More Than an Upgrade:
The Austin Water Utility Experience

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In 2003, the Austin Water Utility upgraded its GIS from Arc/Info 7.x to ArcGIS 8.x. The year-long effort included business process analysis, migration to the Oracle platform and an ArcSDE/enterprise geodatabase (plus database redesign), customized ArcGIS data entry productivity tools, interfaces to hydraulic modeling applications, integration with Hansen maintenance management system (MMS), and ArcIMS Web applications. This paper describes the project from its inception--business drivers, management buy in and goals--to the final hurrah--the outcomes and benefits realized. The City of Austin, Texas owns and operates its water and wastewater utilities and maintains 3,000 miles of water pipe and 2,300 miles of wastewater pipe. The Austin 2000 metropolitan area population was 1.2 million, with 650,000 people residing within the Austin city limits.

Introduction

Although we refer to this project as a Geographic Information System (GIS) *Upgrade*, it was actually much more than the name implies. We experienced a change in data models, database platforms, programming languages, and of course software applications, to name a few. We also integrated the new GIS with other existing systems. There were of course, many technical challenges to navigate and overcome. But there were also many non-technical challenges encountered that could make the difference between a successful and a not so successful technology project. We set out to change the way we used GIS technology, but we also changed the way the Austin Water Utility perceives and values GIS in the organization.

History

The Austin Water Utility began using automated mapping technology in 1978 and migrated to GIS in 1997. Recognizing the growing importance of Information Technology within the Austin Water Utility, an Information Technology Master Plan (ITMP) was commissioned from Westin Engineering, Inc. in 1999. It was to address the overall information needs of the Utility and to formulate a roadmap to provide direction. The comprehensive and high level plan consisted of:

1. An Executive Summary
2. A needs analysis prepared from user input sessions
3. An alternatives analysis
4. Recommendations for implementation
5. Several technical memoranda

The first phase of recommendations included development of a comprehensive Program Management office to coordinate the Enterprise IT initiatives to be implemented, upgrades to the GIS, Hansen maintenance management system (MMS) and MP5 plant management system (PMS) to ready each system for integration and a Utility-wide data model/data store which would hold data from the GIS, Hansen MMS and MP5 PMS, respectively.

Following the completion of the ITMP, the Utility commissioned ESRI to conduct a more in depth needs analysis that focused strictly on the GIS. The report ("Implementation Strategy" – March, 2000) attempted to identify GIS stakeholders and current data inventories and maintenance routines, provided a needs analysis focusing on integration and implementation of the latest industry models and approaches and, finally, made recommendations on how to proceed. Additionally, the GIS team conducted a week-long workshop (September, 2000) with ESRI in which a draft GIS database design, based on the industry-developed ArcFM water data model, was created which incorporated many of the recommendations in both the ITMP and the GIS Implementation Strategy report.

A comprehensive RFP to implement Phase I of the ITMP was abandoned in the spring of 2001 due to a downturn in the economy and the Utility's desire to take a more incremental approach to implementing the recommendations. A subset of the Phase I tasks was chosen to proceed. This subset was focused on integrating the GIS and the Hansen MMS.

Even with the comprehensive ITMP, and other GIS specific technology planning efforts, there were still those who believed technology implementation projects were doomed efforts. Some believed IT projects were likely to fail if system integration was involved, no matter how well planned or well run. There was plenty of talk in the IT literature at the time to make anyone think more than twice about taking on a project of this kind. It took many months of the Utility GIS staff's persistent, steady efforts to educate and gain acceptance of non-technical management to get a comfort and confidence level established that allowed us to proceed.

Business Driver and Goals

The primary driver to upgrade the GIS was to better meet the Utility's business needs by expanding the implementation and integration of the GIS and MMS. Upgrading the GIS was a necessary step to integrating the GIS and MMS. The Utility had made substantial investments in both systems. To receive a greater return on investment, it was felt that the GIS and MMS should be linked to leverage the data and value of both systems. Working together, the GIS and MMS could provide the kind of information that could facilitate work and problem identification and analysis, in addition to its already valuable uses of facility location and analysis.

The Hansen MMS is an integral part of the Utility's business and information management. It tracks and manages work orders and service requests on a daily basis on all water and wastewater facilities (with the exception of facilities inside treatment plants – which is done with a separate system – MP5). The GIS is also considered an integral part of the Utility's business and information management. The GIS database is the repository for all spatial information for non-treatment plant facilities. It is also the authority on several descriptive attributes associated with these facilities including diameter, material, length and ownership.

The overall goals of this effort were to increase staff productivity and to improve decision support. This was to be accomplished by providing staff with increased GIS functionality and improved access to the large amounts of valuable data and information contained in both the GIS and the MMS. Specifically, this includes improving services, reducing costs, limiting staff growth and effectively using existing technology investments. Our intent was to expand GIS analytical capabilities and improve ways to deliver geospatial data as understandable, value-added information to meet our increasing needs for desktop decision support.

Two Projects

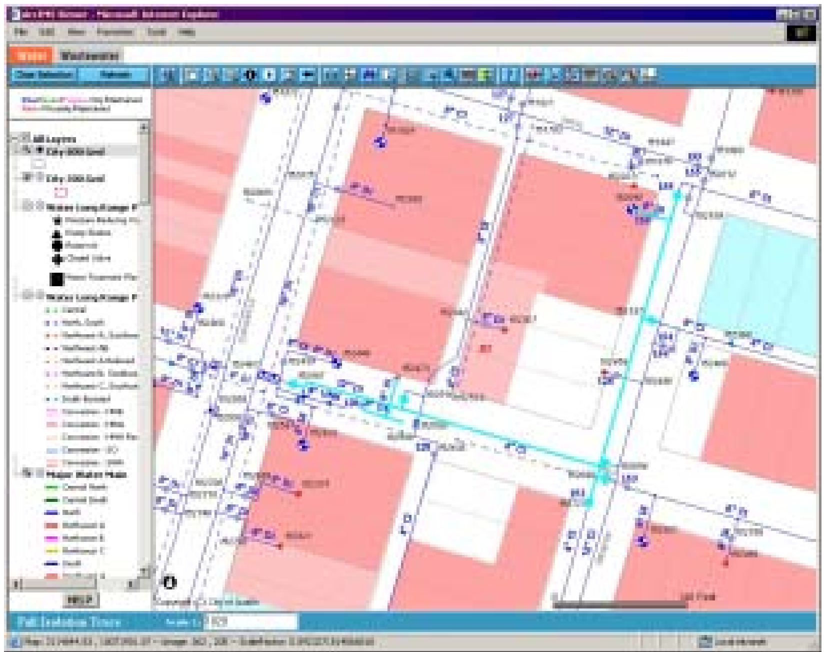


Figure 1. ArcIMS Application

The effort that the Austin Water Utility undertook from August 2002 to September 2003 to upgrade its GIS, encompassed two concurrently run, tightly integrated parallel projects.

GIS Upgrade Project

One project was referred to as the GIS Upgrade Project, and it transitioned the Utility to the latest versions of ESRI software and the Oracle database platform, not only to improve efficiencies and take advantage of the latest technologies, but also to facilitate integrating the GIS with other data rich systems. Interfaces to the water and wastewater hydraulic models were developed as part of the GIS Upgrade project. Integrating the GIS with the Hansen MMS was accomplished as part of the second project.

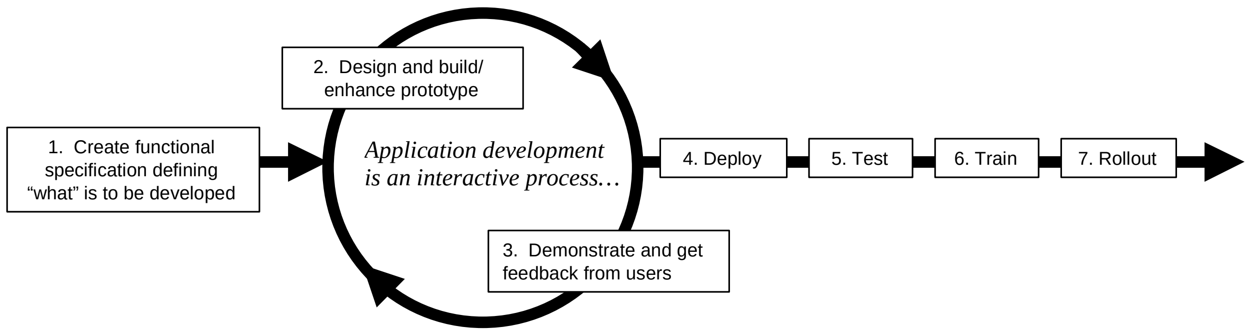
The upgraded system is based on ArcGIS 8.3 and ArcIMS 4.0.1 using the full capabilities of the geodatabase stored within ArcSDE 8.3 running on Oracle8*i*. The new web applications utilize the ArcMap Server extension to ArcIMS and were significantly enhanced from the existing site to include water and wastewater network tracing, wastewater profile generation, and red-line submittal. The new system was installed on the Utility's existing Oracle and Web servers (both Dell Poweredge 4400 servers with dual Pentium III 1 GHz Xeon processors running Windows 2000 Server).

After a competitive procurement, the Austin Water Utility contracted with ESRI (prime contractor) and a team of subcontractors consisting of Westin Engineering, Marshall & Associates, and Sunland Engineering to assist in its GIS Upgrade Project. Westin Engineering was tasked to perform the business process analysis, which complemented and leveraged their previous work for the Utility with the ITMP. Marshall & Associates was tasked to create the new ArcMap software-based data entry and editing productivity tools which needed to be closely coordinated and integrated with a parallel project for the Utility to integrate the existing Hansen MMS with the GIS. Sunland Engineering, a minority business enterprise, was selected to upgrade the existing H2ONet (water) and HydroWorks (wastewater) GIS-to-hydraulic modeling interfaces for the new environment.

ESRI developed the System Update and Data Migration Plan and geodatabase design, migrated the data, developed the new Intranet site based on ArcIMS, performed the system installation, and supported the acceptance testing and rollout of the system. As prime contractor, ESRI was responsible for the overall project coordination, technical design, and quality control.

The GIS Upgrade project work plan was largely based on a standard waterfall design approach that also incorporated an evolutionary-prototyping methodology to the application development. The project started with a kick-off meeting that included a four-hour presentation to the project team, end users, and other City departments. The presentation provided an overview of the entire project and acquainted everyone with the latest GIS applications and tools through several software demonstrations.

Figure 2. ESRI's Application Development Methodology



The first task was performing the business process analysis (BPA). It kicked-off with one full week of workshops. Several shorter follow-up presentations and workshops were conducted to complete both the "existing" and "future" workflow diagrams that were the heart of the final BPA report. As is frequently the case with business process analysis, the existing work processes were inadequately documented, making the results of this effort very enlightening to all those involved.

