Customized Decision Support System for Sewer Right of Way Tracking

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Abstract:

In-house staff at Metropolitan Sewerage District of Buncombe County, North Carolina, have been working on customizing ArcMap to facilitate the integration of spatial functionality into its existing business processes and information system. Right-of-way tracking is a practical example of an application that demonstrates how these customizations have enabled non-GIS staff in the right-of-way department to easily manipulate spatial and non-spatial information, while behind the scenes programming creates on-the-fly symbology, SQL Server database updates, SDE feature class updates, and data calculations. This paper will discuss the impact of the application on right-of-way analysis and its usefulness to staff. With a few clicks, this application can flag right-of-way special conditions before construction, access scanned easements, create right-of-way clearing projects, access county tax databases, and assist with many other right-of-way functions and analyses.

Introduction

The Metropolitan Sewerage District of Buncombe County, North Carolina (MSD) was formed in 1962 to operate, maintain, and construct a wastewater treatment facility to intercept and treat sewage for municipalities and sanitary districts within Buncombe County. In 1990, these municipalities and sanitary districts transferred ownership of their sewerage systems to MSD, consolidating both the collector lines and waste water treatment plant under one organization. A logical step after the consolidation was to map the sewer lines MSD had recently acquired. A comprehensive survey of the system began soon after the consolidation and has served as the foundation of the mapping system to this date.

The survey information was delivered in an AutoCAD format. Until a few years ago, it was maintained using a custom program in the AutoCAD/Microsoft Access environment. As GIS tools became more prevalent during the 1990's, some ArcView 3.x tools were used for display and analysis, but mapping information and maintenance would remain in AutoCAD.

In order to take advantage of technological improvements, improve data quality, and improve decision making capabilities, MSD recently completed the migration of its GIS from an AutoCAD/Microsoft Access environment to a Geodatabase/SQL Server environment and has also begun the migration of business data from the Microsoft Access format to a SQL server format. The migration has included the transition of sewer shapefiles and AutoCAD files to the SDE format using the sewer/stormwater Geodatabase data model as a guideline, transitioning editing and maintenance from

AutoCAD to ArcGIS, and transitioning user interfaces for mapping information from AutoCAD to ArcMap.

Even the most basic benefits of migrating to ArcGIS software were immediately noticed. Attribute information, stored in features, is available with a click; users could choose and specify symbology and cartographic effects; maps could be easily exported and e-mailed for faster customer service; data viewed by users was now live; data could be edited by multiple users at the same time; and business data, such as work order information, could be viewed in the mapping system.

More advanced features of the Geodatabase model and ArcGIS systems were also implemented. The geometric network is used for tracing and route locations; linear referencing is used to place pipe defects at their exact location on a pipe; the SDE/Geodatabase model is used to centralize and store relationships, domains, subtypes, and tables; and new editing procedures, enhanced by the model design, increase the speed and accuracy of As-Built data entry exponentially. As-Builts are now entered into the system at the time of delivery.

While the ArcMap application opened up an enormous amount of possibilities with GIS data and analysis, the ability to easily customize and program the new system also gave IT staff the opportunity to empower non-GIS staff to perform their own analysis and mapping. GIS staff support for maps, analysis, and information has slowly migrated to GIS application development for non-GIS staff. Custom user interfaces and tools would make it easier for staff to use and interact with the mapping system, while behind the scenes programming would take care of more complex and repetitive functions.
MSD has always used programming and application development for database programs, but mapping applications would be a new addition to user interfaces for business processes.

After successfully migrating the GIS system to the SDE environment, IT development turned its attention to Right of Way for several reasons. First, all easement files had been maintained as hard-copy, paper files. For more flexibility of use and database improvements, these files needed to be scanned to be accessible electronically. Second, the legacy database applications for tracking the ROW negotiating process and acquired easements were in dire need of updating. Third, a new ROW clearing program needed management tools and naturally lent itself to an ArcGIS development project. Because of the differences in design and user needs, the system would be developed in three separate projects including Project I, the ROW documentation scanning project, Project II, the management and negotiation tracking component, and Project III, the ROW clearing component.

Because of the need to integrate legacy data, the new ROW Negotiation Tracking and Easement Management application would require creative and innovative use of newly implemented technologies to provide an end-user tool that is friendly, comprehensive, allows easy retrieval of information from both database and spatial searches, and

facilitates end-user review and quality control of legacy data. Because the ROW clearing information was relatively new, the application could be designed and developed from scratch, offering an opportunity to explore the new capabilities the recent SDE migration offered. It also proved an ideal test for new in-staff programming skills integrating form-based data management into the ArcGIS interface through VB and VB.net.

