Improved Capital Programming Powered By GASB 34 Compliance: A Case Study From Winchester, MA

By

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Abstract

The Town of Winchester, Massachusetts in an effort to comply with GASB 34 reporting requirements and improve capital programming for town infrastructure, has been exploring asset management system options with researchers at the Massachusetts Institute of Technology. As part of a team assigned to assist with collection of data associated with the implementation of a GASB compliant system, I propose that such an endeavor could be more successfully undertaken by a private contractor in future installations throughout the United States. By establishing a solid working agreement with a municipality, a private contractor would be better positioned than the municipality to provide the necessary data collection and software support services to implement the asset management system. Through a series of rigorous data collection and user interface development techniques, the contractor could quickly and cost effectively collect data for the system, allowing the municipality to comply with GASB 34 and improve their capital programming capabilities.

Thesis Supervisor: John B. Miller
Title: Associate Professor of Civil and Environmental Engineering

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Part I: Background

1. Governmental Accounting Standards Board – Statement No. 34 (GASB 34)

Overview authored by another member of the Infrastructure Systems Development Research Team, Thomas Messervy (Messervy, 2002).

The Governmental Accounting Standards Board defines their responsibilities as developing standards for state and local governmental accounting and financial reporting that will produce more functional information for users of the financial statements. The first concept statement (Statement No. 1) was published in 1987 and stated what the Board felt were important objectives of governmental financial reporting. The Board received input on these relevant issues from many sources, both public and private, in an attempt to develop better overall decisions and subsequent regulations.

GASB issued Statement No. 34 (GASB, 1999) in June 1999 after many months of discussions and public input. This statement contains guidelines about how the government-wide financial statements should be organized.

Statement No. 34 requires the implementation of more detailed government-wide financial systems. The majority of local governmental organizations have not kept clear inventories, assessments, or annual outlays for maintenance and improvement of infrastructure assets. Therefore, the amount of resources each government has needed to effectively manage their respective asset portfolios has not been available. The new GASB guidelines will facilitate comparisons between a government's annual operations, as well as between local governments.

The importance of an accurate and effective annual report cannot be underestimated. If a town hopes to receive appropriate funding, their need should be demonstrated through auditable records. Similarly, a government's effectiveness in managing its asset portfolio may affect municipal borrowing rates through bond rating.

GASB has developed a tiered implementation schedule for governments based on their total annual revenues:

GASB Classification	Total Annual Revenues ($)	Implementation for periods after:
Phase 1 Government	Revenues > 100 million	15-Jun-01
Phase 2 Government	100 million > Revenues > 10 million	15-Jun-02
Phase 3 Government	10 million > Revenues	15-Jun-03

The reporting is divided into prospective and retroactive reporting. The chart above states when prospective reporting must be completed. Prospective reporting includes all infrastructure built or improved upon after the effective GASB date. Retroactive reporting includes all infrastructure built or improved upon on or after June 15, 1980. This retroactive reporting is optional for Phase 3 governments. Phase 1 and Phase 2 must begin reporting on the fiscal years beginning on June 15, 2005 and 2006, respectively.

Minimal governmental compliance with GASB Statement No. 34 dictates annual statements to include (1) Management's Discussion and Analysis (MD&A), (2) Basic Financial Statement consisting of a) Government-wide financial statements, b) Fund financial statements, and c) Notes to the financial statements, and (3) Required Supplementary Information (RSI).

Statement No. 34 allows governmental organizations to choose between two separate means of accounting for their infrastructure collection: a standard or modified approach. The differences between the two options will be described in the following sections. In both methods, GASB divides infrastructure costs into three categories: maintenance costs, preservation costs, and additions and improvements. Maintenance costs allow an asset to continue to be utilized during its original established useful life. An example of this type of activity is filling in a pothole or mending a guardrail on a bridge. Preservations costs are those outlays that extend the useful life of an asset. An example of this type of cost is resurfacing a road or relining a water pipe. The final category is additions and improvements which are costs incurred to increase the capacity or efficiency of an asset. An addition or improvement cost would be if a lane were added to an existing roadway. Depending on the method chosen, these costs should either be considered as expenses or the costs should be capitalized into the value of the asset.

The standard approach for reporting governmental assets utilizes GAAP[1] depreciation methods. Capital and infrastructure assets (with a useful life over one reporting period and not reported under modified approach) should be reported at historical cost. Capital assets may be grouped by infrastructure system or other reasonable combination and depreciated over their estimated useful life.

As an infrastructure system is depreciated, it must be accounted for in the financial statements as a future liability. The rationale is that at some point in the future, the government will incur the cost to replace or improve the infrastructure asset to its original or comparable condition. As a government needs to issue bonds, large amounts of future liabilities may translate into lower bond ratings than if the infrastructure had been maintained at a prescribed level.

Infrastructure assets that are part of a network or subsystem of a network do not have to be depreciated and may be handled under the modified approach as long as certain requirements are maintained. The two main requirements are that the asset is managed under an asset management system and that the asset is being preserved at an established condition level as disclosed by the government.

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[1] Generally Accepted Accounting Principles

An acceptable system should:

- *Maintain a current inventory of eligible infrastructure assets*
- *Perform condition assessments on assets at least every three years and summarize the results using a measurement scale*
- *Estimate the annual amount to maintain and preserve the eligible infrastructure assets at the condition level established and disclosed by the government*
- *Maintain auditable expense records on each asset*

2. Infrastructure Systems Development Research (ISDR)

Asset Management System

For the past two years, the Infrastructure Systems Development Research (ISDR) Team has been testing a graphically integrated database developed by MIT Professor John B. Miller, which will support GASB 34 compliance and improve capital planning the Town of Winchester, Massachusetts. The prototype system uses Microsoft Access Database, and has a graphical interface through the GIS software ArcView (see Appendix A for sample views). With ArcView, maps and plans of Winchester's infrastructure were scanned and fit over GIS maps provided by the town. The interface allows several functions to be performed by town planners. First, the planner may simply click on any of the town's streets, displayed on a full color map, and have access to all information about that street or any infrastructure that may run under or parallel to it. Typical information includes original installation dates and costs, replacement costs, a complete maintenance and repair record, construction specifications (e.g. pipe size, pipe type, pavement thickness, etc.), and current condition assessments. Also, the software will allow the planner to search for specific occurrences in the system, for instance, all water pipes in poor condition or all roads resurfaced in the last five years. By allowing planners to get the big picture of the condition and value of their infrastructure, they will be better prepared to make long-term planning decisions to ensure that the systems remain operating at appropriate levels. Further, they will be able to forecast needed funding to put money in place at the right times for not only proper and timely maintenance of the systems, but also to be able to construct new infrastructure to meet the demands of changing population demographics.

Agreement with Winchester, Massachusetts

In an effort to test the asset management system, the ISDR Team sought out a test case. The ideal candidate was one that would be representative of most towns in that it would possess most types of general infrastructure, to populate the database with broad and realistic data. But the town also needed to be small enough so as not to present too daunting of a trial run. Adding to those qualifications, the town would also have to be patient in working with a new system besides being willing to give the ISDR Team access to all of their infrastructure records. Fortunately the team was able to find just such a candidate in the Town of Winchester, Massachusetts. The ISDR Team has been allowed access to all of Winchester's records and plans for their infrastructure. This working agreement is shown in its entirety in Appendix B. The goal is to use Winchester to test the viability of this asset management system, both in its ease of implementation and its long-term value to the town.

3. Winchester, Massachusetts

Excerpted from a passage authored by another member of the Infrastructure Systems Development Research Team, Thomas Messervy (Messervy, 2002).

The Town of Winchester is located northwest of Boston, Massachusetts. Winchester has a population of approximately 20,000 and is one of the wealthiest towns in the Commonwealth of Massachusetts.

The town's ruling body consists of elected officials referred to as Selectmen. The five-person Board of Selectmen, the "executive branch", is responsible for overseeing all of the fiscal, prudential, and municipal affairs of the town. A Town Manager is appointed by the Selectmen to serve as the chief administrative officer of the town. The "legislative branch" takes the form of a representative town meeting. Eight residents from each of the 24 precincts are annually elected to Town Meeting for three-year terms, so the Town Meeting consists of 192 members. Town Meeting is the sole appropriating body for Winchester, which means that it has the power to set the size of the municipal budget, under the guidelines of Massachusetts state law. There are certain exceptions to Town Meeting's control over municipal revenues, but as a general matter all Town expenditures must be approved by Town Meeting through inclusion in the Budget that is passed every spring.

In the year 2000, the Selectmen decided to appoint a FACTS[2] review board to conduct a long-term financial and operational plan for the town. The FACTS 2000 preliminary publication contained this conclusion,

> *"Historically the Town has under invested in Infrastructure. The steady growth in operating budgets has historically been financed by reducing expenditures on capital and maintenance. This can be*

[2] Financial Advisory Committee To the Selectman

seen in the condition of the school buildings and the condition of roadways in particular...the committee has not identified a ready source of funds within the existing budget to meet this need."

Winchester's leadership understands the fundamental need for long-term planning. Their basic minimum goals are a five-year financial plan for municipal and education departments and a twenty-year infrastructure replacement plan. Furthermore, they state a willingness to expend the financial resources required to develop and maintain needed information systems. These plans vary greatly from how budgeting has occurred in the past.

The Department of Public Works (DPW) is one of the largest of Winchester's service agencies. DPW is in charge of constructing and maintaining the town's entire infrastructure including: roads, sewers, school buildings, town buildings, public spaces, the cemetery, as well as managing the water distribution system. Over the last decade, expenditures by DPW have gone down slightly as a percentage of the total of General Fund Expenditures in the Town, from just over 6.73% in 1992 to 6.5% in 2000. For budgeting purposes, DPW has been divided into the following 8 different categories, or "functions": Administration, Water and Sewer, Maintenance-Highways, Fields and Public Spaces, Maintenance-Buildings, Garage, Transfer Station, Snow and Ice, and, finally, Cemetery.

Winchester's roadways consist of approximately 18 miles of major roads and 72 miles of minor roads. There is no known software program in operation for tracking routine maintenance of the Town's roads and sidewalks. The major criterion that determines how many miles of roadway are worked on in any given year is the amount received from the State's highway aid fund, referred to as Chapter 90[3]. DPW maintains a priority list of streets that are most in need of work, but the major purpose of this list is to determine the order in which streets are worked on,

[3] Chapter 90. Go to http://www.state.ma.us/legis/laws/mgl/90-34.htm

not how many miles of roadways are maintained each year. This is because Chapter 90 is currently the only source of funds for road maintenance in Winchester. According to the preliminary FACTS 2000 report, if Winchester receives $270,000 in Chapter 90 funds in a year, then $270,000 of highway maintenance is performed. Were Chapter 90 to be suspended because of the Big Dig, then no work would be done on Winchester's roads unless additional sources of funding became available.

This sole reliance on Chapter 90 is not the optimal way to maintain Winchester's roads and sidewalks for at least two reasons. First, there is no connection between the State's Chapter 90 amount and the work that should be done on Winchester's roads in any given year. An adequate operating budget has not been determined, but it may be reasonable to accept DPW's estimate that the Town should be spending between $500,000 and $600,000 each year on its roads and sidewalks. The 5-year historical average for Chapter 90 funds is approximately $240,000 per year.

