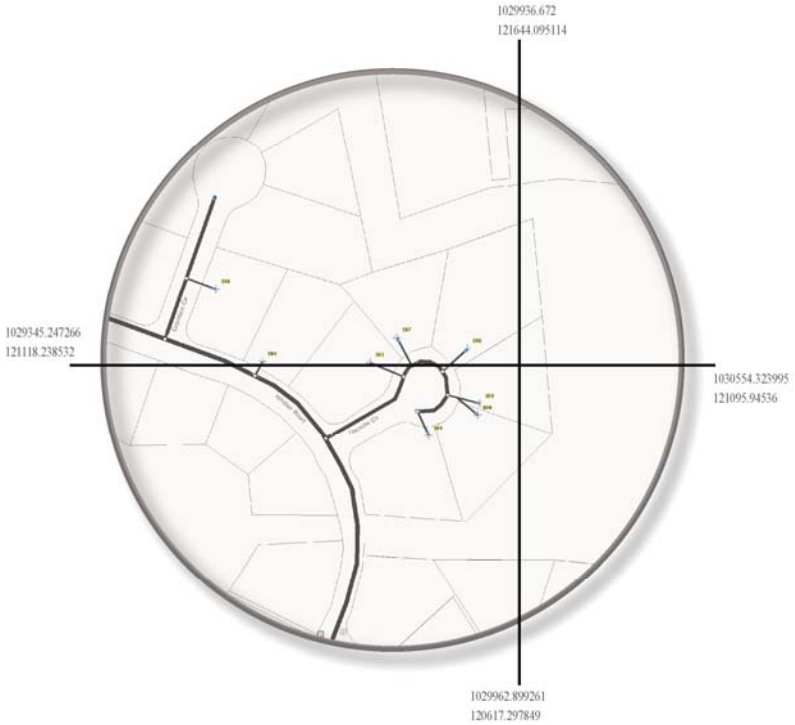
Merrimack Village District
Water Works

GEOGRAPHIC INFORMATION SYSTEMS NEEDS ASSESSMENT



December 2006

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GEOGRAPHIC INFORMATION SYSTEMS NEEDS ASSESSMENT

FOR

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EXECUTIVE SUMMARY

The Merrimack Village District (MVD) is the water utility for the Town of Merrimack, New Hampshire. The utility services approx. 9,100 customers. The service network contains approx 74 miles of piping, 800 hydrants and roughly 4,700 valves. The system is fed by eight source wells, two of which are currently inactive.

MVD has contracted with the Nashua Regional Planning Commission (NRPC) to undertake a Geographic Information Systems (GIS) Needs Assessment and to make recommendations towards a GIS implementation plan. This report provides a needs assessment for enhancing geospatial technology activities beneficial to MVD. MVD has expressed interested in exploring geographic information system (GIS) capabilities to improve current and future agency administration and customer service. GIS can provide benefits through increased efficiency, cost avoidance, or service enhancement. As a result of implementing GIS technology, MVD can expect to realize a number of benefits. A summary of potential GIS benefits include:

- More up-to-date, accurate, and reliable information
- Increased productivity
- Improved coordination between groups and departments
- Enhanced analytical and technological capabilities
- Better service to the public and other government agencies
- More economical use of organizational resources

What is GIS?

Geographic Information Systems (GIS) are a powerful tool for manipulating, analyzing and publishing any type of geographic information. GIS is one part of an organization's overall information technology system. GIS data links information, or attributes, about an object to that object's geographic location on the Earth's surface. Much of the information maintained in databases has a geographic and spatial component (e.g. Addresses, xy coordinates, parcels, streets, etc.). GIS is a spatial database that allows these objects to be displayed as tabular data or viewed as a map. GIS data can be queried spatially and the spatial relationships between objects can be analyzed.

Benefits of GIS to Water Utilities

Nearly all the data used by a water utility is tied to a geographic location or feature. GIS technology can be used to track the location and condition of water mains, valves, hydrants, meters and storage facilities. Water utilities use GIS technology to integrate all kinds of information and applications with a geographic component into a manageable system. GIS is an important tool for utility managers to record utility asset information and relate that information to the world around them including; customers, roads, government boundaries and waterways. GIS allows a utility to organize, manage, and distribute geographic information to administer infrastructure and plan for the future. There are typically three levels of GIS use for water utilities:

- **Decision Making and Budgeting** – Water utilities can use GIS to forecast for budgets, rate justification and redistricting.

- **Planning** - Water agencies can use GIS to map the full extent of their water distribution systems and link them to a database defining each element. GIS can be used for system-wide planning, population and demand projections, site analysis and capital improvement project tracking. GIS also facilitates interdisciplinary analysis and provides a water district with a method for accessing and using data held by others on issues such as land use, zoning, locations of other public infrastructure and natural features.

- **Operations, Maintenance and Customer Service** – GIS can assist in the daily functions of a water utility office including: customer service, complaint tracking, work order management and inspections. GIS applications allow agency staff to query information and display maps on agency

assets, on-going work and historical data. Integration of images allows for maps, drawings, and pictures to be associated with valves, meters and other network features to provide instant access to valuable information.

Payback on GIS implementation costs is often quickly achieved through greater efficiency, labor reduction, improved customer service, and the ability to identify where revenue is coming from compared to where facilities are located. A GIS can provide a better and faster response to public, regulatory, and legislative inquiries that are geographic in nature. Increased benefits come from improved functionality and new capabilities as a GIS implementation is continually integrated into agency operations.

Based upon information gathered in this needs Assessment, it was determined that MVD personnel are anxious to embrace GIS technology, and look forward to maximizing the benefits offered by GIS data and systems.

OVERVIEW

A needs assessment is the first step in implementing a successful GIS within any organization. As a part of the process NRPC conducted interviews with Merrimack Water District staff. One group interview with MVD office and field staff provided the majority of information needed in the assessment. This was followed up with individual phone interviews with other staff, including operations and outside support including Hydrologic model, engineering and computer services support. The purpose of the interviews was to collect information on the functions, systems and procedures of business operations that could be improved through the use of geographic information systems. Both the need for GIS and the desire of staff to utilize certain GIS based functions was ascertained. An examination was also made of existing resources within the agency including, existing maps, databases, applications, software and hardware. The primary categories of information gathered as a part of the needs assessment process are:

- **GIS GOALS & OBJECTIVES**
- **GIS DATA NEEDS**
- **GIS APPLICATION NEEDS**
- **GIS TRAINING NEEDS**
- **EXISTING MAPS**
- **EXISTING SOFTWARE / DATABASES / HARDWARE**

This report summarizes the findings and recommendations in each of these categories.