Project I:

Scan Hard Copy Easement Information

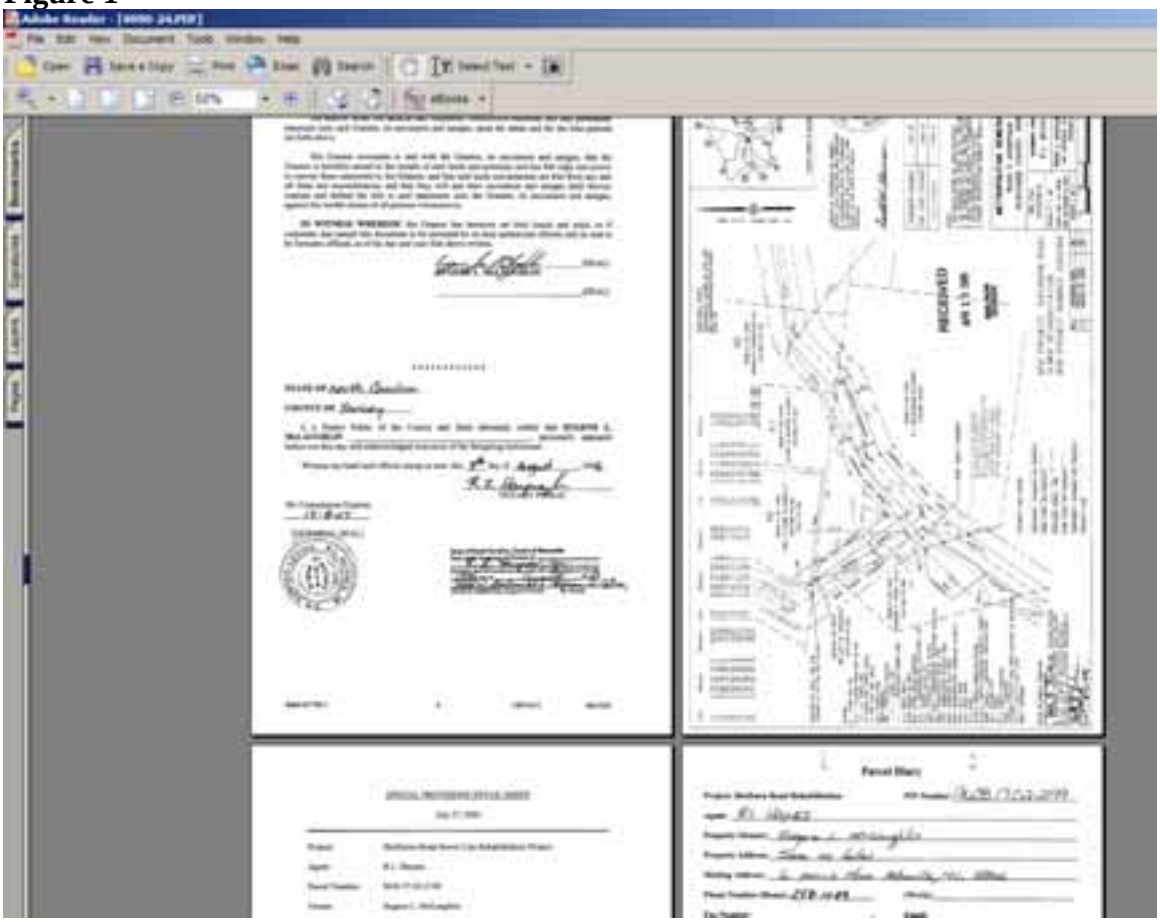
The decision to scan the approximately 3,000 ROW easement files was made because of the need to store the information digitally. These scanned documents would be linked into the ROW database so that they could be easily reviewed by in-house staff and, eventually, be made available as a resource to the general public. However, it was several years later before this project got any steam, when a high speed copier with network scanning capabilities was leased for the ROW department. This copier/scanner was not only very fast, but efficiently handled a variety of paper sizes and shapes automatically, making it possible to scan an entire file of mixed documents with relative ease.

By scanning the easement files and making them available at a mouse click from the related database record, an end-user could quickly review the recorded easement and examine any special provisions mandated by the land owner for use of the easement area. The only remaining difficulty lay in effectively linking these scanned files to the correct ROW record.

A simple hyperlink in each easement record opens the scanned document (in Adobe Acrobat .PDF format). When each paper file was scanned, a database record was created that included the property owner name, the primary Parcel Identification Number (PIN), and the book and page of the recorded easement. Initially, only about two thirds of the scanned documents could be accurately linked to an easement records through the register of deeds book and page numbers and PIN. The rest had to be matched manually because of the ambiguity of the PINs, so a special form was created that showed every possible easement record for each scanned file PIN. This allowed the ROW staff to quickly review each record and match it exactly to a ROW ID.

Hard copy information that could now be accessed digitally as a result of the scanning project included documents such as easement agreements, easement plats, parcel diaries, negotiation records, and detail sheets that contain special provisions to follow for property access either during or after construction (**Figure 1**).

Figure 1



PROJECT II:

ROW EASEMENT MANAGEMENT/NEGOTIATION TRACKING COMPONENT

History

Originally, all ROW paper files were organized by PIN number. Because PIN numbers referring to an easement frequently changed due to subdividing of a development or combining of land parcels, there were often multiple files of different PIN numbers cross-referenced to refer to a single easement document.

In the mid-1990's, a Foxpro database table was developed for logging of easement information. Each record in the table represented an easement file, and was identified by a single PIN number. Multiple PINs were appended to the record in a comment field without any attention to standardization or search-ability. A few years later, another database was developed to allow ROW staff to track the status of easement negotiations. The negotiation tracking database organized the various easements by ROW project. Each easement still consisted of a single record, with sub-tables that allowed multiple entries per easement to log the status of negotiations. The problem of multiple PIN

numbers per easement was not addressed and creative cross-referencing continued unabated; however, ROW needs were met for reporting on the negotiation process for various projects. When an easement was completed, it was posted to the original Foxpro ROW easement table.