The Water and Sewer function of DPW is the largest operation on the Municipal side of Town Government, with an average budget of approximately $5 million per year. The Sewer System operation consists of seven lifting stations that transport waste to the MWRA treatment system. The department does not have a current complete database of existing water/sewer/storm lines.

According to the Preliminary Facts 2000 Report, Winchester owns and manages 25 buildings with over 800,000 square feet of space. The Winchester Education Superintendent maintains school related building records. A basic database, in Microsoft Excel format, of town owned properties was supplied to the research team by the Assessor's Office. The database contained information pertaining to location, size, and appraised value. The Assessor's Office stated that because Winchester was not receiving tax revenue from these properties, updating of this data was not a high priority. This type of behavior seems to be the standard, rather than the exception.

Part II: Test Case Implementation

1. Infrastructure Asset Survey Methods

Infrastructure plans for Winchester, Massachusetts were provided by the Town and distributed to the ISDR Team. From the plans, the Team obtained quantity surveys for the city's physical assets above and below ground for each attribute associated with a particular system (e.g. roads, water, sewer, etc.). To this point, plans for the road system, water supply system, sewer water system and drain water system have been surveyed. The surveyed assets were allocated to descriptive location segments, usually streets, sections of a street, or extension from a street. In all instances, except for the road system, two types of take-offs were done; one manually, directly from the plans and the other in software using digitized copies of the plans. The road system was done digitally and the information was then augmented both by information provided by the Town and by manual checks of the actual plans.

Plan Take-off

Plans

The Team received mylar copies of the city's utility plans in 400-scale, where 1 inch equals 400 feet. Multiple paper copies of the plans were made for distribution to various estimators for the quantity surveys. The plans distributed for survey were for the water supply system, the sewer water system, and the drain water system. Each plan was given to at least two estimators (except sewer) for redundancy.

Segments

A list of identifying segments was provided for each of the utility systems, containing the necessary quantities to be taken-off of that particular drawing. These segments were generally attached to the streets they ran under. In some cases, large streets were broken into multiple segments, or segments that did not run under a street were named as an extension of a street where it began or terminated. This segment list was generated in part with the help of the City Engineer of Winchester and in part out of convenience for keeping track of the asset quantities.

Rules

All of the segments of interest for the plans surveyed contained lengths of pipe. To account for the pipe under a segment, two attributes were of importance for the quantity survey, pipe diameter and length. While the type of pipe (e.g. concrete, iron, etc.) is also important, that information was already contained in the database under the identifying segments. If a segment had multiple sizes of pipe, the two largest diameters were accounted for separately. That is, each of the two largest diameters was recorded along with their corresponding lengths. The remaining lengths of pipe in the segment, regardless of diameter, were summed together and recorded as one additional length of pipe quantity and was not assigned a corresponding pipe diameter.

Accuracy

As the plans being used were on a very small scale (1" = 400'), a metric needed to be established upon which the estimators could rely to round their numbers on a consistent basis. At the beginning of the exercise, all of the estimators were using a 12-inch long plastic scale. It was determined that they should be able to reasonably estimate the length of segment attributes to within 10 feet. To better facilitate comparable estimates, estimators were instructed to rigorously measure segments from center of street to center of street or center of intersection to center of intersection. Later in the exercise, some of the estimators began using a digital scale to estimate lengths, the Scale Master II Digital Plan Measuring System. It was determined that when using the digital scale, estimators should round to the nearest 5 feet, double the expected accuracy of a standard scale.

Experience of Estimators

In order to simulate possible situations municipalities might encounter while trying to implement our asset management system during the quantity survey phase, the Team used estimators of varying levels of experience and familiarity with the town. In total four different estimators were used. The least experienced had no formal education in doing quantity surveys, no experience working with plans and no familiarity with the City of Winchester, an inexperienced outsider (E1). Another estimator had some experience working with plans but no prior knowledge of Winchester (E2). A third estimator had fairly extensive experience doing quantity surveys and working with plans but no prior knowledge of Winchester (E3). The fourth estimator had both experience doing quantity surveys and intimate knowledge of Winchester, being a resident for many years (E4).

Quality Control (QC)

At least two estimators did take-offs for each utility plan. Afterwards, the hand written quantities, filled into a printed out spreadsheet containing the segments and required attributes, were entered into the spreadsheet on a computer. The two estimates were then compared side-by-side in the spreadsheet. The estimators performing the quality control check, the checker, of the data then went through the data using a three-part process to verify accuracy and completeness and to resolve any discrepancies. First a column was added to the combined spreadsheet to determine the percent difference between the two estimators' quantities. If the percent difference was 15% or greater the checker would then go back to the plans and measure the segment again, recording the correct quantities. Second, the checker would look for segments where one of the original estimators did not record any values but the other did. Also in this instance the checker returned to the plans to verify the correct quantities. Third, the checker would go through all of the segments with no quantities recorded by either estimator to ensure that that segment did not have any associated asset quantities that needed to be recorded for that particular take-off.

After compiling the final segment list with checked and correct quantity surveys, the checker would return the spreadsheet to the database administrator for addition to the system. At that time any discrepancies about segments not found on the plans or segments found on the plans that were not on the list were resolved by additional segments either being added to the database or by the quantities being plugged into another adjacent or appropriate segment.

The following table summarizes the approximate times required to perform the infrastructure take-offs and quality control procedures:

	Research		**Member**	
Action	E1	E2	E3	E4
Water Take Off	23	19		10
Water QC			12.5	2.5
Sewer Take Off				13.5
Sewer QC			2.5	2.5
Drainage Take Off	10		9	
Drainage QC			5	

Implementation

The implementation of the system through quantity surveys of the three different plans, using four estimators with varying levels of experience proved to be quite a learning experience for the Team. From the lack of data for the most inexperienced estimators it is not clear how defined their learning curves were for the tasks. The only quantifiable fact to be draw from the work of E1 and E2 is that their accuracy and attention to detail, in terms of their completeness of the surveys, did not improve with practice. Granted the procedure was only repeated a few times. The performance of the more experienced estimators, E3 and E4, appeared to remain the same as far as productivity. However, actual performance might be hard to judge considering the different types of systems surveyed. It might be valuable to see how the estimators' learning curves improve by doing quantity surveys of similar types of plans for a new city.

One of the challenges for the estimator performing the QC checks, and certainly for the estimators at times as well, was locating a street to be checked. This perhaps represents the biggest learning curve of the entire exercise, familiarity with the map of the town and location of streets, previously unknown to the individual. The initial QC check of the water supply system took almost as long as one of the quantity surveys. In part this was due to the overall inaccuracy of the first two take-offs. E3 had to go alphabetically through the list, find the street on a gridded map off of an index, and then transfer over to the plan to re-measure the segments assets. The estimators' familiarity with the city's street layout proves invaluable, particularly at the early stages of implementation.

After experimenting with two methods of measurement, using a standard scale and a digital scale. The expected levels of accuracy needed to be revised. It was unrealistic to expected accuracy to within 10 feet for a standard scale. A revised expectation of within 25 feet is much more realistic. While using the digital scale greatly improves accuracy of measurement, it is also very sensitive and can easily be made to have readings much higher or lower than the actual attribute being measured. For these reasons, rounded the displayed measurement to the nearest 10 feet makes more sense for expected levels of accuracy. Of course, the use of 400-scale plans largely affected the expected levels of accuracy in measurement. The choice of 400-scale was rather arbitrary, but convenient for the ability to then capture the whole of city on one piece of paper that could fit on a standard desktop. With 40-scale plans being available, their use could have greatly improved the accuracy of measurement, very confidently by as much as one significant figure.

Recommendations

Where available, 40-scale plans should be used in order to obtain more reliable and accurate quantity surveys, both in terms of the ability to locate and count attributes as well as the ability to accurately measure attributes to within 5 feet. For that matter, the use of the digital scale was highly successful overall, particularly in the towns such as Winchester with winding streets that do not measure easily with a long, straight and inflexible standard scale. While the availability of estimators will vary from town to town, it makes sense to have someone familiar with the towns layout do at least the initial quantity surveys, for the sake of time. Experienced engineers, if possible, should certainly perform future surveys as well as the quality control check at the end. The QC check in particular should be reviewed by a city engineer familiar with the utility plans and capable of making decisions as to the best placement of assets and their attributes to specific segments used in the survey.

Digital Take-off

The Digital Take-off Section was co-authored with Thomas Messervy and David Greenblatt.

Another area of research involved digitizing these same maps and merging them with the digitized road outlines in the ArcView program. These digitized road outlines are available, with slight modifications, through U.S. Census websites and the Boston Electric Company (BECo). Challenges arose when the hand-drawn town infrastructure maps did not directly match with the digitized road files. The town infrastructure maps had to be slightly modified to facilitate a meaningful overlay with the digitized road segments. Possible causes of these variations between maps could be slightly different uses of coordinate systems when plotting the maps or simply human error when surveying the town or drafting the maps. Once the town infrastructure system map had been compiled in ArcView, built-in functions were utilized for some of the elements of the takeoff such as determining length of independent sections. Other elements such as counting and noting of fire hydrants had to be performed manually.

In order to convert the Winchester-supplied infrastructure system plans to digital format for use in the ArcView program, certain actions had to be performed. The initial step involved scanning the maps and registering the maps to known coordinate locations. Digitization of the maps also included the addition of utility extensions. Additionally, in order to facilitate ease of use in ArcView, scripts were developed to automate functions that would commonly be utilized to access the information contained in the database. The following sections will explain in greater detail how the digitization and resulting take-offs were performed.

Scanning of Plans

Winchester utility maps (water, utility, and storm drain) were scanned using a drum scanner. The size of each map was approximately 3 x 5 feet. It was found that mylar copies of the maps scanned more easily and with better clarity than paper copies. After each map was scanned, the images were saved as .tif images and then opened using Adobe's Photoshop 6. In Photoshop, each .tif image was first converted to .jpeg format. The image's resolution was subsequently reduced from 300 pixels per inch to 100 pixels per inch, thus reducing the file size from 22.5 MB to 2.5 MB. All three .jpeg images were reduced to the same resolution and image size. This made the digitizing of extensions (described below) much easier. The formatted .jpeg images (approximately 1.2 megabytes each) were saved on a zip disk. The entire process took approximately 6 hours, with the majority of time spent on properly aligning the maps during the scanning process. The amount of time required could be reduced by scanning mylar, rather than paper maps.

Registering Maps

To register a map it is necessary to know the absolute coordinates (x,y-coordinates) for at least four points on the map. Three photogrammetric control points were obtained from Control Report No. C7-07, Winchester, Massachusetts, Sewall Project No. 29150S, July 5, 2001. The three points obtained include:

Pt. #	**Easting (X)**	**Northing (Y)**	**Name**
Point 306	753991.02	2991771.01	Ciarcia Field/ Super Stop & Shop
Point 307	751236.46	2989468.83	Center of Fletcher/Copley St.
Point 309	741571.06	2987368.83	Center of Thornberry/BerkshireDr

Horizontal Datum: NAD 1983 – Massachusetts State Plane (Mainland Zone) Units: US survey feet.