Using the existing 7.x data model and information from the business process analysis activities, ESRI created a draft of the new geodatabase design based upon the UML templates shipped with the ArcGIS Water Utilities Data Model handbook. New water, wastewater, and reused water data models were needed to take full advantage of the network, connectivity rules, domain validation, and associated editing and analysis tools available in ArcGIS 8.3. With a draft in hand, ESRI then led a two-day on-site workshop to interactively review and enhance the design (using Microsoft Visio 2000) with key members of the project team. The geodatabase design was continually updated throughout the data migration and application development efforts, with progressive versions of design exchanged through FTP until the design was finally frozen just prior to the final data migration supporting system rollout.

At the same time, another task group worked on consolidating what the project team had learned during the business process analysis and started development of the Software Update and Data Migration Plan. This was the primary document deliverable controlling the system development, which included a high level design of the application tools to be created and a full set of data translation matrices that prescribed exactly how the existing data records and individual attributes would be migrated to the new data model.

The central element of the work plan was two on-site development review meetings in which successive versions of the migrated data and applications were demonstrated to the end users. In the first review meeting, the applications were only partially complete and were running on only a small portion of the original data. However, the purpose of this first meeting was to get user feedback as early as possible to ensure that the developers were interpreting the application design correctly. As a result, many changes to the application design and geodatabase design were mutually agreed upon and implemented in the final system. The second (final) review meeting was conducted using the completed applications and the fully migrated data. ESRI successfully demonstrated the full functionality of the tools and data, so it was agreed that the project team was ready to start the acceptance testing, user training and rollout activities.

Acceptance testing was conducted by Austin Water Utility staff over a two-week period, with ESRI staff supporting on-site during the first three days. Several minor bugs were found in applications, but were quickly corrected, such that the user training started only two days after the completion of the acceptance testing period, with the rollout of the entire system conducted the following week with on-site support from ESRI.

GIS/MMS Integration Project

The upgrade project provided an opportunity to establish a more integrated GIS/MMS environment that provided for more efficient business process flow in data input, maintenance and access. A separate contract with Marshall & Associates as a sole source, was entered into with the goal of integrating the existing Hansen MMS with the upgraded GIS. The GIS/MMS Integration Project, as it was known, was run in parallel with the GIS Upgrade Project. The two projects followed similar methodologies. Marshall supported the GIS Upgrade project during business process analysis and geodatabase design phases to make sure Hansen integration issues were considered and accounted for. Application development and implementation phases were very closely coordinated.

There were three tiers to the GIS/Hansen MMS integrated solution. The core tier was a set of tools for synchronization, integrated editing and data maintenance for the GIS/MMS. This set of tools included the GeoAdministrator and the Post-Processing Tool Extension. The GeoAdministrator is a commercial off-the-shelf (COTS) product from Hansen which is delivered as an ArcGIS extension. The Post-Processing Tool Extension are a set of tools developed by Marshall that extends the functionality of GeoAministrator to support the City's editing and maintenance business process in an versioned environment. As the developer of Hansen's GeoAdministrator product and Hansen's preferred GIS services provider, Marshall was able to provide the Austin Water Utility with this set of extended functionality. Another tool provides GIS functionality (spatial queries, graphic viewing) from the Hansen user interface (Hansen's' Integrated Map Viewer). And another component provides enhanced web access to Hansen data (including data downloading and reporting) via buttons on an ArcIMS application toolbar. All these tools combine to provide a robust GIS/MMS integration solution.

Business Process Analysis

The Austin Water Utility had an established GIS built upon Arc/Info 7.x (using Librarian for GIS data storage) and ArcView (3.x) that was long overdue for a major upgrade. As the GIS had expanded over the years and the number of applications, auxiliary data formats, and system interfaces exploded, the data maintenance workflows to support the system had become so complex that the map-tile update process was prolonged into a four to six week cycle. The Utility clearly understood that the entire map maintenance process needed to be analyzed thoroughly and completely re-engineered to take advantage of the latest ESRI technology. Therefore, the business process analysis performed by Westin was a top priority for the upgrade project.

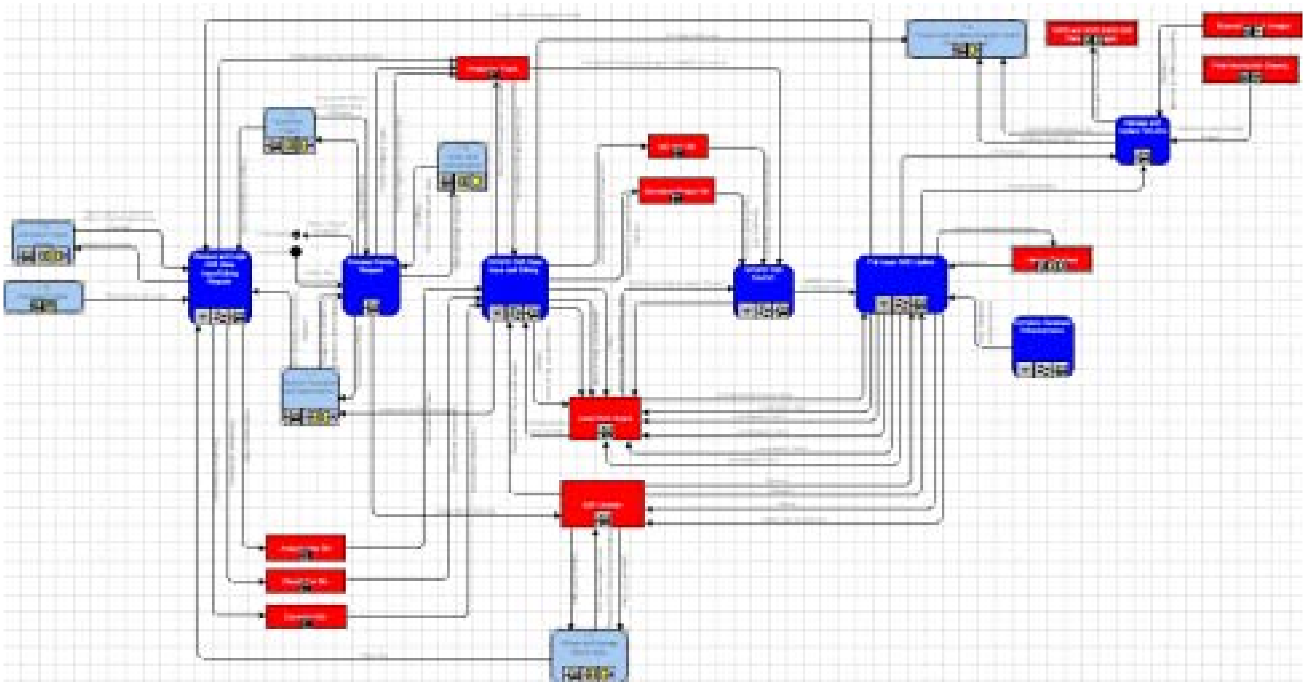
The objective of this task was to review the existing GIS data management procedures and to identify process improvements that take advantage of the new GIS technology. The primary focus of the business process analysis was to examine three major existing business processes, identify the needed modifications to implement improved business processes to effectively use the new GIS technology, and implement accepted industries' best practices. The three primary business processes included in the analysis were the following:

- Data Entry and Editing with Integration to the QA/QC Process
- Web-Based Application Development
- Water and Wastewater Model/GIS Interface

The business process analysis also looked at several other processes to define how the GIS data is used and how the use of the Utility's GIS data could be expanded within the Utility and the City. The additional functions that were contained in the business process analysis included

- Wild Lands Conservation
- Obtaining and Loading Sewer System Evaluation System (SSES) Program Data
- Preparation and Updating of the Strategic Water Resource Data
- The Capital Improvement Project Life Cycle
- The Integration of GIS Data with the Maintenance Management System

Figure 3. Sample Workflow Diagram (Westin Engineering)



Specific workflow models were prepared for all of the above processes. A total of 24 different "existing" and "to be" workflow models were prepared and included in the BPA Report.

Once the business process analysis was completed, the entire project team had a much better understanding of the existing workflows and how these contrasted the new workflows based upon the capabilities of ArcGIS. For example, dozens of manual steps and AML programs that were needed in the existing process were simply no longer necessary in the new system. Knowing where and how the new and upgraded tools were going to be used in the new workflows also helped Utility staff to understand the design of the new system and its richer capabilities.

BPA results:

- Provided an overview of the entire process
- Improved and streamlined the GIS processes
- Provided essential input to the geodatabase design
- Identified critical requirements for several applications
- Built consensus

The business process analysis portion of this project was seen as essential to the effective and full implementation of the new GIS. Aside from the intended technical benefits of this phase and its positive impact on improved processes, database design and application specification, the BPA was also very important to the overall success of the project. It helped non-technical issues by:

- Generating consensus and understanding among the users during the process
- Helping staff and management to see the big picture, how it all fits together
- Showing the value of the project and the interrelationships with other projects
- Shoring up non-GIS staff and management buy in

“It is the marriage of the new GIS business processes and the new ESRI GIS technology that will result in achieving the cost savings, improved GIS data quality, and enhanced GIS services. Simply implementing the new software without modifying the GIS business processes will not produce the expected benefits.” (Jim McKibben, Leeanne Pacatte, *Business Process Analysis/Modeling for Defining GIS Application and Uses*, 2003 ESRI User Conference). Please see above mentioned paper for more details on the business process analysis phase of Austin’s upgrade project.

Geodatabase Design

Central to any ArcGIS 8.x implementation is the geodatabase design, which generally can be created from scratch or based on an existing design. The Austin Water Utility opted to base their design on the ArcGIS Water and Wastewater Utilities Data Models. The standard Utilities Data Models provide a comprehensive base that is designed to be customized for specific applications. The unique business processes at the Austin Water Utility, including hydraulic modeling, Hansen integration, business procedures for planning new infrastructure, and other needs, were taken into consideration during the geodatabase customization phase of the project.

While ESRI completed the actual geodatabase schema using Microsoft Visio, the project staff at the Utility took an active role with the development of the design. As the staff gained experience and education regarding modeling principles, they were able to work with peripheral project staff to refine attributes, domains, and classes in the three model sections. The model went through thirteen successive versions, initiated by both ESRI and Utility staff. This iterative approach to refining the model led to a final design with innovative layouts, comprehensive domain tables, and a robust set of classes and attributes.