As development in GIS advanced, there was much discussion of digitizing the ROW easements into the MSD mapping system, but estimates of time and expense to do this always resulted in management concluding "not yet". In addition to the desire of field crews to simply see where easements are located, there was a frequent need to reference which easements had "special provisions" that needed to be taken into consideration before work could be done. These special provisions include such diverse things as preserving specific trees or not working during certain hours. The legacy system required that ROW staff go to a map, identify a parcel PIN, locate the paper file for that PIN, and manually review the file for special provisions before advising field workers.

Also, integrating ROW information with the mapping system would make the data available for spatial analysis related to sewer line locations, pipe conditions, construction projects, field work orders, customer services calls, and many more related functions/services.

When the IT programming staff was approached with the need to update the ROW data management system, we were faced with a) the large Foxpro database table of all easements, full of incomplete records, expired PIN numbers, and loads of creative cross-referencing, b) the existing negotiation tracking database which was better organized than the Foxpro table but still did not handle PINs or easement complexities well, c) thousands of scanned document files cross-referenced to easement files by recorded book and page number, and d) no references whatsoever to easements in our mapping system.

Solutions and Project Implementation

Developing and implementing a new right of way system that would meet both data management and mapping needs, like many other development projects, was put off for years because of the overwhelming tasks and resources involved with re-configuring both data managements systems and business processes for the department. The focus for technical and procedural design would encompass solutions that would need to both meet user needs and remain as reasonable and efficient as possible regarding organizational resources. The following are major needs and implementation methods addressed in the development and design of the system:

ROW Easement ID and PIN Numbers

The primary organizational confusion in the legacy ROW data resulted from the frustration of attempting to use PIN numbers as the key reference index for an easement record. In fact, a single easement could traverse multiple properties with several PIN numbers and over time the PIN numbers of a property crossed by an MSD easement could easily change. The solution was to define a unique auto-number field in the primary ROW table to represent each easement, and to

link this ROW ID number to a separate table containing one or more PIN numbers per ROW ID. In short, we separated the process of tracking PINs from the organizational structure of the easement table. Using complex parsing techniques, IT staff was able to extract many of the multiple PIN numbers from the Comment field of the legacy table. ROW staff has been further updating the relational PINs table as they become aware new PINs.

The result is a set of tables that can be cross-referenced to very accurately reflect the true evolution of an easement over time. The legal easement itself remains a uniquely identified entity. It might initially traverse a single PIN number, but over time as subdividing occurs, additional PIN numbers can be added to the PIN table that reference that same ROW ID. A field was added to the PIN table to flag each PIN so that its relationship to the easement record became clear, i.e., "original" or "expired". In some cases, where easements cross or where multiple construction projects are done in the same area, a single PIN might reference multiple ROW IDs. Database functionality was created to allow users to search for easement records by PIN (perhaps finding several records), by ROW ID, by property owner name, or simply listed by Project Group. In addition, a spatial search for any of the related PINs will take the user to the same ROW record.

Special Provisions

To flag for special provisions, a simple check box in the easement record was used to indicate that the recorded easement contained one or more special provisions that should be reviewed before work was done at that site. This simple indicator allowed the special provisions to be symbolized in ArcMap. An end-user could then click on an easement symbol and immediately open the scanned file to review the details of the special provision.

Mapping

One of the first ideas discussed for depicting easements in the mapping system was to digitize every easement from plat information. The cost of the project, with 3000 easements to be researched and digitized, would be too large. Also, maintenance for this technical process would be time consuming and would need to be performed by a GIS editor. Recourses were not available for this method.

The best available resource in the ROW database management system for mapping easement locations was the PIN number. Though some PIN information and issues had been sorted out in the database, there were still several issues to using PINS as an identifier for location on the map. PIN numbers can and will change over time. Many of the PIN numbers would not match the current GIS parcels database because they had already changed. Because PINs change constantly, easement information will lose its accuracy.

Our solution for dealing with problems created by PIN numbers would include the concept of extracting coordinates available in PIN numbers that represent the center of the parcel and then displaying mapping information based on the

coordinates. Though PINs might change, the easement point would not move and would represent the center of the parcel that once existed.

One of the largest benefits to using this method would be the ease of maintenance and mapping manipulation required by the end user. Using this technique as a method for providing a location point, a user would define the location by simply entering a PIN number. Database and mapping automation would immediately take care of creating the point, linking the easement information, updating symbology in all layers. Also, easement informaiotn that did not match a parcel would still display at the center of where the parcel used to be, making it easier to analyze the proper location of the easement using plat and As-Built informaiotn. The method and details for pursuing this solution are outlined below.

In the database, a VB script was written that would automatically extract the northing and easting when a PIN is entered for an easement and then put them in appropriate fields (**Figure 2**).

