as geometric network nodes, and can contain many of the attributes associated with the base manhole features. One of the most common connections was a "blind junction," which, in effect, is an intersection point on the network without access to the surface. In the previous datasets, these features were included with the manhole features. The subtype allowed a better definition and model of the actual connection point on the network. These features were combined into the CSINode feature class. The primary benefit was to reduce the number of relationship classes needed in the database to increase performance of the beta application. The existing feature class had 12 relationship classes with more likely to be developed as the database matures. These would have to have been duplicated in both of the original feature classes.

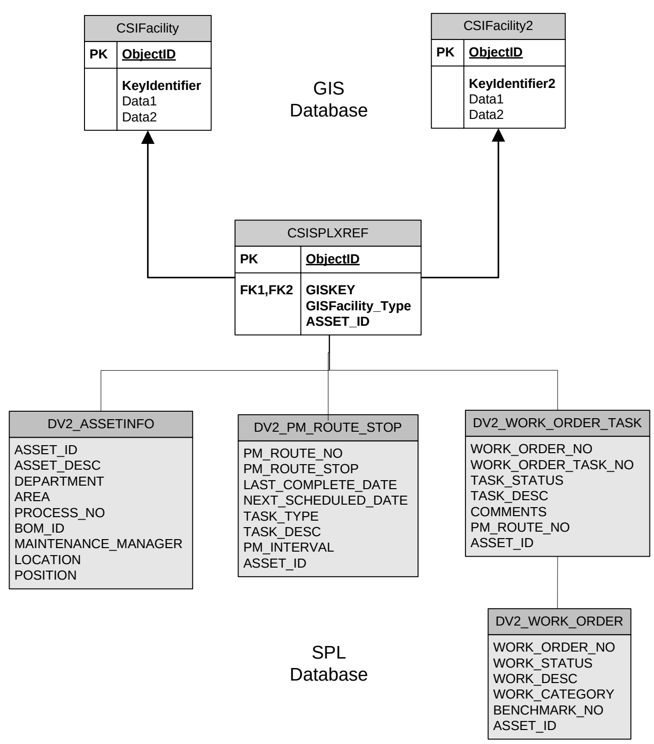
- CSIRegulators – Regulators have been the focus of much debate during and after the Geodatabase implementation. Regulators are devices in the sewer network that control flow during dry and wet weather events. Regulators are probably the most accessed District feature both for online information and in the day-to-day support operations of the District departments. Because of their importance in the business process, defining their existence on the sewer network has been the center of the debate – should these facilities exist as a feature class or as an object class? In the database's current state, regulators are an object class with a relationship to a CSINode feature. The regulator gets its geometry and network position via the CSINode. A fundamental problem with modeling regulators is that many exist inside manholes (although some do not) – but for them to co-exist on the geometric network, the regulators would have to have been artificially separated from the manhole. Even if the regulators were in the real world, they are located at an offset from the manhole; many do not have spatial data that showed this separation. In addition, the District had a culture of associating the location of the regulator with the accessible manhole and not the actual physical location of regulating device.

- CSIAutomatedRegulatorsArea – Automated regulators are essentially large facilities that contain a number of features inside them – many of which are non-network features. The model provides for a polygon that has relationship classes with the features that exist within the boundaries of the automated regulator area. These features were originally modeled as point features on the network. This polygon feature for large facilities was duplicated for Odor Control Facilities, Junction Chambers, and Treatment Plants.

- CSIInspections, CSIDocuments – Providing a repository for inspections and associated documents for features was a complex issue. The database was originally designed to hold Pipe and Manhole Inspection data. During the database design, the District standardized on the NASSCO pipe inspection format and tables for holding sewer pipe inspection data for day forward data. Historical pipe inspection reports would be stored as image (or .pdf) files, accessible through the GIS portal. The District also maintains various other media associated with inspections, including documents, pictures, and videos. A necessary database requirement was to provide for access to image records related to the GIS features – and provide for many media sources to any individual feature. The solution for including this “spider web” of inspection-related material was to create an inspection history table. This cross-reference table stores links to GIS features and to inspection events or records (via a table key) that can be used to link documents, photos, and videos.

- Maintenance Management Data Integration – The District’s SSMO Department directly influenced the creation and attributes for the District facilities they maintain. User requirements included the need to integrate the Computerized Maintenance Management System (CMMS) with the GIS – connecting work order and preventive maintenance route histories to GIS features. This initial link was established using a cross-reference table, and Oracle view assembled the required viewing information. The following diagram details how the table works:

Figure 5 –CMMS Integration Tables Example



- LIMS – The District's WQIS Department often used the GIS portal for locating water quality and industry-related sampling points. WQIS identified a user need to view laboratory data associated with sampling points through the GIS portal. A link similar to the CMMS described above was implemented. Another requirement for the Department was the ability to use geometric network tracing – specifically, to trace the network upstream for possible sources of various chemicals found in receiving streams linked to industrial users connected to the District's collection system.

Section 5 - Database Maintenance

The importance of detailed and accurate database documentation was greatly stressed from the onset of this project. This would serve as a benefit to the technical staff during database design, application development, and interface development with other District applications. It also benefits the end-user community as they utilize the data with their desktop and reporting tools.