Major changes:

- Plan features to be added
- Water and wastewater service taps to be added
- Reuse/reclaimed water to have its own layer
- Alternative wastewater systems to be added
- Red-line features
- Water pipes to be added as an integrated feature with Hansen
- Data availability

Particularly innovative to the model was the inclusion of planned infrastructure within the geometric networks representing actual infrastructure. The Austin Water Utility wanted to include the ability to review infrastructure in all stages of planning from proposal to installation in their system views. Their solution included duplicating the database design for the actual system within each geometric network, thereby allowing users to include or ignore planned facilities in relation to the actual complete system. The end result is a model where normal business processes can take into account only the existing actual system, while planning procedures can include selected portions of the planned infrastructure as if it were part of the actual system.

The flexibility of the geodatabase and its underlying schema allows for connection to external systems. Since, the Austin Water Utility uses Hansen as an asset management system, and also implements water and wastewater hydraulic modeling systems external to ArcGIS, careful coordination is required between the geodatabase and the related systems.

The relationship between the systems is handled via a unique identifier and with user-interface controls. Special ID and type attributes from Hansen were added to the geodatabase schema to manage the interface with the Hansen system. Hydraulic modeling and other interfaces can use simple queries and the standard Facility ID values in the model.

Marshall assisted the Austin Water Utility and ESRI with creating a Hansen Geodatabase Model for the Utility's Water and Wastewater data. ESRI's ArcGIS Water and Sewer UML data models were the bases used in the designs. Marshall identified data model enhancements that would facilitate automated and process-driven attribution of key Hansen fields. This provided the capability to link GIS features to assets stored in the Hansen database, and allowed for the synchronization of attributes between the two systems.

Data Migration

The ESRI team migrated the Utility's data from Arc/Info 7.x format to the Geodatabase model implemented in the ArcGIS 8.x–SDE/Oracle environment.

The following are the high level tasks performed by the ESRI data migration team during the data migration portion of this project:

- Develop Data Migration Plan
- Develop data dictionary for water, wastewater and reuse model
- Examine the source data delivered by the Utility
- Coordinate with Utility project personnel for any data issues
- Coordinate with the project geodatabase design team for any design updates
- Develop tools/programs (AMLs, Oracle Sql scripts)
- Preprocess the source data
- Data loading
- QA/QC the data after data loading
- Build geometric network for water, wastewater and reuse model

Utility staff preprocessed source data prior to ESRI's preprocessing and post processed data to establish the segmentation to fit the new data model. This also included bringing in the necessary Hansen IDs to manage the interface between the two systems. Some adjustments had to be made to the Hansen database to accommodate the new schema.

The data migration was performed in 3 phases, including migration planning and documentation, two prototype migrations and a final migration. The prototype migrations were intended to test the data migration process and its tools based on the migration plan prior to the final/full data migration. The prototype migrations were also used to validate the geodatabase design and application tools before they were deployed in the final system. The prototype phase approach provided an opportunity to make sure the issues related to data, design, productivity and application tools identified during this phase were identified and accounted for prior to the full data migration and system implementation.

The ESRI data migration team developed a set of AMLs (Arc Macro Language) to pre-process the coverage data before loading it into the SDE geodatabase. Also a set of Oracle SQL scripts were developed to facilitate the population of attributes within the Geodatabase, and to perform quality control on the loaded data after the migration.

As a part of data migration task, the ESRI data migration team developed a data dictionary document for water, wastewater and reuse, (reclaimed water) models. This data dictionary document shows the target feature class names, attributes definitions, domains, source attributes, and so forth (Figure 4) to facilitate the design of extraction and loading process.

Figure 4. Data Dictionary Target Features

Fitting — JUNCTION: Geometry Type = esriGeometryPoint, AncillaryRole = esriNCARSourceSink

Junction representing a Fitting

Attribute	Type	Size	Domain	Null	Default	Source
Austin.Junctions						
SubProject_ID	Double	P9 S3		Yes		NULL
GridID	String	L 5		Yes		Water: TILE
MAPSCO	String	L 10		Yes		Overlay with OMNIGRID cov and get values from MAPSCOPAGE field.
WWW_ID	Integer	P 9	D_IDRange	Yes		Water: WWW_ID
AddBy	String	L 16	D_AddedBy	Yes		Default to "INIT_MIGRATION" during the migration
DateAdded	Date			Yes		Water: DateAdded (Redefined from FEATURE_ID field)
RotationAngle	Integer	P 3	D_Angle	Yes	0	Water: ANGLE
CompType	Integer	P 9		Yes	70	Water: COMPTYPE [illegible]

Migration instructions were specified on each page (5) of the data dictionary document for every feature class. Utility project personnel reviewed this data dictionary document and provided feedback throughout the project cycle.

Figure 5. Data Dictionary Migration Instructions

Migration Instructions

1. From DistribNode table, all records where WNM_TYPE = "WPIPEFIT" and Fitting_Type = Refer below Table
2. From DistribNode table, all records where WNM_TYPE = "WFIRELIN.
3. From LeadSVC Table, all records where WNM_TYPE = "WFIRELIN"
4. Calculate the Subtype value according to the FittingType attribute value.

Value to put into FittingType attribute	*Original value in WaterNode: FITTING_TYPE*	*SubType*
CROSS	CROSS	1
PLUG	PLUG	3
REDUCE	REDUCER	4
TEE	TEE, LN_FLIN	1
	Original Values in WaterNode: WNM_TYPE	
FIRELN	WFIRELIN	

Next, a set of logic tables was developed as specifications for the update of attributes. For example, the attributes Owner, MaintainedBy, OperationalStatus and AdministrativeStatus area based on the existing coverage attribute information as shown in Figure 6.

All these migration instructions and specifications were translated into processes and programs to actually perform the data migration.

Figure 6. Logic Tables

Logic Table To Calculate Owner and MaintainedBy Fields			
EDGES			
OLD GIS System		New GIS System	
Owner	PR_ZONE/BASIN	Owner	MaintainedBy
C	PR	PRIV	CITY
P	PR	PRIV	OTHER
C	AB	NULL	
P	AB	NULL	
C	<> AB or PR	CITY	
P	<> AB or PR	CITY	

Logic Table To Calculate OperationalStatus and Adm		
EDGES AND JUNCTIONS		
OLD GIS System	New GIS System	
Status	Operational	Admin
" "	NULL	NULL
AI	AB	AB
IS	IS	IS
PR	PR	PR
AR	REM	AB
AB	AB	AB

On all data conversion/migration projects, ESRI develops QA/QC plans as a part of the data migration plan document. The quality assurance/quality control plan includes feature count reporting (before and after the data migration), domain coded values checking, and attribute transfer checking documentation to ensure that the data delivered meets data quality specifications. From the beginning to end of the data migration activity, quality checks were performed at all stages. Issues identified during these quality control steps were resolved in coordination with City personnel.

ArcGIS Productivity Tools

Going from a tile structured data storage methodology to versioned editing in SDE and synchronizing with another very active database presented some challenges in the data editing process. SDE versioning is essential to coordinate work flow with the new system. To begin the editing process, a Control version is created from the default version. From the Control version, Edit versions are created for each editor. The Edit version is edited using ArcMap standard editing tools and customized productivity tools (described below). When the editors complete their edits, the QA/QC staff is responsible for running QA/QC processes and reconciling each Edit version up to the Control version. When all Edit versions have been reconciled and posted to the Control version, QA/QC staff use the Post Processing tool to synchronize the Control version edits with the Hansen database. Finally, all edits in the Control version are reconciled to the default version and posted. The default version is used for the ArcIMS applications, for producing the system maps and images and for passing data to the hydraulic modeling interfaces.

Figure 7. GIS Data Editing Cycle

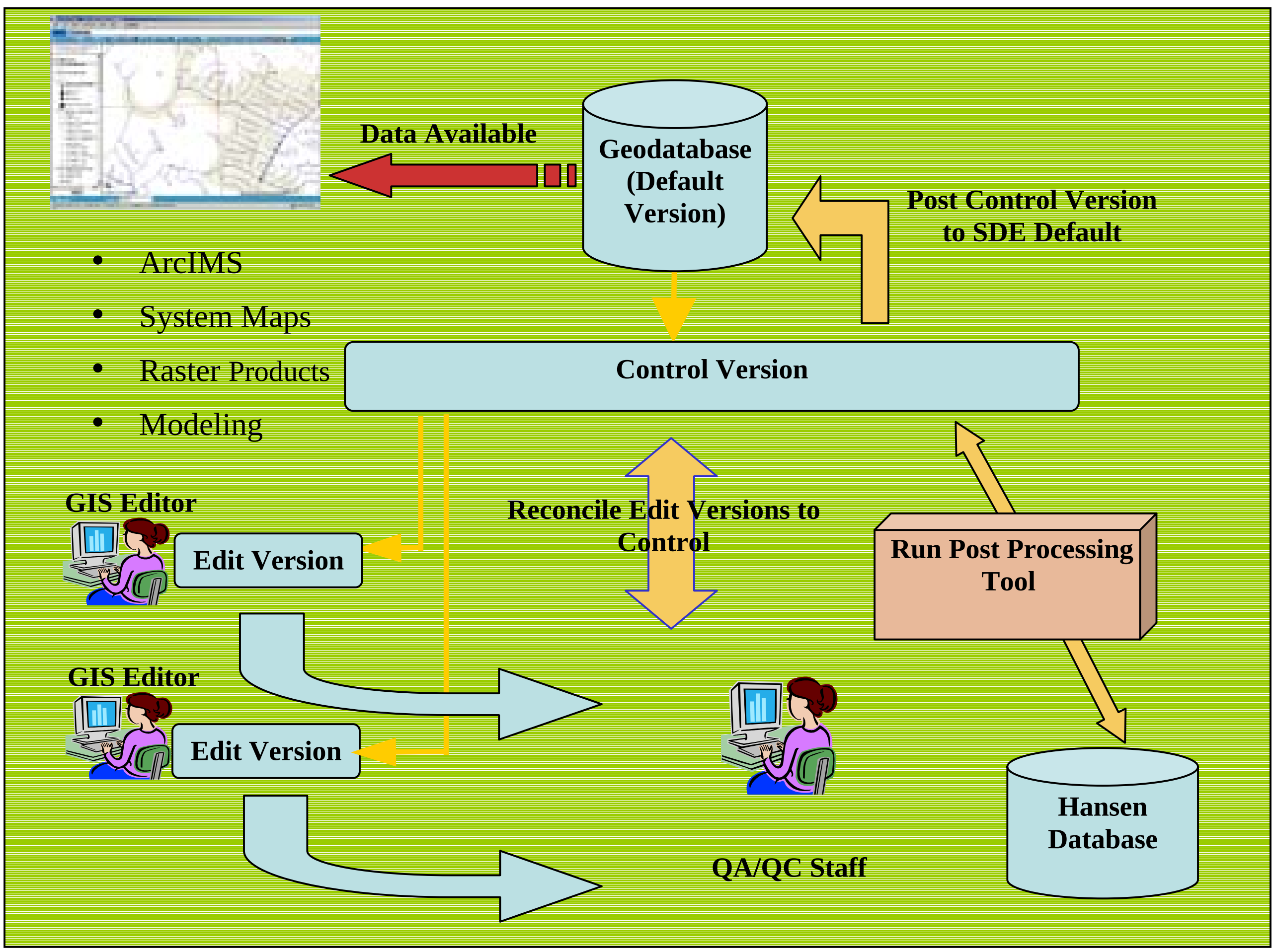
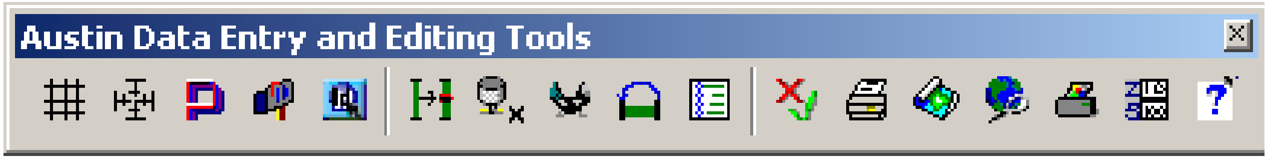


Figure 8. Data Entry and Editing Toolbar

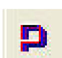


Navigation Tools

Five navigation tools were built to aid in navigating through the GIS data to desired locations. These tools assist the user in quickly finding a specific location in the spatial extent of the water and wastewater GIS database.