It was later realized that BECo's street centerlines shapefile was digitized according to the absolute coordinate system. This street centerlines shapefile contains x and y coordinates for all vector lines. The name of the file is Winch_stcl.shp

The actual registering of the maps was accomplished using Kenneth McVay's ImageWarp Extension, which was downloaded from the ESRI web site. http://gis.esri.com/arcscripts/details.cfm?CFGRIDKEY=-1206309428

There is extensive documentation in the help file on how to properly load and use the tool for registering and warping maps. Each map .jpeg image was registered to the BECo street centerlines shapefile. After registering each of the map .jpeg images, it was noticed that several regions of the original utility maps (which were hand drawn) did not entirely line up with the street centerlines. This problem was handled by warping each of the scanned .jpeg maps using the Image Warp Extension tool. Warping the .jpeg scans resulted in the alignment of approximately 80% of the streets. It was found that using at least 10 control points - widely dispersed throughout the entire map area – allowed for better alignment accuracy. Registering and warping each of the utility map .jpeg files took approximately 15 hours. Most of this time was devoted to working out glitches in the warping process. For example, initially the scanned images were saved in a non-grayscale .tif format. It was later discovered that non-grayscale .tif formatted images cannot be warped with the ImageWarp Extension.

Initial Digitizing

Heads-up Digitizing was used to perform feature editing throughout the project. A digitizing tablet is an alternative means to input and edit data. Rather than performing the complete digitization procedure for Winchester, it was decided that BECo's street centerline shapefile could serve as the foundation of the segments theme created in our ArcView project. However, even after warping each of the utility map scans, approximately 20% of BECo's street centerlines did not align with the streets drawn on the scans. All streets not aligned were either edited or redrawn. The decision to edit and redraw BECo's more geometrically accurate centerlines implies that the spatial accuracy of the segments theme is offline in certain areas (most of the altered roads were concentrated in the northwest corner of the town). To address some of this distortion, the finished segments theme could be warped or redrawn using BECo's original street centerlines file as a guide. The disadvantage of rewarping/redrawing the final segments theme is that it will no longer line up with the scanned .jpeg images. The water supply scan was used as the backdrop while editing the street centerlines shapefile.

Once BECo's street centerlines were completely aligned with the streets drawn on the water supply map, all digitized line segments with a common name were joined. In other words, each road was graphically represented as a single polyline rather than multiple segments with a common road name. If BECo's roads had been segmented at each intersection, a summary table could have been generated to aggregate the segments by street name. Generating summary tables from multiple segments facilitates the process of revising individual street sections if changes occur as implementation continues. However, the majority of streets in Winchester are relatively short and are maintained, preserved, or improved as an entire street rather than as individual sections of a street. Furthermore, four of the longest streets that traverse the town were broken at meaningful intersections in the ArcView project. For instance, Main Street was divided into Main St. North, Main St. Central, and Main St. South. Joining and renaming all of Winchester's road segments required approximately 8 hours. The majority of time was spent determining the appropriate names for each road.

Once the roads have been digitized, certain useful data becomes more easily accessible. The lengths of the segments can be measured by ArcView and also can be accessed in tabular format for comparison with manual takeoffs. If a high level of resolution was obtained during the scanning process, it can facilitate easier viewing of the plans to determine required information. However, this high resolution is often not obtained because of the resulting size of the files produced. Therefore, smaller details become difficult to discern on the digitized maps.

Addition of Utility Extensions

All roads that were not represented by a vector line in BECo's street shape file but existed on the water utility map were drawn and named according to the water supply map. Once all the roads had been completed, water, sewer, and drain pipes were drawn according their respective .jpeg scan. It was decided that water, sewer, and drain pipes lying under paved roads would not be digitized, due to the fact that the network of utility lines closely mirrored the roadway system. These underlying pipes were assigned the same name as the street they paralleled. At this point, the street centerlines theme became an all-inclusive segments theme. In other words, "Street Name" now referred to not only the road, but also the underlying infrastructure. All water, sewer, and drain lines that did not run under paved roads were digitized and named according to the following format: "Street Name" + "type_ext" (type = water, sewer, or drain,). Each set of extensions was digitized according to its respective .jpeg scan. Sizing and warping all the utility maps in a standard manner made it easier to align extensions in one all-inclusive segments theme. While the drain and sewer scans did not entirely line up with the segments theme, the association was accurate enough to draw lines in their proper location and proportion. The water utility scan was used as the final check for evaluating the shape and location of each utility extension. Areas in which there existed 2 or more overlapping utility extensions were named "Combined_Ext." However, the type of extensions that composed each "Combined_Ext" was noted in the segment theme attribute table. Digitizing all utility extensions and determining overlapping areas took 20 hours in total. Determining the location of extensions by analyzing the .jpeg scans was very time consuming. This was especially true for the drain extensions.

Utilization of Scripts

In order to ensure that the information contained in the database would be easily accessible through the ArcView interface, scripts were developed to automate some of the required processes. The development of these scripts would not have been possible without the gracious assistance of Daniel Sheehan of MIT's Information Systems. Sheehan developed the scripts and assisted the research team in optimizing their use in the Winchester application.

The following table summarizes the main parts of the digital take-off process, their implementation time, some challenges encountered and recommendations for their use in future applications.

Step	**Estimated Time**	**Challenges**	**Recommendations**
Scan Maps	6 hrs	proper alignment	use mylar copies
Register Maps	15 hrs	software incompatibility	obtain maps w/control points
Initial Digitizing	8 hrs	aligning CDM roads w/ utility maps	--
Adding Utility Ext	20 hrs	finding location of ext's	use common .jpeg size

Data Research

At times during the process of trying to populate the database, not all of the required information could be taken directly off of the town's utility plans. In those instances, other data sources had to be found and explored. The following summary was written by ISDR team member Michael Crafts (Crafts, 2002) and illustrates a situation where holes in the database were filled in using alternate data sources.

Data Required

In order to comply with the GASB 34 reporting requirements, the research team was tasked with finding the following types of data for each pipe run in the sewer system: pipe size, pipe age, pipe material, and historical costs. An existing database, previously created through performing engineering take-offs from town maps, contained approximately 400 sewer segments requiring data entry. The take-off process had successfully provided pipe size information for nearly all the sewer segments, but had been unable to provide age, material and cost data.

Data Source Identification

In order to collect the missing sewer system data, arrangements were made to gain access to the engineering archives located at the Winchester town office. Interviews with town employees confirmed that no existing files, databases or drawings contained all the desired data in one location, requiring the eventual use of separate data sources. A physical search of the engineering vault identified the following four potential data sources:

1. Sewer Assessment Maps
2. 1980 Sewer System Evaluation Study
3. 1978 Winchester Infiltration / Inflow Study
4. Sewer House Connection Card File

Initial spot checks of each source resulted in the following observations. Source 1 was organized as 232 maps numbered from 2401 to 2633, which appeared to landscape and profile views for single pipe runs on individual streets, including size and installation date information. Sources 2 and 3 contained details of manhole inspections for portions of the sewer system, including pipe size and material information. Source 4 provided dated sewer connection information, organized by street name and number.

Initial Assumptions & Decisions

After the initial identification and review of the data sources above, it was decided that the following review guidelines would be implemented:

1. One person should be designated with the sole function of updating the database on a portable computer immediately as data was identified.
2. The other one or two people should both examine the data sources and maintain a paper log of all data identified from each.
3. Data previously identified through the engineering take-offs should be spot checked against new duplicate data to subjectively examine the accuracy of the take-off process.
4. The Sewer Assessment Maps would be utilized first, based on assumption that they would be the most comprehensive source and also contain several types of data.
5. The two sewer studies were to be examined next, as they appeared to contain several types of data.
6. If no installation date information could be determined from the Sewer Assessment maps, the date of the earliest house connection would be used.
7. In the event of data conflicts, the newer data source would prevail.

Based on the pre-existing structure of the asset management database to be populated with data, the following limitations were imposed on the process:

1. Only the three largest pipe sizes were documented for each segment.
2. Only one installation date data block existed for each segment.
3. Only one material type data block existed for each segment.

Sewer Assessment Maps

As discussed above, the town sewer assessment maps were the first data source that was analyzed. This data source provided 128 new data points, comprised of 98 initial installation years and 30 material types. Total time effort spent on this data source was 56.5 man-hours. The following issues and decisions were encountered while using these maps.

Issues:

- Different parts of each sewer segment, which were principally linked to entire street lengths in the previously developed database, were often installed in very different years as the town expanded.
- Pipe material data was only listed for certain installation years on multi-year segments.

Solutions / Decisions:

- Only the oldest installation year that comprised greater than 30% of the total segment length was enter in the one available data block.
- If pipe material was known for any portion of a database segment, it was listed in the one available data block.

1980 Sewer System Evaluation Study

The second data source analyzed was the sewer system evaluation study that was completed in 1980. This data source provided 27 new data points, comprised of 24 material types and 3 pipe sizes. Total time effort spent on this data source was 3 man-hours. The following issues and decisions were encountered while using this source.

Issues:

- Material data was only provided for isolated manholes contained in multi-manhole segments.

Solutions / Decisions:

- If pipe material was known for any point in a database segment, it was listed in the one available data block.

1978 Winchester Infiltration / Inflow Study

The third data source analyzed was the infiltration / inflow study completed in 1978. This data source provided 31 new data points, comprised of 30 material types and 1 pipe size. Total time effort spent on this data source was 3 man-hours. No new data collection issues were raised during the use of this source.

Issues:

- Different parts of each sewer segment, which were principally linked to entire street lengths in the previously developed database, were often installed in very different years as the town expanded.
- Pipe material data was only listed for certain install years on multi-year segments.

Solutions / Decisions:

- Only the oldest install year that comprised greater than 30% of the total segment length was enter in the one available data block.
- If pipe material was known for any portion of a database segment, it was listed in the one available data block.

Sewer House Connection Card File

The final data source analyzed was the sewer connection card file. This data source provided 166 new data points, comprised of 154 connection years, 10 material types and 2 pipe sizes. Total time effort spent on this data source was 27 man-hours. The following issues and decisions were encountered this source.

Issues:

- Earliest connection year is not necessarily the year the pipe was installed in the street.
- Some cards listed multiple material types for different portions along a database segment.
- Year, material and size data for some database segments now came from multiple sources.

Solutions / Decisions:

- The earliest connection was to be used as the install year entered, based on the assumption that initial connections would have been made immediately following the availability of sewer service.
- A coding system was developed to identify different material types in the data block: 1 for Vitreous Clay (VC), 2 for Asbestos Cement (AC), 3 for a combination of VC and AC, and 4 for PVC.
- An additional data block was added for each segment and a coding system developed to identify the data source: 1 for the Sewer Assessment Maps, 2 for the 1980 Sewer Assessment Survey, 3 for multiple sources, 4 for the 1978 Infiltration / Inflow Survey and 5 for the Sewer House Connection Cards.