Database documentation consists of three documents. The data model, created in Microsoft Visio, was used to initially create the SDE database in Oracle 9i. The data model has continued to be maintained with any additions and modifications after database creation. Maintaining an up-to-date data model provides an easy–to-view visual of the data and relationships.

In addition to the Visio data model, a data dictionary and domain dictionary documents were created in Microsoft Excel and continue to be maintained. The data dictionary is a comprehensive listing of feature and object classes within the database. Table attributes are described in detail, as well as the data source to populate the tables. Any data migration issues are also noted for each table. The domain dictionary document lists all domains in the Geodatabase. All valid codes and descriptions are documented, as well as the feature or object class where the domain is referenced.

The database documentation creation and maintenance is a combined effort among the project's consultant team, and the District's technical and end-user staff. Accurately maintaining each of these documents is no small task, but by doing so, the documentation will continue to be an excellent reference tool for present needs and future development initiatives.

The database documentation has led to data standards at the District. In order for data to be included in the District's enterprise Geodatabase from current design and construction projects, new sewer inspections, asset naming needs, and other projects, the data must be captured as defined in this documentation. Extensive input from District staff was solicited for the defined data standards. Although every effort was made to meet all user requirements, it is difficult to please everyone with new standards and practices. However, standards do provide benefits of data and format consistency for all users.

Other documentation consists of workflow diagrams and standard operating procedures for tasks such as schema changes, map document modifications, geometric network maintenance, outside agency data imports, and several other areas. It is important to have the steps for these tasks documented. Productivity is increased, duties are defined among departments, and duplication of effort is reduced. A cross-functional understanding among technical and non-technical staff is generated, with each area gaining an understanding of each others roles and responsibilities. Documenting these procedures also aids backup personnel when the need arises for tasks to be performed when primary support staffs are unavailable.

Documenting database structures, data standards, and standard practices and procedures has provided many benefits at the District. Communication among departments has been greatly improved, consistent procedures are being followed by District staff, and sharing data between the District and outside agencies is much easier. Defining standards and procedures has been well received, with only a short learning curve required. These documents have provided a great framework for more efficient and better collection of information.

Section 6 - Database Sharing

One of the outcomes that the District was hoping for during the GIS implementation project was to promote data sharing with other agencies within the State of Ohio. By promoting data sharing, it is the District's intent to facilitate communication among many agencies in Northeast Ohio. The District has taken steps toward this goal by meeting with County and City agencies that currently have GIS data. The GIS implementation team discussed with them the idea of creating a Common

Interface Model (CIM) that would allow all involved agencies to share common datasets by sending updated information into CIM for other agencies with access to the information to download data on a regular basis.

While reviewing the data that are available from the two agencies, NEORSD needed to consider the differences and commonalties between all models involved. CoordinatiNG the development of CIM is critical to creating a CIM that suits all needs. Because the County is in the process of re-developing its data model and has chosen to modify the District's data model to suit County needs, integration of County data to the CIM along with District data will be a relatively easy task. The City has fewer data fields than NEORSD currently has for its common feature classes. This may force the CIM to have fewer fields, which may make the whole process easier.

One other issue that involves sharing information with multiple governmental agencies is database platforms. Currently, the District stores information in an ESRI SDE Geodatabase in Oracle 9i, which is similar to the City's situation; City staff currently use ESRI SDE Geodatabase only when they use Oracle 10g. The County is unique because it is using Oracle 10g with the SDO Geometry type to facilitate the use of the data over multiple county agencies that utilize various GIS software packages. Conversion of data between the City and the District is relatively easy; however, data transfer to and from the County poses it own set of challenges. It is possible to work through the conversion issues, but creating the process to do so is not easy.

One other item to consider during the whole database development process is how to share information with other agencies that do not support the ESRI Geodatabase. Most of the smaller communities in the area do not even have a GIS system. This forces NEORSD to consider multiple delivery methods, such as paper maps and .jpg files in addition to shapefiles and personal geodatabases.

One of the considerations in processing this request is what data the District provides does the District just information on what NEORSD maintains? Does it provide local pipe information even though the District does not maintain this information? How should NEORSD handle data QA/QC issues when a community informs the District of inaccurate information? These issues have led NEORSD to create the following legal disclaimer that accompanies all of data and map requests.

Section 7 - Summary and Future Plans

The effort expended by the District resulted in an enterprise database that has helped establish a common knowledge base of what data should be tracked in the enterprise GIS, what data is shared in other enterprise systems and who the data owners really are. The database is highly scalable when looking at the future business needs for the District. The ability to add addition feature datasets, manage bulk import and exports, and for data distribution are key long term successes for the sustainability of the GIS enterprise data. In addition, the ability to add datamodels, such as EVENTS or TIME based data will ultimately add value when considering the integration with other data systems and applications.

The most measurable success of the enterprise database development effort is the understanding and ownership of the database and documentation materials. All parties involved understand the documentation materials as well the rationale for the decisions made in the design.

Acknowledgments

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