 Locate by Map Grid Identifier: User selects the tool and enters or selects from a dropdown list the map grid of interest, which then appears in the map grid area in the user's display.

 Locate by State-Plane Coordinate: User selects the tool and enters the X and Y coordinate values of the point of interest and the GIS area centered on the input point value is displayed.

 Locate by Project Number: User selects the tool and enters the project number of interest, and the GIS area containing features associated with the project number is displayed.

 Locate by Address or Intersection: User selects the tool and enters an address or intersection of the location of interest, and the GIS area centered on the input address or intersection is displayed. The tool first attempts to match the address to an address point and, if that fails, matches to an address range based upon the street centerline.

 Locate by Asset Identifier: User selects the tool and enters/selects a unique identifier. User selects a dataset to search and a feature class (optional). The GIS area centered on the feature with a matching identifier is displayed.

Feature Editing Tools

Several data editing tools or functions were developed to streamline business processes for data inserts, deletes, updates, splits, merges and flips.

 Split Main: Provides a tool to select a point along a main as a new "split" and automatically inserts a user-selected feature (e.g., manhole, valve) into the line, creates or updates node point values, and validates connectivity. This tool tightly integrates the creation of new features, the transfer of specific attributes, and the management of Hansen history, and ensures that the "split" adheres to all business rules. Attributes and values required for a successful reconciliation to the Hansen database are managed and validated.

 Lateral Creation/Junction Placement: Adds a new lateral to a main as well as the related junctions, fittings and valves. User configures the junctions that may split a main.

Merge Mains: Merges two selected mains (e.g., features) in the geometric network into one main. Attributes of the upstream main are used by default, however, the user has the ability to change any attribute prior to completing the merge. The tool can be configured to not provide a default value, requiring specific attributes to be entered manually.

Flip Main: Provides a means to reverse the "from" junction and "to" junction designations of a line segment digitized in a direction opposite the desired flow (upstream or downstream) direction. The tool flips both the geometry and attributes impacted by the flow direction such as upstream and downstream inverts.

Set "Sticky" Attributes: A specific attribute value can be user defined as "sticky" or persistent during the input of multiple features (e.g., project number, operating status, owner, and basin may be common for a number of features being created). Sticky attribute values, easily modified during an edit session, are validated against domain values to ensure data integrity.

Create System Identifier for New Feature - A unique ID is created automatically when a feature is added using a database sequence table.

Autorotate Symbols Perpendicular or Parallel to Mainline - Rotation angle is automatically calculated when a feature is added and used to rotate the symbol for a new point feature, so that the symbol is displayed parallel or perpendicular to a related line.

Quality Assurance/Quality Control Tools and Map Production Tools

Two quality assurance tools were built to aid GIS editors and managers with checking the spatial and attribute data entered in ArcMap. These tools assist the user in identifying errors either through automatic validation or by printing check plots by desired geographic areas of interest.

QA/QC Report - Provides automatic data validation. User selects the tool, and the application validates the data that has been created in ArcGIS then returns a report with any errors found. The report allows the user to select a specific error and zoom in to correct the problem. The user can also print and save the report. To ensure data integrity and completeness, the QA/QC tool includes checks for the following conditions and data inputs:

- List the number and type of junction points for a project.
- Check that sewer mainline slopes are within an acceptable range.
- Check that the diameters of mainlines entering and leaving a reducer are different.
- Check that the material on mainlines entering and leaving a material separator junction are different.
- Check that the project numbers on mainlines entering and leaving a project separator junction are different.
- Check that the ownerships on mainlines entering and leaving an owner separator junction are different.
- Check that the jurisdictions on mainlines entering and leaving a jurisdiction separator junction are different.

User can zoom to the features listed in the report window using a context menu.

Print Check Plot: User selects the tool and enters in project number or grid of interest and desired feature data set to validate. The application zooms to that location and automatically creates a plot with a title, legend, logo, north arrow, scale bar, labels and a list of any errors found with newly created GIS data within that extent. This includes two ArcMap templates to choose from.

Map Production: Performs batch printing/exporting.

Update Service Area Map: Update map showing area where Utility data is available.

Print Service Area Map – Prints latest version of service area map.

The new tools simplified the user interface and enhanced QA/QC functionality. The productivity tools, in conjunction with the seamless database, are more streamlined and efficient to use.

Hydraulic Modeling Interfaces

The Austin Water Utility had been passing data from the GIS to the hydraulic water and wastewater models for several years. But with the new technology, those tools would no longer work and would need to be updated. The water system uses H2ONet for its hydraulic modeling and the wastewater system uses HydroWorks. *Sunland Engineering*, as a subcontractor to ESRI, developed the interfaces.

The old program:

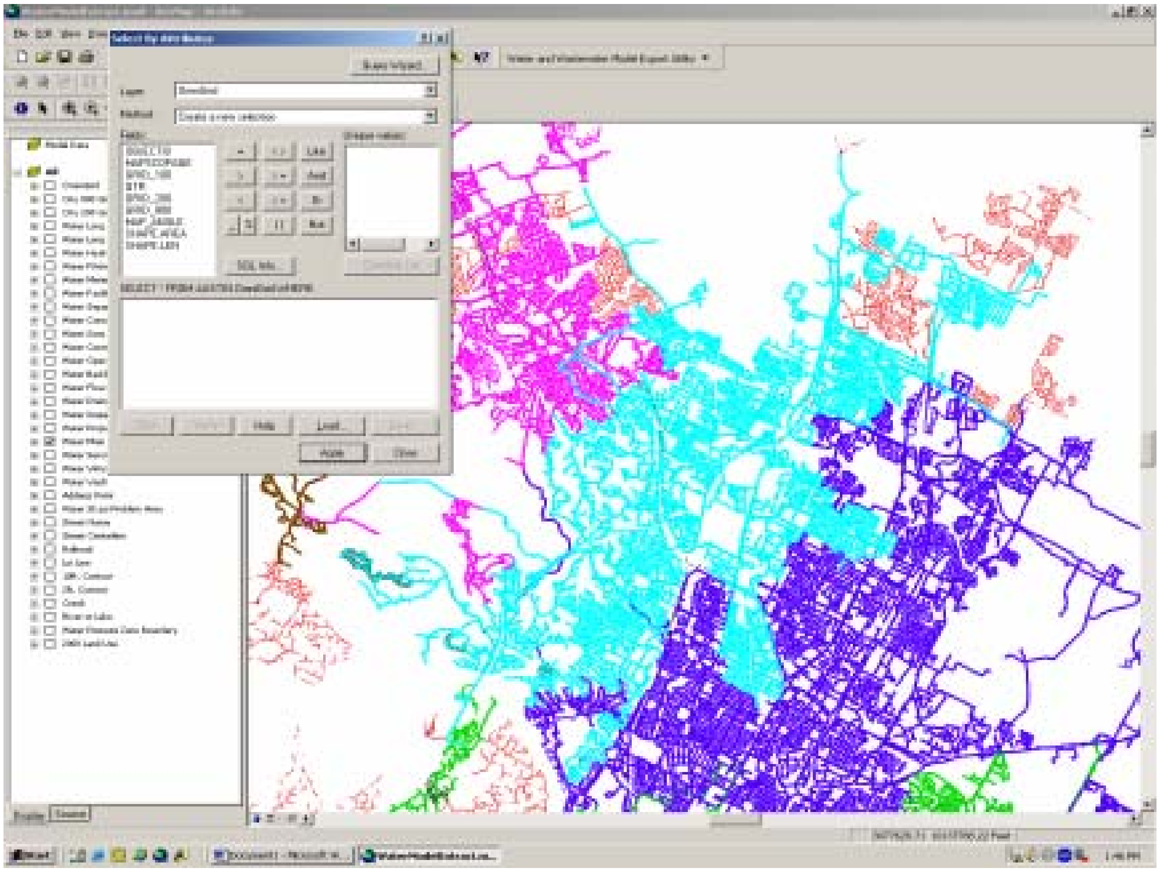
- Slow post-processing method
- Not run very often
- Data processing schedule dependant upon technical team's schedule rather than modelers' needs
- Technical problems with data such as disconnected pipe groups
- Based on 7.x/3.x technology using AML/Avenue
- ID system different from what rest of Utility uses

The new program:

- Stand-alone program which modelers can run against database at any time
- Solved technical problem of pipe grouping
- Written in modern programming language of Visual Basic
- Uses ID system that rest of Utility uses

First, the modeler builds a selection set of water or wastewater pipes in the GIS. This can be based on pressure zone or last date updated or other criteria. Then an export file is created. The user supplies the location for the export file and chooses a template. Processing time for the average pressure zone is two to three hours. Previously it was several days to a week. A personal geodatabase is then ready for importation into the hydraulic models to update model networks.

Figure 9. Select Pipes to Export to Hydraulic Models



GIS/Hansen Integration Tools

The customized ArcGIS/Hansen Post Processing Tool extends the functionality of Hansen's GeoAdministrator to synchronize the Austin Water Utility's geodatabases and Hansen data. The post processing tool works with ESRI's ArcEditor and a versioned geodatabase to enable multiple users to "check out" a geographically referenced data set, perform updates, and check finished data sets back in to the SDE database.

