Deploying a GASB Compliant Asset Management Tool in Winchester, Massachusetts

By

Thomas S. Messervy

B.S., Civil and Environmental Engineering (2000)

The Citadel

Submitted to the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil and Environmental Engineering at the Massachusetts Institute of Technology

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Abstract

Governmental organizations often do not develop strategic plans for infrastructure maintenance and capital improvements. Infrastructure assets frequently receive a disproportionately small amount of a government’s budget. With a relatively modest amount of time and money, governments can develop strategic capital asset planning that can optimize how infrastructure assets and corresponding funding are handled. However, this is not usually the case and infrastructure maintenance is often neglected; often only top-priority projects are handled when funds become available. One important step in rectifying this process is to create an infrastructure asset inventory and condition evaluation database. Recent Governmental Accounting Standards Board (GASB) guidelines contained in Statement No. 34 have laid the foundation for this type of infrastructure inventory and condition assessment database, as well as increased spending accountability. A government’s access to capital markets through revenue bond sales may subsequently be based on this information. My research goal, in conjunction with the ISDR (Infrastructure Systems Development Research) group, was to implement and test a user-friendly, cost effective database program in the Town of Winchester, Massachusetts. This system allows governments to develop and maintain an accurate record of their infrastructure collections, as well as historical and estimated future activities and spending. Auxiliary applications include the integration of a visual interface tool utilizing a Geographic Information System (GIS) directly tied with the CHOICES software. These programs will allow governments to comply with GASB standards, while deploying an effective infrastructure maintenance and planning tool.

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

Introduction

The urgent need to develop and maintain a capital asset inventory is being realized in the United States, both in the public and private sectors. In most governmental organizations, there are only limited amounts of compiled information available on infrastructure assets such as water and sewer systems, roadways, and buildings. Furthermore, any information that is available is usually scattered and rarely integrated within larger, all-inclusive systems. The result is a major decrease in the ability of governments to accurately predict and properly allocate future spending as well as inefficient maintenance programs. Many organizations do not realize what assets or systems most need the available funding and therefore resources are often spent ineffectually. GASB has developed a new system of accounting guidelines contained in Statement No. 34 that, among other new practices, will advise governments to develop and maintain an inventory of infrastructure assets. In conjunction with this inventory, officials will have the option to depreciate these assets using standard practices as seen in the Generally Accepted Accounting Procedures (GAAP) or choose a newly developed modified approach. The modified approach requires periodical assessments of an asset’s condition and if the asset is maintained at the same general level, depreciation does not need to be calculated. By requiring a much more detailed inventory management system, governmental funding sources will be able to more appropriately determine how resources should be allocated. Failure to comply with these standards may result in future changes in funding or decreased bond ratings for the government.

The development of an adequate inventory and corresponding condition assessment for even a relatively small city can be more difficult than it may seem. Depending on the amount and condition of existing information, this process can be time and labor intensive. As seen in the Town of Winchester, located northwest of Boston, Massachusetts, the information is often not readily available and must be developed and organized from basic maps and records. As the information is obtained, it is compiled in a database format developed by Dr. Miller. The database format is divided into the major infrastructure systems such as water and roads. Each system is connected to the central database through the use of segments; these segments are based on the existing road network. The information contained in the database is compiled using queries that allow
the government to better understand the different characteristics of the system. Furthermore, the database is linked to a visual interface tool, ArcView, which allows the information to be graphically represented on the map of Winchester. Additional queries and compilations can be utilized in ArcView to facilitate efficient maintenance and strategic planning.

One possible progression of this tool is to develop applications that will facilitate the input of this information into the “CHOICES” software developed by Dr. Miller and the ISDR research team. The program develops various financial and planning scenarios for the maintenance and upgrading of the infrastructure allowing the most advantageous choice to be selected and then optimized based upon the town’s needs and abilities.
Chapter Two

Project Delivery Methods and the ABA 2000 Model Procurement Code

The delivery method primarily relied upon since WW II for public infrastructure projects has been design-bid-build. The predominance of this delivery method has led to the tailoring of the procurement process to streamline this method. Unfortunately, the shaping of the system has increased the difficulty of using different, but more effective delivery methods. Recent developments in delivery methods allow owners a choice in how to balance value in infrastructure quality, technology, service, and price. As these methods emerge, an optimal planning strategy will consider all delivery methods to better facilitate effective infrastructure acquisition and sustainment. Miller (1997) suggests a new discipline “Engineering Systems Integration” that treats project delivery and finance methods as variables to be managed in the infrastructure development process, rather than as constants that engineers and planners have no control over. The engineering systems integrator focuses on optimizing the project delivery and finance configuration at both project and system levels.

The 2000 revisions of the 1979 ABA Code will allow government organizations to more effectively manage their respective portfolio of infrastructure assets. The guidelines allow simultaneous consideration of multiple project delivery methods in configuring a collection of infrastructure projects. Additional objectives of the revisions are to (1) reduce transaction costs for all government entities at the state and local levels, (2) reduce transaction costs to private suppliers of goods and services, (3) substantially increase the spectrum of competition through modern means such as electronic communications, and (4) encourage the use of new technologies and means of performing.

The revised code defines five new delivery methods besides the design-bid-build method found in the 1979 code. The addition of the design-build, design-build-finance-maintain, design-build-operate-maintain, and operations and maintenance delivery
methods allow for added flexibility and potential efficiency increases in asset management.

The following chart shows how a typical project schedule can vary with the selection of different project delivery methods. These time savings can produce lower overall project costs for the governmental owner and earlier usage of the infrastructure asset being constructed.

<table>
<thead>
<tr>
<th>Quarter</th>
<th>DBB</th>
<th>DB</th>
<th>DBO</th>
<th>DBFO (BOT)</th>
</tr>
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<tbody>
<tr>
<td>2</td>
<td>Project Viability</td>
<td>Project Viability</td>
<td>Project Viability</td>
<td>Project Viability</td>
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<tr>
<td>3</td>
<td>Project Advertising</td>
<td>Project Advertising</td>
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<tr>
<td>4</td>
<td>Design Competition</td>
<td>Design Build Competition</td>
<td>Permitting</td>
<td>Permitting</td>
</tr>
<tr>
<td>5</td>
<td>Complete Design</td>
<td>Single Competition 30% Design</td>
<td>Finish Design</td>
<td>Finish Design</td>
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<tr>
<td>6</td>
<td>Permitting</td>
<td>Permitting</td>
<td>Construction</td>
<td>Construction</td>
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<tr>
<td>7</td>
<td>Construction Competition</td>
<td>Construction</td>
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<td>8</td>
<td>Construction</td>
<td>Operations</td>
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</tbody>
</table>

Chart from Principles of Public and Private Infrastructure Delivery, John Miller. Pg. 59

The impacts of these new regulations are very significant to governmental organizations. In previous decades, governments were forced to finance their capital improvements through the use of accrued resources or by taking on debt. With the financing flexibility described in the 2000 Code, governments can organize for private companies to finance and operate the asset utilizing user fees as compensation for the designer/constructor's services. Furthermore, governments can facilitate faster schedules and decreased costs with the new project delivery methods. Although the public sector implementation of these methods is still relatively new, there are completed projects that have manifested these time and cost saving opportunities.
The following two illustrations compare the net present value of a hypothetical highway grade separation project. An assumed project cost of $1 million using the design-bid-build (DBB) method and an annual public benefit of $500,000 are used for this example. For comparison, a constant time period of 15 years is used to analyze the DBB method and Design-Build-Finance-Operate (DBFO) method. This simplified example manifests the possible savings in utilizing different project delivery methods. The NPV, from the government owner’s perspective, of the DBB project is $853,000 compared to an NPV of $2,711,000 for the DBFO project.

<table>
<thead>
<tr>
<th>Project Delivery Method</th>
<th>DB</th>
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</thead>
<tbody>
<tr>
<td>Year</td>
<td>0</td>
</tr>
<tr>
<td>Cash Flow in Year ($)</td>
<td>C0</td>
</tr>
<tr>
<td>&quot;Public Benefit&quot;</td>
<td>500</td>
</tr>
<tr>
<td>Present Value (Year)</td>
<td>-20</td>
</tr>
<tr>
<td>Net Present Value</td>
<td>853</td>
</tr>
</tbody>
</table>

Chart from Principles of Public and Private Infrastructure Delivery. John Miller. Pg. 61

<table>
<thead>
<tr>
<th>Project Delivery Method</th>
<th>DBFO</th>
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</thead>
<tbody>
<tr>
<td>Year</td>
<td>0</td>
</tr>
<tr>
<td>Cash Flow in Year ($)</td>
<td>C0</td>
</tr>
<tr>
<td>Initial Capital Expense</td>
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<tr>
<td>Operating Expense</td>
<td>0</td>
</tr>
<tr>
<td>&quot;Public Benefit&quot;</td>
<td>500</td>
</tr>
<tr>
<td>Present Value (Year)</td>
<td>-20</td>
</tr>
<tr>
<td>Net Present Value</td>
<td>2711</td>
</tr>
</tbody>
</table>

Chart from Principles of Public and Private Infrastructure Delivery. John Miller. Pg. 62

Infrastructure Evaluation of Selected Cities

The town of Cranston, Rhode Island is similar to many small towns in the United States. As explained in Miller’s book, Principles of Public and Private Infrastructure, the budget for infrastructure asset management is minimal and there is a general absence of
an effective long-term planning mechanism. Cranston has negligible finances available for major new construction or improvements for capital assets. The city's historical strategy has been to completely rely on state or federal funding for major repairs. However, in September 1997, the city made a dramatic step that resulted in an improved infrastructure portfolio. A contract was made with Triton Ocean State, L.L.C. for a 25 year Design-Build-Operate contract on a wastewater treatment facility. The contract produced an immediately positive $78 million improvement in Cranston’s cash position. These savings can be used to improve other areas of the town’s infrastructure and can be used as an example for other governments to follow.