The conclusion from needs assessment interviews is that GIS would assist the MVD by providing better and more accessible information to agency staff. GIS would improve inventory, record-keeping, system analysis, and streamline everyday operations by providing detailed information quickly to staff both in the office and in the field.

GIS DATA NEEDS

Before any GIS applications can be implemented the data must be present. Some data may already be available in GIS format from other sources and some data may need to GIS. Comprehensive, current, and accurate data are fundamental to the successful implementation of GIS. The MVD has considerable data resources tied to printed maps and schematic drawings which will need to be digitized into an electronic GIS format. This section will discuss primary data layers associated with a water distribution system and recommend methods for conversion to GIS.

To be consistent with Town of Merrimack and other state data, the following projection/coordinate system should be used with any data created:

New Hampshire State Plane
Projection: Transverse_Mercator
False_Easting: 984250.000000
False_Northing: 0.000000
Central_Meridian: -71.666667
Latitude_Of_Origin: 42.500000
Linear Unit: Foot_US (0.304801)

Geographic Coordinate System:
GCS_North_American_1983
Angular Unit: Degree (0.0174532925199433299)
Prime Meridian: Greenwich
(0.000000000000000000)
Datum: D_North_American_1983
Spheroid: GRS_1980

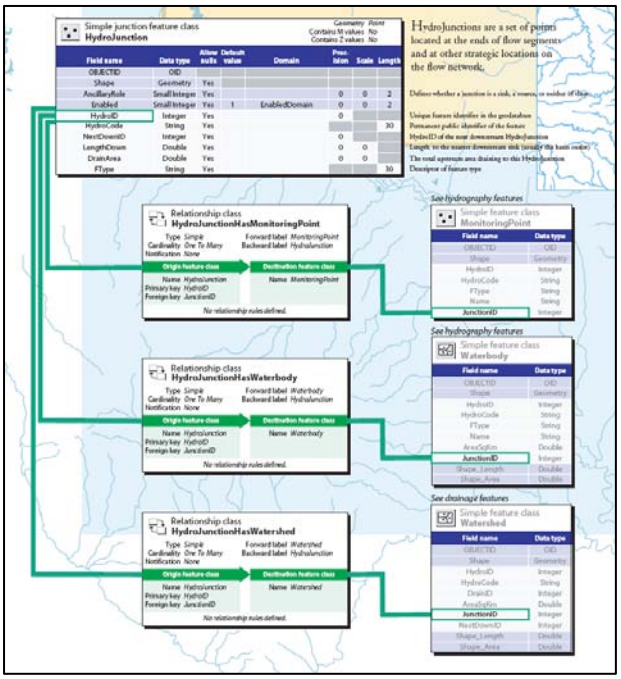


Figure 1: Example Data Model (ESRI Water.Wastewater)

Before any data is digitized into a GIS format some forethought should be given to data standards and a model of how data will interact. At a root level this means deciding on what attributes will be collected for each feature, deciding how the feature will be uniquely identified and how this data will be linked to other maintained information. The design of a Data Model (See Figure 1) is imperative before any data features are gathered. This section will present sample or recommended attribute data for each map layer.

Meters/Valves/Pumps/Junctions

Geometry: Point Features
It is recommended that this information be created through a combination of on-screen digitizing, using Flushing Maps and GPS data collection (See Figure 2). For those features accessible above-ground, a sub-meter GPS location point will provide the best, most-accurate data layer. This data collection process could be achieved through a contract with an outside agency or through a cooperative partnership where MVD staff would do much of the data gathering. Inaccessible features could be obtained from Flushing Maps.

Figure 2: GPS Data Collection

Recommended base attributes for this data layer:

Attribute	Notes
ID	Unique ID
Type	Meter/Valve/Junction/Other
Age	Year Installed/Serviced
Size	Diameter, etc.
Flow	Max/Min/Avg/Other

These are base attribute recommendations. Other attributes would likely be customized to the MVD system. Feature points (Meters, valves, pumps, junctions, etc) are represented as one data layer identified through a "Type" attribute. Based on data needs, these may be maintained as separate data layers.

Pipes

Geometry: Polyline Features
It is recommended that network pipe data be digitized on-screen from Flushing Maps. The locational accuracy of pipe features will be greatly enhanced by connecting to previously obtained, accurate GPS

point feature locations. Staff knowledge may be very important to locate water main pipes as accurately as possible.

Recommended base attributes for this data layer:

Attribute	Notes
ID	Unique ID
Type	Function
Size	Diameter
Material	Construction Material, PVC, etc.
Age	Year Installed/Serviced
Depth	Depth In the Ground

Other System Features

Wells, Water Towers, Other
Geometry: Point Features
Most system source wells already exist in GIS format. Water Towers and other point features are relatively few in number and could be obtained quickly through GPS.

Service Areas or Routes
Geometry: Polygon Features
This simple three-polygon layer could be quickly digitized from the printed Route Map.

Mainline & Curb Cards
GIS digitization of resource cards is not recommended. Most cards do not provide sufficient geographic reference points and the detailed locations provided by the cards would be much more easily obtained through GPS. The cards do contain a great deal of information that will be needed even in a full GIS environment. Scanned images of cards could be linked to a street address, lot number or unique customer ID obtained from the CUSI customer database. It is recommended that the cards be scanned and each image given a file name based on a pre-defined ID value.

Available GIS Data
The Town of Merrimack is in the early stages of building GIS capabilities. A contract for aerial ortho-imagery has been contracted and flown and digital Planimetric and parcel adapt is being created. When available, this data will be very valuable as background, base layer information.

Overview of GIS Data Recommendations
• Define data standards and attributes for any features to be digitized.
• Decide how this feature will be linked to other GIS data or databases. i.e. Customer database - Creation of a data model.
• GPS accessible network point features such as meters, pumps, valves, junctions
• Digitizer system pipes using geo-referenced Flushing Maps, aerial imagery & connecting to GPS point features.
• Digitize other non-network features from available maps, imagery or GPS. i.e. Route Areas
• Scan Mainline and Curb Cards identified uniquely by image file name.
• Gather other available GIS background layers into an organized GIS database.

GIS APPLICATION NEEDS

Operations and Maintenance

Mapped system information is a valuable resource for everyday operations and long-range planning. It is recommended, initially, that a basic GIS browsing project be created on any office or laptop computer that has GIS software installed. This application would have all relevant data layers added and symbolized, allowing staff to browse information quickly without building a new GIS project. Data in the application would be linked to a pre-established, centralized GIS database. Also, any data joins or hyperlinks to other information, such as customer databases or scanned cards, could be established in this project with little or no customization of the standard desktop GIS software. This same project could be moved to a laptop in the field with minor data path adjustments.

