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EXECUTIVE SUMMARY

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CHAPTER 1 – OVERVIEW AND METHODOLOGIES

The City 's Geographic Information System (GIS) design and implementation is typified by a phased approach that utilizes industry standard open architecture hardware and software platforms. The phased approach has been embraced in order to ensure the implementation of best of breed technology at the most reasonable cost throughout all phases of the project's life cycle. The open architecture philosophy will protect the City's investments in data and applications throughout the course of the project.

Over twenty different departments or agencies will benefit from the implementation of the City's planned GIS. In an effort to ensure the needs of each of these distinct user groups will be supported by the system, an exhaustive Needs Assessment was performed as the first step in the implementation process. The Needs Assessment lays the foundation for the remainder of the implementation processes by clearly identifying the following:

- Potential City-wide GIS benefits
- Potential applications
- Preliminary application definitions and designs
- City-wide user groups
- Prioritized Focus Applications
- Landbase feature and accuracy requirements

From this point forward, all system design, procurement, implementation, and development decisions will be governed by the groundwork laid out in the Needs Assessment.

While the Needs Assessment justifies the GIS, and defines its basic components, the Implementation Plan provides the framework for its implementation. The Implementation Plan outlines the general system design, including:

- GIS database
- System interfaces
- Customized GIS product options
- Field access options
- Mapping graphics structure
- Recommended off-the-shelf GIS products
- Network and Inter/Intranet options

Additionally, the implementation Plan presents a schedule for the following implementation activities and expenditures:

- Hardware and software
- Training
- Data conversion
- Remaining technical tasks

The Implementation Plan organizes the findings and recommendations resulting from the Analysis component of the Planning Phase (Needs Assessment, Data Survey, and Management Plan reports) and presents them in a format that will support the City's future decisions regarding implementation of the planned GIS.

CHAPTER 2 – GENERAL SYSTEM DESIGN

The City of Suffolk's planned GIS will be a distributed system, whereby data sets are maintained by a variety of distinct user groups. In consideration of this type of organization, the GIS must be designed to support rapid access to the various geospatial data sets, while providing the tools required to ensure data currentness, integrity, and security. To achieve these goals, the planned GIS must be capable of:

- Operating across the City's existing local area and wide area networks (LAN/WAN)
- Administering a broad range of access and security controls
- Supporting complex data editing, posting, retrieval, and display functions
- Seamlessly integrating with a variety of the City's existing legacy applications

Each of the system design considerations required to ensure the success of the City's planned GIS are described in detail in the following sections. Detailed system specifications will be developed as part of the GIS design phase.

Database Philosophy

A critical component to the successful implementation of any GIS is the database philosophy embraced by the organization. The database philosophy and its underlying architecture dictate, to a large degree, how the geospatial data is accessed and distributed throughout the organization. The City of Suffolk has embraced an open architecture GIS design that will utilize an Open Database Connection (ODBC) compliant Relational Database Management System (RDBMS) such as Oracle, Informix, or SQL Server. Implementing such a database solution will provide the City with the following benefits:

- Ability to manage spatial data with conventional RDBMS tools, languages, and techniques
- Facilitates access to data from a variety of widely used business systems
- Promotes open standards and Application Programming Interfaces (API)
- Encourages data sharing and open access
- Supports data mining and Enterprise Resource Planning (ERP) functions

The base mapping and Focus Application specifications determined as part of the Needs Assessment dictate the graphic features, and their associated attributes, required for population and maintenance in the City's GIS database. The following graphic features, along with their associated tabular attributes, were identified for inclusion in the City's GIS database design:

Data Set	Graphic Features	
Base Map Data	Building Foot Prints	Hydrography
	Contour Lines – Existing	Parking Lots
	Driveways	Sidewalks
	Edge of Pavement	Street Centerlines
Parcel Data	Easements	Parcel Centroids
	Parcel Boundaries	
Boundary Data	Business Districts	Political Districts
	Chesapeake Bay Areas	Subdivisions
	Communities / Neighborhoods	Wetlands
	Flood Plains	Zoning Districts
Census Data	Census Blocks	Census Tracts
	Census Groups	
Public Utilities / Public Works Infrastructure Data	Contour Lines – Proposed	Survey Control Points
	Parking Facilities	Transportation Infrastructure
	Sanitary Sewer Infrastructure	Water Distribution Infrastructure
	Sewer Service Area Boundaries	Water Service Area Boundaries
	Storm Sewer Infrastructure	
Environmental Data	Hazardous Materials	Soils
Private Utility Infrastructure Data	Cable Television System	Natural Gas / Petroleum System
	Electric Power System Infrastructure	Telephone System Infrastructure
	Fiber Optic System Infrastructure	

The Environmental and Private Utility Infrastructure data sets are not required to support any of the City's Focus Applications. For this reason, these data sets will not be given further consideration in terms of the

City's base system implementation schedule and budget. However, since these data sets offer valuable information that will enhance the overall functionality of the City's GIS, they should be considered for development in subsequent years.