In a study performed by Garvin et al (1999) on the City of Medford, Massachusetts, it was discovered that decaying assets, municipal constraints, and funding shortfalls have created intense capital infrastructure requirements. A cash flow analysis manifested the difficulties faced by city planners and engineers. Most accounting methods do not support capital decision making, so useful conclusions for future planning are difficult to make. The available federal and state infrastructure funding is dependent on erratic annual budgetary requirements and competing legislation. The result is the historical inability of local governments to predict state or federal funding allocations. The available financial support often has inherent restrictions on how the money is used, which in-turn limits governments’ ability to utilize new, cost-effective project delivery methods.

Current Management and Reporting Practices

Governmental organizations often have large, segregated sections of information on various infrastructure assets. This “information” is often either hand-written or in an unusable typewriter or outdated computer programming format. In the Town of Winchester, an Excel (Version 97) street database exists, but steps have not been taken to keep the information current. The respective manager often has a general knowledge of the conditions, but may not feel they have the time, nor see the benefits of continually updating the inventory list.

In previous years, when governments needed to develop a database, they often chose to outsource the entire task. Two problems can result from this type of outsourcing.
The database is usually given in a format that the organization does not have the capability to maintain or utilize to capacity. The database may not be well tailored to the specific needs of the government. Furthermore, there is often an extremely high level of detail reported. Although this level of data may be beneficial in specialized applications, the amount of data makes database sustainability nearly impossible. Without sustainability, an optimal capital budgeting program will never exist because the data will become outdated. Citizens and leaders who assume a planning role are often overwhelmed by the intricate details and lose sight of the central issues that need to be thoroughly examined. Conversely, if the level of information contained in the database is too broad, beneficial maintenance and planning information will be difficult to compile.

The current manner of most governmental budgeting techniques is flawed from the perspective of capital asset management. An examination of budget funding percentages manifests that a disproportionately small amount of money is delegated for capital asset maintenance. The availability of funding for capital asset improvements is often even sparser. Local entities, such as the Winchester Department of Public Works, who are responsible for the maintenance of the sewer, water, and storm systems often have to depend on federal and state funding for the vast majority of their resources. The top priority jobs are handled first. The relative priority of jobs is often not congruous with a well-developed, long-term infrastructure maintenance plan. In any town, repairs need to be made for emergency breaks and other unpredictable occurrences. Unfortunately, other resources are allocated based on resident input and pressure, not by what is beneficial to the overall sustainment and improvement of the entire system. Necessary scheduled maintenance is often neglected until the following years when funding becomes available. Neither the town governments, nor the state or federal governments, currently have a complete understanding of what funds are needed to effectively maintain, and upgrade when necessary, the vast collection of infrastructure assets. Current city planners and engineers are often limited in regards to available information to aid in infrastructure planning. The most commonly seen forms of available information are historical accounting and budgeting data. Current practices require only summary accounts of expenses to be reported. It is often difficult or impossible to determine where the resources were allocated or what results were accomplished through this outlay. Slightly
more detailed accounts are available for Enterprise Funds (water and sewer) where user fees assist in covering the operating expenses. However, these accounting records do not supply sufficient detail to develop information as to where resources were allocated or what particular results obtained. The key components needed for effective present and future operations and maintenance are condition assessments, planning, financing, and acquisition data, which are often not available. Studies conducted by Wooldridge et al (1999) suggest that the common usage of cash-basis accounting, line-item budgeting, and lack of cost accounting do not support the capital planning process. Only in recent years have developments emerged that will result in the production of useful planning information.7 A major step in the direction towards accountability of government spending is through GASB Statement No. 34. These directives have the potential to dramatically increase the efficiency of infrastructure management.

Governmental Accounting Standards Board-Statement No. 34

Background

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. Furthermore, these guidelines can help to educate the public, including issuers and auditors, about the actions of the government.8 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 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. The sections pertaining to handling of infrastructure assets are only one portion of a larger set of guidelines and suggested changes.
GASB believes these new guidelines will help users:

- "Assess the finances of the government in its entirety, including the year’s operating results"
- *Determine whether the government’s overall financial position improved or deteriorated*
- *Evaluate whether the government’s current-year revenues were sufficient to pay for current-year services*
- *See the cost of providing services to its citizenry*
- *See how the government finances its programs-through user fees and other program revenues versus general tax revenues*
- *Understand the extent to which the government has invested in capital assets, including roads, bridges, and other infrastructure assets*
- *Make better comparisons between governments*

**Purpose**

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 portfolio has not 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.
Effective Dates

GASB has developed a tiered implementation schedule for governments based on their total annual revenues:\(^\text{10}\)

<table>
<thead>
<tr>
<th>GASB Classification</th>
<th>Total Annual Revenues ($)</th>
<th>Implementation for periods after:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1 Government</td>
<td>Revenues &gt; 100 million</td>
<td>15-Jun-01</td>
</tr>
<tr>
<td>Phase 2 Government</td>
<td>100 million &gt; Revenues &gt; 10 million</td>
<td>15-Jun-02</td>
</tr>
<tr>
<td>Phase 3 Government</td>
<td>10 million &gt; Revenues</td>
<td>15-Jun-03</td>
</tr>
</tbody>
</table>

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.

General Requirements

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).
The following GASB diagram illustrates the informational structure developed for governmental accounting through Statement No. 34:

Two Acceptable Approaches: A Major Decision Point

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 following chart illustrates how to allocate infrastructure costs under GASB Statement No. 34:11

<table>
<thead>
<tr>
<th>Type of Cost</th>
<th>How to Allocate Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance Costs</td>
<td>Modified Approach: Expense</td>
</tr>
<tr>
<td></td>
<td>Standard Approach (Depreciation): Expense</td>
</tr>
<tr>
<td>Preservation Costs</td>
<td>Modified Approach: Expense</td>
</tr>
<tr>
<td></td>
<td>Standard Approach (Depreciation): Capitalize</td>
</tr>
<tr>
<td>Additions and Improvements</td>
<td>Modified Approach: Capitalize</td>
</tr>
<tr>
<td></td>
<td>Standard Approach (Depreciation): Capitalize</td>
</tr>
</tbody>
</table>

**Standard Approach**

The standard approach for reporting governmental assets utilizes GAAP 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.12

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. The actual implications of this scenario will need to be reexamined in the future.

**Modified Approach**

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.13

An acceptable system should:

1. Maintain a current inventory of eligible infrastructure assets
2. Perform condition assessments on assets at least every three years and summarize the results using a measurement scale
3. Estimate the annual amount to maintain and preserve the eligible infrastructure assets at the condition level established and disclosed by the government
4. Maintain auditable expense records on each asset
Chapter Three The Hypothesis

A Proposed Solution

The next ten years will be a critical time in determining the direction in which infrastructure management proceeds. The guidelines set forth in Statement No. 34 can serve as a catalyst for governments to change the way they account for their infrastructure and related expenses and revenues. GASB has adopted a new paradigm for facilitating accountability in governmental operations and spending patterns. Historically, governmental policy agencies have often utilized a “command and control” philosophy that would describe to governments a specific way of managing and reporting on their infrastructure assets. If the guidelines were not followed, governmental actions were often taken to penalize the particular group. Statement No. 34 describes what type of information and actions are desired. The specific method or means in which a government should comply with GASB is not specified. A variety of different methods will be taken to meet these objectives. Failure to comply may result in a decreased ability for a government to access capital markets through revenue bond sales. The ideal response would have governmental organizations implementing a system for GASB compliance that simultaneously provides a basis for dramatic improvements in maintenance, operations, and strategic planning.

As viewed by Porter in The Competitive Advantage of Nations, GASB is acting as the governmental body to influence the actions of state and local governments. These new requirements have the potential for producing dramatic improvements in governmental operations. The relationship between the federal government, as manifested by Statement No. 34, and state and local governments is generally balanced to facilitate results, but not overly restrictive to produce a negative outcome.14

The goal of my efforts on the ISDR team at MIT was to test and critique a model database decision support system in the Town of Winchester, Massachusetts. A database system developed by Professor Miller was to be tested as a potential approach to manage the town’s portfolio of infrastructure assets. The assets were broken into six primary divisions: streets, storm system, water system, sewer system, public buildings, and town
owned open spaces. The completed system, if successfully tested and implemented, will facilitate compliance with GASB standards and supply managers and planners with the information needed to produce alternative, viable portfolio management scenarios for discussion, debate, and selection by the Town. The goal of this research is to establish that a common approach can be extended from Winchester to governments across the country. Inherent in this effort is the availability of the project delivery and project finance methods of the ABA 2000 Model Procurement Code.

**Possible Outcomes**

When developing and testing a new system to implement in public organizations, the range of results can be very diverse. The optimal result would be for governments to implement a system that will facilitate GASB compliance and strategic planning. Unfortunately, this will not always be the case. Almost all governmental organizations consider themselves to be under strong fiscal pressures. Government bodies will often be hesitant of granting current resources for promised future benefits. In this case, governments will make the choice whether to develop a system or procedure to obtain the minimum requirements for GASB or implement a system that can aid in many different facets of infrastructure operations. Many governments will take an approach somewhere in between. A solution that only allows minimum compliance will provide some benefits, but far less than are obtainable with only a minor incremental increase in time and cost.

Governments, like many organizations, are examples of inertia in that change can be very difficult. Since the federal government is requiring some change, this is an ideal time to make significant steps to improve the overall infrastructure management process. If this opportunity is not utilized, it will be exponentially more difficult to implement a new system once a government has already begun to use a basic compliance tool. Through a successful demonstration in a town such as Winchester, the research team has the potential to share the resources with other willing governmental bodies.
Chapter Four

Background

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.15

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 precinct 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.16

In the year 2000, the Selectmen decided to appoint a FACTS 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 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."17
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.¹⁸

*Winchester’s Infrastructure Portfolio*

**Public Works (DPW)**

The Department of Public Works 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 on 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 2000.¹⁹ 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.

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.²⁰ 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.