Office map display applications are beneficial to daily functions including, customer service, complaint tracking, work order management and inspections. GIS applications allow agency staff to query information and display maps on agency assets. See Figure 10 (Page 11) for an example screenshot of a map display application integrated with other system database information. Network features, meters and pipes, located through GPS are highly spatially accurate. Aerial imagery provides a background reference allowing for features to be easily located on the ground. Some attributes features such as meter ID and pipe size are labeled and all other feature attributes can be quickly accessed. Finally, scanned Mainline and Curb cards, automatically linked to the highlighted parcel, are displayed on screen. All of this information could be printed or carried into the field on a laptop for a work order, customer service or maintenance purpose.

There are several maps the agency may want to designate for large size printing and display in the office. It is recommended that projects for these maps be built and maintained on office computers with GIS software. Suggested display maps include: Mainline System Map, Route Map & smaller complete system maps. These complete map projects can be exported into universal file formats such as PDF or image files, to be printed wherever a large format printer is available.

Inventory and Analysis

A mapped distribution system in GIS is an electronic inventory of all assets that can be easily queried spatially or by attribute information. It can be a powerful asset management tool. It is recommended that all network features be coded with service dates or other maintenance information. This data will allow agency staff to query information and display maps on maintenance history and on-going work. All information concerning the count of assets, their location and any information coded into attributes is contained in the GIS database and immediately available to staff.

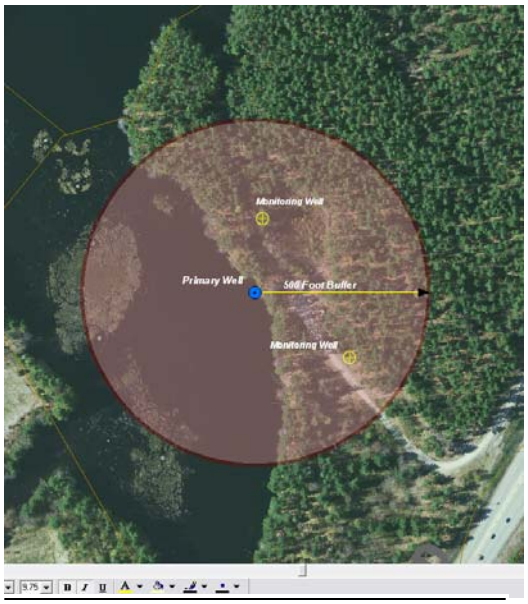


Figure 3: Example Monitoring Well Analysis

The ability to analyze the system assets spatially or based on proximity is an important feature of GIS. The power to analyze monitoring wells and their proximity to primary wells, and to map the results, is an example of the potential for GIS maintained data (Figure 3).

When linked to the customer database, GIS is beneficial in the analysis and display of customer accounts including very high water usage customers or high usage areas using actual billing data, customers behind on their bills, recent or frequent work order locations or customers classified by type.

A system wide GIS network will allow for the inventory and analysis of assets including mapping meters by type, pipes by size of type and any asset by last maintenance date. Because a GIS is a visual inventory of the system it can be exceedingly useful in the scheduling of services, installations, flushings, inspections, maintenance or any other system activity. A GIS provides a visual and database foundation for planning, budgeting and redistricting decisions by offering complete system information and the ability to utilize other data such as land use, zoning, locations of other public infrastructure and natural features.

The administration of lands and rights-of-way, often a difficult task for utilities, can be greatly enhanced through GIS. With the addition of available parcel data, users can easily inventory, query and analyze land accessibility and ownership.

Data Privacy Protection

Digitized system data can raise new security concerns beyond any established policies for hard copy information. Highly accurate spatial and attribute information is contained in network GIS data. Concerns about the protection of privacy can be addressed by limiting data access through the use of passwords on system computers with the ability to access GIS data. Also, it is recommended that distribution agreements be a part of any outside vendor contracts for the creation of GIS data or applications.

Software

GIS software ranges in cost and scale from desktop user versions, to server-based enterprise applications to intranet/internet mobile solutions. The level of desired GIS implementation will decide which solution or combination of solutions will work for the agency. There are several considerations in the implementation of a GIS system including:

1. Changes to current workflow structure
2. The cost of software and hardware
3. Hiring new personnel or training existing personnel

Full enterprise solutions integrating GIS and proprietary water management workflow solutions are available through various software vendors. However, based on interviews with staff, a more gradual approach to GIS implementation appears to be the most appropriate for MVD at this time. At its most basic this could include one or more version of desktop GIS software (ArcView by ESRI is the recommended industry standard). This is the GIS software that others in the Town of Merrimack use.

Additional Software Consideration

In interviews conducted with staff, a desire for field personnel to have access to mobile mapping information was expressed. There are several escalated methods to achieve this. First, field personnel could simply bring printed maps from the office for a specific site. Second, a static PDF map or a complete system wide PDF map book could be created and loaded onto laptop or PDA systems. The next possibility would be a free map browser such as ESRI's ArcReader could be loaded onto laptop computers. This would require the cost of an extra software extension up front, but would allow unlimited distribution of query and interactive map browsing to field personnel. Another solution that would be best if only one or two field personnel need GIS access is to install a full version of GIS software on field laptop computers. This may require the purchase of additional desktop licenses but would allow field staff to utilize the same GIS applications that run in the office.

A final solution for supplying field staff with GIS capabilities, considered beyond the scope of the recommended initial GIS implementation, is the use of GPS enabled PDA's, running GIS software and communication wirelessly to a central database server. While there are large costs involved in the implementation, this solution would allow personnel to browse and update live map information from the field.

Hardware

Current MVD desktop computers are satisfactory for desktop or browsing GIS software programs. Minimum system requirements for ArcView Desktop GIS are:

Platform	PC-Intel
Operating System	Windows 2000 or Windows XP (Home Edition and Professional)
Memory	512 MB RAM
Processor	1 GHz

New desktop computers with increased memory and standard or better video cards would be beneficial for GIS applications. Also larger viewing monitors, 19" inches or greater, is beneficial for any office computers displaying GIS mapping.

Enterprise GIS solutions would require a high-end server computer and improvements to the current peer-to-peer local area network.

Overview of GIS Application/Software/Hardware Recommendations
• Define workflow GIS applications to be implemented - Browsing, editing, Analysis
• Decide upon and purchase the level and amount of GIS software needed to achieve application goals.
• Purchase any additional hardware (computers, monitors, servers) required to run GIS software.
• Design custom applications or projects and install on network computers.
• Define which printed display maps are required and design those custom projects.
• Define policies and procedures for data security.