Figure 2

```
'Set Coordinate Values from PIN
 Dim FirstE
 FirstE = Mid(frmCoordsZoom.txtPIN, 1, 1)
 If FirstE = 0 Then
 FirstE = 10
 Else: FirstE = Mid(frmCoordsZoom.txtPIN, 1, 1)
 End If
 FirstN = Mid(frmCoordsZoom.txtPIN, 2, 1)
 SecondE = Mid(frmCoordsZoom.txtPIN, 3, 1)
 SecondN = Mid(frmCoordsZoom.txtPIN, 4, 1)
 ThirdE = Mid(frmCoordsZoom.txtPIN, 7, 1)
 ThirdN = Mid(frmCoordsZoom.txtPIN, 8, 1)
 FourthE = Mid(frmCoordsZoom.txtPIN, 9, 1)
 FourthN = Mid(frmCoordsZoom.txtPIN, 10, 1)
 FifthE = Mid(frmCoordsZoom.txtPIN, 11, 1)
 FifthN = Mid(frmCoordsZoom.txtPIN, 12, 1)

'Concatenate values to create Northing and Easting
 Easting = (FirstE & SecondE & ThirdE & FourthE & FifthE & 0)
 Northing = (FirstN & SecondN & ThirdN & FourthN & FifthN & 0)
```

The script above will run when the user enters a PIN and automatically update the Northing and Easting (Figure). If the user needs to place a point at a specific location on the map, they can simply get the coordinates from the map and enter the northing and easting straight into the appropriate boxes (**Figure 3**).

Figure 3

PIN Numbers	Status	Filed By	Northing	Easting
964512962775	Current	☑	656750	949270
964512978417	Current	☑	657470	949810
	Current	☐		

A record is created when the user enters a PIN that will contain values for the easements PIN, Northing, Easting, and also the ROW ID that will link the record with the rest of the easement information such as the project name, scanned document path, contact person, date, easement type, etc (**Figure 4**).

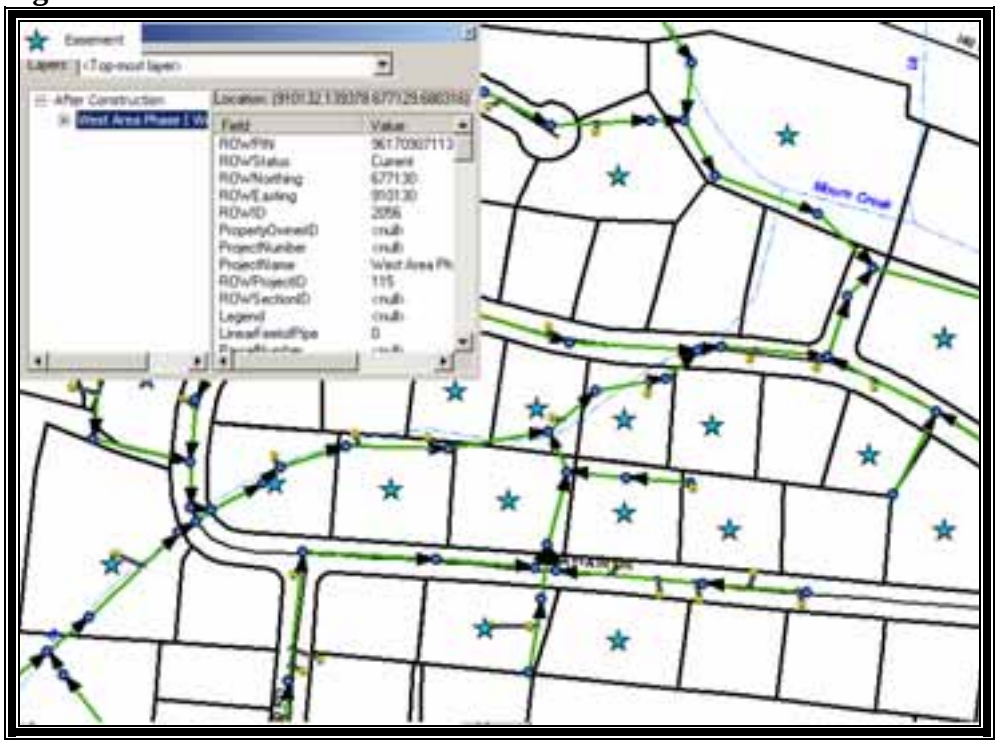
Figure 4

Data in Table 'PINS' in 'ROW' on 'GIS'

PINID	ROWID	PIN	Northing	Easting
6	6	965815636062	683020	956660
7	7	965817120316	682360	951010
8	8	965815635260	683200	956560

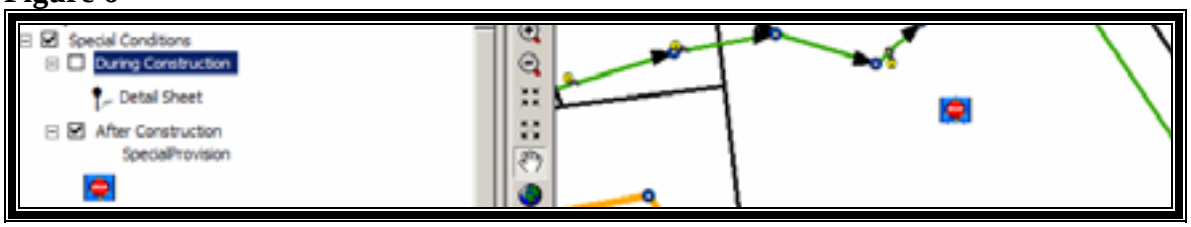
A SQL view was created associating easement information such as easement type, special conditions, etc. with each record in the "PIN" table and also associating the scan using the ROW ID. Using the Northing and Easting in the SQL view, easement points are displayed graphically in ArcMap using an event theme. When an easement point is identified, all information from the SQL view is displayed (**Figure 5**).