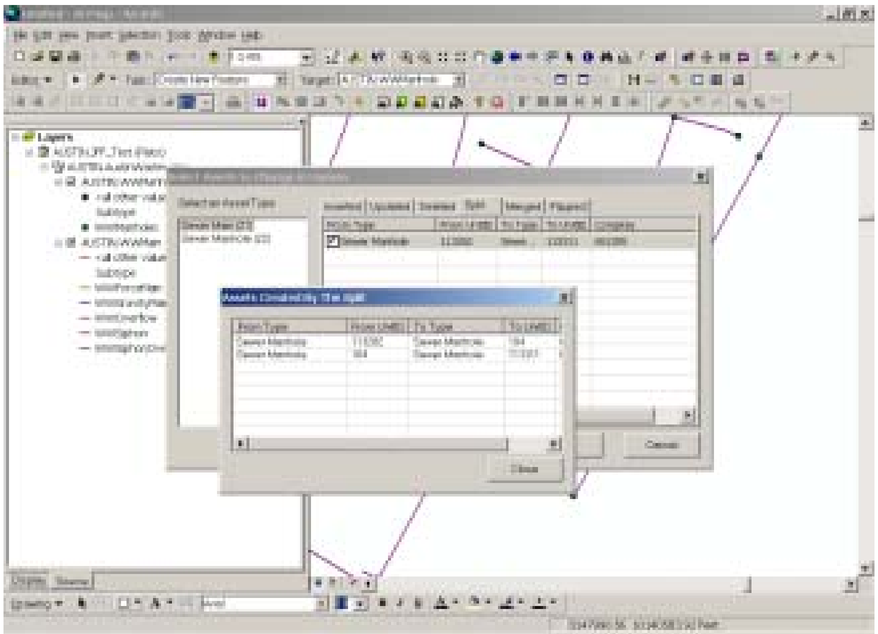
The post processing tool offers these key functions:

- Ability to verify spatial edits prior to making any changes to the Hansen database
- Ability to selectively identify spatial edits to apply in Hansen
- Ability to create new Hansen assets, expire assets, split linear assets, merge linear assets, flip flow direction of linear assets, and modify attribute information in a single process
- Ability to produce a log of all modifications to the Hansen database, and any failed operation attempts

As GIS features are created, edited, or deleted they must be reconciled and posted to the Hansen asset database to ensure tight synchronization between the GIS and Hansen data stores. Marshall built a two-step tool to automate this reconciliation.

1) Detect GIS Changes: This tool identifies each GIS feature changed in a versioned ESRI ArcSDE geodatabase and creates the appropriate data and actions for updating data in both the GIS and Hansen datasets. New features are processed for adding to Hansen, deleted features are processed for retiring the corresponding Hansen asset, and updates generate actions to appropriately change the Hansen asset information.

Figure 10. Split Detected in GIS Changes Tool



2) Update Hansen and GIS: Actions and data prepared in the change detection step are executed and validated to ensure a complete and accurate update to each data set. This tool performs data changes bi-directionally. GIS features and attributes are written to Hansen, and Hansen ID information is written to the GIS to create and maintain a tightly synchronized linkage between the GIS and Hansen data sets.

Web-Based Tools

The Austin Water Utility had existing home grown ArcViewIMS applications that had become embedded in many of the Utility's daily activities.   What began as a pilot in 1998 to demonstrate the possibilities of Web-based GIS, quickly became very popular and useful tools. To minimize changes to the current user interface and reduce the need for additional training, the new functionality was blended into the existing applications as much as possible. When necessary, the changes and additions were made according to the Utility Web design style. The mapping styles were maintained as well.

As popular and useful as the old Web applications were, there were technical limitations:

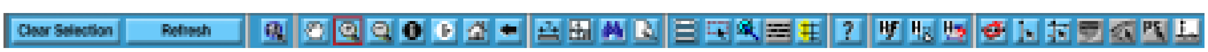
- Based on older limited technology
- Difficult to program
- Single proprietary programming environment
- Difficult to add new features
- Not scalable
- Shared system environment
- Incompatible with new GIS system and processes

The new web applications have overcome these limitations and are:

- Based on current technology utilizing current web standards for development
- Much easier to program
- Multiple supported programming environments
- Easier to add new features
- Scalable
- Independent system and user environment
- Compatible with new GIS system and processes

The functionality can be grouped into three categories, Basic Web Tools, Advanced Web Tools and Hansen Integration Tools.

Figure 11. Austin Water Utility Web Toolbar (with full access)



Access to the different tools is configured based on the Windows NT group of the user. To access the restricted functions, the user has to log in (same as Windows NT login). Based on the user's membership in the NT login group, all, some, or none of the advanced Web tools are made available.

Basic Web Tools

Pan

Zoom In

Zoom Out

Zoom to Full Extent

Zoom to Previous Extent

Zoom to Street Address: Zooms to the specified address. If more than one address is found, displays a list of selectable candidates.

Zoom to Asset Identifier: Zooms to the feature with the specified unique asset identifier and displays its attributes. The tool will search within the entire dataset for the asset ID or, if provided, will only search within a specific feature class.

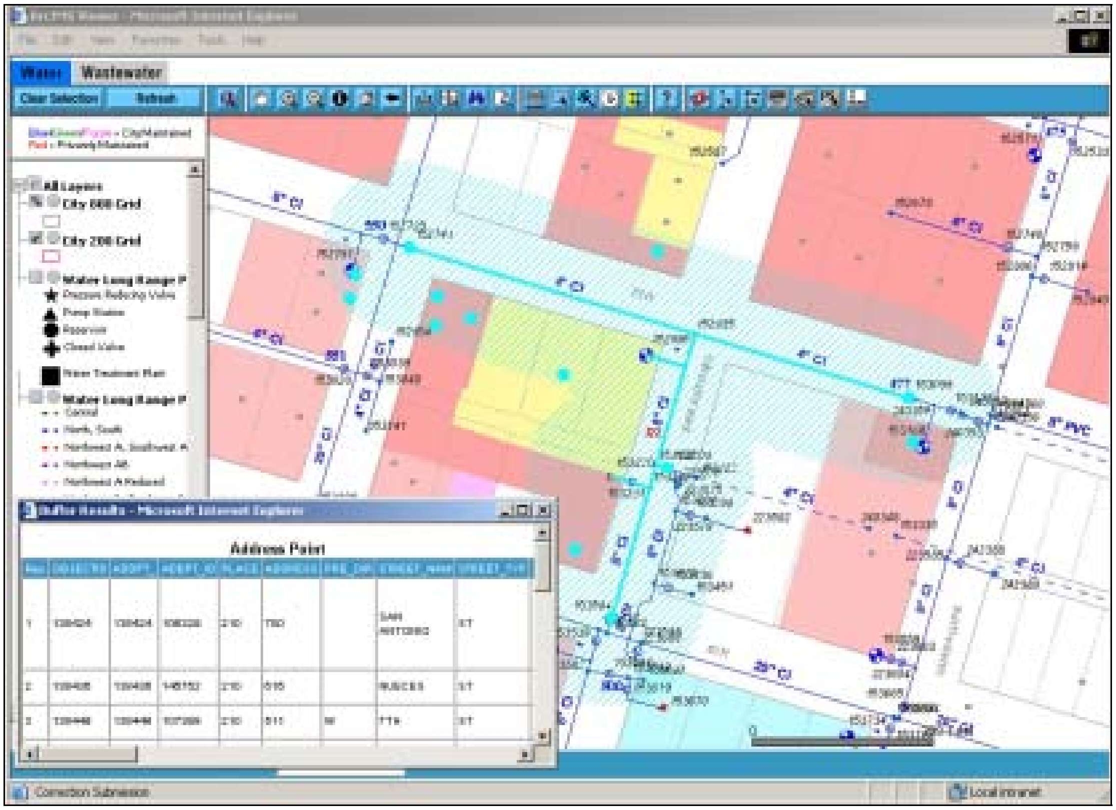
Select with Line or Polygon: Selects features from the active layer that intersect a line or polygon.

Select by Rectangle: Selects features from the active layer that intersect a rectangle.

Clear Selection: Clears selected features.

Buffer: Creates a buffer around selected features, for example for finding the customer addresses near the pipes that will be affected by a mainline shutdown.

Figure 12. Buffer Tool



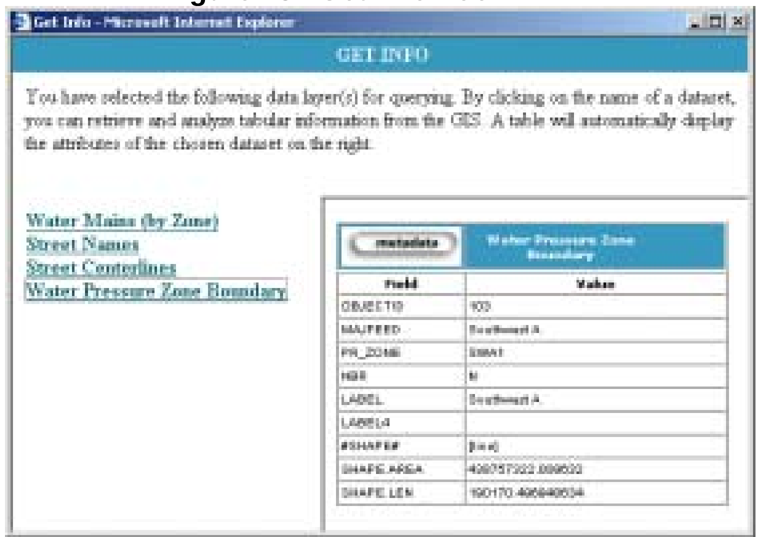
Measure: Measures distance on the map.

Set Units: Sets a new unit for measurements/scale units.

Display Attributes: Displays attributes for selected features.