GIS TRAINING NEEDS

An implementation of GIS in an agency the size of MVD can be a straightforward process. Initial data development and design architecture will need to be supplied by an outside source. However things change quickly. Customer changes and the network changes can quickly make newly created data out-of-date. Just as processes for the current record card system have been established, processes for the maintenance of digital GIS data will need to be established. The roles of agency staff need to be identified in relation to any new GIS applications or resources. Without adequate training and experience the benefits of GIS cannot be fully realized. The amount of expertise required will depend on the level of GIS implementation. There are several possibilities for fulfilling training needs:

1. Assign one or more current staff GIS responsibilities and provide training. This approach is sufficient if staff is essentially end-users of designed applications and data. However, problems can quickly occur if staff are responsible for data maintenance or analysis. End-users need technical training when the program begins and additional scheduled training as software or system needs change.

   Training opportunities include online self-guided courses, regional training workshops & contracting GIS professionals for personal training.

2. Contracting with an outside consulting source to provide ongoing GIS data maintenance and application support. This may consist of an on-call, hourly basis of support or an established set of hours per period. The increased cost of this solution is offset by the level of expertise available and a better assurance that the initial investment in GIS data will not be wasted.

3. Establishment of a new position with full or partial GIS responsibilities and with the required experience for hire. This solution is beyond the scope for the recommended level of implementation. However, having GIS expertise on staff can quickly become essential for any agency implementing an enterprise GIS solution.

Overview of GIS Training Recommendations
• Define roles for personnel using GIS based on level of implementation and applications to be utilized.
• Define training requirements for these personnel.
• Decide how the required expertise will be obtained - through staff training or contracting outside assistance.
• Establish procedures for on-going training or support.

EXISTING MAPS

In the implementation of GIS, it is necessary to create a map of the basic water system structure. Therefore, as a first step, it is important to inventory the existing spatial and cartographic resources available to the agency. Existing mapping for the system consists of printed maps created by outside agencies, hand-drawn maps for field use and two different systems of cards maintained in the office that display detailed information on a site.

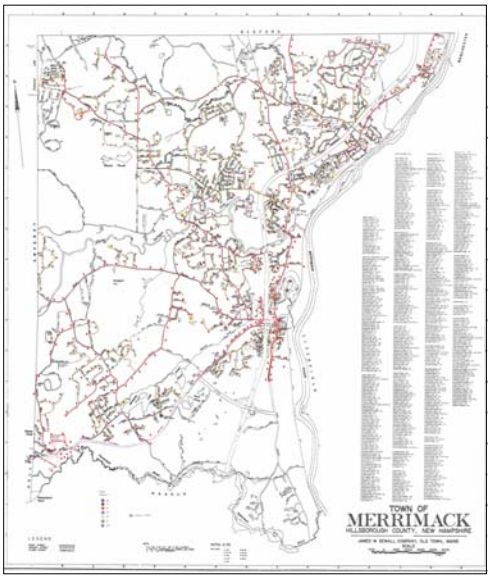


Figure 4: Distribution Map

Existing Printed Maps

The system is currently mapped in several different ways, including small-scale display maps, hand-draw field maps and large-scale, site-specific cards. These sources exist at varying degrees of accuracy and completeness and are dispersed throughout the organization. The following is a report of the existing cartographic resources available and strategies for conversion to digital formats.

Distribution Map (Figure 4)
The overall water system, including water mains, hydrants, wells and tanks, is hand-colored onto a town-wide street map last updated in 2001. Water mains and their sizes are indicated by a thematic color key of the street segments. Water mains do not identify flow direction. Hydrants have been GPS located by the Merrimack Fire Department and are available in GIS format. However, they are indicated by hand-drawn points on the Distribution Map. This map is for general office use and is often used by developers or engineers to identify the availability of water.

Water mains should be digitized in GIS as part of the overall network, but at a greater detail than this map allows. This map could be easily reproduced with updates when all data is fully converted into GIS.

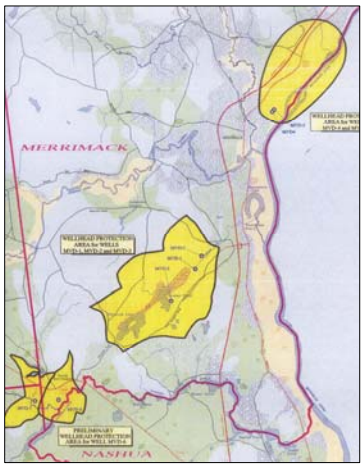


Figure 5: Wellhead Protection Map

Wellhead Protection Map (Figure 5)
The Wellhead Protection map is an office use display map that indicates source wells, wellhead protection zones and stratified drift aquifer areas. All of the map layers in this map use standard regional and statewide datasets currently available in GIS format.

Route Map
The Route Map is a small display map containing hand-drawn route areas onto a street map last updated in 2001. There are three routes, or service areas, that are tied to the customer database.

The data on this map could be easily converted to GIS as the service areas represent polygons that generally follow street centerlines.

Flushing Maps (Figure 6)

Flushing Maps are hand-drawn 11" x 17" printed maps created by engineering staff to provide greater detail for some complex network areas. Their geography is usually limited to intersections or single subdivisions. The flushing maps do not provide a complete coverage of the entire system. These maps are highly detailed, including: pipes, valves, valve numbers, meters, hydrants and often contain distance and angle measurements. Underground pipe locations are not spatially exact, but do represent roughly the correct side of the street. As the name indicates they were created to provide the necessary information for flushing a segment of the system.

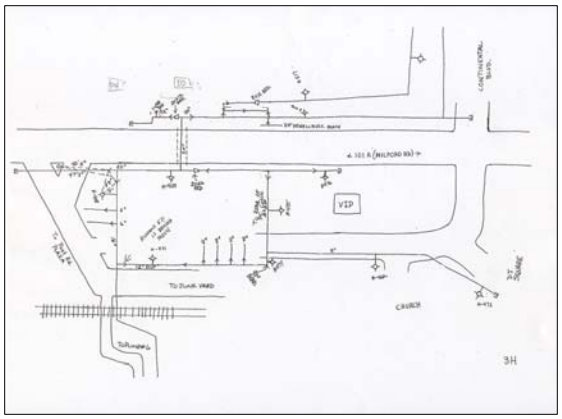


Figure 6: Example Flushing Map

The Flushing Maps, scanned and geo-referenced would provide the best source for digitizing the overall network, including pipes, valves and meters. While the map features are not spatially exact, they represent the most complete, accurate information currently available. Digitized data, created through these maps could be combined with, or corrected by, GPS data obtained in the field.