Figure 5



The points in ArcMap could now be symbolized using any easement information contained in the event theme. A layer was created for the type of easement (Figure) and to flag for special provisions (**Figure 6**).

Figure 6



Because the information in the event theme contains a link to the scan, if the user sees a point flagging for a special provision such as a stop sign, the user can identify the point, click on the link to the scanned document (**Figure 7**), and view the special provisions found in the easement negotiation documentation (**Figure 8**).

Figure 7

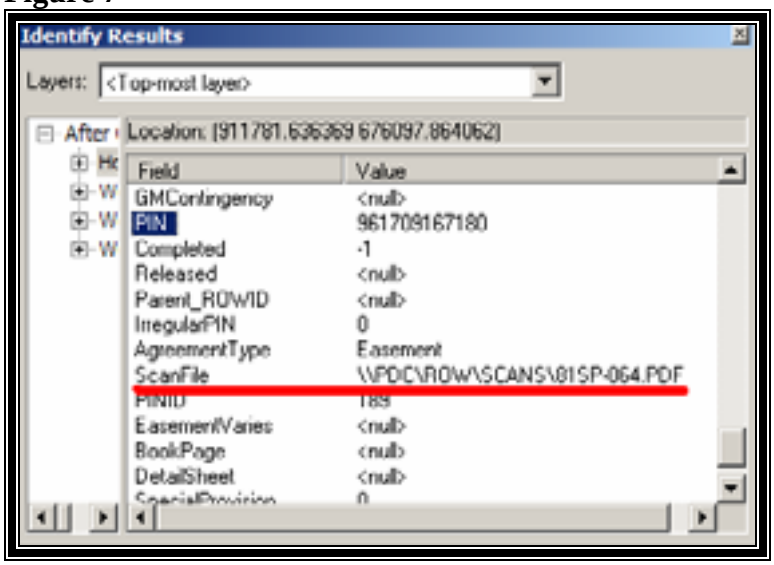
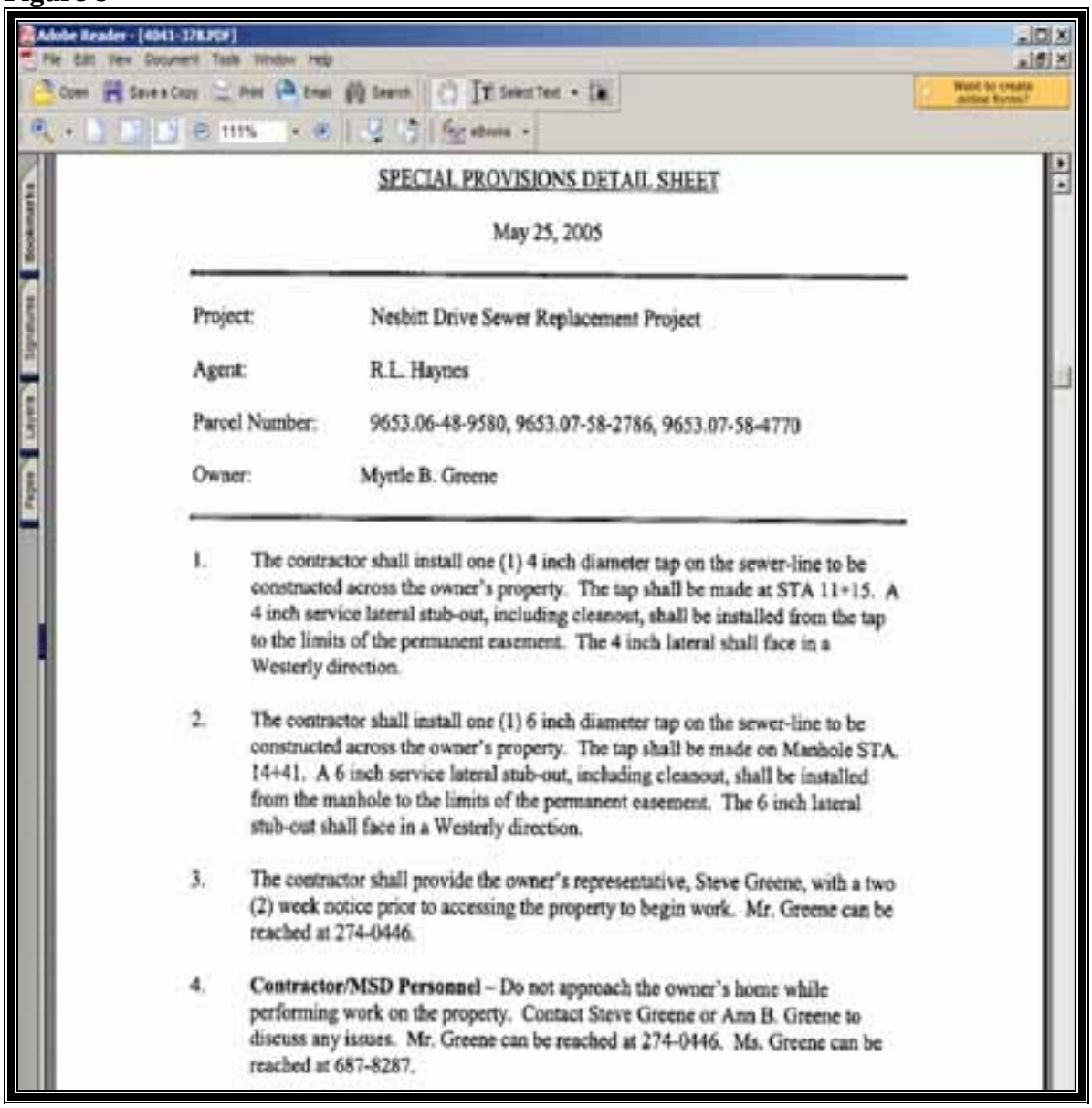