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. 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, 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 a year on its roads and sidewalks. The 5-year historical average
for Chapter 90 funds is approximately $240,000 per year.21

Winchester Owned Buildings

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.
Chapter Five Testing the Model Database

Objective

The development and implementation of a multiple user, database management system will serve a dual role: (1) to fulfill all GASB standards given in Statement No. 34 and (2) to serve as an effective tool in organizational capital infrastructure asset planning and maintenance. The database will join the many different organizations within a local government to maintain and compile current data. A town manager or mayor may access the data for a selected organization at the desired level of detail. An easily accessible common database will serve to integrate the presently segregated divisions of a town’s operating structure.

Benefits of this Database Format

Current practices for capital asset management are inefficient and ineffective. A major transformation must occur or governmental organizations will defer the maintenance and upgrading of these assets until they develop into insurmountable financial obstacles. As expected, life-cycle cost analyses demonstrate that regular maintenance will extend the life of an infrastructure asset, as well as reducing overall cost to the government. The new GASB requirements have rendered this complete postponement much more difficult and costly.

The database software will be user-friendly for data access, continual updates, and any necessary modifications or system additions. Individual entities will input their respective data in a level of detail that is useful in planning, but not overly detailed rendering the database time or labor prohibitive to maintain. The database will allow governmental officials to view accurate estimates of upcoming repair, maintenance, and replacement costs based on prior cost records.

The use of this database will offer a low-cost alternative to hiring external consultants for original database development and planning assistance. Government officials can utilize past expense data to benchmark and establish reliable estimates of future obligations. Often governments do not have access to accurate records of historical
spending. In this case, government officials should estimate their costs and these preliminary estimates will be improved upon as additional information becomes available.

**Scalable**

The database model will have two major benefits that distinguish it from current systems utilized by many governments. The system will have a fundamental format that can be expanded as needed to meet the needs of any size government or private entities focusing on asset management. The only variables that will change are the individual assets and the corresponding data.

Additionally, the database will be based on a multiple user interface. Each governmental organization, such as the transportation department, will input their respective data into the system. The information will then be aggregated into a government-wide database. Each organization or town leader can have access to the desired level of information from other departments. For planning purposes, the information can be sorted to the desired configuration to optimize planning functions.

**Development of Database Structure**

The database structure developed by Dr. Miller for testing in Winchester is based on a layered format (See Database Graphic One). The basis of this format is to spatially link each infrastructure asset to a specific segment. These segments are defined as centerlines of the existing roadways. (Further explanation of how segments are defined can be found in Chapter Six.)

The layered format allows for all of the information on a particular infrastructure system to be contained in a grouping of tables. Each table has information on only one infrastructure system, such as the water distribution or road network. The database structure is designed to focus only upon that information which would be useful in obtaining the desired objectives of GASB compliance and strategic planning and maintenance. The May 2001 version of the test database can be seen in Database Graphic Two. In this version, all maintenance and repair records were kept in the same table for the entire infrastructure collection. In order to ease overall use and data processing, tables
for maintenance and repair records were developed for each infrastructure system. The September 2001 version of the test database can be seen in Database Graphic Three. The tables (from September 2001 version) associated with each particular infrastructure system can be seen in Database Graphic Four- Database Graphic Nine.

Dr. Miller supplied the September 2001 version of the test database for use by the research team. The database was used for research during implementation in the Town of Winchester.
Database Graphic One:
The following diagram represents the layered approach used in developing the database model.
Database Graphic Two
System Relationships
Street Relationships
Water Relationships
Utilization of Queries to Access and Organize GASB 34 Compliance Data

Along with the challenging task of researching the asset inventory and its condition, is the need to design additional database and ArcView tools to make the database as useful as possible. One of the driving goals is to develop a tool that will enable the town to comply with GASB Statement #34 standards. The effective use of standardized queries will allow the effortless compilation of data. Varying degrees of consolidation can be designed to show relevant data to each department or town manager. Queries will show different cost and maintenance trends, as well as individual and system condition assessments. Furthermore, as historical data is accumulated, future spending can be more accurately estimated. A preliminary set of possible queries was presented during the meeting with a request for the Winchester officials to make any comments about how these queries could become more helpful. Ideas on additional queries that would help the town were also requested.

With the information available about the water infrastructure in Winchester, queries were developed in order to give town officials an accurate description of the system characteristics. When developing these queries, it is important to ensure that the application is dynamic. In other words, their needs to be an active connection with the database so that when the information in the database is modified or improved, the queries will reflect these alterations. Intermediary queries are set up in order to obtain the desired values, lengths, and percentages. Examples of queries that were developed are total length of pipe in the system, condition of pipe by percentage of total length, and diameter of pipe by percentage of total length. (See Query Graphic One for examples of queries performed on the water system of Winchester.) These queries will allow government employees and managers to better understand the current system utilizing previously unavailable methods. Certain information, that can be compiled using queries, relating to condition and expenses will be required of every town in order to comply with GASB standards. Other queries will be helpful for town planners and managers to improve maintenance and strategic planning. Furthermore, once the database has been implemented, a municipality can tailor the queries to their specific needs. Additionally, queries serve as an effective tool to summarize data so a town manager may examine the
aggregated data and does not have to spend the time and labor to decipher the larger picture through individual segment information. Query Graphic Two and Query Graphic Three illustrate GASB compliance information that can be compiled through database queries.
<table>
<thead>
<tr>
<th>Pipe Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductile Iron</td>
<td>2.9476926096</td>
</tr>
<tr>
<td>CV/CI</td>
<td>3.3175695312</td>
</tr>
<tr>
<td>Cast Iron</td>
<td>93.7347378592</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pipe Size (Inches)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>40.8938846237</td>
</tr>
<tr>
<td>6</td>
<td>26.6763974331</td>
</tr>
<tr>
<td>12</td>
<td>14.9288225247</td>
</tr>
<tr>
<td>10</td>
<td>12.1596580828</td>
</tr>
<tr>
<td>24</td>
<td>1.66818230066</td>
</tr>
<tr>
<td>2</td>
<td>1.26650945993</td>
</tr>
<tr>
<td>1</td>
<td>0.33163464011</td>
</tr>
<tr>
<td>4</td>
<td>0.08290911503</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pipe Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td>4.45947017018</td>
</tr>
<tr>
<td>Excellent</td>
<td>12.011851159</td>
</tr>
<tr>
<td>Good</td>
<td>12.2739314266</td>
</tr>
<tr>
<td>Average</td>
<td>30.4761599227</td>
</tr>
<tr>
<td>Unknown</td>
<td>40.7902533657</td>
</tr>
</tbody>
</table>
Query Graphic Two

The following chart illustrates a portion of the required information for government’s utilizing the modified approach to reporting infrastructure assets. Governments are required to determine the condition of their infrastructure collection, as well as compare estimated needs for maintenance/preservation costs vs. the actual amount utilized. Queries in the database software will produce this information with minimal effort. In the Town of Winchester, partial condition data is available and when budgetary information becomes available from government officials, similar charts can be developed.

### Condition Rating of the City’s Street System

<table>
<thead>
<tr>
<th>Percentage of Lane-Miles in Good or Better Condition</th>
<th>2002</th>
<th>2001</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main arterial</td>
<td>93.2%</td>
<td>91.5%</td>
<td>92.0%</td>
</tr>
<tr>
<td>Arterial</td>
<td>85.2%</td>
<td>81.6%</td>
<td>84.3%</td>
</tr>
<tr>
<td>Secondary</td>
<td>87.2%</td>
<td>84.5%</td>
<td>86.8%</td>
</tr>
<tr>
<td>Overall system</td>
<td>87.0%</td>
<td>85.5%</td>
<td>87.3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage of Lane-Miles in Substandard Condition</th>
<th>2002</th>
<th>2001</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main arterial</td>
<td>1.7%</td>
<td>2.6%</td>
<td>3.1%</td>
</tr>
<tr>
<td>Arterial</td>
<td>3.5%</td>
<td>6.4%</td>
<td>5.9%</td>
</tr>
<tr>
<td>Secondary</td>
<td>2.1%</td>
<td>3.4%</td>
<td>3.8%</td>
</tr>
<tr>
<td>Overall system</td>
<td>2.2%</td>
<td>3.6%</td>
<td>3.9%</td>
</tr>
</tbody>
</table>

### Comparison of Needed-to-Actual Maintenance/Preservation (in Thousands)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Needed</td>
<td>$2,476</td>
<td>$2,342</td>
<td>$2,558</td>
<td>$2,401</td>
<td>$2,145</td>
</tr>
<tr>
<td>Actual</td>
<td>2,601</td>
<td>2,552</td>
<td>2,412</td>
<td>2,279</td>
<td>2,271</td>
</tr>
<tr>
<td>Arterial:</td>
<td>1,485</td>
<td>1,425</td>
<td>1,535</td>
<td>1,441</td>
<td>1,287</td>
</tr>
<tr>
<td>Needed</td>
<td>1,560</td>
<td>1,531</td>
<td>1,499</td>
<td>1,367</td>
<td>1,362</td>
</tr>
<tr>
<td>Actual</td>
<td>1,040</td>
<td>1,021</td>
<td>1,023</td>
<td>960</td>
<td>858</td>
</tr>
<tr>
<td>Secondary:</td>
<td>990</td>
<td>937</td>
<td>1,023</td>
<td>960</td>
<td>968</td>
</tr>
<tr>
<td>Needed</td>
<td>1,040</td>
<td>1,021</td>
<td>1,023</td>
<td>960</td>
<td>968</td>
</tr>
<tr>
<td>Actual</td>
<td>990</td>
<td>937</td>
<td>1,023</td>
<td>960</td>
<td>968</td>
</tr>
<tr>
<td>Overall system:</td>
<td>4,931</td>
<td>4,684</td>
<td>5,116</td>
<td>4,802</td>
<td>4,290</td>
</tr>
<tr>
<td>Needed</td>
<td>5,201</td>
<td>5,104</td>
<td>4,863</td>
<td>4,557</td>
<td>4,541</td>
</tr>
<tr>
<td>Actual</td>
<td>250</td>
<td>420</td>
<td>(253)</td>
<td>(245)</td>
<td>251</td>
</tr>
</tbody>
</table>

Note: The condition of road pavement is measured using the XYZ pavement management system, which is based on a weighted average of six distress factors found in pavement surfaces. The XYZ pavement management system uses a measurement scale that is based on a condition index ranging from zero for a failed pavement to 100 for a pavement in perfect condition. The condition index is used to classify roads in good or better condition (70-100), fair condition (50-69), and substandard condition (less than 50). It is the City’s policy to maintain at least 85 percent of its street system at a good or better condition level. No more than 10 percent should be in a substandard condition. Condition assessments are determined every year.

