Renewal/Rehabilitation Prioritization: Using Technology to Make More Informed Decisions

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Most Public Works organizations are faced with aging infrastructure. Identifying, coordinating and funding these projects can be challenging. This paper will outline a method utilized by the City of Arlington Water Utilities department.

There are many factors to use in prioritizing infrastructure replacement and identifying prime candidates for renewal or rehabilitation. Often, the information needed to make responsible and informed decisions is spread throughout the organization and may not be easily accessible or retrievable. The information could even be as vulnerable as existing only in the mind of the field manager with 25 years of experience wtih the organization who just retired. To further complicate the maters, not everyone in the organization might agree on what makes a water line or a sewer line a good candidate or priority for renewal.

This paper outlines the path taken by the City of Arlington Water Utilities to consolidate information and standardize methods used to derive a prioritized list of assets needing renewal or rehabilitation. The result is a ranking system based on information derived from Geographical Information Systems (GIS), Work Order Management Systems (WMS), relational databases, knowledge management and custom application development in the prioritization process.

Background

Historically, Arlington Water Utilities (AWU) pursued annual funding through the operating budget for renewal of water lines and sewer lines. The funding became somewhat dependent on the capacity of the budget to handle this funding without raising water rates. For instance, during a year or years where other expenditures were increasing, the renewal funding might be reduced in order to offset the other increased expenditures. As a result, there were years in which the annual renewal amount was decreased instead of increased.

Prior to 2002, the method of selecting the renewal projects was based solely on input from the field operations staff. Their recommendations were based on personal knowledge of water main pipe segments repaired due to leaks and breaks. The sewer line repairs were primarily spot repairs or repairs based on structural failures found during a reactive response to a blockage. In addition, sewer line deficiencies identified during Sanitary Sewer Evaluation Studies were added based on inflow/infiltration affecting the system capacity.

Prior to 2000, water and sewer line renewals were constructed independent of street maintenance activities. AWU selected the renewals and used a 'zipper' patch to repair the trench made in the roadway. Since 2000, there has been a collaboration and policy to eliminate the use of zipper patching roadways. This decision provides a better end product to the citizens of Arlington. The implications of this coordination and the need for a planning tool will be discussed throughout this paper.

In 2002, the City of Arlington voters approved a ¼ cent sales tax for roadway maintenance which provided a new source of income for street maintenance. As a result of this expanded maintenance funding and activity, Arlington Public Works and Water Utilities departments determined the need to coordinate renewal projects for best use of funds. A committee called the Roadway, Water and Drainage (RWD) committee was created with the purpose of discussing and coordinating projects. The ultimate goal was to eliminate the practice of 'zipper' patching roadways. When the streets were being renewed, the water and sewer infrastructure below the road should be evaluated. In addition, when the water and/or sewer infrastructure were being renewed, the pavement rating was studied in order to determine the best overall repair treatment.

Part of the mission, vision and values for AWU is the commitment to using technology to improve effectiveness and efficiency. Also, technology is used to enhance customer service delivery. AWU's historical commitment to maximizing the use of technology includes the creation of a GIS Application Development Plan. This plan documents application requirements for the organization. The plan also recognizes the need to integrate GIS in all of the business processes where applicable. Planning for renewal and rehabilitation each year was one of these business processes where the use of GIS would optimize the process.

Creating a Rating

With additional demands for infrastructure renewal, AWU needed to create a standardized method of rating infrastructure. Using multiple sources of information and a committee of individuals with vast and varied knowledge, the criteria used to determine the rating for the condition of water and sewer lines was developed. The criteria included such items as:

- Age of pipe
- Pipe material
- Soil
- Work order history

Compiling this information meant reaching into existing information systems and extracting pertinent data. The data also had to be organized into a manner that could be accessed and input into formulas for the rating calculation. The ability to revise this formula based on findings was important also.