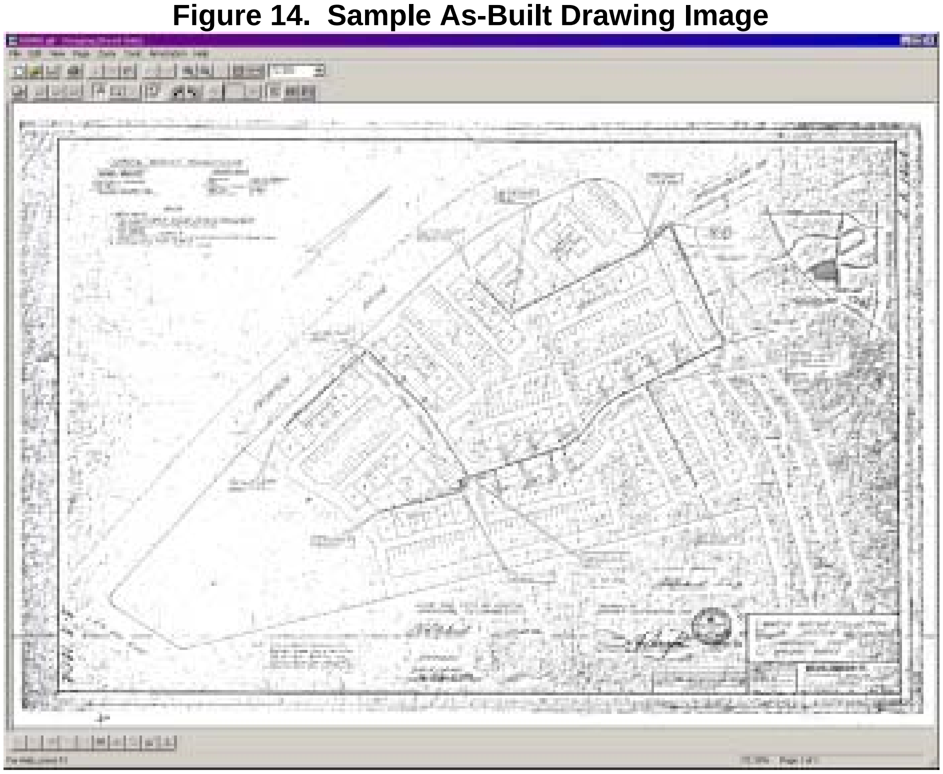
Get Info: Retrieves attribute information for all visible layers in the Table of Contents at the location.

Figure 13. Get Info Tool



Hotlink to Raster Images: Displays images linked to visible features on the map.

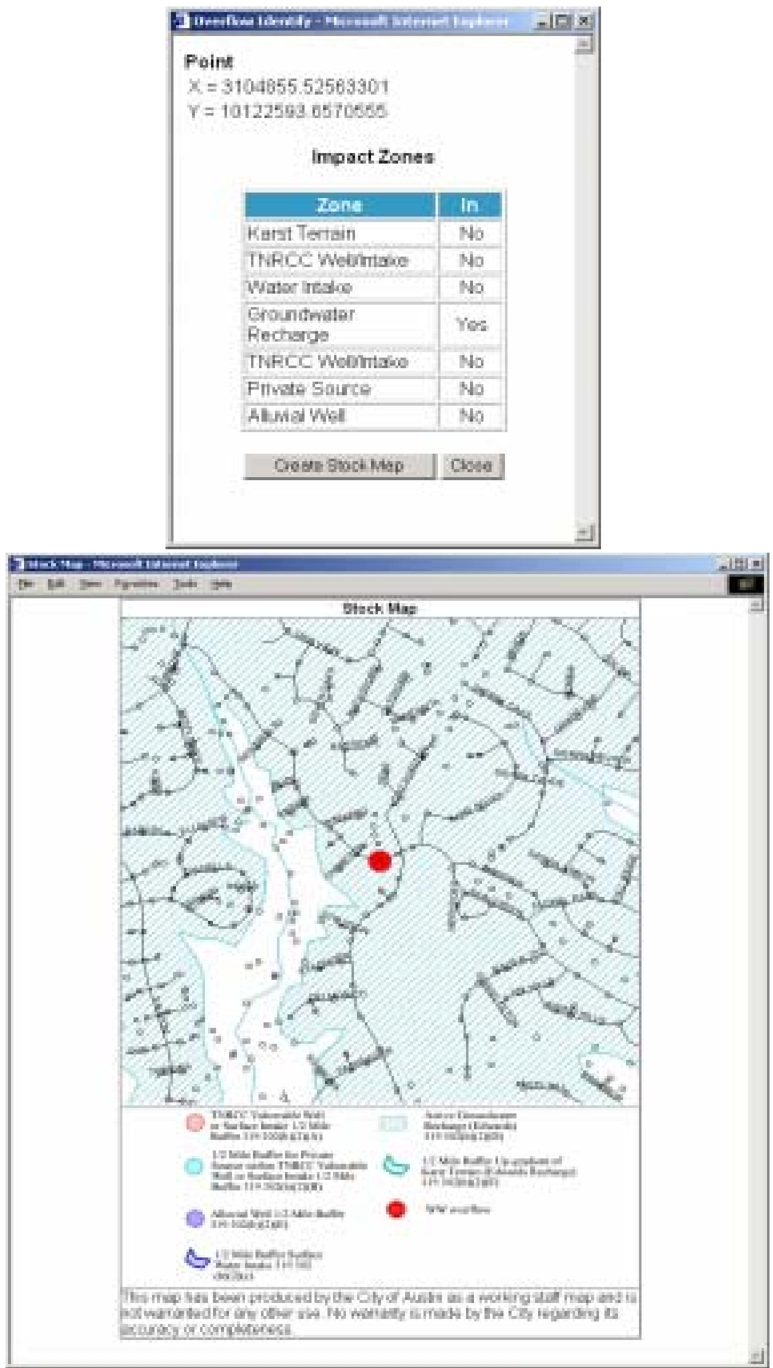
Figure 14. Sample As-Built Drawing Image



Advanced Web Tools

Identify Overflow: Indicates whether the user selected overflow location is within predefined impact zones and generates a standard stock map showing the location of these zones.

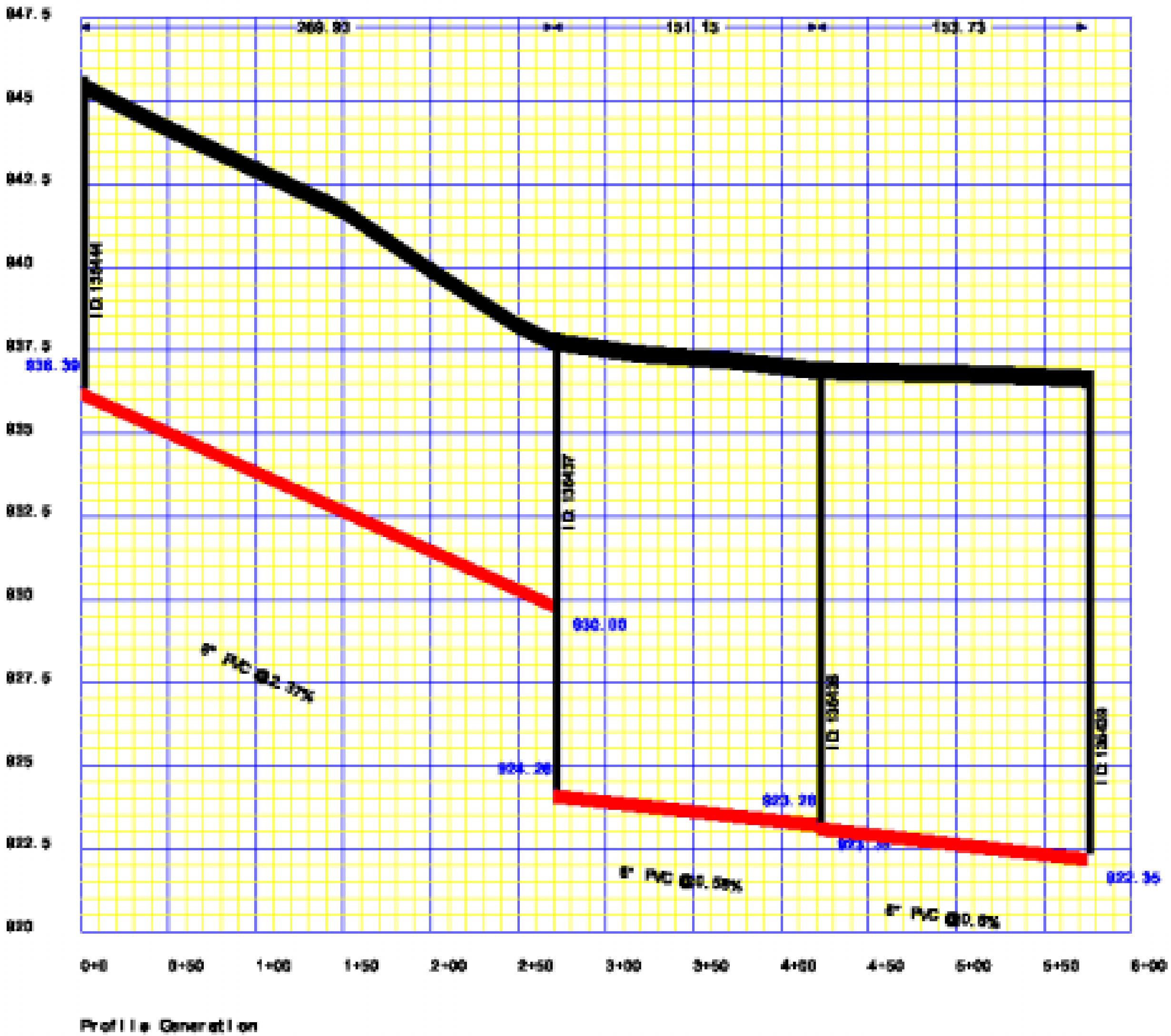
Figure 15. Identify Overflow Tool and Stock Map



Profile Select: Creates a selection of connected wastewater mains. By selecting first, before generating, provides built in QC.