(Chart from “Primer: GASB 34. A FHWA Primer on the Governmental Accounting Standard’s Board’s Statement 34: Basic Financial Statements-and Management’s Discussion and Analysis- for State and Local Governments”. U.S. Department of Transportation, Office of Asset Management. November 2000. pg. 44)
Query Graphic Three

The following chart illustrates additional information required under GASB guidelines. Each government will need to value their infrastructure assets and document any changes in those values that occur from additions or retirements of the respective infrastructure system. The second section of this chart contains information required under the standard approach which utilizes depreciation. Assets that are not maintained at an auditable condition level (as seen in the modified approach) must be depreciated. As a valuation of Winchester’s infrastructure becomes available, database queries can compile these figures. As additions or retirements are made, respective entries will be inputted into the database and running the appropriate query can retrieve the required GASB information.

Capital asset activity for the year ended December 31, 2002 was as follow (in thousands):

<table>
<thead>
<tr>
<th>Governmental activities:</th>
<th>Beginning Balance</th>
<th>Additions</th>
<th>Retirements</th>
<th>Ending Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>$ 29,484</td>
<td>$ 2,020</td>
<td>(4,358)</td>
<td>$ 27,146</td>
</tr>
<tr>
<td>Buildings and improvements</td>
<td>40,861</td>
<td>334</td>
<td></td>
<td>41,195</td>
</tr>
<tr>
<td>Equipment</td>
<td>32,110</td>
<td>1,544</td>
<td>(1,514)</td>
<td>32,140</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>94,575</td>
<td>13,220</td>
<td></td>
<td>107,795</td>
</tr>
<tr>
<td>Totals at historical cost</td>
<td>197,030</td>
<td>17,118</td>
<td>(5,872)</td>
<td>208,276</td>
</tr>
<tr>
<td>Less accumulated depreciation for:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buildings and improvements</td>
<td>(10,358)</td>
<td>(691)</td>
<td></td>
<td>(11,049)</td>
</tr>
<tr>
<td>Equipment</td>
<td>(9,247)</td>
<td>(2,676)</td>
<td>1,040</td>
<td>(10,883)</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>(15,301)</td>
<td>(1,020)</td>
<td></td>
<td>(16,321)</td>
</tr>
<tr>
<td>Total accumulated depreciation for:</td>
<td></td>
<td></td>
<td></td>
<td>(38,253)</td>
</tr>
<tr>
<td>Governmental activities capital assets, net</td>
<td>$ 162,124</td>
<td>$ 12,731</td>
<td>(4,832)</td>
<td>$ 170,023</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Business-type activities:</th>
<th>Beginning Balance</th>
<th>Additions</th>
<th>Retirements</th>
<th>Ending Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>$ 3,691</td>
<td>$ 145</td>
<td></td>
<td>$ 3,836</td>
</tr>
<tr>
<td>Distribution and collection systems</td>
<td>36,977</td>
<td>2,527</td>
<td></td>
<td>39,504</td>
</tr>
<tr>
<td>Buildings and equipment</td>
<td>126,370</td>
<td>2,827</td>
<td>(32)</td>
<td>129,165</td>
</tr>
<tr>
<td>Totals at historical cost</td>
<td>167,038</td>
<td>5,499</td>
<td>(32)</td>
<td>172,505</td>
</tr>
<tr>
<td>Less accumulated depreciation for:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution and collection systems</td>
<td>(7,654)</td>
<td>(897)</td>
<td></td>
<td>(8,551)</td>
</tr>
<tr>
<td>Buildings and equipment</td>
<td>(11,789)</td>
<td>(808)</td>
<td>32</td>
<td>(12,565)</td>
</tr>
<tr>
<td>Business-type activities capital assets, net</td>
<td>$ 147,595</td>
<td>$ 3,794</td>
<td>0</td>
<td>$ 151,389</td>
</tr>
</tbody>
</table>

*Depreciation expense was charged to governmental functions as follows:

<table>
<thead>
<tr>
<th>Function</th>
<th>Depreciation Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>General government</td>
<td>$ 275</td>
</tr>
<tr>
<td>Public safety</td>
<td>330</td>
</tr>
<tr>
<td>Public works, which includes the depreciation of general infrastructure assets</td>
<td>1,315</td>
</tr>
<tr>
<td>Health and sanitation</td>
<td>625</td>
</tr>
<tr>
<td>Cemetery</td>
<td>29</td>
</tr>
<tr>
<td>Culture and recreation</td>
<td>65</td>
</tr>
<tr>
<td>Community development</td>
<td>40</td>
</tr>
<tr>
<td>In addition, depreciation on capital assets held by the City's internal service funds (see D-3) is charged to the various functions based on their usage of the assets</td>
<td>1,708</td>
</tr>
<tr>
<td>Total depreciation expense</td>
<td>$ 4,387</td>
</tr>
</tbody>
</table>

Chapter Six Implementation In Winchester

Model Implementation

As research and development continued and a suitable model database had been developed, it was important to implement the database in an experimental setting. Through this testing process, the database can be modified, if necessary, to optimize the database program. When determining which government to conduct this experiment with, a few factors must be considered. The size of the town or city you wish to target should be congruent with the research objectives. A very small town may be overly basic and potential problems may not be realized. Conversely, a large city will have an extremely complex infrastructure and the effort required to implement this type of system might be time and labor prohibitive from a research perspective. An additional factor to be considered is the willingness and determination of the government officials to participate in this study. Without their assistance, infrastructure inventory and condition assessment can be extremely difficult. Supplemental information such as historical cost and spending information will be nearly impossible to research without governmental assistance.

The selection of the Town of Winchester, MA was fairly simple. The research advisor, Dr. Miller, is a resident and active participant in infrastructure operations in Winchester. This established relationship facilitated a beneficial research partnership. The degree of Winchester’s willingness to assist our research needs has been directly proportional to the success of the project. Without their assistance, the team would not have been able to accomplish its goals.

Segment Definition

Segments serve as the base reference point for all of the infrastructure systems contained in the database. Therefore, one of the fundamental decisions is how the base segments are defined. The primary identifier, or key, is the current road network. Applicable information on each of the other systems, such as water or sewer, is referenced to a particular segment of road in which the pipe lies underneath. The team was faced with the decision of whether or not to divide the segments wherever a road intersected another road. A consensus was met that the most effective utilization of the
database would be to have the segment consist of the entire road, regardless of intersections. The only exception would be if the road were discontinuous. Other decisions must be made where pipes in an infrastructure system do not lie directly under a road segment. A decision was made that the additional length of pipe would be documented as part of the segment that it extends from. When a section of pipe extends away from one segment and connects to a pipe on another segment, a case-by-case decision must be made. As a general procedure, the pipe in question should be attributed to the segment that had the largest pipe diameter. As future towns implement this type of asset management system, a formal exceptions procedure should be developed. This procedure will help to ensure that the data entry is standardized, even when multiple parties are contributing to data input.

As the takeoffs were conducted and preliminary results were being checked for accuracy, the research team learned many valuable lessons that can be utilized in future governmental implementations to save time and effort. One substantial action that should take place at the beginning of infrastructure takeoffs is the development of the complete segment list. This list should be obtained by examining the water, sewer, and drainage plans. The team should search for areas on the map where the piping or infrastructure system does not lie directly under the respective segment as defined by the road in place. A decision must be made as to whether or not the section of pipe that does not lie under the segment can be included in the segment or renamed as another segment. If the section in question is relatively short compared to overall length of segment, for example less than approximately 100 ft on a 1000 ft segment, the total length of the pipe can be included in the original segment. This system works well when the pipe in the segment remains linear and does not fork or make sharp turns that could confuse the operators of the system. Another option in naming the segments where the section of pipe extending beyond the segment is longer or non-linear is to add a segment extension. For example, if a sewer pipe on the Adams Street segment extended beyond the segment, the protruding section could be renamed Adams Street Sewer Extension or Adams Street_SE. If on Adams Street the water pipe also extended beyond the original defined segment and followed the basic path of the sewer extension, the combined water and sewer extension would be named Adams Street_Ext. Likewise, the same procedure holds true for a
combination of drainage, water, or sewer lines. When there is more than one infrastructure system, such as water and sewer, both extending beyond the original segment, but the two systems do not follow the same path beyond the segment, two separate extensions will be developed such as Adams Street_WE and Adams_Street_SE. (Additional Segment Extension definitions can be found in the Digital Takeoffs: Addition of Utility Extensions section)

Database Evolution: Multiple Pipe Sizes

The developed database format consisted of a table for each of the infrastructure systems. Preliminary arrangements of the table allowed for the entry of one pipe diameter and the respective length of that size pipe for each segment. Shortly after examining the Winchester water plans, the team realized that many segments included pipes of more than one diameter and therefore the current database format would be inadequate to effectively record the infrastructure system. Different options were considered to effectively record the system, but not to add superfluous columns to the table that would clutter and possibly confuse future users of the system. A thorough examination of the three sets of plans allowed the team to come to the conclusion that the majority, approximately 95%, of the segments had one or two different size pipes. The database format was altered to contain columns for two pipe sizes and their respective lengths, as well as a column of total length of all remaining pipe length in the segment not already recorded. The segments that have three or more different size pipes in the same segment would record the two largest pipe diameters and their respective lengths. The additional length recorded would be the sum of all remaining length and the database does not record what size diameter the additional pipes are. A design of this nature will allow managers to examine the predominant pipes in each segment and facilitate further investigation into the remaining pipes if necessary by showing the length not contained in the two largest pipe sizes. In future applications, if it is seen that the majority of segments contain three or more different size pipes, the database format can be tailored to the specific needs of the government. Yet another option is to reduce the size of larger segments by splitting the segment into sections, so that each new segment contains fewer different size pipes. For instance, the original Main Street segment was broken into
North, Central, and South Main Street segments. A decision of this nature must be made by comparing all of the infrastructure systems that will be included in the database to ensure this is the best overall choice for the town. If the segments become too small, their overall number will increase, resulting in a more detailed database. However, the time and labor required to maintain the database will also increase with the creation of additional segments.