Figure 8



SPECIAL PROVISIONS DETAIL SHEET

May 25, 2005

Project: Nesbitt Drive Sewer Replacement Project

Agent: R.L. Haynes

Parcel Number: 9653.06-48-9580, 9653.07-58-2786, 9653.07-58-4770

Owner: Myrtle B. Greene

1. The contractor shall install one (1) 4 inch diameter tap on the sewer-line to be constructed across the owner's property. The tap shall be made at STA 11+15. A 4 inch service lateral stub-out, including cleanout, shall be installed from the tap to the limits of the permanent easement. The 4 inch lateral shall face in a Westerly direction.

2. The contractor shall install one (1) 6 inch diameter tap on the sewer-line to be constructed across the owner's property. The tap shall be made on Manhole STA. 14+41. A 6 inch service lateral stub-out, including cleanout, shall be installed from the manhole to the limits of the permanent easement. The 6 inch lateral stub-out shall face in a Westerly direction.

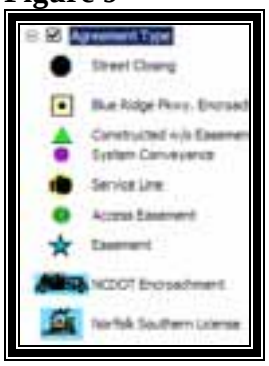
3. The contractor shall provide the owner's representative, Steve Greene, with a two (2) week notice prior to accessing the property to begin work. Mr. Greene can be reached at 274-0446.

4. **Contractor/MSD Personnel** – Do not approach the owner's home while performing work on the property. Contact Steve Greene or Ann B. Greene to discuss any issues. Mr. Greene can be reached at 274-0446. Ms. Greene can be reached at 687-8287.

Any other information in the negotiation records can be viewed as well including information such as the easement agreement, easement plat, and negotiation status logs.

A layer was also displayed showing the type of easement (**Figure 9**).

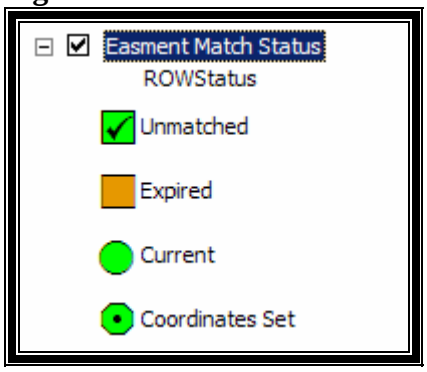
Figure 9



Quality Assurance and Maintenance

About 80% of the PIN numbers initially matched current GIS parcel information. The majority of easements that did not match were the result of larger parcels subdivided into smaller parcels for development. Easements that did not match would have to be manually analyzed in a review process to update and link the new or additional PIN information with the easement. A status field and layer were created to easily view the easements that matched a parcel, the easements that did not match, and the easements that had been through the review/QA process. Easements that matched were labeled as "current", easements that did not match and had not been reviewed were labeled as "unmatched", and easement records that had been reviewed and corrected were labeled as expired. These records were not deleted for record keeping purposes. If coordinates had been used to place a point as opposed to PIN number, the record was tagged as "coordinates set" (**Figure 10**).

Figure 10



Because parcel information changes daily, a method and process would have to be designed to update easements with new property information. When property information is received from the county, a geoprocessing overlay is performed on easements and parcels. Match Status values are re-calculated. Easements not tagged as "Coordinates Set" or Expired that are not contained within the appropriate parcel (with the appropriate PIN) change status to Unmatched and

will be manually reviewed by ROW staff to update PIN information. It is possible that promised future ESRI technology concerning data history will be very helpful with automating this portion of the project.

Project Summary

The impact on time savings and improved analysis methods this project provided for the Right of Way department proved invaluable and its usefulness for analysis even surpassed initial expectations. Search methods and data organization in both the database and the mapping system made finding easement documentation much easier. Hard copy easement files previously filed and stored away are now available with the click of a mouse. Database management was re-organized to facilitate the actual process of easement and negotiation information. Easement information can now be spatially analyzed by the number of easements, the type of easement, and whether the easement has a special condition. Easements can also be analyzed in combination with other data such as property, railroads, streets, and sewer lines. Easement points are added to and maintained in the mapping system by simply putting a PIN number in the database.