Data Collection

The first step in the data collection process was to determine the information most useful in assessing which water lines and sewer lines are the best candidates for renewal and rehabilitation. AWU held meetings and individual interviews in order to capture and document a list of useful information and datasets. Part of the challenge was to quantify the experienced staff members "gut feelings". As expected, there were tangible underlying reasons for the "gut feelings". For example, comments like, "It just seems like this particular stretch of sewer line gives me the most problem", coincided with quantifiable observations such as number of repairs and cost of repairs. In order to accomplish this, the project team needed to ask follow up questions such as "why does this section cause the most problems?"

Some of the data that was determined to contribute to the "gut feelings" were:

- Water main breaks
- Sewer stops
- Sewer televising requests

After a defined list of data needed for the prioritization process was established, it was necessary to locate sound sources of information for each item on the list. Electronic data was preferred over hard copy data. Much of the information needed was already located in the Water Utilities' GIS and WMS. Examples of items already collected in the GIS are pipe material, pipe age, pipe diameter, and length. Other GIS layers such as soil type, hospital locations, and critical life support patient locations were created for the Renewal/Rehabilitation Prioritization (RRP) process. This data could be compiled from other electronic data sources such as Access databases, Excel spreadsheets or GIS layers from other organizations (soil type layer). Some of the data was located on paper work orders that were kept in file cabinets. A full list of data sources can be found in Appendix A.

The WMS is an important source of information for observed events that contribute to the decision for a water or sewer line to be renewed or rehabilitated. The WMS has information such as sewer line breaks, sewer stops and backups. These events are tracked in the WMS using Activity Codes. Before the WMS could be queried for use in the RRP project, it was necessary to establish which Activity Codes would be used. For example, an Activity Code of 3353 is "Sewer Manhole Overflow" and an Activity Code of 3354 is "Sewer Stopped with No Overflow". In addition to the Activity Code, Cause Codes are used in considering the cause of the work order event. For example, a 'sewer stop' work order many have a cause code indicating 'grease'. A full list of Activity Codes and Cause Codes can be found in Appendix B.

The RRP database was created in SQL Server as a central location to collect, store and query information for the RRP process. This selection was made based on the database standards established by the City of Arlington. Next, an attribute common to all RRP information was needed to link the information together. Since it is the water and sewer lines that are ranked in the RRP Process, it is necessary to link all the information from

the various sources for these features. AWU GIS already had an established unique identifier for each water and sewer line feature. It is called the UTGISID.

When the current WMS used by Field Operations was implemented in 2002, the AWU Information Services Section worked with the vendor to include the UTGISID on each Field Operation's work order. This strategic planning was a result of the GIS Application Development plan mentioned earlier in this paper. In the AWU applications development document, AWU required that the UTGISID's be recorded on all work orders. This enabled work order information to be tracked by UTGISID. This was valuable to the linking and joining of work order data in the RRP database to each water and sewer line feature.

For field operation's work prior to 2002, it was necessary to obtain these work orders from the file cabinets. The work orders were scanned. Specific data from these work orders, including address, activity code, date, and cause code were input into a database. These work orders were geocoded against the city's GIS street centerlines. Geocoding is an operation for converting street addresses into spatial data that can be displayed as features on a map or saved as a GIS layer. This allowed staff to automatically assign the work orders to a specific water or sewer line based on its location along the street centerlines.

Some of the data was not available in existing databases. For example, the application utilizes a linear foot cost estimate for various types of pipe replacement. These values were obtained from the AWU Engineering Section and placed in a table in the RRP application. This table is easily updated by the user.

Data Processing

After storing the RRP project information in a central database and linking the information to the individual water and sewer lines, it was necessary to develop rating criteria. The rating criteria are used to rank the sewer and water lines based on the probable need for renewal or rehabilitation. In order to accomplish this task, it was necessary to organize the information into risk factors.