Interaction with Town Officials

An essential aspect of research involved direct interaction with town officials to utilize any existing data that had already been compiled by the town or could be assembled with minor effort. Effective utilization of this step can greatly accelerate the overall speed of the data compilation process. In the case of Winchester, the departments and personnel that have been utilized are the Town Manager, Department of Public Works, Town Engineer, and Assessor’s Office.

The preliminary meeting occurred with the research team; Brian Sullivan, the town manager; and George Zambouras, head of DPW. The meeting discussed the basic principles of our research and goals of implementation of this system. Topics such as what information we would be compiling and our requests for any additional information they might have available were discussed. A second meeting was conducted to discuss possible similarities with an outsourced Winchester GIS project.

The Town of Winchester has contracted out a GIS software development contract with Camp, Dresser, and McKee. The deliverables will include a GIS program utilizing new, color aerial photographs. Asset information will be included for both public and private assets. The scope of CDM work will be different than that of the MIT research team. CDM will go into much more detail about each particular asset. Also present at this meeting were the Town Engineer and Asst. Town Engineer, Bob Conway and Frank Iebba respectively. CDM supplied the research team with the Boston Electric Company (BECo) road database for ArcView to use as the baseline for the MIT Winchester project. At that point, the BECo road database was not the spatial foundation used for the segment layer. By utilizing the BECo road database, it will make the possible integration of the MIT and CDM projects much easier to facilitate. The meeting ended with a request by
the research team for all available asset information the town currently had available or could feasibly compile.

When discussing the implementation of the database tool with Winchester officials, two major concerns arose. First, the maintenance of asset information is viewed as a large labor burden. Compliance, in their view, might require as much as five new staff members to input data and keep the database updated. Secondly, the requirement of three-year assessments of the infrastructure portfolio condition will be a challenge for outside consultants to accurately perform and also for the town in the potential incurred costs. The inherent difficulty of getting a reasonably priced, overall condition assessment of underground systems was discussed. One role of the research team will be to develop and implement a viable transitional procedure.

The transitional period of implementation of the new database and visual interface tool will be crucial to the overall future success of the project. Procedures for how to handle insufficient data and irregular occurrences must be developed. A sound transitional plan will help to assist a government when implementing a system with minimal disturbance and manageable time and labor costs. (Additional information can be found in the Implementation Considerations section.)

As the project developed, the research team presented the project to the Winchester officials. These presentations served a dual purpose: 1) To allow the officials to see the progress and make any comments concerning ease of use or features they would like to see included; 2) It highlighted areas where the research team had not been able to collect data and served as a catalyst for the appropriate official to aid in compiling the required information. In any research project, it is critical that the developers ensure that the product they are producing will match or exceed the requirements of the end users. Continual interaction with the Winchester officials should help to ensure the success and usefulness of the final research product.

**Infrastructure Inventory**

In order to employ the tools of the asset management system, the preliminary step of gathering relevant data on the town’s infrastructure assets must be conducted. The
desired data includes a complete inventory of the infrastructure assets systems including: roads, sewer, water, drainage, public buildings and property. For these assets, the team attempted to gain information pertaining to date constructed or renovated, relevant dimensions, and a basic condition assessment. The process of obtaining this data was divided into three different areas in an attempt to utilize all available resources to compile the required data as soon as possible. The three areas were manual takeoffs from the research team, digitization of town infrastructure systems maps to allow computer takeoffs, and an attempt to compile condition data through the use of Town supplied data.

Plan Take Off

The Plan Take Off section was co-authored by Tyler Harrison and Thomas Messervy.

Introduction

Preliminary research and town assistance supplied basic maps of the town’s water, drainage, sewer, and road system. These maps show system piping in comparison to the town’s roadways. From these maps, the length and size of pipes, location of gates, and location of fire hydrants can be determined. Two undergraduate civil engineering students and members of the research team including Tyler Harrison and Dr. John Miller contributed to the manual takeoff of this data. A basic overview demonstrating the fundamental techniques of gathering data (take offs) from the plans was conducted. The individuals’ level of familiarity with plans and takeoffs differ. During the takeoff process, the researchers recorded the time spent performing the work and the amount of information gathered during each respective working period. By analyzing the time sheets, the team can begin to understand approximately how much time a town could expect to manually perform takeoffs with varying levels of trained personnel.

Many governments will have drawings, in plan view, of the major infrastructure systems in their town such as water, sewer, drainage, and roads. As one might expect, these drawings may be in non-optimal condition. Often the plans will be difficult to discern and sometimes outdated. However, in the Town of Winchester, these plans were generally sufficient for the team to conduct takeoffs and assemble an asset inventory database. The team’s confidence is high that the database accurately represents what is drawn on the plans. This confidence comes through a quality control system that was
utilized on the water, sewer, and drainage takeoffs. The following sections will discuss in greater detail the steps taken during the plan takeoffs.

**Winchester Supplied Plans**

The Group 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 (except sewer) was given to at least two estimators for redundancy.

**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 or would be researched while performing condition evaluations. 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 were not assigned corresponding pipe diameters.

**Accuracy**

As the plans being used were of 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 Group 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 (except sewer). 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.

Results of Water Supply System Take Off

The three estimators for water were the experienced resident (E4), the inexperienced student (E1), and the student with some experience (E2). E4 was able to complete the quantity survey of hydrants and gates in 9 hours over a 2-day period, while it took estimator 1 and 2, 20.3 and 15.7 hours throughout an entire week to perform a complete takeoff of the water distribution network. These numbers do not include the time necessary for data entry into the computer, which took E4 about 1 hour, and E1 and E2 just over 3 hours. All the estimators used the standard scale to measure lengths. The quality control check for this utility was performed by E3, the experienced outside engineer. Initially the QC check was done on the data provided by the two least experienced parties, E1 and E2. The result was a 10-hour session in which the checker virtually had to replicate the quantity survey due to discrepancies in the data, missed segments and wholly incorrect understanding of the plans. A QC check was also performed on E4’s data to ensure the information was correctly entered into the database from the hand-written take off notes. This QC check took both E3 and E4 approximately two and a half hours.

Problems with the Water Quantity Survey

The first issue that arose during the water take-off was the disagreement between estimators as to the proper segment placement of system attributes. In the water supply system take-off, besides water lines, fire hydrants and water gates (or valves) were accounted for. The gates were represented by dots in the water lines, so their placement was not a problem. However, their small size made them difficult to see and count in crowded portions of the plans, so the number of gates from the estimate may be slightly inaccurate for certain segments. The hydrants proved to be most difficult to place,
particularly at the intersection of two or more streets. E3 suggested a method for locating them based on the orientation of the symbol relative to that of the street. E4 however, based on experience, pointed out that using the method while consistent for the plans, was not always true to life and therefore might be inaccurate as well. Eventually, the method suggested by E3 was used as a starting point for the research team. If new information becomes available it can be entered into the database at that point. While the age and accuracy of the list is questionable, it allowed a standardized data set to be employed and at least temporarily resolved the quantity survey discrepancies.

**Sewer Water System**

The research team’s goal was for the sewer take off to be performed by E1 and E4; however, external factors prohibited E1 from performing the take off. Therefore, productivity data was only available for E4 who completed the survey in 13.5 hours. E4 used the digital scale, the Scale Master II Digital Plan Measuring System. A QC check was performed to ensure the hand-written take off data prepared by E4 was accurately entered into the database. This process took approximately five hours.

**Problems with the Sewer Quantity Survey**

While a QC on the data entry was done, there were issues that needed to be resolved to complete the survey. The biggest challenge was adapting the segments to accommodate the many sewer extensions that did not run directly under streets. Unlike the water supply system, where almost segments aligned with streets, the sewer system often ran under buildings or open ground. Eventually, the segments were named as extensions to streets where they either began or ended. Another issue was, water supply lines often ran right next to or nearby the sewer extensions. The resulting segments were named generic extensions, instead of specifically being called water or sewer extensions, as they contained more than one type of utility. Lastly, the city’s sewer plan contained sewer lines that did not belong to the town. These sewers served as collectors for Winchester’s sewer waste. These segments were not included in the take-off because Winchester is not responsible for the maintenance and improvements of these lines.
Drain Water System

Performed by E1 and E3, productivity data showed E3 completed the task in 7.5 hours plus an additional 1.5 hours to put the information into the computer. E1 performed the drain take off in approximately 10 hours. E1 used a standard scale to measure, while E3 employed the digital scale.

Problems with the Drain Quantity Survey

The QC check was done by E3 and was estimated to have taken two hours. The data provided by E1 was incomplete and largely inaccurate, so the vast majority of the finished take-off was data directly taken from E3’s quantity survey. Here a big challenge was again dealing with large sections of pipe not under any street segment. While some extensions ran next to a water or sewer line, the majority did not and approximately half of the total extensions listed in the database are solely for drain water. The most difficult attributes to place in the drain water system were the street drains. They were both hard to see (and thus count) as well as hard to attribute to a particular segment, especially at intersections and with the commonly curved streets found in Winchester.

Discussion of Quantity Surveys

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 Group. 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 drawn 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 one or two times. The performance of the more experienced estimators, E3 and E4, appeared to remain constant in regards to productivity. However, actual performance may be difficult to judge considering the different types of systems surveyed. It may 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 performing the original surveys, 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 grided 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 expect 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, rounding the displayed measurement to the nearest 10 feet increments makes more sense for the 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 chosen because these plans capture the entire city on one piece of paper and fits on a standard desktop. With 40-scale plans being available, their use may have improved the accuracy of measurement. This increase in accuracy may have been up to one significant figure, but the time required to perform the take offs would have increased significantly.