PROJECT III

ROW CLEARING COMPONENT

Since the 1962 consolidation, MSD has invested money and resources for the acquisition of recorded easements across properties to provide permanent access corridors for the initial construction work necessary to rehabilitate aged and deteriorated sewer lines. The easements would also support future operation and maintenance of these lines. As the volume of rehabilitated lines and recorded easements grew, the need for regular clearing of trees and underbrush from these easement corridors became obvious. Recently a pilot clearing program was funded. A major aspect of the program is the need to track many pieces of data such as easement corridors prioritized for clearing, corridors that had been cleared, tracking project specific details such as dates, logs, linear feet cleared, equipment used, costs, etc. and setting up intervals for the future inspection and re-clearing of the corridor. The needs for the program include both mapping and database functionality.

In previous projects, where database and mapping information were integrated, an existing database would be used for data updates and maintenance and then linked to the mapping information to view and analyze. Because this was a new project with little historical data, this portion of system development was chosen as MSD's first application where ArcMap, along with custom VB programming, would facilitate all functionality including database management and updates using data forms and mapping functionality.

The project was begun by meeting with ROW clearing staff to understand all of the needs associated with the project. After several business process and technical meetings, the following were chosen as the basis of the functionality the application would provide.

- Track potential ROW clearing projects that would be prioritized for clearing
- Track current ROW clearing projects that are or have been cleared

- Track and flag projects for re-inspection using a repeat date for clearing
- Track process logs for each day of a clearing project
- Track project details such as feet cleared, contractor info, etc
- Track personnel used for each day of a clearing project
- Track equipment used for each day of a clearing project

ROW Clearing Application

When analyzing design concepts for developing the application in ArcMap, it was necessary to take into account the fact that the end user for the application had little computer experience and virtually no experience with GIS mapping. The functionality and methods provided in the interface would need to be simple to use and understand.

The following describes the functionality and details of the application that was developed for Right of Way clearing:

Add Clearing Project

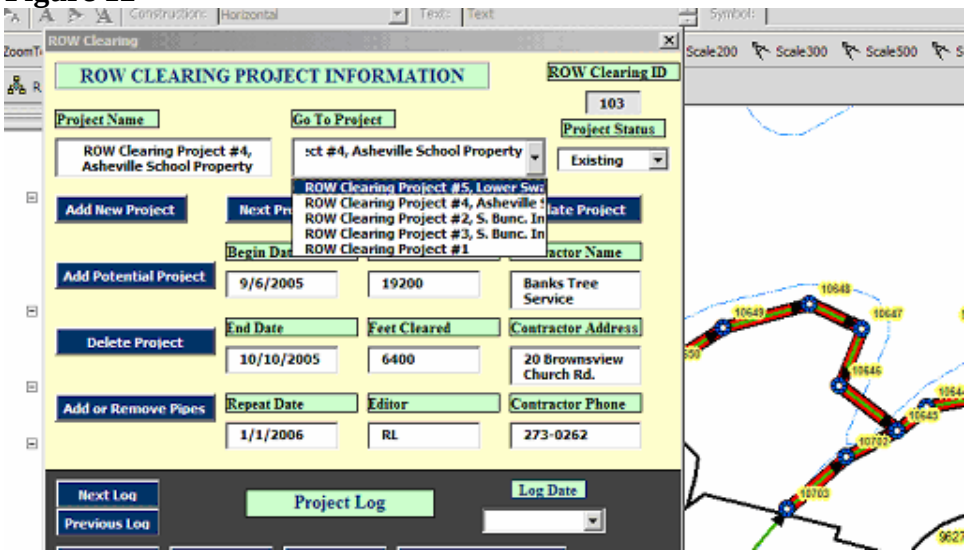
To add a new project, the user simply selects the pipes associated with the clearing corridor, opens the form, and enters the project information. A layer will immediately symbolize the project as a clearing project by its status (existing or potential). The program will add the project to the SQL clearing database, associate each pipe ID with the project, and refresh the data frame (**Figure 11**).

Figure 11

Alter a clearing project

Once the user has entered the project, any project data can be manipulated or accessed in the form. A user can change or update project information, access other projects, delete a project, or add/remove pipes from projects. All spatial changes of a project made using the form, such as adding a pipe or deleting a project, are done by selecting the pipes and pressing a button. The changes will immediately display on the map. A drop down menu is also available to view all projects. Selecting a project from this menu will both show project information and zoom to the project location. Database and spatial functionality are completely integrated (**Figure 12**).