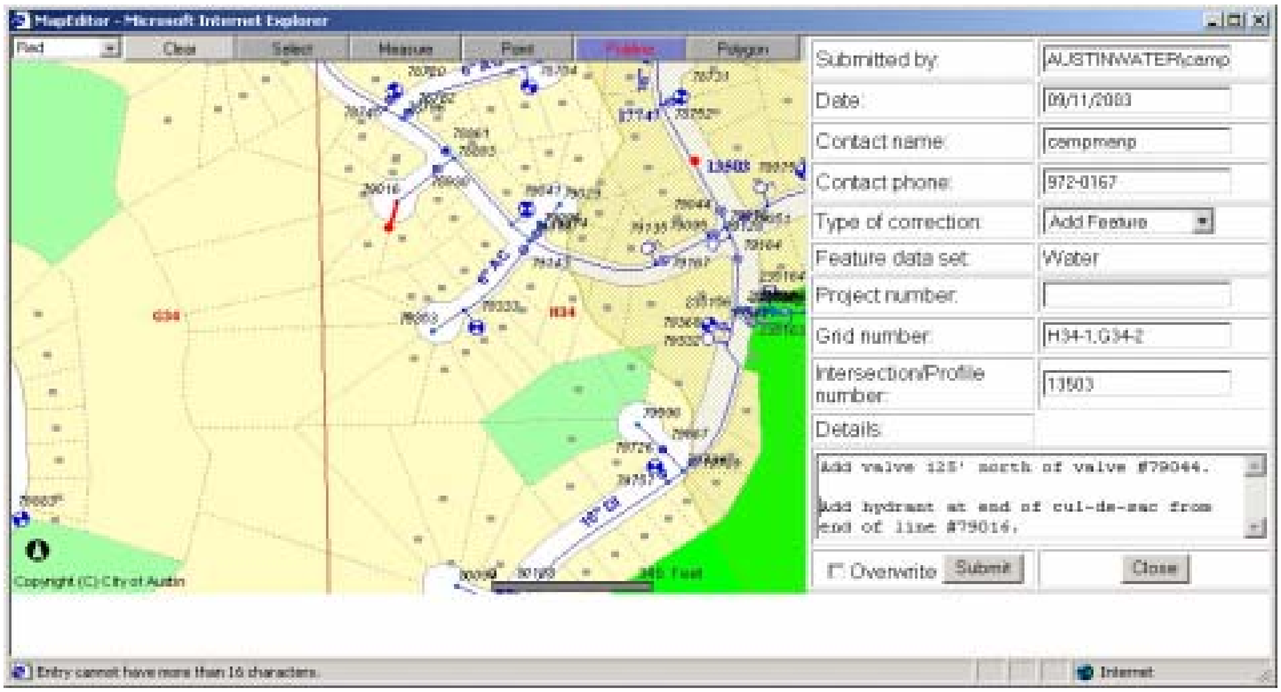
Profile Generation: Generates a profile of a selected set of wastewater mains in PDF format.

Figure 16. Sewer Profile Generated in PDF Format



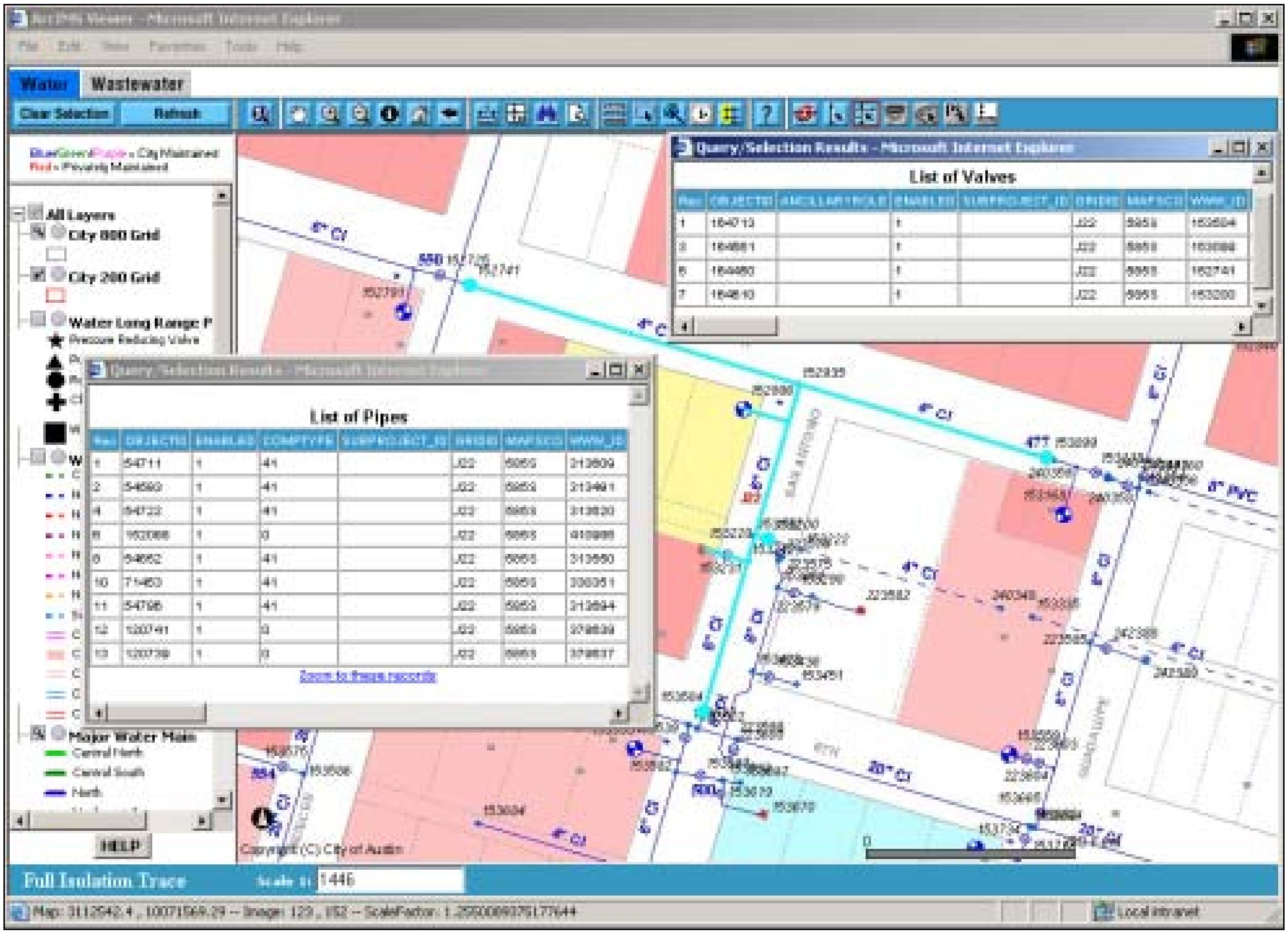
Correction Submission: Submits request for correction of GIS data. The request consists of a spatial and a tabular component.

Figure 17. Correction (Red-line) Submission Tool



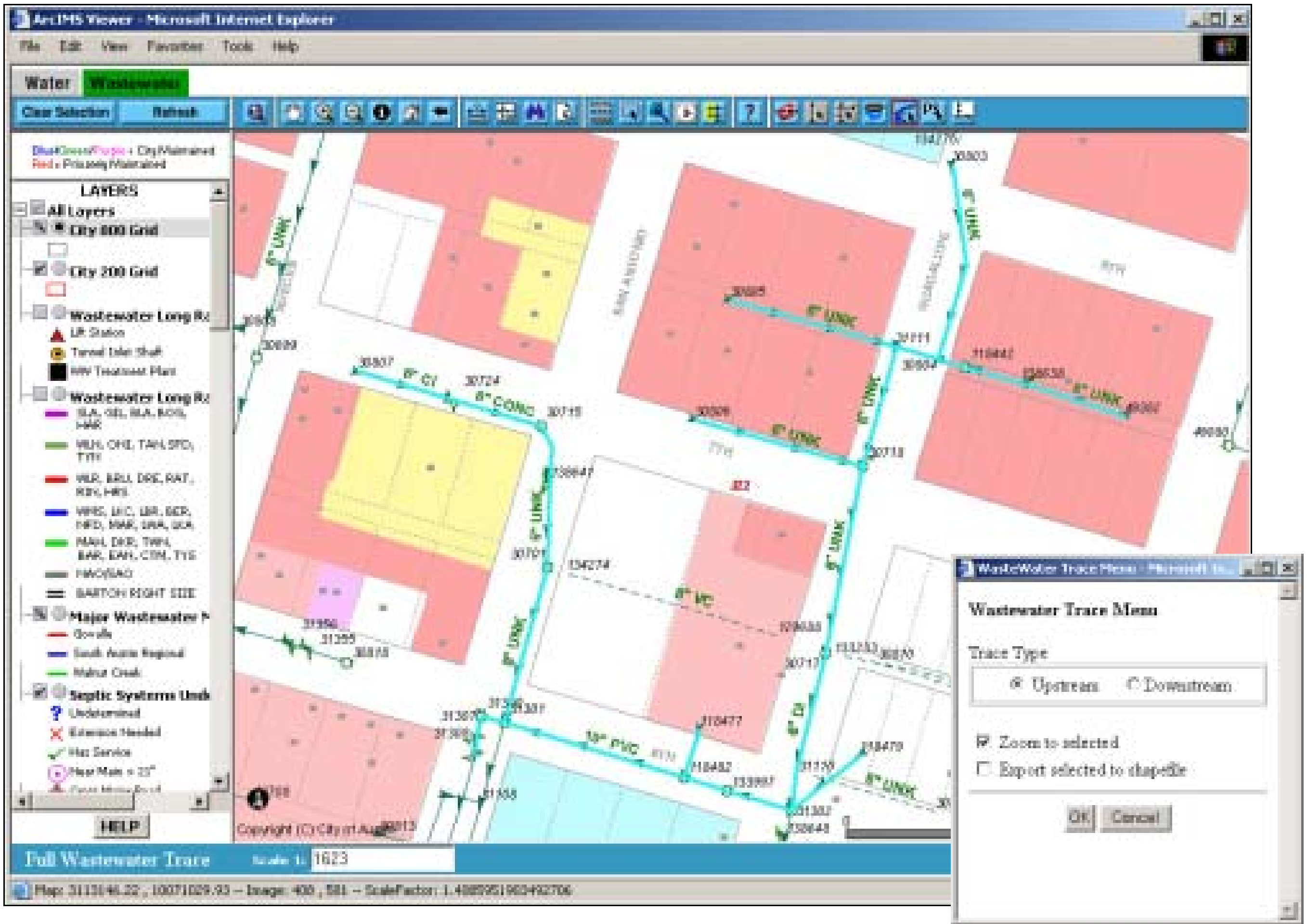
Mainline Isolation Trace: Identifies in a table the valves that need to be closed to isolate a selected main. Zooms to the valves and lists them in a results window.

Figure 18. Mainline Isolation Trace Tool



Wastewater Trace: Performs upstream trace to determine branching or downstream trace to find the path to the sink (treatment plant). Zooms to the extent of the results. Features selected by the trace can be exported to shapefiles and downloaded.

Figure 19. Wastewater Trace



Hansen Integration Tools

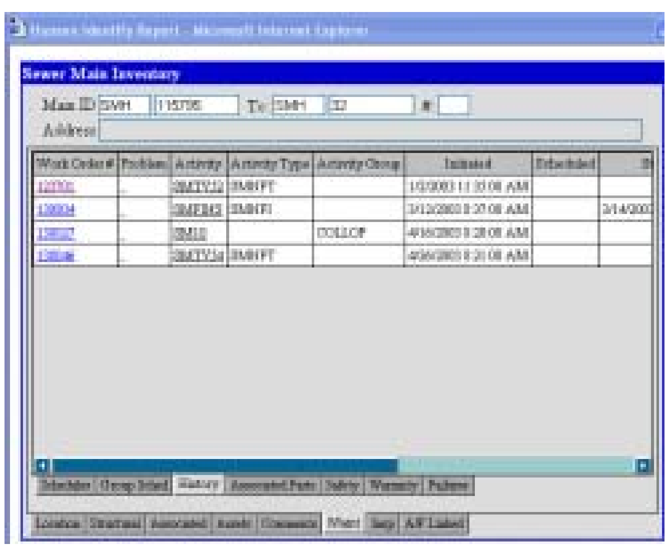
The ArcIMS Hansen integration tools are a set of customized Web components that extend the functionality of the City's existing ArcIMS site. These tools are based on ArcIMS and .NET technologies, and allow a single interface to connect the City's users to work orders, customer service requests, and assets and property data. Access is provided via a Web browser. The tools present a City-wide view of assets and associated existing work orders and service requests.