Mainline Cards (Figure 7)

Mainline Cards are postcard size, hand-drawn schematics of individual sites, lots or intersections. These diagrams contain the most detailed system data available, including: pipes, valves, meters, poles, structures, and angle and distance measurements. The mainline cards are used in the field but are kept in a large file box in the office. They are believed to be a complete coverage of the system.

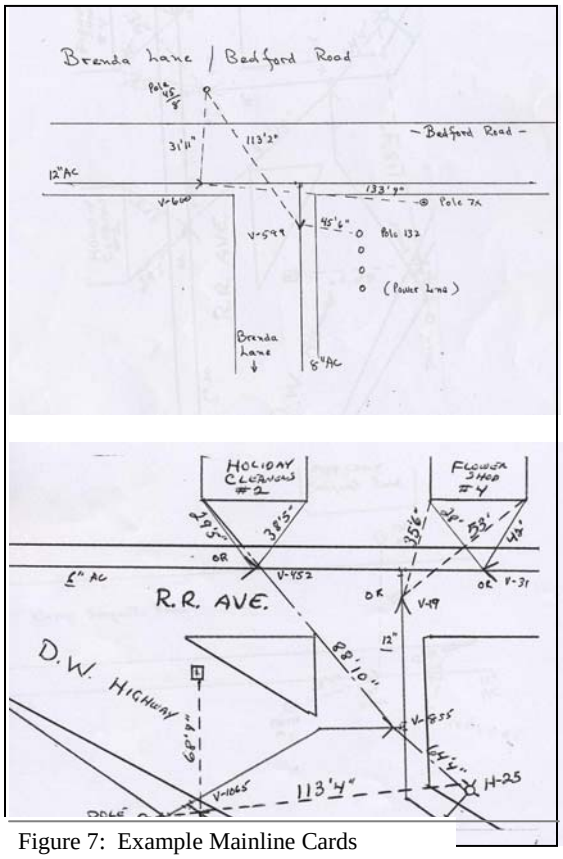


Figure 7: Example Mainline Cards

Curb Cards (Figure 8)

Curb Cards are small, postcard size printed cards that are linked to the customer billing system. The cards are originally hand-drawn in the field then created using a template provided in the customer billing database software. Curb cards are used to locate the shutoff valve by providing angles and distances from the corner of a structure. The cards also contain street and house numbers, lot numbers, owners, development, dates for entrance and measurements and water pressure. The cards are available for every house in the system. The cards are maintained in the office in a large file box.

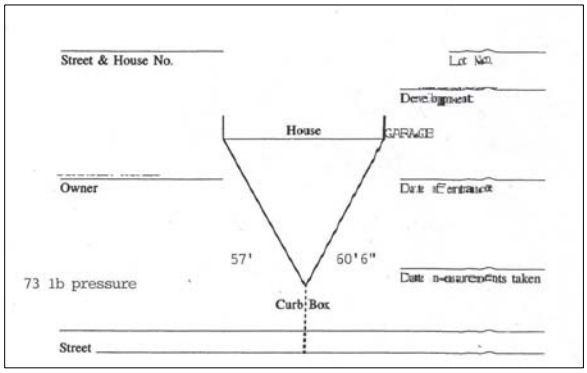


Figure 8: Example Curb Card

Mainline and Curb Cards, while containing detailed information, lack the geographic reference points to make digitization into GIS practical. Also the large number of cards would make this a time-consuming and expensive task. A better alternative would be to scan each card and link it electronically to features in the digital network. Cards could be hyperlinked to house numbers, lot numbers or other features on the system. The cards could be displayed on screen together with a map of the system containing background data such as lots, building footprints or aerial imagery (See Figure 9). Depending on the software and hardware implemented, the display could be viewed in the field, saved as an image or printed in the office.

Record Drawings (As Builts)

Printed copies of site plans are now being submitted to the agency as part of the development review process. These drawings are kept on file and may be a useful resource for digitization.

Digital Map Data Available

In addition to printed maps and cards, there are several sources of digital GIS data that is or will be available to the agency.

Figure 9: Example of Planimetric Data

Town of Merrimack

The Town of Merrimack recently contracted with an outside company to have digital aerial imagery flown for the community. This geo-referenced imagery is six inch on-the-ground resolution and will be exceptionally useful as a base layer and for further digitization. Planimetrics (See Figure 9) are also part of the contract deliverables. These are spatially accurate GIS layers of street edges, sidewalks, curbs, building footprints and other features that can be derived from the imagery. The Town also plans to contract for updated digital parcel data.

Regional Planning Agency

The Nashua Regional Planning Commission is a resource for GIS data. NRPC currently maintains an un-official GIS parcel layer as well as zoning, street centerlines, hydrography, wetlands, aquifers, topography and other standard statewide datasets. New full-color aerial imagery, one-foot resolution on the ground, and contracted through New Hampshire Department of Transportation, is available through NRPC.

NH GRANIT

The New Hampshire Geographic Information System (NH GRANIT), housed at the Complex Systems Research Center at the University of New Hampshire, acts as the repository and distribution center of statewide GIS datasets. Many statewide datasets used by towns, cities, regional and state agencies are obtained through GRANIT. These datasets include: Hydrography (Streams, lakes, reservoirs and wetlands), floodplains, aquifers, soils and watershed boundaries.