Figure 12

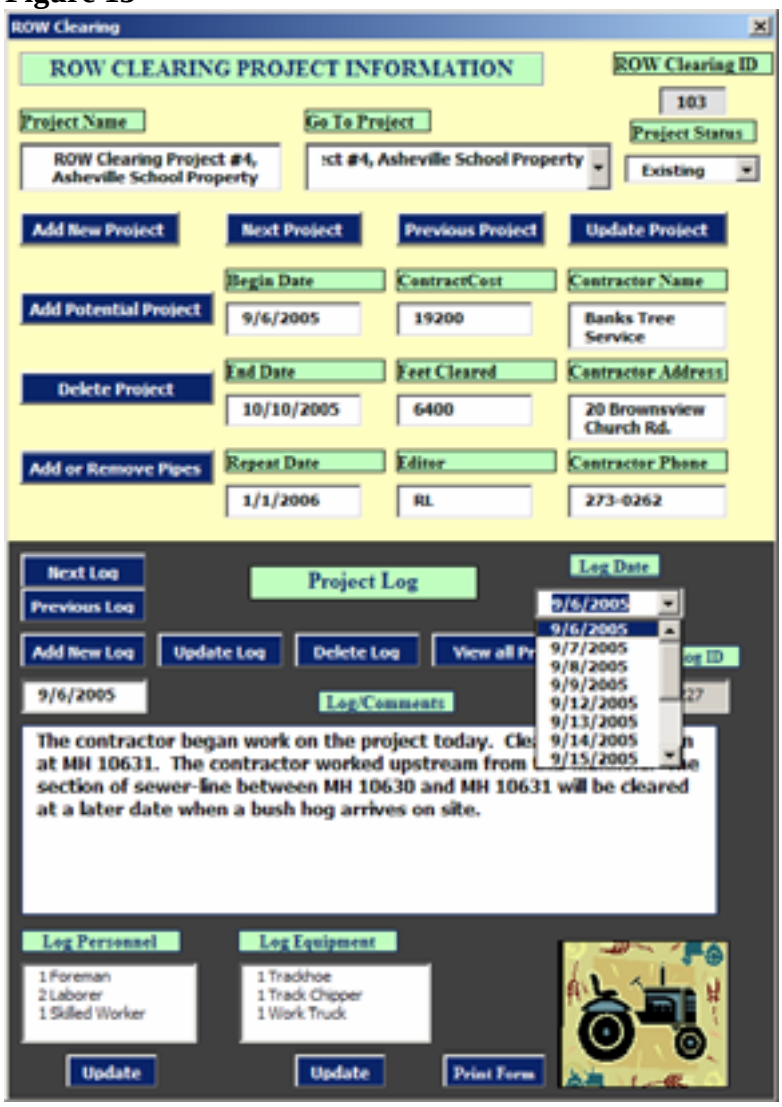


Project Logs

The project manager kept log information for each day of a clearing project. The log would contain details of the project on that particular day including information about the weather, the personnel that were used, equipment that was used, and any significant notes or events that happened that day. By keeping logs, a user can easily look through the logs of a project and know the specifics of the daily events. Also, cost analysis for projects is more accurate with a daily description of equipment and personnel.

To update log information in the application, the user selects the project and then presses a button to add a log; update an existing log; add or remove personnel or equipment; or search through logs. As with project information, pressing the log date drop down menu will list each log by its date, and when selected, will update the form with the log information (**Figure 13**).

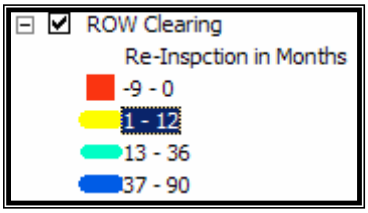
Figure 13



Tracking re-inspection dates

Using the repeat date (re-inspection date) the user enters, the program will automatically calculate the time between the date the user enters the information and the repeat date in months. A layer was created, symbolizing row clearing projects by the amount of time left before their next inspection. Re-inspection dates can be analyzed using both spatial and tabular methods (**Figure 14**).

Figure 14



Project Summary
Until the time of this project, all programming in ArcMap had been coded using ArcObjects. Also, updates to data made through the ArcMap interface had only been attempted on SDE data. This application had the need of updating tabular information stored in a separate SQL database (non-SDE). ArcObjects would not accommodate the manipulation data outside of a GIS format. The solution was to use ADO or ActiveX Data Object libraries to facilitate all updates made to the SQL database. The combination of using ADO and ArcObjects would provide a great deal of versatility in how the program handled retrieving information and user inputs/updates. For instance, ArcObjects was used to retrieve information from selected objects such as Pipe and Manhole IDs. The information and variables retrieved using ArcObjects could then be used to sort, search, or update SQL tables using ADO.

Once again, the flexibility in applications and programming provided by newly implemented tools would prove to be very powerful and efficient in application development. Though the user is merely selecting a pipe and pressing a button on a form, the program is retrieving spatial selections, searching the SDE database, creating records, associating records through SQL views, maintaining ID's, calculating data, and maintaining symbology for any updates or changes made to clearing corridors. Sophisticated application automation combined with simple and minimal user manipulation and input has made data management much more streamlined and consistent.

Conclusion

The development of the Right of Way system included many aspects of GIS and database design, development, and implementation. Technically, legacy data and user needs would drive design ideas. Newly implemented tools and methods such as SQL server, SDE, and programming techniques provided a great of flexibility in the development of applications and data. These technical enhancements, combined with an element of freedom to experiment with and explore new technology, would allow IT staff to advance and improve the organizations data, applications, and system while creating new methods that would be easily transferable to other systems and applications.

Procedural changes in business processes were another key element that is almost always integral to the successful implementation of a new system. Project development and application design was a team effort between IT and ROW staff with IT driving technical solutions and ROW driving end user needs and requests for design. ROW staff's openness in communication and willingness to learn and experiment with new technology made development smooth and effective. The result is a system that profoundly improves decision making capabilities for almost every aspect of Right of Way processes. When an intense quality assurance is completed and this system is made available on MSD's web site, it will also be a tremendous resource to developers,

attorneys, surveyors, real estate professionals, property owners, and anyone who needs information on the public sewer system.

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