The City's database design will also account for the interfaces with the City's existing legacy applications, required to support a variety of Focus Applications. These legacy applications may either be absorbed into the overall GIS, or continue to function as stand-alone applications interfaced with the GIS (through ODBC relates or ASCII loader files). This issue is further addressed in **the Interfaces to Other Systems** section of this chapter.

Graphics Definition

A graphics definition needs to be developed for each of the graphic features to be maintained in the City's GIS database. A complete graphics definition for each feature will include a description of the feature's attributes, including color, thickness, line symbology, geometric design, and scale. The graphics definition will also define map output product standards in order to ensure consistency throughout the City's user groups. As part of the GIS design phase, a complete graphics definition will be developed for each of the following GIS features:

- Building Footprints
- Census Boundaries
- Community Boundaries
- Edge of Pavement
- Hazardous Material Symbols
- Parcel Boundaries
- Permitting Symbols
- Sewer Cleanouts
- Sewer Manholes
- Subdivision Boundaries
- Water Mains
- Water Storage Facilities
- Zoning District Boundaries
- Bus Stops
- Census Centroids
- Contour Lines
- Fire Hydrants
- Hydrography
- Parcel Centroids
- Political Districts
- Sewer Laterals
- Sewer Service Area Boundaries
- Survey Control Points
- Water Service Area Boundaries
- Water Valves
- Business District Boundaries
- Chesapeake Bay Areas
- Easement
- Flood Plain Boundaries
- Inspection Symbols
- Parking Facilities
- Rail Depots
- Sewer Mains
- Street Centerlines
- Transportation Routes
- Water Service Laterals
- Wetlands Boundaries

In addition to the feature graphic definitions, a layering scheme will be developed in order to facilitate easy access and organization of the features within the database and associated GIS software programs.

The layering schema should utilize intuitive naming/numbering conventions that group associated features in a logical manner.

Interfaces to Other Systems

The Needs Assessment identified a significant number of existing legacy databases and information systems currently in use by many of the City departments. The majority of these systems are not critical to the development of the Focus Applications, but rather will add additional functionality/value to the applications once implemented. Some of the systems will function best when interfaced with the GIS through ODBC methods, or custom programming interfaces. Others will function best when they are incorporated directly within the planned GIS database design. The databases/systems that will impact the functionality of the Focus Applications are listed in the table on the following pages.

INTERFACES TO EXISTING SPATIAL DATABASES/SYSTEMS			
Department	**Database / Information System**	**Focus Application Impact**	**Interface / Integrate**
Assistant City Manager – Development	Property Inventory (address – based computerized inventory)	Parcel Mapping, Development	Integrate
City Assessor	Real Estate Database (AS400)	Parcel Mapping	Interface (AS400)
	APLUS CAMA Database	Parcel Mapping, Development	Interface (ODBC)
City Manager's Office	Various Federal and State level databases	Census Data Analysis	Interface
Commissioner of the Revenue	Business License Database, Meal Tax Database, Personal Property Database	Parcel Mapping, Development, Permitting/Inspection	Interface (ODBC)
Economic Development	ProCure Database	Parcel Mapping, Development	Interface (ODBC)
Finance	Various financial databases	Parecl Mapping, Development, Infrastructure	Interface (ODBC, AS400)
Fire Department	Various Federal, State, and Local databases	Parcel Mapping, Development, Permitting/Inspection, Dispatching, Routing	Interface (ODBC)
Information Technology	Fixed Assets Database	Infrastructure	Interface (ODBC)
Neighborhood Development Services	Permits Database	Parcel Mapping, Development, Permitting/Inspection	Interface (AS400)
	Code Enforcement Database	Permitting/Inspection	Interface (AS400)