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

<table>
<thead>
<tr>
<th>Action</th>
<th>Research</th>
<th>Member</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E1</td>
<td>E2</td>
</tr>
<tr>
<td>Water Take Off</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Water QC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewer Take Off</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewer QC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drainage Take Off</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Drainage QC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Recommendations for Future Applications

Where available, 40-scale plans should be considered as an option 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. However, this choice must take into account the increased time and costs incurred when using 40-scale plans. Additionally, the use of the digital scale was highly successful overall, particularly in the towns such as Winchester with winding streets that are not easily measured with a long, straight and inflexible standard scale. While the availability of estimators will vary from town to town, it may be beneficial to have someone familiar with the town’s layout perform the initial quantity surveys, for the sake of time. If possible, experienced engineers should perform other surveys, as well as the final quality control check. 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 surveys.

Digital Take Off

*The Digital Take Off section was co-authored by David Greenblatt and Thomas Messervy.*

Introduction

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. 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. Furthermore, changes in pipe
diameter must be manually digitized if respective lengths of pipe sizes are required. Under the current database format, digitized breaks between pipe sizes were not included in the final system.

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:
### Table

<table>
<thead>
<tr>
<th>Pt. #</th>
<th>Easting (X)</th>
<th>Northing (Y)</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point 306</td>
<td>753991.02</td>
<td>2991771.01</td>
<td>Ciarcia Field/ Super Stop &amp; Shop</td>
</tr>
<tr>
<td>Point 307</td>
<td>751236.46</td>
<td>2989468.83</td>
<td>Center of Fletcher/Copley St.</td>
</tr>
<tr>
<td>Point 309</td>
<td>741571.06</td>
<td>2987368.83</td>
<td>Center of Thornberry/BerkshireDr</td>
</tr>
</tbody>
</table>


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. For an overview of
both heads-up digitizing and digitizing with a digitizing tablet see Chapter 10 in Hutchinson and Daniel’s *Inside ArcView GIS*.\(^{22}\)

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. (A description of each theme in the Winchester ArcView project is provided below in Appendix I.) 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 warping/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. However, information such as pipe size and number of hydrants per segment must be performed manually. 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. See Appendix III for the complete list of scripts and their respective functions.

Table I. Process Summary Table

<table>
<thead>
<tr>
<th>Step</th>
<th>Estimated Time</th>
<th>Challenges</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan Maps</td>
<td>6 hrs</td>
<td>proper alignment</td>
<td>use mylar copies</td>
</tr>
<tr>
<td>Register Maps</td>
<td>15 hrs</td>
<td>software incompatibility</td>
<td>obtain maps w/contr pts</td>
</tr>
<tr>
<td>Initial Digitizing</td>
<td>8 hrs</td>
<td>aligning CDM roads w/ utility maps</td>
<td>--</td>
</tr>
<tr>
<td>Adding Utility Ext</td>
<td>20 hrs</td>
<td>finding location of ext’s</td>
<td>use common .jpeg size</td>
</tr>
</tbody>
</table>

Condition Assessment

In order to develop information that will be helpful for maintenance and strategic planning, as well as GASB compliance, both the infrastructure inventory and approximate condition must be known. Measured in terms of labor and time expended, determining condition data can be more involved.

When conducting the asset inventory, the team had presumably reliable engineers’ plans. Unfortunately, developing an accurate condition database proved to be a different type of undertaking. The team discussed the goals with the members of Town Hall and DPW along with possible types of documents that could contain the appropriate condition data. The team was hoping for some type of spreadsheet or compilation of information that recorded dates of pipe installation and previous work records. The ideal
version of this type of information was not available. However, DPW was able to produce a record that showed when a portion of Winchester’s water pipes had been put into service. The water/sewer operations manager, Ed Grant, also included a list of when those pipes had been cleaned and lined. Furthermore, a water plan was marked to show certain criteria about which pipes had been cleaned and lined, which had been abandoned, and which cast iron pipes had been replaced with ductile iron pipes. When discrepancies arose between the two sets of information, the information supplied on the street list was used. On the water plan, no dates were specified as to when the operations in question occurred. With this preliminary data, a condition database could begin to be compiled. After the available information was assigned to the respective segment, approximately 60% of the segments had defined conditions. The condition information was broken down into categories including excellent, good, average, poor, failing, and unknown. Any government can use these general guidelines, but certain governments may choose a different set of criteria. A particular condition was attributed to pipes that fell between certain assumed ranges. For example, a segment of pipe was given an excellent rating if it was cleaned and lined after 1995 or replaced in or after 1990. Pipes that were designated as cleaned and lined, but no date of service was assigned, were given a fair rating to signify that they have been serviced but the particular date is not clear at this point. If the Winchester officials wish to modify these assumptions, the condition database can be changed with only a minor time expenditure. With the inventory and condition of the water system substantially complete, queries to facilitate GASB compliance and management of the water system can be developed. (For some examples of the queries performed on Winchester’s water system, see the Utilization of Queries section)

Additional information was also supplied relating to the condition of the road network in Winchester. A database of Winchester’s roads contained information regarding dates of last paving, as well as traffic volume indexes for most of the town’s roads. Although this information can serve as a foundation for the road condition database, a substantial amount of energy must be exerted to integrate the information into the database. The roads in the paving records were often broken into different sections than the research segments. Furthermore, depending on the accuracy of the given
information, it was difficult to obtain a condition assessment on a road that was last resurfaced over five years ago. With additional assistance from the government officials to clear up discrepancies, a road condition database can be developed.

An important point to remember when assembling a condition database inventory is that GASB does not state that the desired level of detail is extremely high. The guidelines hope to establish a base condition evaluation that can be improved upon in the future as more information becomes available.

**Implementation Considerations**

The proper implementation of a database of this nature is very important. If the implementation is not effective, many negative results may occur. Inadequate training and explanation to government users will result in sporadic and incorrect maintenance of the database, or in a worst-case scenario, no utilization or updating of the database. Many different approaches can be taken when implementing the system for a municipal government. One approach is to have an independent entity, such as a consultant, develop the entire system and then transfer it to the government with minimal training or explanation. Conversely, the local government can attempt to apply their infrastructure inventory to a database system utilizing internal labor and knowledge. While this approach may be relatively successful, it is possible that many functions of the database system will not be utilized or time and labor saving opportunities may be overlooked. A recommended approach would be to find the equilibrium between these two approaches, a more balanced implementation process.

**Training for Employees**

A balanced implementation would utilize both the knowledge and labor of the database supplier and the government employees. Since these employees will be in charge of maintaining the database system, it is essential that they receive proper training in general database principles and concepts, as well as information relevant to the GASB compliant infrastructure system.

Each government body must decide which employees will have the responsibility of maintaining the database. The number of employees required will depend on many
factors such as organizational structure and size of the municipality. One option is to select a single person or group of employees whose central responsibility is to maintain the database. However, smaller governments will not need a devoted database operator, nor will they most likely have the budget for this type of structure. For larger governments, this may be a more viable option.

Another approach is to develop a system that facilitates an employee within each department to input their department’s respective data. For example, the manager in charge of roadway maintenance and construction would enter in all the data pertaining to their department’s work or future plans. The design of the database, incorporating the use of queries, facilitates summarizing information within the database. For many governments this would be an effective decision in terms of cost and labor management. The database is designed to serve as an effective tool in the maintenance of the infrastructure, not simply a means for strategic planning and GASB compliance. To effectively utilize the capabilities of the database, it is important for each of the infrastructure system managers to be familiar with the system.

Transition Period

The initial steps of implementation of a system of this magnitude can be time and labor intensive. Furthermore, organizational systems tend to exhibit a sense of inertia, in that change can be strongly resisted. Most local government bodies have been operating, maintaining, and tracking their inventory in a particular way for many decades. Some members of the government may understand the inherent benefits of implementing this type of system; unfortunately, others will not see the need or the beneficial outcomes that will result through utilizing and integrating this asset management database. Employees often feel they do not have the time or the resources to implement a system of this nature. Initially these responsibilities may be viewed as a burden until the benefits of use become evident. As mentioned, it is critical to expend sufficient time and effort to train and educate the affected employees on how the system works and what benefits it will produce. Without this proper training, employees may be reluctant to contribute their valuable knowledge gained while working with these assets. In the worst-case scenario, employees could effectively sabotage the utilization of this type of system.
As seen in our research experience, it may prove difficult to extract and obtain information on relevant infrastructure assets even when employees seem supportive of this type of system. Different approaches can be taken to overcome these challenges. In the educational process, it is necessary for everyone involved, not only the managers, to understand that GASB compliance is necessary and must be completed by a certain date or the government may face detrimental consequences. If governmental funds are available, consultants can be utilized to aid in optimizing the implementation of the database. The data entry involved in putting the database into service can be time and labor intensive. However, with a firm commitment to the goal of completion, the task can be accomplished with the available resources.
Chapter Seven ________ Supplemental Tool Integration

Geographical Information Systems

While developing the model database, another step was taken to further enhance the effectiveness of this software by integrating the database with a visual interface tool. The software program selected was ArcView GIS 3.2 for its widespread use and array of available tools. As seen in the Winchester implementation, the interface will operate using aerial photos or digitized infrastructure maps of the desired area. Each town must determine what backgrounds, or combinations of backgrounds, serve to most effectively represent the desired visual information. The various capital asset tables in the database are tied to the visual interface using an ODBC (Open Database Connectivity) driver. This function utilizes SQL programming to link the database information with other applications such as ArcView. The graphical interface improves the overall effectiveness of the system. For instance, the interface allows a maintenance employee to simply click on an object, a street segment for example, and view the current equipment and historical data associated with the each of the infrastructure systems located in that segment. One goal of this research is to facilitate updating and maintenance of the information contained in the database. For example, once a given set of repairs has been completed, the employee can alter the data by entering it in the database via the graphical interface. ArcView Graphic One-ArcView Graphic Seven demonstrate some of the various capabilities that were produced through the integration of these programs. See Appendix I-Appendix III for additional information on the structure of the ArcView program and the integration with the asset database.
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This screen illustrates the basic segment structure of the Winchester project. As seen in the top left, there are five type of segments. In this black and white format, the general segments are the thickest, combined extensions are medium thickness, and the individual extensions are the thinnest segments in this illustration. In the color application, the different segments are represented by various colors.
This screen illustrates the application of an informational theme. The theme shown, “Landuse.shp”, illustrates the census bureau’s description of the various land uses in the Town of Winchester. These types of illustrations can aid town managers, engineers, and planners in their various decision making processes.
The top screen shows the segment base map integrated with the water supply system map. From this map, water extensions were drawn and the digital take off was performed.