After listing the factors, it was apparent that some of the factors were complementary to each other. The chart below illustrates the factors grouped by main categories for water lines:

Factors Contributing to Base Renewal Rating (Water Lines)

<table>
<tr><th colspan="11">Base Rating (0-100)</th></tr>
<tr><th colspan="4">Customer Service 20%</th><th colspan="7">Probability of Failure 80%</th></tr>
<tr><td>High Risk Customer 20%</td><td colspan="2">Water Quality 10%</td><td>Fire Flow Capacity 0%</td><td>Min. pipe dia. (6”) 70%</td><td colspan="3">Assumed Pipe Condition 30%</td><td colspan="4">Observed Pipe Condition (Repair History) 70%</td></tr>
<tr><td></td><td>Low Cl2 0%</td><td>Dead End Main 100%</td><td></td><td></td><td>Age 40%</td><td>Material 40%</td><td>Soil Type 20%</td><td colspan="2">Repair Frequency By Street, # per 1,000 Ft 60%</td><td colspan="2">Repair Cost By Street, $ per 1,000 Ft 40%</td><td>Cause of Breaks* 0%</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Misc. Failure 0%</td><td>Struct. Failure 0%</td></tr>
</table>

*Insufficient data to use.

Factors Contributing to Adjustment of Base Renewal Rating

Construction Efficiency (Flag Only)			
Street repairs/ construction	Drainage project	Sewer renewals	Scheduled Master Plan/ infrastructure improvements

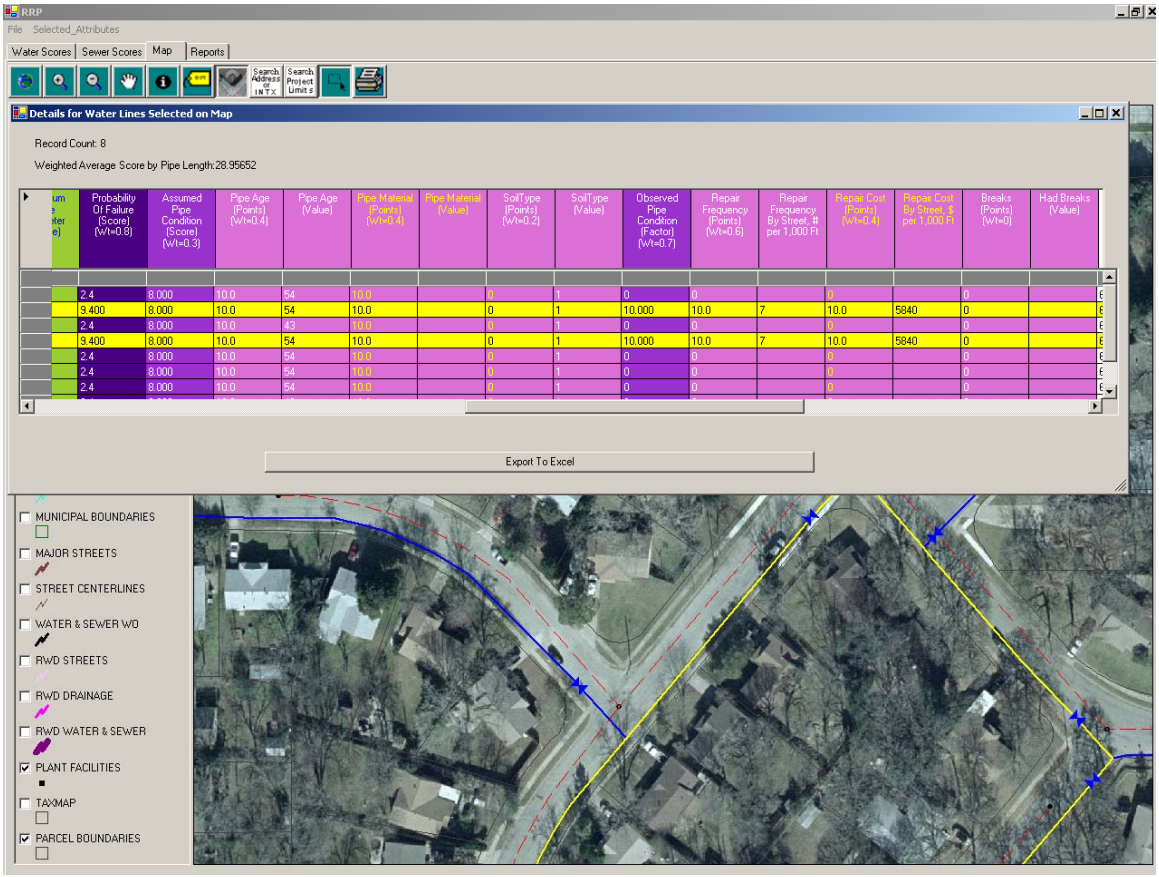
Factors Contributing to Replacement Cost Calculations