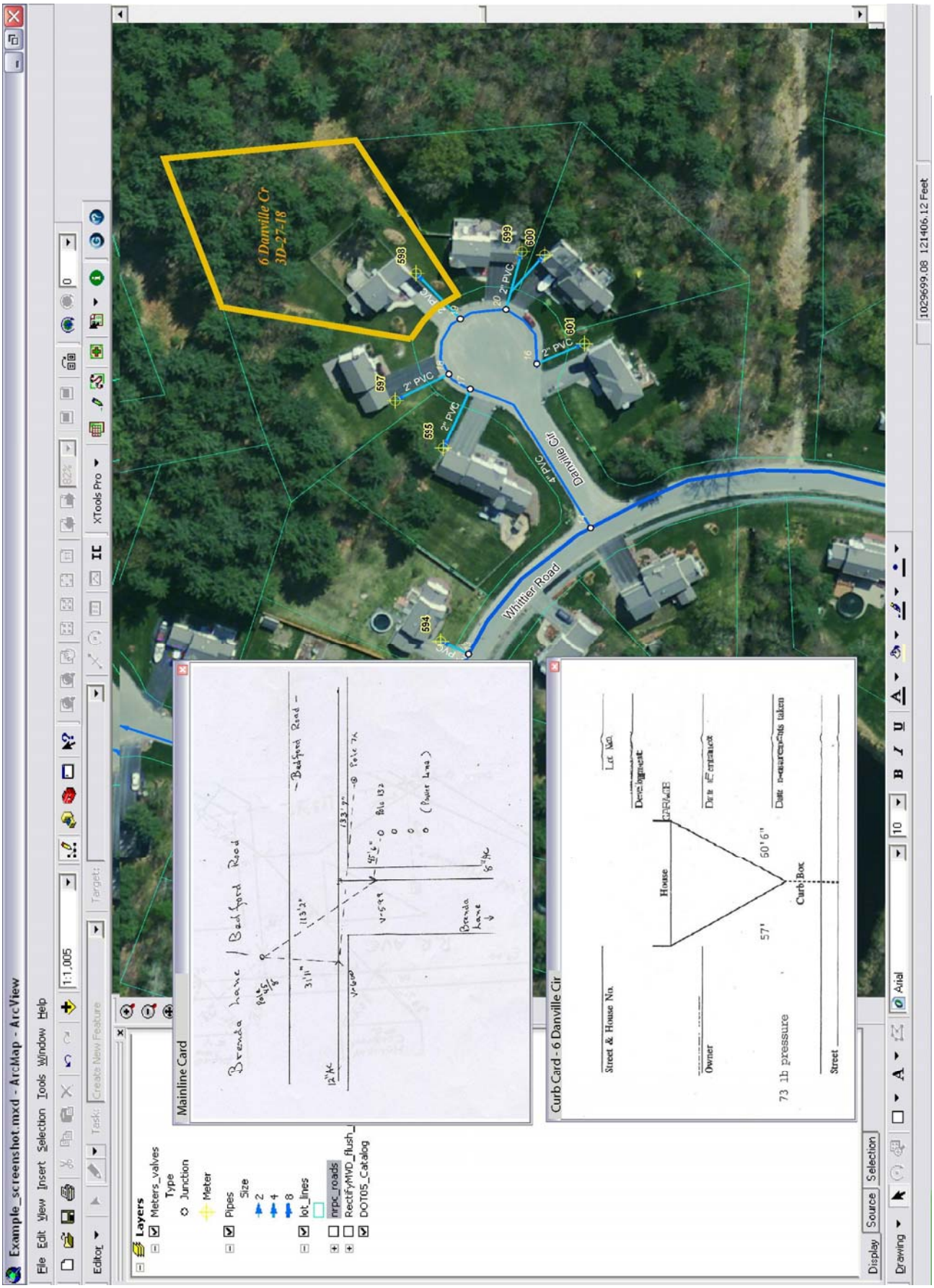


Figure 10: Example of an integrated application with network data and scanned cards.

EXISTING SOFTWARE/DATABASES/HARDWARE

The Merrimack Village District staff consists of approximately five office staff and approximately eight field staff. There is currently no staff with GIS experience.

A Geographic Information System is a software application that should integrate with and complement the existing applications of the agency. GIS is a map viewer and spatial database that can be a principal part of the work flow process. Therefore it is important to understand the existing software applications, how they are applied to the work process and their relation to geographic content.

This Summary report will inventory the software application currently used by MVD and then inventory the existing hardware those applications run on. Strategies will be explored for integration into a GIS environment.

Software/Databases

Billing/Customer Database (Figure 11)

MVD operates Continental Utility Systems Inc. (CUSI), third-party, billing software to manage customer accounts. CUSI users interact with a Microsoft FoxPro database through simple tabbed forms. Customer information maintained includes: property address, billing address, water supply information (hydrant only? Sprinkler system?), account history, type of account, etc. CUSI also serves as a work order generator. Currently work order information (i.e. service request), including account details and instructions, is printed and supplied to field staff. Printed customer cards are maintained from the CUSI interface including archive cards of closed accounts. CUSI is proprietary software and therefore it can be difficult to automate the integration between it and GIS. However, access to the back-end database appears possible. This will ease the process of linking customer account attributes to GIS data. Attributes from the billing database that could be linked to GIS features and therefore mapped include: address, customer number, parcel ID, work order history, account types, route number, meter information, billing history, etc.

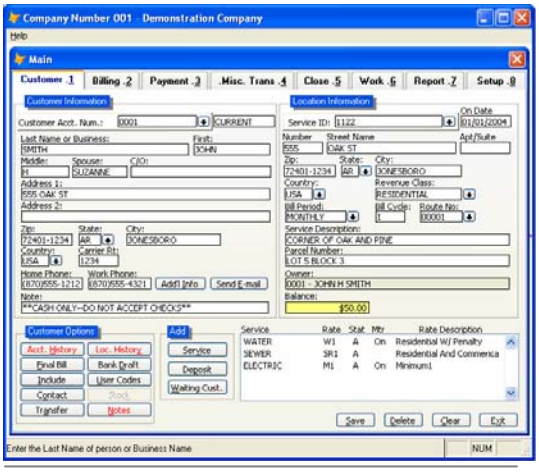


Figure 11: Example CUSI Screenshot

The customer database is the single most important database in daily operations and is therefore linking to GIS data provides significant benefits. Every piece of information held in the customer database can be classified, mapped and analyzed spatially in a GIS. Mapping and analysis of customer accounts in relation to billing, water usage, work orders, installation dates, maintenance dates or customer types (Service connections, building type, hydrant only, sprinkler system) would be readily available in GIS.

Hydrologic Model

MVD contracts with an outside firm, Prism Environmental, to maintain the hydrologic model of the water system. Prism runs a Haestad Methods Model in WaterCAD software. MVD staff does not directly interact with the model. Requests are made to Prism for a model run and analysis and Prism delivers a report in return which highlights any problems or stresses on the system. The hydrologic model is not a geo-referenced file and is independent of all other GIS data. Newer WaterCAD versions allow GIS background data to be added to the visualization of the model and there are methods to convert the model to a GIS format. However, it is recommended that the hydrologic model remain independent of other mapping data. MVD staff is not currently prepared to maintain a hydrologic model themselves and the model output would not be improved by integration into a GIS system. Accurate GIS data, once in place, may improve updating and overall coordination between the model provider and MVD staff.