Summary of Data Collection

The four data sources examined provided a range of data type, quantity and effort required, as summarized in the table below:

Source	Years	Materials	Sizes	Total Data	Man-Hours
Sewer Assessment Maps	98	30	0	128	46.5
Sewer System Eval. Survey	0	24	3	27	3
Infiltration / Inflow Study	0	30	1	31	3
House Connection Cards	154	10	2	166	27

2. Current Project Status

Currently, the team has completed a first pass through three of the town's major utility systems from 40-scale plans: water, sewer and storm drain. Basic data from those three systems has been taken-off and passed through at least one quality assurance check, either from a second estimator or digitally from the overlaid utility plans scanned into ArcView. For the water and storm drain systems only pipe length and diameter for each segment has been determined with some condition information for the water. For the sewer system, the additional research mentioned earlier also captured some information regarding pipe type and installation year, besides the pipe length and diameter data taken-off the plans. The Town of Winchester is currently undertaking a condition assessment of the sewer system and that data will be made available shortly. Street data for Winchester was taken largely from Microsoft Excel files provided the Town Engineer's Office. This data included street widths and lengths as well as some vague condition assessments. Spot checks from the paper and digital plans verified the accuracy of the information before it was entered into the database.

Aside from the data entry tasks to populate the database, progress was also made on the software and graphical interface side of the operation. The database has undergone minor adjustments as decisions about how to deal with real data have been made. Specifically, assignations of utility extensions that did not run along street segments were determined and placed according to existing street segments they spurred off of, or were assigned completely new segment names if the situation was merited. Further, extensions that contained more than one utility type were given combined extension designations instead of creating new segments for each utility type in the same location.

Graphically, CDM GIS maps were added as a layer to the system as they became available. From these maps and information from the Town, a layer was added that showed all public lands in the Town and their uses, such as green space or buildings. Additionally, as was mentioned earlier, all of the scanned 40-scale utility maps have been warped over the BECo. Street segments to digitally define all of the utilities relationships with the street segments.

The database is populated with enough data to properly test some of the basic queries, the necessity of a broad range of segment assignations, and how well the graphical interface meshes with the database information. The Team has become comfortable with several methods of data recovery including plan take-offs, digital take-offs and archival research, establishing a methodology on how to deal with the general data as well as with exceptions. From this point a clear idea of what remains to be completed to get the asset management system fully up and running has been determined along with the necessary processes.

3. Remaining Work

The most pressing activity left for the ISDR Team in Winchester is to finish populating the database. That involves fully characterizing all of the utilities, including adding all relevant information regarding material types, installation dates, condition, and past maintenance activities (when available). Additionally, information is still needed about the finishes on the road system such as curbing and sidewalks as well as data about the value of Town-owned buildings and property. From that data, some computational and accounting work must then be done to complete the information asked for by the database to comply with GASB 34. This information includes, historical installation costs (where applicable), infrastructure replacement costs and maintenance costs to fully determine Winchester's infrastructure asset value and to begin the process of sustainable infrastructure capital planning.

Two sets of information are necessary to determine the replacement and maintenance costs of any given piece of infrastructure, its exact specifications for construction and the requisite construction costs to meet those specifications. Possible mechanisms for developing this information are emerging. For example, the Town of Winchester has adopted, revised, and updated a set of standard construction specifications for new road, water, and sewer infrastructure work into a book put out by the engineering department (The latest edition of which is Special Provisions, 2002). Going forward, these standards could be combined with estimates of construction costs provided in estimating packages such as the Means CostWorks 2002 CD-Rom (Means, 2002). CostWorks has been made available to the ISDR Team by Prof. Miller through RS Means, to explore the costs of infrastructure systems and various maintenance activities. The Means software is a widely used flat file database of construction costs, which are regionally adjusted and periodically updated to reflect the true cost of construction in any part of the country.

If the database is can be fully populated, analysis can begin to find viable capital programs to maintain the Town's infrastructure at high operational and quality of service levels. These plans may be arrived at in a variety of ways, by looking at current spending levels compared with reasonable replacement and maintenance costs on a year-to-year basis. Once the Town decides on acceptable levels of service, prioritization can begin on the infrastructure system from which a capital budget will emerge for the next several years. Also, since Winchester is completely land-locked by other towns and for the most part built-out, a long-term capital program may be established for the replacement of major infrastructure systems and public buildings. Planned for in advance, the Town will be better able to handle their high costs.

The last two remaining issues to be resolved involve the future maintenance of the asset management system itself, and the different levels of control and access to the database that the Town will require. The more pressing of the two is the access issue, which involves the physical interaction by people with the graphical interface of the database and its ability to quickly, and easily provide clear information to aid the Town's decision-makers. The importance of determining who specifically will use the database and what types of information they will require as well as what types of information the Town wishes them to have access to directly affects the construction of the graphical interface and must be resolved before a working prototype could be turned over to Winchester officials. The other question revolves around who will maintain the back-end of the system, keeping the database up-to-date by recording all new constructions and activities performed on the various infrastructure systems. Clearly, this is an issue that must be resolved by the Town of Winchester since they are the ones who will bear the cost of the necessary manpower. However, in getting this asset management system online, the ISDR Team has encountered and overcome many of the difficulties associated with inputting and maintaining data in an active database. Therefore, it seems reasonable that the Team could offer the Town assistance in both deciding appropriate staffing for the job as well as initially training the personnel in the use of the system and useful estimating techniques.

To summarize, the asset management system being tested in Winchester still needs to be completely populated with data containing all of the infrastructure systems' characteristics. Then construction specifications and construction activity cost data will be applied to the database to determine historical, replacement and maintenance costs associated with each of the utility systems. From these costs, capital planning can be done to maintain sustainable levels of service in Winchester's infrastructure systems using available funding. The Town must then decide how it best wishes to use the asset management system be designating future levels of access for different people inside and out of the town government as well as setting up a process to maintain the database's information in perpetuity.

4. Test Case Hypothesis

After working with the ISDR Team in Winchester and witnessing first-hand the interaction between the research group and the Town officials, it is my hypothesis that the process of implementing Prof. Miller's asset management system can be standardized and taken to any municipality in the United States. I also propose that the task of implementation may be best undertaken in future applications by a private contractor, hired by a municipality to facilitate the transition to this comprehensive asset management system which will allow GASB 34 compliance and lead to improved capital programming. A private contractor set up to tailor the database to each specific municipality and then populate it using a variety of well rehearsed estimation, research, and computational techniques, would be much more efficient both in time and cost, to having public employees either hired or retrained to do the same tasks. The private contractor would also bring a wealth of prior experience to the project as its employees are accustomed to implementing this asset management system, which would be invaluable to the municipality in making critical decisions about system access, maintenance, and data representation as they pertain to both GASB 34 compliance and future capital programming. Leading from the hypothesis, the remainder of this paper is dedicated to outlining a method of implementation for Prof. Miller's asset management system, based upon lessons learned, during the ISDR Team's ongoing case study in Winchester, Massachusetts.

Part III: Hypothetical Implementation

1. Project Planning

The beginning of the implementation process for the asset management system is a preliminary planning phase where all the details of what needs to be accomplished are predetermined. A course of action is laid out that encompasses rules and standards for classifying the data, an idea of what the finished interface will look like as well as how it will perform, and a basic understanding of who will provide what information and when. The planning phase is also a good time to set out realistic project performance goals, to keep everybody accountable and informed of where the implementation process should be. This chapter deals with those issues and provides some insight into possible solutions based on my experience with the ISDR Team in Winchester. Included in Appendix C1 is a diagram showing what the relationships between the municipality, the contractor, and the asset management system might look like during the implementation phase. It also shows the flow of information and ideas. The diagram in Appendix C2 represents the interactions various parties might have with the asset management system during its operational and maintenance phases. These diagrams may be referred to at the reader's pleasure throughout Part III as a visual guide for an overall sense of how the sections topics might interact in practice.

Working Agreement

As seen in Appendix B, the agreement between Prof. Miller and the Town of Winchester covers a lot of information, some parts of which are more applicable than others in a general implementation of the asset management system, if only because the system will not still be in a trial stage. That aside, those parts of the agreement which do protect the intellectual property of the system would still be present, though the municipal collaborator would have much less interaction with the internal code of the system. Overall the sample agreement in Appendix B is a solid starting point for writing a working agreement between the private contractor and the municipality.

There are several purposes for writing a comprehensive working agreement. The most obvious purpose is to establish a relationship between the parties, in this general case, a private contractor and a municipality. The involved parties are identified and the lead contacts for each named. From there the working agreement goes on to establish the reason for the collaboration between the two parties, which is for the municipality to provide the contractor with all the necessary information to populate an asset management database to account for all of that municipality's infrastructure so they can achieve GASB 34 compliance and improve the capital planning capabilities. Beyond that particular statement of purpose there needs to be specific clauses indicating what information each party is privy to during the process. This stipulation is to protect any proprietary information either party may have, and to bind the other party, in the event of disclosure of such information, to keep that information in confidence.

Now that both party's interests are protected, the working agreement can go on to establish what the private contractor's terms are for implementation of the system, such as compensation, required time, required manpower support from the municipality, performance delivery dates, and what role the contractor will be required to perform in the future with respect to maintenance and upgrade of the system.

A good way to regulate the cost of implementation is a two-pronged approach, involving an estimate from the contractor of time of implementation and a probable scenario of how many people will be working on the project full-time during each stage of the process. From there, an hourly billable situation can exist for each of the contractor's employees working on the project. The municipality would get a minimum estimate of how much implementation will cost based on expected hours for different types of employees, at different phases of the project and at different hourly rates depending upon the employee's specific position. Above that minimum, the municipality would agree to pay for any additional required work depending on the necessary hours for each of the contractor's employees on the project. The contractor in turn would guarantee a maximum price, a cap to the amount the municipality would have to pay. In this situation the municipality has a good idea of what the project will cost and can budget for a maximum amount. The contractor has some flexibility as unexpected problems are sure to arise, but also has some guaranteed money. Finally to provide some incentive to the contractor and reassurance to the municipality, performance bonuses and penalties based on the final system delivery date could be included. That way if the contractor performs ahead of schedule, they get a bonus; say a maximum of 10% of the final contract price spread out equally up to several months before the performance date. The municipality would get compensated for every day the contractor is late, perhaps for punitive damages in amounts similar to the contractor's potential performance bonuses plus actual damages suffered by the municipality.

As is mentioned above, performance deadlines are critical for both parties. In that respect, they should be carefully evaluated before the working agreement is signed. Two factors are inextricably linked to the final performance date and both be worked out in advance, one a commitment from the municipality, the other a guide for the contractor.

The commitment is for certain amounts of manpower assistance to the contractor from the municipality. It is unrealistic to expect that a private contractor would be able to find all of the necessary information to populate the database, resolve discrepancies in the data, and then perform capital programming activities devoid of any assistance from municipal officials. It would be fair for the private contractor to have a contact inside each division of the municipality whose job it is to interact and aid the contractor. While this need not be the full-time responsibility of the employee, it is reasonable to ask that they be made available at certain hours if not every day, then a few times a week to resolve issues that will arise. It is also important that these employees have power to make decisions regarding the system's implementation, without that power anytime meeting with such an employee would be a wasted time for both parties.