The ArcIMS-Hansen tools offer these key functions:

- Ability to access Hansen asset inventory information for a selected asset, including maintenance schedules and history
- Ability to produce a summary report of work orders or service requests matching user defined filter criteria, optionally based on a spatial selection set
- Ability to print the resulting report
- Ability to display and print a map showing the locations of the assets associated with the matching work orders or service requests
- Ability to download both the spatial features representing the matching assets in shapefile format and the records in the report in Microsoft Access database format to the client machine

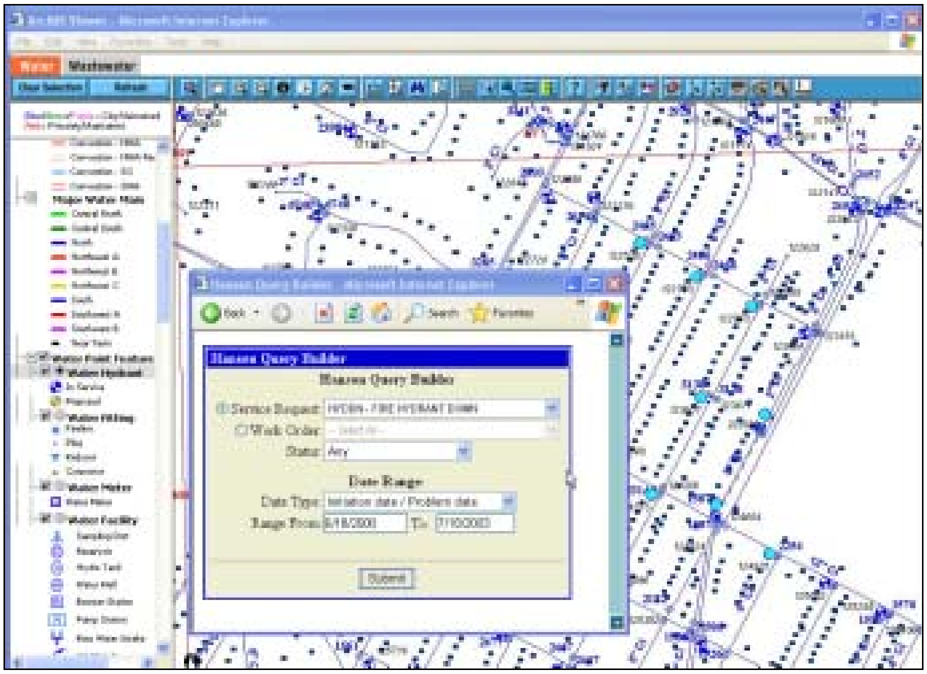
Hansen Identify Tool: This tool allows the user to click on an individual asset (water or wastewater) on the active layer and pull up an HTML form that looks similar to the Hansen V7 asset information form in a separate browser window showing Hansen information for the selected feature.

Figure 20. Hansen Identify Tool



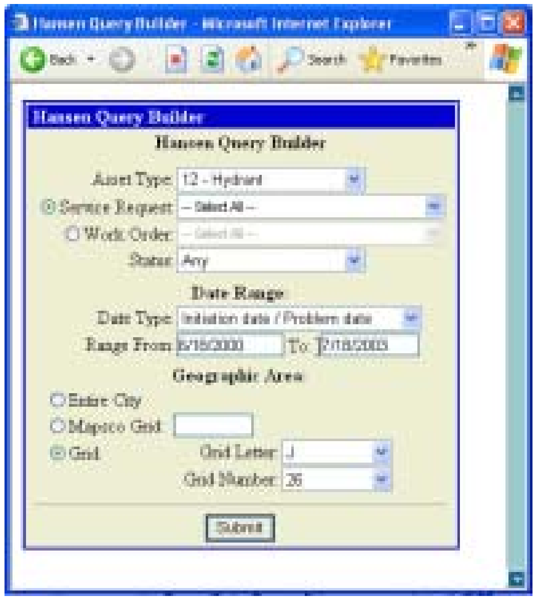
Hansen Query Builder Tool: This tool allows the user to select multiple assets (water, reuse, or wastewater) within the ArcIMS viewer and return history (closed work orders or service requests) or activities (open work orders or service requests) in a printable report format based on the selected assets in the map.

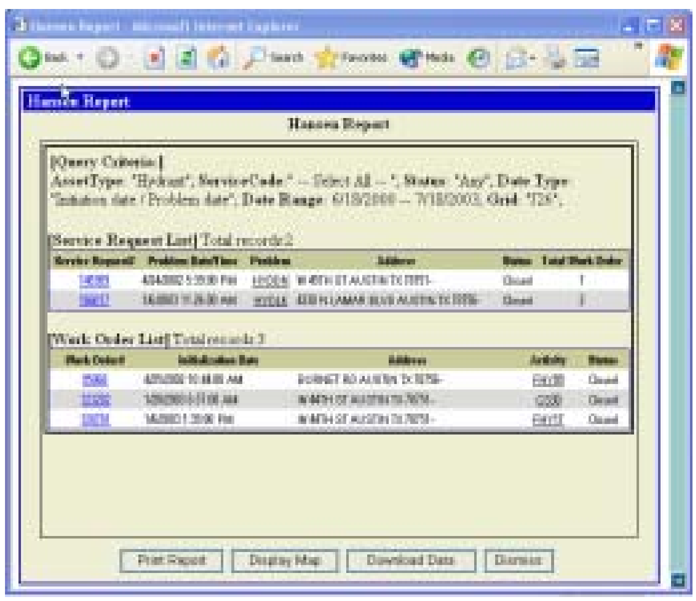
Figure 21. Hansen Query Builder Tool



Hansen Attribute Query and Report Tool: This tool allows the user to enter an attribute query and return history (e.g., closed work orders or service requests) or current activities (e.g., open work orders or service requests) to display the query results in a report and then a map. Service request numbers and work order numbers listed in the report hotlink to existing detailed reports.

Figure 22. Hansen Attribute Query and Report Tools





Summary of Benefits

The Austin Water Utility's experience during this "upgrade" project was many things, but most notably it was a very successful experience. The final products and outcome of the project have been enthusiastically received by Utility staff and customers. The success of the project has helped in forwarding the evolving view of GIS in the Utility, from a mapping tool to a flexible business information system capable of supporting the Utility's ever changing business needs.

Some business needs don't change and one is "to do more with less" -- always. The efficiencies and improvements realized through this project are many, some are listed below.

- Reduced duplicate data entry and divergent data sets. Improved tools synchronize the data between the GIS and the Hansen Maintenance Management System. New features are now entered only once into the GIS and then synchronized with the Hansen system regularly.
- Improved timeliness and availability of utility data. Previously, updates to the corporate GIS database and the Hansen database took place about every six weeks, due to time-consuming processing, incompatible data structures and limited data management technology. Now this process is much faster and easier with substantially less effort. Current plan is to get to a one week turnaround time.
- Enhanced Hansen data usability and value. From the Hansen user interface, users can now perform GIS functions, such as viewing the data graphically and making spatial queries of the data.
- Improved data entry productivity. The streamlined editing tools and processes have already improved staff editing productivity by about 20%.
- Increased time efficiency in water and wastewater hydraulic modeling runs. What previously took days to accomplish due to processing time and the need for technical staff assistance, now takes hours and can be run by the modelers themselves.
- Enhanced data accessibility through improved GIS web tools. The new tools contain many enhancements that will improve staff productivity and increase staff effectiveness as users learn how to incorporate these tools into their daily work efforts. New functionality includes:
  - Overflow identification of environmentally sensitive areas, also produces a map
  - Dynamic wastewater profile generation (to assist in avoiding main breaks during excavation)
  - Redlining capabilities to streamline correction information flow
  - Water network tracing tools to assist in determining which valves to close to effect a shut out, can also buffer those pipes and then select the addresses affected
  - Wastewater network tracing tools to identify the upstream source and downstream flow of effluent

    - Improved access to Hansen data (including data downloading). GIS features are linked to Hansen data and can now access Hansen maintenance history as well. Can also pull service requests and work orders based on a GIS feature selection (select feature on screen) or on a database criteria selection (data range, asset type, geographic area).
- Improved data sharing and technical staff efficiencies.
    - The change to a non-proprietary, industry standard database management system (Oracle) and programming languages enable more open communication between various systems and applications.
    - Completely updated and redesigned the GIS data structure to be more compatible with existing technology initiatives such as Hansen and hydraulic modeling. We can now pass many more features to Hansen than in the past.
    - Necessary technical skills sets are more widely available with the new standard database and programming languages. New technologies are easier and more efficient to manage and maintain, takes less staff time.

Unlike the always present need to be efficient and effective, some business needs do change or evolve. In the early years of GIS at the Utility, facility location was the primary use of the technology. The Utility needed to know what assets were in the ground and where they were located in order to best manage and maintain them. This of course remains a primary need and will be greatly enhanced by the integration of the GIS and the Hansen MMS. However an additional and increasing need has been to answer questions about Utility facilities based on attributes and spatial relationships to each other and other types of data. So part of the success of this project will be realized over time as we expand our GIS analytical capabilities and improve ways to deliver geospatial data as understandable, value-added information using the new technologies we have implemented. Completing the year-long GIS upgrade and Hansen MMS integration effort has been a big step on the path to meeting our increasing needs for desktop decision support, which will continue to be a priority for the direction of GIS technology at the Utility. Expectations are high for the GIS to deliver more than it ever has. We set out to change the way the Austin Water Utility uses GIS technology, and changed the way the organization thinks of GIS; way more than an upgrade.

Credits

Austin Water Utility staff participated all through out the project described in this paper. The key GIS staff included Steve Hutton, Programmer Analyst, who provided the lead on programming and database support. Philip Campman, Business Systems Analyst, was the lead on the ArcIMS tools and Paul McKnight, GIS Supervisor, was the lead on the Productivity tools. Leeanne Pacatte, GIS Manager, was the project manager. Donn Lorbieski, Business Systems Analyst and Hansen support staff, was the lead on the Hansen integration tools.

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