Total Cost (Flag Only)			
Pipe Length	Street $/Ft.	Pipe $/Ft (include manhole cost)	
	Pavement Type	Location (IS, BC, Easement)	Pipe Dia.

Once all of the data was collected, a formula was developed using recommendations from staff involved in the previously manual renewal recommendations. Not all factors are of equal importance in calculating rating. Weightings were assigned to individual factors such as pipe age and groups of factors such as Assumed Pipe Condition. These weightings are built into database tables and can be revised via a custom user interface.

User Interface

The users that plan the renewal and rehabilitation projects need to be able to view the rankings of the water and sewer lines. This is accomplished through the user interface of the RRP Application.



Enhancements

Since the original release of the RRP Application, enhancements have been made. These include automation of data population, a mapping component, the capability to search by street name or project limits. The automation of data population included writing scripts that can be executed on demand to update the tables containing the WMS, GIS and Billing System data. The mapping component provides a graphical user interface for selecting a particular water line or sewer line segment. The user can also select a group of segments at one time. After selecting the segment, the user is provided with that RRP rating and the statistical information. The selection of water line or sewer line segments can be done by clicking on the graphic shown on the map or by a street name or project limit search. As shown above, a legend is included in the application that allows the user to turn various layers on and off.

Future enhancements being considered include statistical analysis and reporting tools. Statistical analysis is currently run by the programmer. The statistical analysis is used to determine averages, standard deviation and median information for the entire group of water lines or sewer lines. This information is used to help determine priorities as well

as infrastructure gap which will be discussed below. Future enhancement would provide a desktop interface for the end user to obtain this information with a click of a button. Interviews are being conducted to determine which reports would be useful to the end users.

Five Year Plan

The City of Arlington Public Works and Water Utilities departments are committed to working together to coordinate capital improvements and renewal and rehabilitation projects. In order to plan and budget for upcoming improvements, a three year plan is being developed.

Historically, if water and/or sewer line infrastructure work was needed in an area where street maintenance was planned, AWU completed the work prior to the street maintenance project. The cost per linear foot for water and sewer line renewal (replacement) work is significantly higher than the cost for mill and overlay, microseal or reclamation. The linear footage cost relationships are shown in the table below:

Utilities Renewal Project (line replacement)		
Diameter (inch) - Material	**$ / FT**	
	Water	**Sewer**
6-8 – PVC	80.00	90.00
6-8 – Ductile Iron	90.00	100.00
Street Maintenance Project		
Maintenance Type	**$ / FT**	
Rebuilds (37%)		202.66
Reclamation (11%)		35.37
Mill & Overlay (11%)		27.97
Micro-Seal (11%)		6.72
* Data from 2005 study on RWD processes		

The funding available to AWU is not sufficient to keep up with all the planned street maintenance activity. The RRP application is utilized by AWU to determine which of the water and sewer infrastructure has the highest ratings and should be renewed. The type of street maintenance activity is also considered when planning which water and sewer lines to renew.

Additionally, in order to renew the water and sewer line ahead of the street maintenance, planning is required. The lead time for the water and sewer line renewal includes engineering design and construction. This can easily take 8-12 month lead time prior to the planned street maintenance date.

Creating a 3-5 year plan is currently a goal of the RWD committee (joint Public Works and Water Utilities). The plan is to include the recommended list of maintenance activities for a three (3) year forecast each year. The projects in year 1 would be fairly firm. It is understood that there may need to be some adjustments to the lists for year 2

and year 3 due to activities that may occur during the year. This extended forecast should make it possible for AWU to design and construct the water and sewer line adjustments without delaying the street maintenance schedule.