The guide for the contractor revolves around performance delivery dates. While these dates would not include bonuses or penalties like the final delivery date, they would suffice to keep everyone involved with the project abreast with its progress. These dates would be mutually agreed upon at the beginning of the project as reasonably expected times for completion of various phases of work, such as infrastructure data estimation and characterization, database population, graphical interface completion, replacement and maintenance cost estimation, GASB 34 reporting capabilities, and functioning capital planning capabilities. All are important steps in the evolution of the project from inanimate maps, plans and records to a fully dynamic and interactive asset management system. Whether or not these dates need to be placed in the working agreement is a matter of opinion, however they should at least be set out, published and disseminated at the beginning of the project to both parties.

The last part of the working agreement is the most difficult to qualify as its potential implications are hard to anticipate. This part involves the future commitment of the contractor to assist in the maintenance and upgrade of the asset management system. The implementation process will create a living database that will need to be constantly updated and attended to. For the most part this responsibility will fall to the municipality, but at some times the contractor's involvement will be necessary. For that purpose, clauses in the contract should be included that stipulate the exact levels of future contractor involvement that are mutually agreeable to both parties. More attention is paid to this topic later in Chapter 4 of this Part of the paper.

Information Prioritization

Once a working agreement and an overall understanding of how the project will operate relationship-wise are reached, several decisions must be made before the contractor can easily begin work on the implementation of the asset management system. The first of these planning decisions deals with information prioritization and refers to the particular municipality's wishes for the system's database. More specifically, which infrastructure, public buildings, and public lands should be included, because the municipality may not be interested in anything more than the infrastructure as they might have other systems in place for the buildings and land. Or they may not directly control all of the infrastructure systems that service the municipality, in which case no study is needed. How much information about each of the infrastructure systems the contractor should seek is also of importance. For GASB 34 compliance basic characteristics such as age, size, material, condition and cost will due, but other attributes such as maintenance history, maintenance and repair costs, or placement data (like slope and depth), may also be of interest to the municipality, as they would aid in capital planning, organize more records in a centralized database, and allow more accounting flexibility with GASB 34 in the future. And if the contractor is asked to try and uncover such additional information about the utility systems, then which systems should take precedence if some of the data is not readily available or cost effective to find for every system within the scope of the project's timeframe. From experience in Winchester, not everything that is wanted in the database can be found. A mechanism needs to be in place from the beginning of the project to dictate to the contractor which pieces of information are vital to find or at least estimate if exact numbers are not apparent and which pieces of the database may be left blank or returned to later if time permits. Without such directives, the private contractor may quickly fall off schedule early in the project looking for information that either does not exist in any record or in not vital to the success of the system. Consequently, the contractor might have difficulty performing to the working agreements deadlines and the municipality will suffer from not having the asset management system in place in a timely manner.

Measurement Standards

For the data collection phase of implementation, measurement standards are critical. Beyond this phase, the standards set forth at this point in the project will set the precedence for how things are recorded in perpetuity. The first question is whether to use the English or Metric systems of measurement. This decision may largely depend on two factors, which system the municipality's records and maps are in and which system does the municipality currently use in its engineering and public works departments.

After the system of measurement is chosen, a review of the infrastructure plans would be advisable. From the basic plans of the different infrastructure systems, the contractor will need to decide five things in regard to the estimation of quantities. The importance of these decisions is twofold as they will also need to carry over into the future operational phase of the database's life so as to make all of the data as standardized as possible. The decisions concern map/plan scale selection, segment assignation, measurement techniques, measurement accuracy, and measurement representation.

Plan Scale

A choice of map/plan scale may or may not be present. If it is, the contractor must weigh the importance of data collection accuracy, which is easier on a smaller scale, and not losing sight of the big picture by having any given segment entirely on one plan, which may make the take-offs less reliable. In the end, such issues may be resolved with segment selection, which carries its own associated problems and will be discussed in the next section. However, a suitable plan scale must be identified and then used by everyone working on the project, both plan and digital estimators and anyone else who might need to reference a plan for data verification.

Segment Assignation

Segment assignation is how the municipality's infrastructure is represented in the database. In Winchester, all but a few streets were their own segments and any infrastructure running underneath or along that street was included in that segment. Sometimes, infrastructure did not run with any surface streets and specific extension segments were needed to identify those places. In general, the segments need to be easily identifiable on a map so assigning them concurrent with streets makes sense. The fact that the majority of utilities in cities run with the streets is also helpful. The ease of identification requirement necessitates that the segment names be general enough from someone to easily query, but specific enough to find exact infrastructure locations. Winchester was a relatively small town, with less than 100 miles of public roads, so making each street it own segment made sense. But in larger cities, it will more than likely be necessary to break up the streets into many segments.

The decision about segment size ultimately should rest with the municipal officials. They should understand that with more segments (shorter segments), more detailed information and can be kept track of, for instance slope and depth of a water pipe, if the segments were manhole to manhole as are many GIS surveys. However, this increase in the number of segments adds enormous complexity and time to the project and consequently cost. At the other end of the spectrum, with having as few segments as possible, like in Winchester, the database and graphical interfaces become simpler, but the ability to handle certain types of information might be lost. For most average size municipalities, somewhere between the size of Winchester and a top ten metropolitan area, a compromise is in order. Some smaller streets may be able to be their own segments while other may need to be broken up periodically, maybe at every intersection. Generally, this compromise will probably float from one end of the spectrum to the other depending on municipality size with smaller municipalities having more single-segment streets to the largest of cities having most of their segments go from intersection to intersection.

Once a decision about general segment characteristics has been made, an initial segment list should be assembled. The most obvious starting point would be a list of the municipality's streets. From there the streets can be broken up into multiple segments as needed and additional extensions or separate segments may be added for readily known infrastructure that may not travel with the road system. Since the paper plans to be used have already been chosen, a quick scan of those plans will reveal a majority of the extra extension and separate segments that need to be added. Of course, the final segment list will not be complete until the take-offs are complete and all of the exceptions are dealt with.

Measurement Techniques

Measurement techniques is how the estimators take-off quantities from the plans. In Winchester we used three methods, a hand scale, a hand-held digital scale, and take-off features in the ArcView software on scanned images of the plans. Here consistency is important in that each estimator have a specialty, meaning they regularly only use one measurement technique throughout the project. As far as the whole project is concerned, having several different techniques employed is a good thing for the purposes of quality control checks. Also, some types of plans are better suited to certain techniques. For example in Winchester, for straight pipes under straight roads a hand scale was much quicker and more accurate than the digital scale, but on curvy segments the opposite was true. Measurement techniques to be used on the project should be selected beforehand and then not changed. They should also be congruent with the municipality's estimation capabilities, as they will have to estimate new work done after the system goes online.

Measurement Accuracy

There are two aspects to measurement accuracy, the first involves the precision of measurements, and the second involves the consistency of the measurements. Based on the scale of plans to be used for the take-offs, a certain level of accuracy can be expected. For that matter, a metric of rounding should be set up. How may significant figures can be reasonably obtained from a certain scale of plans? That question depends on the scale of plans, the clarity of the drawing, the skill of the estimator, and the expected level of precision from the chosen measurement technique.

The second aspect concerns measurement consistency. This phase refers to quality control. Every plan take-off should be done by at least two independent estimators using the same metric of measurement mentioned above. If their results are within a pre-determined range of each other, then the data is viable. Digital estimation from scanned plans is useful as long as the images were not warped too much to get them to fit with the previous layers in the asset management system. In Winchester, the scanned images regularly had to be warped to fit the BECo. street profiles we used as a base layer because they were fixed from US Geological Survey points, consequently some measurements around the periphery of the plans were not accurate. If this is not the case than digital estimates probably do not need to be checked. However, in that case, it would be prudent to use the digital estimation quantities to check against those from the plan take-offs. The main key to measurement consistency is that all measurements should be done at least twice, regardless of measurement technique, and compared against each other. The person doing the quality control check on the two sets of data should be different from either of the original estimators. The quality control person should resolve any data discrepancies by checking with a hand tool on the paper plans all of the disputed segment measurements or characteristics.

From these requirements, the private contractor will also know how many estimators are required for the job. At least three are necessary for any project; two for plan take-offs and another for the digital take-offs. That way there are always two plan estimators to check each other or a third estimator to do quality control between a plan take-off and a digital take-off. Of course, greater numbers of estimators may be required depending upon the size of the project.

Measurement Representation

Measurement Representation refers to how numbers are presented both in and by the system. The logical question is decimals or fractions. Here I will make one finite decision for future implementations, use decimals. Another distinction that needs to be determined is the difference in the level of accuracy recorded in the system and the level of accuracy displayed to the user, and this may even varying depending upon the user. In some cases it may be more preferable to present a user with a more rounded number than is present in the database. For the most part the issue of measurement representation is only a matter of aesthetics, but one that should be decided upon in advance the beginning of the process of implementation of the asset management system.

The key to remember with measurement standards is consistency; consistency in how plans and data are interpreted, consistency in how things are measured, and consistency in how those measurements are recorded. And the best way to ensure consistency is to decide upon the necessary standards before the beginning of the project.

Database Interaction

To aid the software engineers in setting up the both what the database looks like and how the graphical interface ties back to it, the municipality should consider the various types of interactions that need to occur between people and the asset management system. While this issue is partly aesthetic, its primary concern is ease of use, how easy it is for a user to find the information they are looking for and then how effectively the system communicates that information back to them. Essentially there are five main types of interactions that will occur with the asset management system, maintenance and data entry, GASB 34 accounting, capital programming, system administration, and general informational access. All of these interfaces may be different and all of them working properly will be necessary for the system to function as planned. In that regard it will be important to consider each interaction and convey their wishes to the contractor about the performance of each at the start of the project.

Maintenance and Data Entry

The first major interaction is database maintenance and data entry. These are activities that will occur during the operational life of the system and primarily will be performed by municipal employees. This interface will need to let the user, change data, update the database with new data, and add graphical features to the map layers. Changing data might include revising original estimates of infrastructure quantities or adding newly found maintenance records into an asset's history. Updating the database will be the main function of this interface and includes recording all new construction, maintenance and repairs, or changes in condition. Simultaneous with updating the database the system's map layers will also on occasion need to be changed to reflect that new construction, for example if a new road is built or a new water main is added for a new housing subdivision.

GASB 34 Accounting

The municipality's accountants will need to access the system for the primary purpose of its original development, GASB 34 compliance. They need to be able to view summaries of the municipality's infrastructure in an manner that not only makes GASB 34 reporting easy, but that also works well with their current account system. In that respect, the accounts should meet with the contractor at the beginning of the project and discuss system needs, like the ability to transfer accounting records from the asset management system into their current operating accounting system.

Capital Programming

Capital planners will probably use the system much in the same way as the accountants. They will want to see summaries that detail, replacement costs, maintenance costs, and current conditions, that they can compare with their budgets to prioritize future spending.

System Administration

An interface for system administration should also be included. While someone at the municipal level might have access to this interface, its main purpose is to give the contractor a future portal for software maintenance. Having such universal access will might only be important to the municipality if they can afford a full-time software administrator for the system, perhaps likely in larger cities, but probably much less often the case for the majority of smaller towns. For that matter, this interface is one that would be designed by the contractor, as it will be the one used at all installations of the asset management system.