Zcorr - Advanced Digital Leak Detection System (Figure 12)
Zcorr is a system of hardware loggers and software used to detect and monitor leaks in a water network. It is supplied by Flow Metric Inc. The loggers, placed along the network, use sound to detect leaks. The recordings, retrieved in the field, can be downloaded to a laptop or office computer and analyzed. The system is GIS ready and comes with a mapping component. The loggers are located through GPS coordinates. The agency's own GIS data can be imported into the back office software and a map of the network, loggers and any leak analyses can be displayed. MVD currently has no GIS data of the actual water network. Any data created as part of a GIS implementation could be leveraged by importing into the Zcorr software. This system has recently been purchased and is being installed. Most important, for the assimilation of Zcorr with GIS, is to ensure that any effort made to implement Zcorr be compatible with data design modifications prepared for GIS. This is simply a precaution to avoid duplication of effort.

Figure 12: Zcorr

Vitals™ Valve Performance Analysis Software (Figure 13)
Vitals™ is software that will be run on a field laptop and is used to log and track the condition of valves in the water system. Information on valves can be uploaded to a PC where the software tracks and analyzes performance. The software is GPS ready. Valves can be located using GPS coordinates. This software acts as a database of any valves that are monitored and therefore it is important to consider GIS when implementing this system. Particularly attention should be paid to what attributes are gathered for each valve as it is entered into Vitals™. The same attributes would ideally be applied to a GIS dataset of valves in the system.

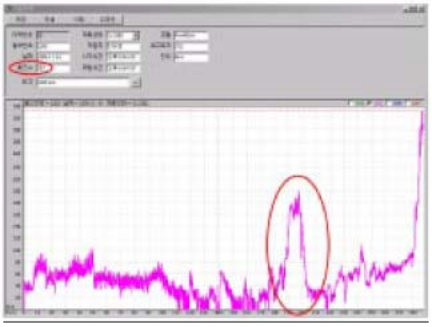


Figure 13: Vitals

SCADA

Supervisory Control and Data Acquisition (SCADA) serves as overall system tracking and maintenance software. SCADA remotely monitors the system including tank levels and intrusion warnings. The system allows for unattended operation, including the ability to automatically turn on booster pumps and maintain water levels and is used primarily by MVD Treatment staff. The SCADA interface is form and schematic based and is not geo-referenced. Any integration of SCADA systems and GIS tends to occur in reporting tasks. SCADA reports on system operations or problem alerts can be tied to network features (i.e. tanks, pipes, etc) that have a geographic component.

Operating System/Office Functions

All MVD computers run Microsoft Windows XP with the exception of one Windows 98 System. All computer desktops run Microsoft Office software. This software is sufficient and compatible for all desktop versions of GIS software.

Hardware

Desktop Computers

MVD office staff currently utilizes three full-time desktop computers and one part-time desktop computer. Three laptop computers are currently available and are most often utilized by field staff. Office computers are currently compatible with desktop GIS software. Upgraded monitors may be beneficial for staff using GIS.

Network/Servers

MVD office computers function as a Microsoft Windows peer-to-peer network. A server computer exists but acts only as storage device and as connection to dial-up internet and email service. The server computer is a converted desktop system.

SUMMARY

A well designed GIS implementation involves several steps and not all involve changes to data, software or hardware. The utilization of GIS data through applications will necessarily have a significant impact on how the agency operates. Not all recommendations in this report involve technology, but involve how system information is used among the staff and how it is provided to the public. These can be fundamental policy and staffing decisions. Many organizations purchase GIS data, software and hardware but do realize the full potential of GIS due to a lack of planning concerning staff training, personnel or workflow procedures.

GIS software and hardware is relatively inexpensive today. MVD will have some significant costs in the creation of GIS data as nearly all of the network features currently exist only in paper format. However a tremendous amount of related background data, including parcels and aerial imagery, are available from other sources. This data can be useful in the digitization of network features. Often the most expensive aspect of GIS implementation is staffing. Effective use of GIS requires staff members that are specially trained and have sufficient time available to dedicate to GIS work.

Benefits to MVD

The greatest benefit of GIS for MVD would be the reduction of labor through the automation of manual tasks and the integration of currently separate operations by linking common asset information. Specific benefits would include:

- Complete geographic inventory of all assets for maintenance scheduling and budgeting.
- The ability to map, query and analyze the entire distribution system.
- A seamless, complete network map providing a comprehensive, holistic view of the system for planning purposes.
- Improved customer service and better efficiency in daily tasks through the linking of GIS system information with other agency records, including the customer database, Zcorr, Vitals and SCADA.
- Reduction of labor in the creation of hand-drawn schematics.
- Better access to information in the field, including, scanned cards and printed or electronic maps containing network features, parcel and ownership information and network features overlaid on aerial imagery.
- Better and easier ability to back-up and secure system information.

Major Findings and Recommendations

- GIS implementation would be beneficial to MVD in increased efficiency, asset management and customer service.

- Network features should be converted into GIS format through a combination of GPS data gathering and on-screen digitizing using existing hard copy maps. A data model, defining feature attributes and connections should be designed prior to data creation.

- It is recommended that information contained on Mainline and Curb cards not be digitized into GIS data, but that the cards be scanned and linked dynamically to the address or area they represent.

- The Town of Merrimack is currently in the middle of a GIS implementation process. MVD should attempt to stay informed and continue to attend meetings related to this process. This will ensure consistency of GIS products and will eliminate any duplication of effort.

- It is recommended that custom GIS projects or applications be created to assist inventory, maintenance, customer service and system mapping. Integration with other existing databases and programs should be attempted as much as possible through data linking.

- It is recommended that MVD either assign a staff position to GIS with the requisite qualifications or rely on a combination of outside support and staff training. Contracted support should include long-term GIS data maintenance and operations support.

- Policies and procedures for operations, analysis and training should be established to fully realize the benefits of a GIS implementation.

Steps to Implementation

A GIS needs assessment identifies the desire and potential for GIS use within an agency and makes recommendations concerning data, application and training needs. The following our general steps required to implement the suggestions made in the needs assessment.

1. Identification of GIS data and application development support. This will be an outside source or internal hire with expertise in GIS development.

2. Development of a GIS Implementation Plan and Data Model. Identification of initial GIS applications to be used and the data required to implement them. Also included in the Implementation Plan should be an identification of who will use GIS and in what capacity in the organization. Per recommendation this would include one or more end-users of daily functions and a contracted support organization.

3. Creation of required GIS data. Before any GIS applications can be implemented the data must be present. Some data may already be available in GIS format from other sources and some data may need to GIS. The MVD has considerable data resources tied to printed maps and schematic drawings which will need to be digitized into an electronic GIS format.

4. Development of GIS applications installed on MVD computers. This would entail the design of custom projects and/or customized interfaces. Applications would utilize GIS data created in Step 3 following the Data Model created in Step 2.