The bottom screen shows a magnified view of the same map to illustrate the details present in the water supply system map.
The top screen shows the segment base map integrated with the sewer plan. From this map, sewer extensions were drawn and the digital take off was performed.

The bottom screen shows a magnified view of the same map to illustrate the details present in the sewer system map.
The top screen shows the segment base map integrated with the drainage plan. From this map, drainage extensions were drawn and the digital take off was performed. The drainage plan map had to be morphed to facilitate a better alignment with the segment base map.

The bottom screen shows a magnified view of the same map to illustrate the details present in the drainage plan.
This screen illustrates the application of an identifier. This identifier was used in conjunction with the water and water condition tables. This function allows governmental officials to select any segment and access all of the available information on the water distribution for this segment. This type of identifier can also be used to access sewer, drainage, public buildings, and open space information contained in the database.
CHOICES Software

Over the past five years Dr. John Miller and the Infrastructure Development Research team at MIT have developed a software prototype program called CHOICES. The program allows a town manager or planner to work with historical data from the respective city or town to develop beneficial strategic planning. The decision support system is used to track past and future repair, maintenance, and replacement across a collection of infrastructure assets. The information is combined with various project solutions to develop long-term capital programming scenarios in order to provide the most beneficial arrangement for the organization. The research and program methods function under the fundamental theory that different project delivery methods all result in varied combinations of cost, financing, and schedule consequences.
Chapter Eight Future Work and Conclusions

Future Work

The past year and a half of research has involved preparation and implementation of the database software for the Town of Winchester. A substantial amount of progress has been made in completing the implementation; however, a considerable amount of work remains. The scope of future work includes completion of the inventory and condition database, valuation of the installed infrastructure, historical and predicted budgetary information, supplemental query development, and additional ArcView/Database integrations tools. The vast majority of purely developmental research has been completed. The majority of future work will require the direct assistance of the Town of Winchester. The assistance will most likely come from additional support and time in facilitating means to determine the necessary information. Without the full support of Winchester, complete installation may prove impossible. The information currently available is beneficial to the town, but completing the database will increase its usefulness exponentially. The ISDR research team is optimistic that the needed governmental participation will become available and the tool will be completed for Winchester.

One of the fundamental steps in implementing the database software was a complete infrastructure inventory. The inventory has been completed for the water, sewer, drainage, and road networks of Winchester. Further research must be conducted to complete the inventory for public buildings and open spaces. In conjunction with the inventory, is the condition assessment for each respective infrastructure asset. The water network assessment has been substantially compiled from the data supplied by DPW. A preliminary road assessment has been compiled, but the data may not be optimal because the complete assessment was performed a few years ago. It is unclear if the conditions have been maintained at the recorded level. There are two basic directions the research team can pursue in obtaining the additional condition information on the remaining infrastructure systems. The most practical means, as measured by time and cost, would be to have the information compiled by the government officials who know best the
condition of these assets. If Winchester cannot supply the information, the research team could attempt to compile the data through manual analysis or through historical town records. Preliminary research suggests the later methods may be time and cost prohibitive.

As the inventory and condition assessment are completed, a valuation of the infrastructure will be desired. The goal of the initial valuation is to set an approximate value, or starting point, that can be improved upon as more information becomes available. Participation of Winchester officials is also needed in this step; the men and women historically responsible for their maintenance can most likely perform the valuation of these assets most efficiently. If their assistance is not available, the research team could consult resources such as RSMeans to set approximate values.

Preliminary indications suggest the Town of Winchester will choose the modified approach to account for their infrastructure assets. Therefore, it will be necessary to make estimations on the required resources to preserve and maintain their infrastructure networks. This information will then be compared with the actual annual expenditures. Winchester officials must supply this information to the research team in order to enter it into the database. As the additional information is compiled on the infrastructure collection, additional queries will be developed. These queries will facilitate the compilation of required data into easily accessible tables. These queries can be developed to provide the desired information for both the employees responsible for everyday maintenance, as well as the town manager who needs the information aggregated into a manageable level of detail for the entire collection of assets.

In conjunction with the development of queries in the database, there will need to be continued development in the ArcView software. The research team’s objective is to produce a seamless interface between the database and visual interface. Currently, the structure of the integration allows the information contained in the database to be accessed and view in ArcView. However, the capability to enter new data or modify existing information in ArcView and have it entered and stored in the database is not available. With additional scripting and modification of the project structure, the team hopes to make this feature available for Winchester officials. Many queries can be very meaningful when represented graphically such as illustrating all water pipes that are in
poor condition or all roads that have not been resurfaced in over ten years. The research team hopes to have additional queries developed and easily accessible for government officials to utilize in ArcView.

The foundation for successful implementation has been laid for the Town of Winchester. The most important variable, in terms of completing a successful implementation process, is the support and assistance of Winchester government officials. Without their continued help, the complete implementation of this tool will be extremely difficult. The research team must not only develop and implement this tool, but must concurrently elicit the support of the Winchester government.

Conclusions

With the publishing of Statement No. 34, GASB has set the stage for a major transformation in government accountability and management practices. The new accounting and reporting standards GASB prescribes are more extensive than most governments’ current capabilities. The timeline has been set as to when governments will need to comply. However, governments need a mechanism to update their systems from previous management methods to a new asset management paradigm. During this time of change, it is essential that governments follow a course that will produce an effective asset management and planning tool as opposed to doing only what is necessary to comply with GASB standards.

The development of an effective database model that can be scaled to different size governments can serve as a valuable tool. The database not only allows governments to comply with GASB, but also provides effective operational and planning tools. Combining the database format with a GIS interface facilitates a maintainable and effective service platform. In conjunction with the future integration of the CHOICES software, the database will be an effective tool for devising strategic planning for a government’s asset portfolio.

Unfortunately, the database tool and visual interface by themselves are ineffectual; it is only when these tools are fully implemented into a city or town that they become useful. My research has focused on implementing this model database in the
Town of Winchester. Although the implementation has progressed, increased assistance from government officials could possibly have made complete implementation a reality.

The management of a city or town is a very difficult task. Often officials can become overwhelmed with various responsibilities and tasks and the result is reactive decision making instead of pro-active actions. The Town of Winchester, by one means or another, will comply with GASB guidelines. From an external perspective, town employees are not yet dedicated to implementing this database to ensure GASB compliance. Without this commitment, the implementation and usefulness will be greatly decreased. It is the research team’s belief that a modest amount of assistance today, will produce substantial gains in future years. Regrettably, for a variety of reasons, the desired amount of government support was not available.

The database tested by the research team attempted to reach a balance between a configuration that is extremely detailed and hard to maintain with one that is overly simplified and does not contain enough information to produce valuable results. In this database, the infrastructure systems are divided into segments or roughly the area of individual streets. The research team believes this structure provides the optimal level of detail to provide GASB compliant information, as well as allow for improvements in infrastructure maintenance and strategic planning without being time and labor prohibitive to maintain. However, other researchers and governments may feel that infrastructure should only be examined at a system level or conversely that an extremely high level of inventory detail is useful and efficient. This illustration is only one of the fundamental decisions a government must consider when developing a means to obtain GASB compliance. Through careful consideration, governments can develop or implement systems that are most appropriate for their needs and future objectives.

It is not likely another government transition of this magnitude will happen again in the near future. It is imperative that the opportunity to put into place effective database and auxiliary tools is not wasted. Although the Winchester implementation has not been completed, it appears that the database program will function as an effective means for the compilation of GASB compliant information and the facilitation of effective maintenances, operations, and planning of an infrastructure portfolio.
Bibliography

7 Wooldridge, Garvin, Miller “Effects of Accounting and Budgeting on Capital Allocation for Infrastructure Projects” Massachusetts Institute of Technology for possible submission into Journal of Management in Engineering. April 13, 2000. pgs 5-8
11 Guide to Implementation of GASB Statement 34 on Basic Financial Statements-and Management’s Discussion and Analysis-for State and Local Governments (Questions and Answers) Implementation Guide. Governmental Accounting Standards Board. Pg. 14 NOTE: Information from the following chart was obtained from this source.
15 FACTS 2000 Winchester Enters the New Millennium A Preliminary Report by the FACTS Committee, Version 0.2. September 18, 2000. Sec. 2-3
16 FACTS 2000 Winchester Enters the New Millennium A Preliminary Report by the FACTS Committee, Version 0.2. September 18, 2000. Sec 3-1
17 FACTS 2000 Winchester Enters the New Millennium A Preliminary Report by the FACTS Committee, Version 0.2. September 18, 2000. pg EXEC 6
18 FACTS 2000 Winchester Enters the New Millennium A Preliminary Report by the FACTS Committee, Version 0.2. September 18, 2000. pg EXEC 1
19 FACTS 2000 Winchester Enters the New Millennium A Preliminary Report by the FACTS Committee, Version 0.2. September 18, 2000. Section One-Department of Public Works
20 FACTS 2000 Winchester Enters the New Millennium A Preliminary Report by the FACTS Committee, Version 0.2. September 18, 2000. Section One-Department of Public Works
21 FACTS 2000 Winchester Enters the New Millennium-A Preliminary Report by the FACTS Committee. Version 0.2. September 18, 2000. Section One-Department of Public Works
23 Miller, John B. Memorandum to Research Team. Dec. 13, 2000
APPENDIX I – Summary of Themes in Winchester ArcView file

This is the project file that has been developed in ArcView for the visual interface to the database software.