General Informational Access

The final type of interface to be predefined is one for general informational purposes. This interface will also be the most restrictive as users will not have any ability to change the system and they will also probably not be able to view all of the information. This is the 'pretty' interface, the graphic intensive, public side of the asset management system. People should be able to use this interface with no training; it should be simplistic and intuitive. Here the municipality may wish to make a distinction, between types of users. Municipal officials would most often fall into the category of general informational system use and might want ready access to all available information in the database. This situation contrasts with the general public, whom the municipal officials might not want to divulge all of the information to, at least in this manner. The question then becomes, does the public even have access to the system? If so then municipal officials might consider using login passwords at this interface to give municipal employees the access they need to perform their day-to-day duties, while keeping the general public's access as simple as possible.

Once the municipality works out with the contractor the different types of interfaces that are necessary and gives specifications for each, the major hurdles in the project-planning phase are complete. The contractor now has a framework to go by and can begin the next phase of the implementation process, collecting data to populate the database.

2. Data Collection

Data collection represents the single most important part of the entire implementation process. Without it, the database would have nothing to report. If it is inaccurate or incomplete, every result queried from the asset management system has the potential of being wrong, costing the municipality time and money. The number of different sources of data further complicates proper data collection, whether they are paper plans, electronic maps or archival records. All of these sources must be found, categorized, assembled and then treated differently, in that they all contain different forms of data, but they also must all be treated similarly to each other, as that is the only way to ensure standardized collection and recording. The Section on Measurement Standards in Part III, Chapter 1 dealt with how to treat all of the data sources the same, how to standardize the process. This Chapter deals with each of the common data sources individually and addresses each of their particular needs as well as how to reconcile their results in the database.

Plan Take-offs

The most common source of infrastructure quantity take-offs and characteristics will be paper plans of the municipality's various infrastructure systems. At this point of the process the scale of the plans to be used has already been selected and now comes the task of taking quantities off the plans. In Winchester, we found the quickest and easiest way to do this was to start at the top of an alphabetized segment list and move down. Since almost all of the segment names were related to street names, a cross-referenced street map with a grid system was used to help locate the segments. The estimators will learn where a lot of the streets are just by working with the maps, but having a reference map will save a lot of time, particularly at the beginning of the project. Then for each segment the appropriate quantities and characteristics are measured, counted, or observed and recorded into an intermediary system. In Winchester, a Microsoft Excel spreadsheet was used for each infrastructure system. The spreadsheet contained the segment list and columns for all of the required input data. Usually the estimator would print out these lists and record the information by hand and then input the data into the electronic spreadsheet file after the paper sheet was filled out. This method was the most time efficient for paper plan take-offs. The Excel files were useful for quality control, as the controller could import the data from both estimators who estimated a particular plan and set up formulas in Excel to quickly check if the data was consistent. Inconsistent data could be flagged red, for example. The person in charge of quality control could then quickly move through the list and verify all of the flagged data using the same paper plans.

Two problems are almost unavoidable with doing quantity take-off from paper plans. The first is clarity. Often the estimators may be forced to work with copies of original plans, or worse yet copies of copies. Municipalities may not even have original copies of their plans and thus the contractor is forced to make copies of copies. Details on the plans, depending upon the scale, may quickly become clouded, particularly in areas of the plans with a high density of infrastructure, like major street intersections. Text identifying sizes, directions, and distances may be hard to make out and symbols used to denote system features might be hard to count. For example, in Winchester, gates in the water system were especially cumbersome to count and we eventually wound up having to use old data from the Department of Public Works.

The other problem is the potential for dealing with maps of different ages. While the scales may be the same, conventions for conveying information may have changed. Attributes of a system may look very different and information may be located in different places relative to the drawing. Here vigilance is the only way to ensure that quantities and characteristics are taken-off the plans in the same way.

Paper plans will be the backbone of the implementation process in most municipalities, dealt with properly and they can be invaluable assets. But without proper care and adherence strict measurement standards, they also have the potential to set back the contractor's operation considerably. In Winchester as a test case, we had estimators with varying levels of skill and knowledge of the town. The experience proved that while knowledge of the town was useful, the skill of the estimator was the most critical factor in obtaining accurate quantity take-off results. It is assumed that the private contractor implementing the asset management system in a generic municipality will have very skilled estimators. However, there still needs to exist an awareness of the peculiarities of working with scaled paper documents of varying ages while attending to the established measurement standards.

Digital Take-offs

Digital take-offs are simply the electronic counterparts of the plan take-offs. Typically, the same maps and plans use for the plan take-offs are scanned and overlaid as a graphic layer in ArcView. Data recording is done in much the same way, only the measurements are taken-off the computer screen, transferred to the printout of the spreadsheet, then put into the Excel for comparison. The major drawback to using these scanned utility plans is that they may need to be warped to fit onto the existing street layout. As mentioned earlier, in Winchester, the map of the town and exact location of the streets was set by coordinates obtained from the Boston Edison Company, which were based on United States Geological Survey points. To make the layers work properly in ArcView the streets had to match up exactly. Since the BECo. street locations took precedence, the scanned utility maps had to be made to fit. The resulting warping made measurements, most notably at the extremities, from the maps slightly distorted and inconsistent with those taken-off of the paper plans. This may or may not be a problem depending on what map is used as the master locator for everything in the municipality.

Other than the occasional inconvenience of map warping, digital take-offs present two distinct advantages over the traditional paper plan method. First, if the scale is precise on the digitally scanned map, very accurate measurements can be made using features in ArcView or any chosen software manipulator. In fact, the measurements are so accurate that that is one of the key reasons to round the data to a certain number of significant figures. The digital tools will be more accurate than the cartographer's hand. However, if used appropriately, the digital take-offs can be very effective at providing accurate information.

The second advantage of digital take-offs versus plan deals more with efficiency than accuracy. Once the scanned map images are fitted as a layer over a master street plan, any segment can be instantly found by simply querying the system for its location. This feature is much faster than looking for the segment name on an alphabetized list, cross-referencing that name on a map with grid coordinates, and then trying to match up where the segment was found on the small reference map with the plan map. However, this time difference must be weighed against the implementation time to get scanned images of the plans overlain properly and linked into the asset management system.

With the digitally taken-off data in an Excel file, the information can then be compared with that of an estimator working from the paper plans. In this case a second pass on the digital plans may not be necessary, but if the contractor chooses to exclusively use the digital take-off method for any or all of the utility plans, a second estimator should also do a digital take-off and the subsequent data compared by a third person for quality control.

Database Population

Once the data from the plan and/or digital take-offs has been collected and properly compared and verified for quality control purposes it is ready to be inputted into the database. The most logical person to physically input the data is the third estimator who was in charge of quality control, since it was that individual that verified the data and made all of the necessary changes in the cases of discrepancies. This person will also know rather intimately what data is missing. The first step in the case of missing or incomplete data is for the quality control estimator to refer back to the plans used by the first two estimators and try to find the data. Most times it was simply overlooked and the problem is solved. However, in the event that the estimator is not able to find the missing information, a list is made and kept for the next part of the process discussed in the next section. At the end of this part of the process, the database has been populated with all of data that was wanted and available off of the plans.

Other Research Methods

The infrastructure and utility plans will never contain all of the data required for the complete population of the database, in the cases where information was expected from the plans and not found and when supplementary information is required, other research methods for data collection become necessary. An example of this type of research was given in the Data Research Section of Part II, Chapter 1. Here the contractor will delve into the municipality's archives looking for any kind of documentation that may be of assistance. It is at this stage that the interaction between the contractor's estimators and the municipality's liaisons first becomes critical to the completion of the database population. The municipal employees' knowledge of what records exist and where supplementary information might be found is invaluable. Without good guidance of where to look, this is a point of the process where the contractor's team could get bogged down for a substantial amount of time.

After a certain time searching through records, either the holes in the database will be filled and the requisite supplementary information found or the information may not exist in any written record. It is here that the information prioritization laid out at the onset of the work becomes important. The decisions made at the beginning of the project will dictate whether the information is left blank, educated guesses need to be made, or if investigation on the municipality's part is necessary to determine the disposition of the disputed infrastructure information (either quantities or characteristics). The information prioritization plan will also say what pieces of data are more important and deserve the most immediate attention as well as giving priority to certain infrastructure systems in a similar manner. This phase is the end all be all for database population. It will determine what information gets found/guessed and recorded and which will never be entered into the system.

Data collection for the municipality's asset management system is now complete. The database is populated with all the available data that was required and exists. Holes were either left blank or filled with estimations. Analysis of the data can now proceed, including calculation of the municipality's total infrastructure asset value, replacement costs, maintenance costs, GASB 34 calculations and future capital programming scenarios.

3. Data Analysis

With data collection complete, the asset management system is close to being fully operational. While some queries are now available and basic information can be found about the municipality's infrastructure systems, the true power of the asset management system is not yet realized. In order take full advantage of that power the data already entered into the database must now be combined with dollar figures to determine the overall value of the assets, replacement costs, and maintenance activity costs. Those numbers will unlock the system's potential and allow GASB 34 compliance and capital programming; taking thousands of pieces of unrelated data and combining them in intelligent ways to create a clearer picture of the state of the municipality's infrastructure.

Current Cost Structures

Using the regionally adjusted Means data for the particular municipality, the contractor will develop a series of costs that will reveal, not only the municipality's asset situation, but also how much it will cost them to maintain those assets at a high level of service quality. It is the costs associated with replacement, maintenance, and repair activities that will shed the most light on the current situation as they will give the municipality numbers to compare against their current budgets and spending patterns to see if enough money is being spent, too much money is being spent, or if the money is not being used as effectively as possible. Those comparisons lead to the evaluation of future spending patterns, which is discussed in the next section. The emphasis in this section is on a reasonable method for calculating those current cost structures to immediately supply information that is pertinent to GASB 34 compliance.

GASB 34 is generally concerned with the current values of the municipality's infrastructure assets, if they are less than twenty years old, and how much money is spent to repair and maintain them. In Winchester, we found historical costs of infrastructure were rather difficult to find. Therefore an alternative method for determining asset value was needed. The most straightforward approach was to find a current replacement cost for all of the assets, and then depreciate that number based on the age and condition of the asset, within GASB 34 specifications. As was the plan for Winchester, I recommend that replacement costs be calculated using a combination of three data sources. The first data source is the quantity take-offs already performed on the infrastructure systems, as it will give the proper amounts of infrastructure to be replaced. However, those amounts are of limited use when estimating construction costs. For that job, specifications about the construction for each of the utility systems and their features are required. In Winchester, the ISDR Team was fortunate in that the town had those specifications both standardized and published in one location, in the form of a book (Special Provisions, 2002). While all municipality's may not have the information in that form, it will be available somewhere. In the worst case, the contractor could obtain copies of the most recent construction specifications, for each type of infrastructure asset, from projects the municipality contracted out to builders for replacement, repair, and maintenance operations. However the data is obtained, the last remaining step is to combine the quantities from the take-offs with the proper construction specifications and then factor in the unit costs for the various construction activities provided from Means CostWorks data (CostWorks, 2002), also entering in the appropriate geographical information.