5. Initial training for MVD staff GIS users. Identification of long-term training needs.

6. Identification of data and application maintenance procedures. As network features on the ground change and software versions evolve, sufficient expertise in support will need to be identified.

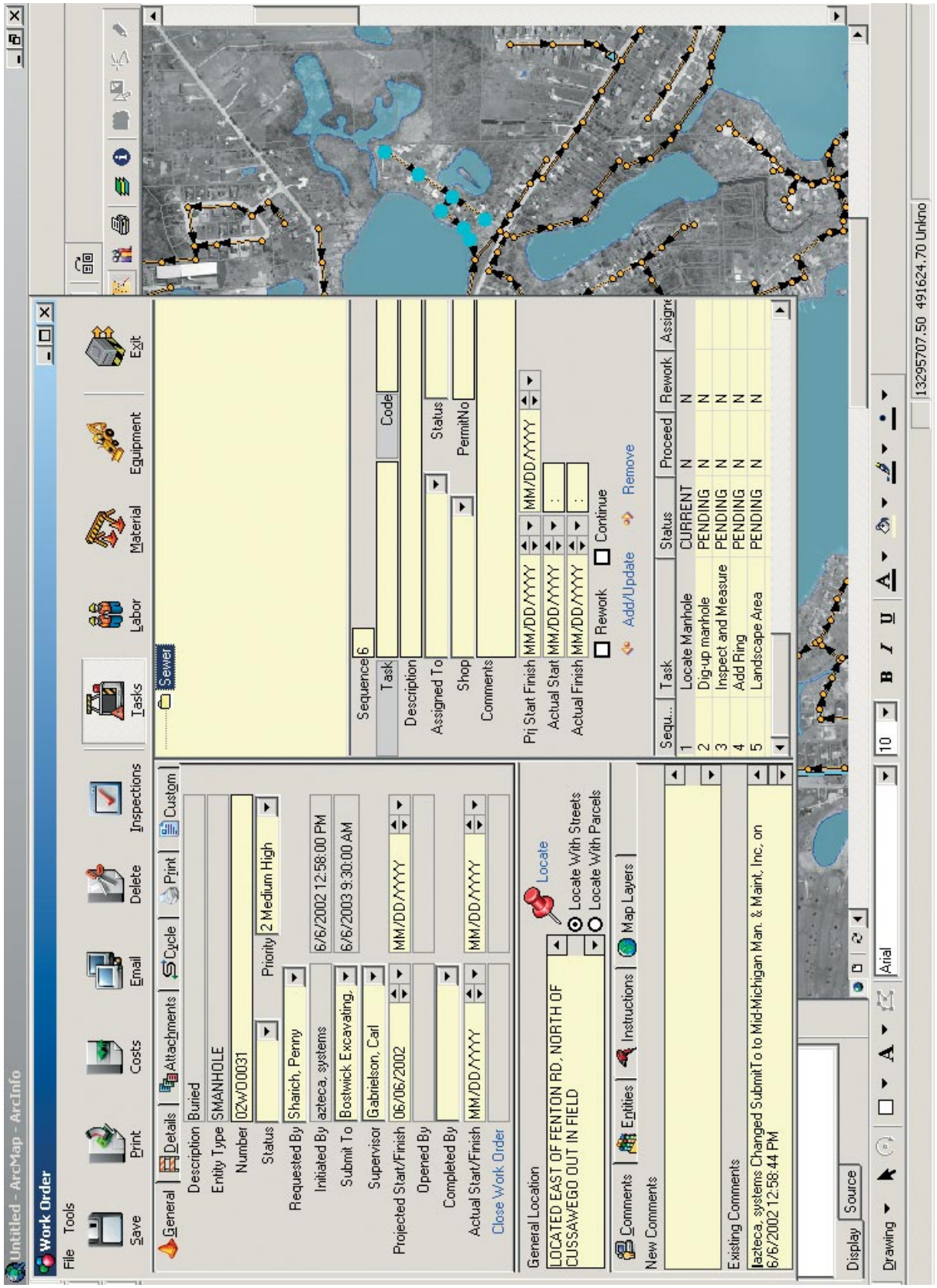
APPENDIX

MVD Staff/Contacts interviewed:

Jim McSweeney - Business Manager/ Superintendent	Ron Miner - Distribution Foreman
Jill Vacchiano - Assistant Business Manager / Superintendent	Kevin Gurney - Treatment Supervisor
Carol Sutton - Customer Service and Billing	Dave Edson - Prism Engineering (Hydrologic Model)
Bob Kelley - Water Quality Testing & Operational Data / MVD Clerk	Harris Burpee - Computer Support

GIS Software Options/Cost

Software	Approx. Cost	Benefits / Issues
ArcGIS (ArcView-Single Use) Desktop	$1500 per License	Powerful GIS software with simple installation requirements. However limited to one license per user.
ArcGIS (ArcView-Floating License) Desktop	$3000 per License	Same application as the Single-Use ArcView. Utilizes a License Manager and allows multiple users to access the program concurrently up to the number of licenses purchased. - requires a networked system and a more complicated install.
ArcGIS (ArcInfo-Floating License)	$9500 per License	Full GIS software application for GIS specialists. Uses License Manager.
ArcReader	Free browser - requires $2500 extension to ArcGIS	Free GIS browsing software can be installed on unlimited computers - Limited analysis capabilities.
ArcIMS	$9000 Per License	Intranet/Internet web mapping software. Requires only a web browser to view. Limited GIS functionality - Application development and web server hardware are required.



Example Enterprise System GIS-based computer maintenance management system - (www.esri.com/news/arcnews/winter0304articles/fenton-township.html)

RESOURCES

- Overview of Geographic Information Systems at GIS.com
  http://www.gis.com/whatisgis/index.cfm

- ESRI Water / Wastewater Resource Page: Including data models, Demos and Case Studies
  http://www.esri.com/industries/water/index.html

- ESRI Software Suite Overview
  http://www.esri.com/software/arcgis/index.html

- Examples of Enterprise Water Utility Solutions integrating GIS
  "Cityworks" by Azteca Systems, Inc. http://www.azteca.com/
  "ArcFM" by Telvent, Miner & Miner: http://www.miner.com/products/index.shtml

- Nashua Regional Planning GIS website
  www.nashuarpc.org/gis

- GRANIT Data website - Complex Systems Research Center at the University of New Hampshire
  www.granit.sr.unh.edu

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Merrimack Village District Water Works
2 Greens Pond Road
Merrimack, NH 03054
www.mvdwater.org

Nashua Regional Planning Commission
115 Main Street
Nashua, NH 03061
www.nashuarpc.org