Infrastructure Gap

Often management or governing entities request infrastructure gap information. This is the gap between what is funded for replacement versus what should be funded for replacement. For example, if water lines are estimated to have a 50 year life, the replacement schedule should include two percent (2%) of the water line infrastructure each year. Instead of automatically replacing the oldest pipes, the RRP tool is used to rate the pipes so those with the worst condition can be replaced. The RRP application is utilized to calculate the infrastructure gap for the water and sewer lines in Arlington. The cost to replace the two percent (2%) water and sewer lines with the highest ratings (worst risk) is calculated. This is compared to the actual funding. The difference between these two numbers is the infrastructure gap.

Conclusion

AWU uses the rating system known as RRP to prioritize projects. RRP is a helpful tool that utilizes factors such as pipe age, pipe material and maintenance history to calculate a pipe rating. Work order history is available and used by the RRP application. The scores that are calculated by the RRP application are an indicator of pipe condition and can be used to determine the risk of failure associated with a particular section of pipe. With additional demands on AWU renewal and rehabilitation fund, it is imperative to use a tool that systematically provides a ranking system. AWU built the RRP tool based on interviews and recommendations from staff. The results of the RRP tool are validated against field operations personnel recommendations to ensure the validity of the tool. In cases where there wasn't a match, ranking criteria in the formula was reviewed to determine if modifications were necessary. AWU uses this tool to prioritize renewals, calculate infrastructure gap and establish a three (3) year plan. Budgeting for proactive renewal work is the objective of this application.

This application provides a sound foundation to responding to public inquiries about infrastructure renewal schedules and priorities. For example, citizens and council members inquire about why certain water lines or sewer lines are being renewed. Citizen pressure may cause an elected official to question the choice of renewals. The ability to describe the criteria used in the ranking process and provide comparisons if needed, is valuable.

Appendix A: Prioritization Factors and Data Sources

Factors	Data Availability	Method Gathered
Prioritization Factors: Water Lines Only		
Life Support Customers	Utility Billing System\WMS	Query and Geocode
Large Volume Users	Utility Billing System\WMS	Query and Geocode
Dead End Mains	Water Line GIS Layer	Query
Pipe Diameter	Water Line GIS Layer	Query
Soil Type	USGS Soil Maps	Spatial Overlay and Query
Prioritization Factors: Sewer Only		
Aerial Crossing	Sewer Line GIS Layer	Query
Pipe Diameter	Sewer Line GIS Layer	Query
Outflows Frequency	WMS	Query
TV Inspection Frequency	Utility Billing System\WMS	Query
Line Cleaning Frequency	Utility Billing System\WMS	Query
Sewer Stop Frequency	Utility Billing System\WMS	Query
Failure Frequency	Utility Billing System\WMS	Query
Prioritization Factors: Both Water and Sewer		
Repair Frequency	Utility Billing System\WMS	Query
Repair Cost	Utility Billing System\WMS	Query
Street Projects	RWD GIS Layer	Proximity Analysis

Appendix B: Work Order Types and Cause Codes

Water Work Orders	
Work Orders #	**Description**
3343	Main Repair
3344	Service Line Repair
3346	Valve Repair
3362	Emergency Valve Box Repair
3363	Emergency Main Repair
3364	Emergency Service Line Repair

Sewer Work Orders	
Work Order #	**Description**
3306	Main Investigation
3308	Investigation Customer
3345	Main Repair
3352	Repair House Backup
3353	Repair Manhole Overflow
3354	Repair No Overflow
3355	Repair Spill Containment
3360	Repair Contractor Damage
3384	PM Jet/Vac Cleaning
3388	PM TV Existing Line

Cause Codes	
Cause Code #	**Description**
38	Water Failure/Missing Part
61	Grease Sewer Cake
62	Sewer Roots
64	Sewer Structural Failure
72	Sewer Failure/Missing Part

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