GASB 34 makes a distinction between repair and maintenance activities. Repair activities are meant to keep a system operational. For example if a water main breaks and the leak is fixed. That is a repair activity. Maintenance activities are those that tend to extend the service life of a particular asset. To continue the water pipe example, if the inside of the pipes are refinished with concrete that extends the pipes life, maintaining the level of service quality. That is maintenance activity. Which repair and maintenance activities should be calculated in the asset management system, is really a matter of what activities the municipality performs. Repair activities are rather straightforward, as similar types of repairs are made on utility systems throughout the United States, so the municipality probably has a well-developed list of common repairs and the contractor will probably already have a good idea of what to expect for previous installations. Maintenance activities will be less uniform from municipality to municipality and as such more collaboration be required between the contractor and the liaisons. Choices of maintenance activities depends on current types of construction in place, asset usage levels, climate conditions and available monies for the activities, as some are much more costly that others and could even approach the cost of replacement. Here the contractor should provide guidance to the municipal officials to ensure that a broad range of maintenance activities are included, but ultimately the choices are in the hands of the officials as they will best know what policy is in the municipality. However, the broad range of options is important to include in order to help improve the capital programming capabilities of the system.

Future Capital Programming

Future capital programming essentially will arise from the comparison of three separate pieces of information, the municipality's capital budgets, the condition assessments of the infrastructure, and the cost structures found using the asset management system in the previous section. Putting these three things together represents the final step in realizing the ultimate capabilities of having a comprehensive asset management system in place. The system, designed to congregate information in an easily accessible manner to reach GASB 34 compliance, can be focused back on the current cost structures of the municipality to greatly improve capital forecasting for infrastructure, allowing money to be better spent and improving the overall performance the municipality's infrastructure network.

The first step is for the municipality to decide upon an acceptable level of service for each of the infrastructure systems, minimum performance specifications that the systems should meet. Then the cost structures generated for replacement, maintenance and repair activities should be used to create a minimum budget for meeting those performance specifications. The condition assessment data will lead the way in that process by showing the gap the municipality must close between current infrastructure performance and the desired service quality levels. Some systems will meet the new requirements, other will not, but this first budget created will give the municipality a first pass look at what will be needed in terms of both time and money to reach the performance specifications throughout the entire system. Next a second budget should be prepared which takes the infrastructure network from a point where it is meeting the new performance specification and lays out the required costs to maintain such a system at those new levels in perpetuity, through a series of preventative maintenance and replacement activities as well as a reasonable allotment for repairs. That second budget represents the true life-cycle costs of a sustainable infrastructure system, while the first budget represents the costs to reach that system in the particular municipality.

It should be clear that this plan of attack for future capital programming has one major hurdle, that it might not be so easy to reconcile the current spending patterns with the required costs of the improvement budget. Maybe not enough money is in the budget, maybe the current system is too antiquated and dilapidated, or maybe the performance specifications were set too high to make the result attainable. When the current spending patterns are compared to both the improvement budget and future maintenance budgets that were created, a certain amount of iteration is to be expected. The municipality must find the right combination of system performance, reasonable improvement time, and responsible capital spending to the proposed changes amenable to the community. Here the power of the asset management system can be used to explore endless possibilities, it is up to the municipal officials once the system is operational to use it to their and their constituents advantage to improve the service level quality of the whole infrastructure network.

4. Database Maintenance

The asset management system has been implemented and turned over to the municipality for the beginning of its operational life. At this point, the daily operation of the system is the responsibility of the municipality, and the contractor primary involvement has ended. Unfortunately the asset management system's database will not maintain itself with the changing real-time conditions of the municipality's infrastructure, nor will the system itself never need updating and periodic check-ups by the contractor. For these reasons it is necessary to conclude by discussing the roles and changing relationship between the contractor and the municipality once the asset management system is turned on. Appendix C2 shows some of the relevant relationships involved with the operational life of the asset management system.

Municipal Employee Responsibility

The municipality will have to deal with staffing coordination to ensure their asset management system's database remains up-to-date. Preferably, as few people as possible should be entering or altering in the database. That way it will be easier to keep track of what data needs to be changed or put into the database and what has already been done. The person(s) responsible for future data entry should also be intimately involved with the everyday operations and maintenance of the infrastructure network. Because it is people in that position who will be less likely to accidentally omit important data, if only for the reason that they deal with that same data on a day-to-day basis. Entering data for new constructions and maintenance/repair activities as they occur may prove problematic. Sometimes the responsible individuals won't have time to do it immediately and it may get put off, jeopardizing the odds of completion of the task. For that reason, I suggest that a monthly time be set to enter the data. Paper records for anything that occurs during the month can be placed in a file and at the end of the month the responsible parties can sit down at a prearranged time when they will not be distracted and update the database. Such a strict procedure is the best way to ensure that there is continuity to maintenance of the database and that no records are omitted from entry.

Future Contractor Involvement

Occasionally, the new updates for the asset management system may be developed that enhance its operational capabilities. At those times the municipality may choose to bring the contractor back in to update their system. The contractor may also promise in the working agreement to provide such updates as they become available. The agreement would stipulate whether or not any costs would be associated with such an upgrade.

Somewhere in the working agreement, it would be wise to include regular contractor involvement. Even if it is only once or twice a year, the contractor can come back to the municipality and sit down with the parties responsible for the database's maintenance and resolve any accrued issues. This time may also be a regularly scheduled training period to initiate any new employees to the system. Whatever the substance of the meetings, regular oversight by the contractor will aid the effectiveness of the municipality to run the asset management system by keeping everyone adequately trained and fixing any problems that may arise.

Another clause in the working agreement may deal with the responsiveness of the contractor to fix major problems should they arise or the contractor's availability to field technical support questions. Obviously, the municipality will want the contractor to fix any malfunction in the system within in a few days and such guarantees need to be present in the working agreement. Also, the guarantee may include a finite warranty, stating that any problems within the first several years will be fixed for free, but service charges may apply after that period expires. The availability of technical support staff by the contractor either through telephone or online may also be an issue for the municipality. The municipality should expect a certain amount of off-site trouble-shooting help to be available as part of the working agreement. Typically, similar services are free for the life of the product and that should be expected in the case of the asset management system.

Good communication and a sensible attention to long-term maintenance, training, and technical support in the working agreement will ensure smooth operation of the asset management system and benefit both parties. The contractor will get regular customer feedback to help improve the product. The municipality will get well trained and well supported employees who are proficient at using the asset management system to their benefit, complying with GASB 34 and improving their capital programming capabilities.

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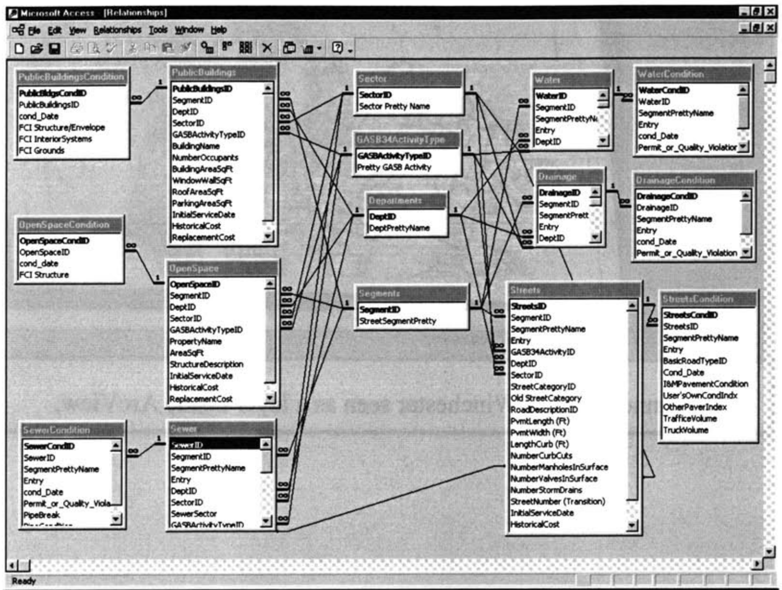
Means CostWorks 2002 [CD-ROM based software]. R.S. Means Company, Inc. 2002.

Messervy, Thomas S. "Deploying a GASB Compliant Asset Management Tool in Winchester, Massachusetts." Massachusetts Institute of Technology. 2002. pp. 12-17, 20-22.

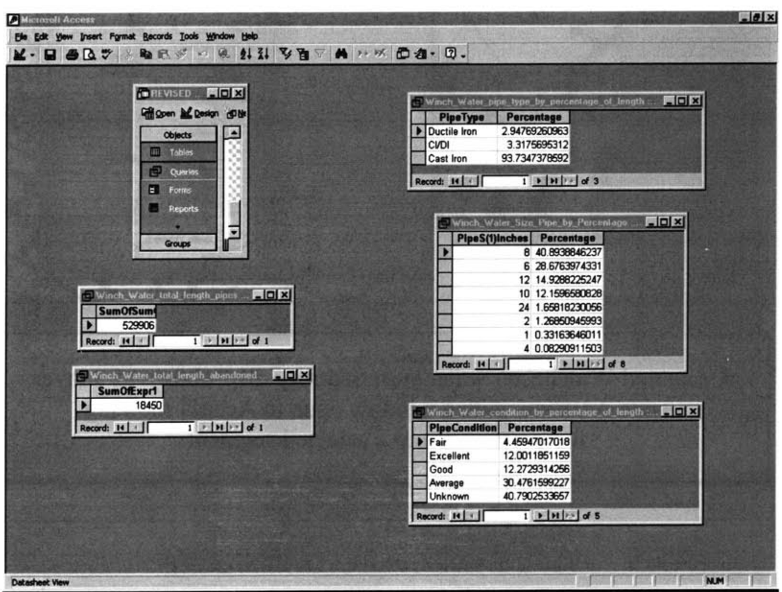
Special Provisions for the Construction of Roadways Including the Installation of Water, Sewer and Drains in the Town of Winchester. Town of Winchester Engineering Department [Departmental Book obtained February 20, 2002]. pp. 2-3, Fig. 21.