**Segments Theme:** Includes a polyline representation of road, water, drain, and sewer networks. Classification is as follows:
- **General Segment**-(0) (road system + all water, drain, and sewer lines that underlie the road system)
- **Combined Ext**-(1) (extension segments that contain two or more overlapping utility extensions)
- **Water Ext**-(2) (water extension only)
- **Drain Ext**-(3) (drain extension only)
- **Sewer Ext**-(4) (sewer extension only)

**Public Buildings Theme:** Includes a polygon representation of all public buildings in Winchester, MA. Obtained from CDM. Classification is as follows:
- **Public Schools**-(1)
- **Fire/Police Buildings**-(2)
- **Department of Public Works**-(3)
- **Water/Sewer Out Build**-(4)
- **Town Library**-(5)
- **Town Hall**-(6)

**Landuse Theme:** The MassGIS 1:25,000 land use data layer that contains 37 land use classifications interpreted from aerial photography. The two land use code items (LU21_CODE and LU37_CODE) in the theme table attributes represent two classifications of land use. The 21 category classification aggregates the categories in the 37 category classification and can be seen in Appendix II.

**Water Distribution Scan:** A jpeg scan of Winchester Water Supply Utility Map
**Sewer Scan:** A jpeg scan of Winchester Sewer Utility Map
**Drain Scan:** A jpeg scan of Winchester Drain Utility Map
APPENDIX II – Land Use Themes

The following are descriptions of the land use themes layer in the ArcView program.

<table>
<thead>
<tr>
<th>Code</th>
<th>Abbrev</th>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC</td>
<td>Cropland</td>
<td>Intensive agriculture</td>
</tr>
<tr>
<td>2</td>
<td>AP</td>
<td>Pasture</td>
<td>Extensive agriculture</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>Forest</td>
<td>Forest</td>
</tr>
<tr>
<td>4</td>
<td>FW</td>
<td>Wetland</td>
<td>Nonforested freshwater wetland</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>Mining</td>
<td>Sand, gravel &amp; rock</td>
</tr>
<tr>
<td>6</td>
<td>O</td>
<td>Open Land</td>
<td>Abandoned agriculture, power lines,</td>
</tr>
<tr>
<td>7</td>
<td>RP</td>
<td>Participation Rec</td>
<td>Golf, tennis, playgrounds, skiing</td>
</tr>
<tr>
<td>8</td>
<td>RS</td>
<td>Spectator Rec</td>
<td>Stadiums, racetracks, fairgrounds</td>
</tr>
<tr>
<td>9</td>
<td>RW</td>
<td>Water-based Rec</td>
<td>Beaches, marinas, swimming pools</td>
</tr>
<tr>
<td>10</td>
<td>R0</td>
<td>Residential</td>
<td>Multi-family</td>
</tr>
<tr>
<td>11</td>
<td>R1</td>
<td>Residential</td>
<td>Smaller than ¼ acre lots</td>
</tr>
<tr>
<td>12</td>
<td>R2</td>
<td>Residential</td>
<td>¼ - ½ acre lots</td>
</tr>
<tr>
<td>13</td>
<td>R3</td>
<td>Residential</td>
<td>Large than ½ acre lots</td>
</tr>
<tr>
<td>14</td>
<td>SW</td>
<td>Salt Wetland</td>
<td>Salt Marsh</td>
</tr>
<tr>
<td>15</td>
<td>UC</td>
<td>Commercial</td>
<td>General urban, shopping center</td>
</tr>
<tr>
<td>16</td>
<td>UI</td>
<td>Industrial</td>
<td>Light &amp; Heavy Industry</td>
</tr>
<tr>
<td>17</td>
<td>UO</td>
<td>Urban Open</td>
<td>Parks, cemeteries, vacant land</td>
</tr>
<tr>
<td>18</td>
<td>UT</td>
<td>Transportation</td>
<td>Airports, docks, divided highway</td>
</tr>
<tr>
<td>19</td>
<td>UW</td>
<td>Waste Disposal</td>
<td>Landfills, sewage lagoons</td>
</tr>
<tr>
<td>20</td>
<td>W</td>
<td>Water</td>
<td>Fresh water, coastal embankment</td>
</tr>
<tr>
<td>21</td>
<td>WP</td>
<td>Woody Perennial Orchard</td>
<td>nursery, cranberry bog</td>
</tr>
</tbody>
</table>

Additional categories in LU37_CODE:

<table>
<thead>
<tr>
<th>Code</th>
<th>Abbrev</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>CB</td>
<td>Cranberry bog</td>
</tr>
<tr>
<td>24</td>
<td>PL</td>
<td>Powerlines</td>
</tr>
<tr>
<td>25</td>
<td>RSB</td>
<td>Saltwater sandy beach</td>
</tr>
<tr>
<td>26</td>
<td>RG</td>
<td>Golf</td>
</tr>
<tr>
<td>27</td>
<td>TSM</td>
<td>Tidal salt marshes</td>
</tr>
<tr>
<td>28</td>
<td>ISM</td>
<td>Irregularly flooded salt marshes</td>
</tr>
<tr>
<td>29</td>
<td>RM</td>
<td>Marina</td>
</tr>
<tr>
<td>30</td>
<td>-</td>
<td>New ocean (areas of accretion)</td>
</tr>
<tr>
<td>31</td>
<td>UP</td>
<td>Urban Public</td>
</tr>
<tr>
<td>32</td>
<td>TF</td>
<td>Transportation Facilities</td>
</tr>
<tr>
<td>33</td>
<td>H</td>
<td>Health</td>
</tr>
<tr>
<td>34</td>
<td>CM</td>
<td>Cemeteries</td>
</tr>
<tr>
<td>35</td>
<td>OR</td>
<td>Orchard</td>
</tr>
<tr>
<td>36</td>
<td>N</td>
<td>Nursery</td>
</tr>
<tr>
<td>37</td>
<td>-</td>
<td>Forested wetland</td>
</tr>
</tbody>
</table>

Source: MassGIS, Datalayers/GIS Database: Landuse – September 2001
Appendix III – ArcView Scripts

The following are the scripts used in the Winchester ArcView program.

_StartUp
This script renames ArcView project file (.apr) to “Winchester” once the ArcView project file is opened.

Av.SetName("Winchester")
return nil

_Login
This script establishes a SQL connection to the Microsoft Access database, called “Winchester_Database”

_theCon = SQLCon.Find("MS Access Database")
return nil

_Logout
This script terminates the SQL connection to “Winchester_Database”

_theCon.LogOut
return nil

_Loadall
This script identifies the default tables that are loaded into the ArcView project once the _AddInitialTables script is run. The default tables include the following MS Access tables: streets, sewer, water, drainage, open space, and public buildings.

av.run("_addInitialTables", ["streets"])
av.run("_addInitialTables", ["sewer"])
av.run("_addInitialTables", ["water"])
av.run("_addInitialTables", ["drainage"])
av.run("_addInitialTables", ["openspace"])
av.run("_addInitialTables", ["publicbuildings"])
return nil
_AddInitialTables

This script adds the default tables identified in the _Loadall script. In addition, it simultaneously adds each default table’s respective condition assessment table ("default name" + "condition"). Once the script has run, the following tables are added to the Tables view in the ArcView Project Window: streets, streets condition, sewer, sewer condition, water, water condition, drainage, drainage condition, open space, open space condition, public buildings, and public buildings condition.

```plaintext
theTable = Self.Get(0)
theProject = Av.GetProject
table1 = theProject.FindDoc(theTable)
if (table1 <> nil) then
    theProject.RemoveDoc(table1)
end

selects = "select *from "+theTable
theVTab = VTab.MakeSQL(_theCon,selects)
locateTable = Table.Make(theVTab)
av.GetProject.AddDoc(locateTable)
locateTable.SetName(theTable)

selects = "select *from "+theTable+"condition"
theVTab = VTab.MakeSQL(_theCon,selects)
locateTable = Table.Make(theVTab)
av.GetProject.AddDoc(locateTable)
locateTable.SetName(theTable+"condition")

return nil
```

_JoinTab

This script joins the default table and "default + condition" table to Segname column in the Segments Theme. Once script is initiated, the user is required to choose among the default table categories. For instance, if "water" is chosen, then both the "water" and "water condition" tables are joined to the Segments Theme. All previous joins are undone each time the _JoinTab script is run.

```plaintext
theListofTables = {"streets", "openspace", "water", "sewer", "drainage", "publicbuildings"}
theChoice = MsgBox.ListAsString(theListofTables, "Choose the type of data you want to work with", "Double click on your selection")
if (theChoice = nil) then
```

- 80 -
msgbox.info("You did not make a selection (choice)", "warning")
return nil
end

theView = Av.GetActiveDoc
theProject = Av.GetProject

theTable = theProject.FindDoc("Attributes of Segments.shp")
if (theTable = nil) then
    msgbox.info("Add the attribute table before running join","warning")
    return nil
end

TheVTab = theTable.GetVTab
theVTab.UnJoinAll
theToField = theVTab.FindField("Segname")
theFromVTab = theProject.FindDoc(theChoice).GetVTab
theFromField = theFromVTab.FindField("SegmentPrettyName")

'join condition table

theVTab.Join(theToField, theFromVTab, theFromField)

theToField = theVTab.FindField("Segname")
theFromVTab = theProject.FindDoc(theChoice+"condition").GetVTab
theFromField = theFromVTab.FindField("SegmentPrettyName")

if (theToField = nil) then
    msgbox.info("the To Field Was Not Found","warning")
    return nil
end

if (theFromField = nil) then
    msgbox.info("the From Field Was Not Found","warning")
    return nil
end

theVTab.Join(theToField, theFromVTab, theFromField)

return nil