Appendices

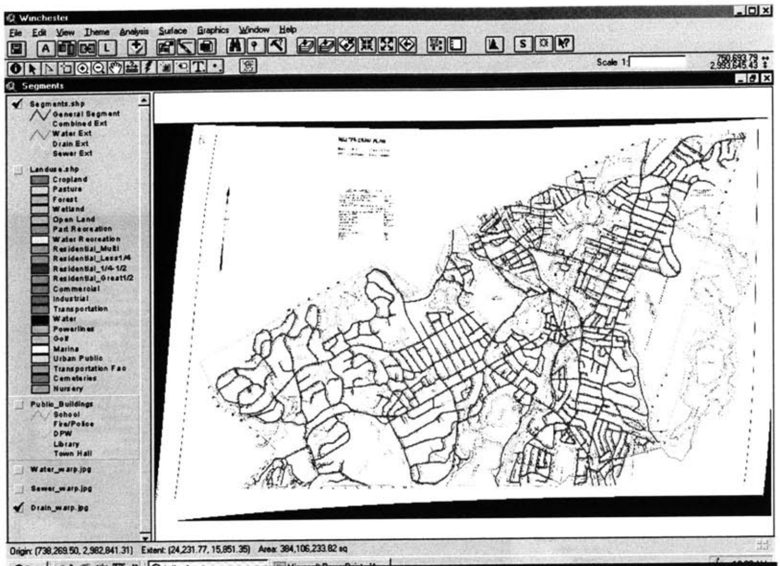
Appendix A – Database Sample Views



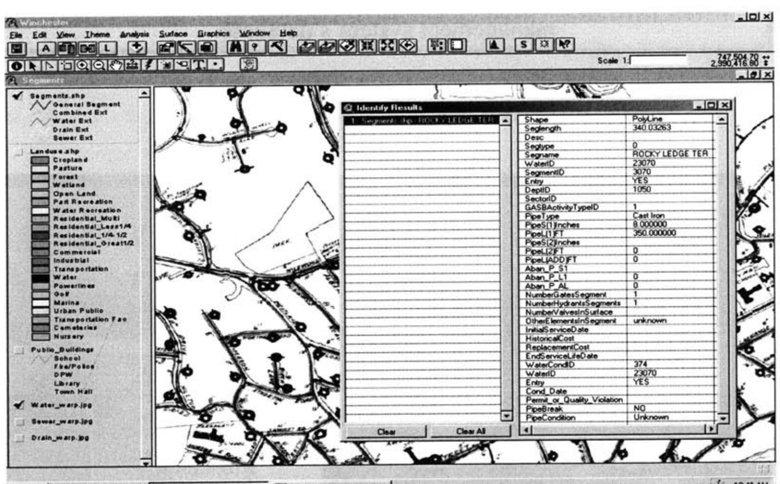
A view from Microsoft Access showing relationships in the asset management system's database.



A sample database query inside Access.



A scanned map of Winchester seen as a layer inside ArcView.



A scanned Winchester water system utility map, shown as a layer inside ArcView with a window open to Access showing information about a selected segment.

Appendix B – Winchester Collaboration Agreement
"SAMPLE AGREEMENT"

NO-COST Collaboration Agreement

Collaboration Agreement between **Massachusetts Institute of Technology**, 77 Massachusetts Ave., Cambridge, MA 02139, (hereafter referred to as "**M.I.T.**") and the Town of Winchester, Massachusetts (hereinafter referred to as "**Collaborator**"). This Agreement is entered into as of ________________ ("Effective Date").

Whereas, M.I.T. is conducting research in the area of the development and implementation of data based systems to report, monitor, and manage dispersed collections of infrastructure assets (such as road, water, and wastewater networks), hereinafter called the "Field" and is interested in gaining further knowledge to enhance its level of performance; and

Whereas, Collaborator possess certain knowledge and expertise in the Field which is of use to **M.I.T.**; and

Whereas, it is of benefit to **Collaborator** to exchange information with **M.I.T.** and to collaborate with **M.I.T.** in the Field;

Therefore, the parties hereto agree as follows:

1. Collaboration Coordinators. The **M.I.T.** coordinator for this Collaboration shall be John B. Miller. The **Collaborator's** coordinator for this Collaboration shall be Brian Sullivan, Town Manager, Town of Winchester, MA. Either party may change its named Coordinator upon notice to the other party.

2. Term of Agreement. The term of this Agreement will be for three years from the Effective Date. It will be subject to extension only by mutual written agreement of the parties.

3. Cost of Collaboration. Each party shall bear its own costs for participation under this **Collaboration Agreement.**

4. Exchange of Information, Materials, Computer Software, Use of Facilities. During the period of Collaboration it is anticipated that the parties may find it of benefit to exchange information, materials or computer software ("Exchanges") and to work together jointly at the facilities of either party for the purpose of improving performance capabilities within the Field. Exchanges which involve proprietary or confidential information belonging to either party shall comply with state and federal law and regulations and shall be governed by a separate agreement(s) between the parties. Such agreements will be attached hereto as Appendices. The failure to so attach will not relieve the parties from compliance with applicable laws and regulations. Exchanges which involve computer software shall be governed by a separate agreement(s) between the parties. The parties agree that information supplied by one party to the other during participation in this Collaboration will not be used for purposes other than those associated with the Collaboration unless permitted under separate written agreement.

5. Publications. **M.I.T.** will be free to publish the results of this Collaboration after providing **Collaborator** with a thirty (30) day period in which to review each publication for patent purposes and to identify any inadvertent disclosure of **Collaborator's** proprietary information.

6. Intellectual Property Rights.

6.1 Patents.

6.1.1 Title to any invention conceived or first actually reduced to practice by **M.I.T.**, its employees, consultants or students under this Collaboration shall remain with **M.I.T.** which shall have the sole right to determine the disposition of any inventions or other rights resulting there from, including the right to determine whether or not a patent application will be filed.

6.1.2 Title to any invention conceived or first actually reduced to practice by the **Collaborator** during the Collaboration shall remain with the **Collaborator**, provided that **M.I.T.** facilities have not been used in the conception or reduction to practice of such invention. The **Collaborator** shall have the sole right to determine the disposition of any inventions that it solely owns.

6.1.3 Title to any invention conceived or first actually reduced to practice by employees of both **M.I.T.** and the **Collaborator** and inventions made solely by the **Collaborator** with use of **M.I.T.** facilities shall be jointly owned. To the extent the **Collaborator** has an interest in acquiring exclusive rights to **M.I.T.'s** undivided interest in any jointly-owned invention, **M.I.T.** (subject to third party rights) agrees to negotiate in good faith to exclusively license the **Collaborator** on a royalty-bearing basis, taking into consideration the relative contributions of the parties.

6.2 Copyrights. Copyrightable works, including non-patented computer software, first created by the parties during this Collaboration will remain the property of the creating party. Each collaborating party will have the right to use the copyrightable work developed by the other for internal purposes related to this Collaboration. Any rights granted to one party for commercial exploitation of the other party's copyrights will be the subject of future negotiated agreements.

7. Use of Names. Neither party will use the name of the other in any advertising or other form of publicity without the written permission of the other, in the case of **M.I.T.**, that of the Director of the News Office.

8. Notices. Any notices required to be given or which shall be given under this Agreement shall be in writing delivered by first class mail addressed to the parties as follows:

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

John B. Miller
Room 1-172
MIT
77 Massachusetts Avenue
Cambridge, MA 02139-4307

COLLABORATOR

Mr. Brian Sullivan,
Town Manager
Winchester Town Hall
Mt. Vernon Street
Winchester, MA 01890

9. <u>Assignment</u>. This Agreement shall be binding upon and inure to the benefit of the parties hereto and the successors to substantially the entire business of a party to which this Agreement relates. This Agreement shall not be assignable by either party without the prior written consent of the other party; any attempted assignment is void.

10. <u>Governing Law</u>. The validity and interpretation of this Agreement and the legal relationship of the parties to it shall be governed by the laws of the Commonwealth of Massachusetts.

11. <u>Entire Agreement</u>. Unless otherwise specified, this Agreement embodies the entire understanding of **M.I.T.** and **Collaborator** for this Collaboration. Any prior or contemporaneous representations, either oral or written are hereby superseded. No amendments or changes to this Agreement shall be effective unless made in writing and signed by authorized representatives of the parties.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

By: ________________________

Title: ______________________

Date: ______________________

TOWN OF WINCHESTER

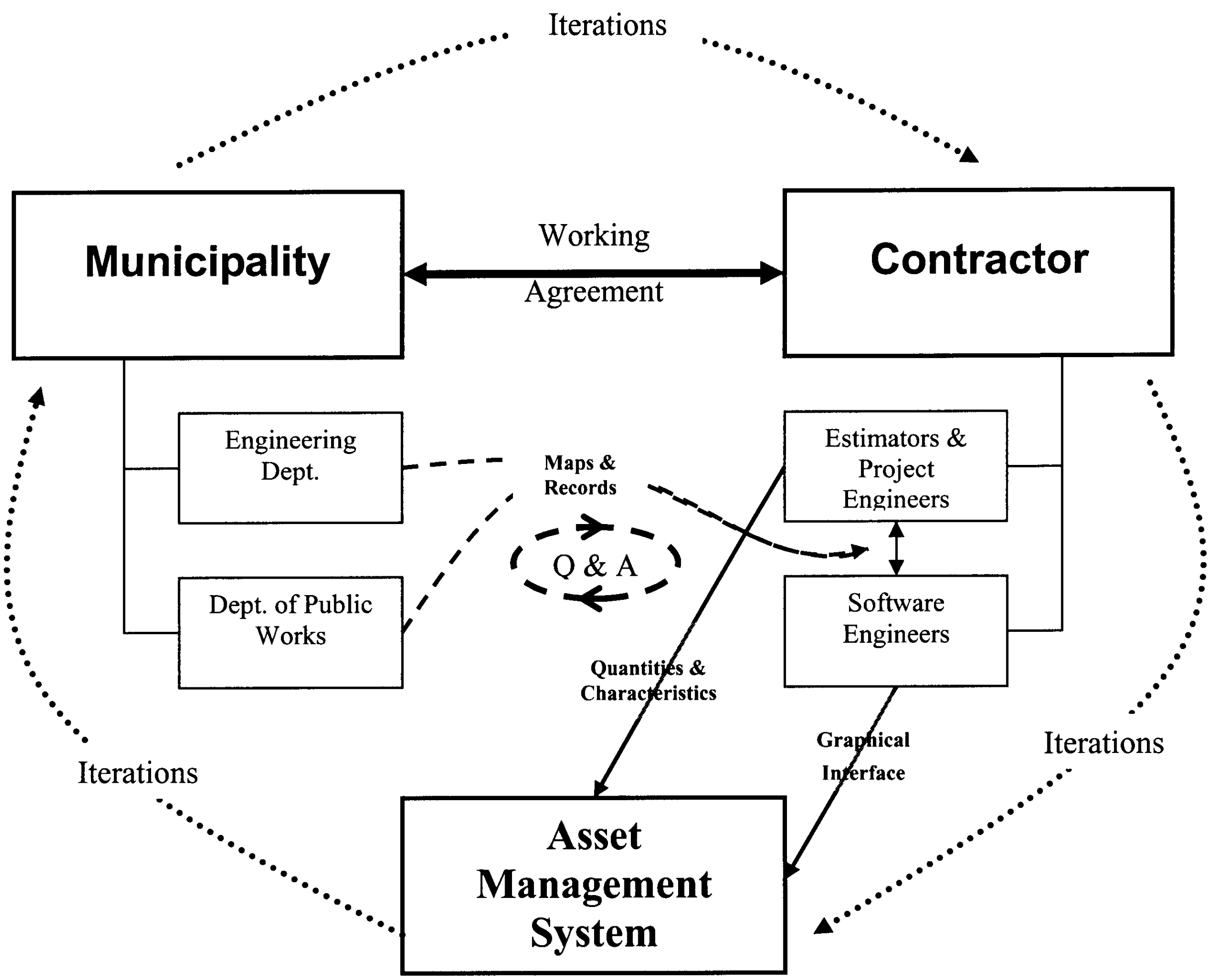
By: ________________________

Title: ______________________

Date: ______________________

Appendix C – Sample Project Organization Diagrams

1. During Implementation



2. During Operation and Maintenance