INTERFACES TO EXISTING SPATIAL DATABASES/SYSTEMS			
Department	**Database / Information System**	**Focus Application Impact**	**Interface / Integrate**
Planning	Minor Subdivision Database, Subdivision Database, Subdivision Variances Database	Parcel Mapping, Development	Integrate
	Street List Database	Infrastructure	Integrate
	Zoning Map Database	Parcel Mapping, Area Analysis, Development	Integrate
	Tower Database	Parcel Mapping, Development, Infrastructure	Integrate
	Plan Tracking Database, Conditional Use Permits Database	Parcel Mapping, Development, Permitting/Inspection	Interface (ODBC)
Police Department	Vision CAD Database	Dispatching, Routing	Integrate (ODBC)
Public Schools	EDULOG Database	Routing	Interface (ODBC)
Public Utilities	Customer Account Database	Parcel Mapping, Development, Infrastructure, Routing	Interface (AS400)
	Cybernet Water Model Database, Node File Database, Water Production Database	Development, Infrastructure	Interface (ODBC)
	Engineering Inspection/Billing Database	Permitting/Insepection	Interface (AS400)

INTERFACES TO EXISTING SPATIAL DATABASES/SYSTEMS			
Department	**Database / Information System**	**Focus Application Impact**	**Interface / Integrate**
Public Utilities (continued)	Billing/Stars Database, Work Order Database	Infrastructure, Routing	Interface (AS400)
	Project List Database	Development, Infrastructure, Permitting/Inspection	Interface (ODBC)
	Wonderware Database	Infrastructure	Interface (ODBC)
Public Works	Refuse Collection Database, Special Trash Collection Database	Routing	Integrate
	Cemetery Database, Storm Drainage and Street Database	Infrastructure	Integrate
Registrar	Various Federal, State, and Local Voter databases	Area Analysis, Census Analysis	Interface (ODBC, Proprietary)
Social Services	Various Federal, State, and Local client databases	Area Analysis, Permitting/Inspection, Routing	Interface (ODBC, Proprietary)
Suffolk Health Department	Sewage and Well Log Database	Parcel Mapping, Development, Infrastructure, Permitting/Inspection	Interface (ODBC)
	Complaint Log Database	Area Analysis, Permitting/Inspection	Interface (ODBC)
	Restaurant Database	Permitting/Inspection	Interface (ODBC)
Virginia Cooperative Extension	Various State level databases	Parcel Mapping, Area Analysis	Interface (ODBC, Proprietary)

Recommended Commercial Off-the-Shelf (COTS) Products

GIS Software

The City has elected to implement the planned GIS around the Environmental Systems Research Institute (ESRI) suite of GIS software. The City's selection of ESRI software will ensure compatibility the with the majority of geospatial data sets currently being developed and maintained throughout the Commonwealth of Virginia and the State of North Carolina. Selection of ESRI software will also provide the best opportunity for the acquisition of prepackaged third-party applications.

ESRI provides an open development environment that enables users to build/customize graphic user interfaces (GUIs), software coding details, output products (maps and reports), and on-screen user instructions. This ensures that the software is capable of meeting the demands placed upon it by its various users.

A description of the different ESRI GIS software packages required to meet the City's needs are listed in the following sections:

Environmental Systems Research Institute's (ESRI) Arc Spatial Data Engine (ArcSDE) and ArcInfo 8™

ArcSDE is a system that creates and stores GIS data from ArcInfo coverages, as well as numerous other computer aided drafting (CAD) and GIS data formats. ArcSDE stores coordinate and attribute information in a third-party Relational Database Management System (RDBMS), such as Oracle™, and allows the user to perform queries to automate map creation. When used in conjunction with ESRI's Professional GIS system, ArcInfo, ArcSDE offers scalability, customization, and a wide range of analysis capabilities.

Environmental Systems Research Institute's (ESRI) ArcView GIS 3.2 ™

ArcView is a modular, customizable data visualization and analysis tool. It is built upon an open system architecture that accommodates different business applications by allowing the purchase

and/or development of various extensions written in ESRI's Avenue™ programming language. ArcView creates and maintains its own feature tables locally, and allows the user to connect to third party enterprise databases such as Oracle, Informix and ESRI's SDE.

Environmental Systems Research Institute's (ESRI) MapObjects 2.0 ™

MapObjects is a set of custom development controls that enables applications to incorporate maps and thematic displays within conventional database applications. These application development tools provide the programmer with several objects that facilitate custom graphical applications to support an organization's business model from the ground up. MapObjects permits developers to contrast, query, and overlay ESRI data sets from within standard form-based programming environments such as Microsoft's Visual Basic ™ and Visual C++ ™.

Environmental Systems Research Institute's (ESRI) ArcView Internet Map Server (IMS)™

IMS is utilized to distribute GIS information and maps across an organization (intranet), or on the World-Wide-Web (www or internet). The software provides a customizable Java applet called MapCafe™, which enables users to quickly create, display, query and print thematic maps from any Java enabled browser application. Also, since IMS accesses standard ArcView projects via an extension, projects created in ArcView are easily distributed throughout the organization without requiring data conversion.

ESRI MapObjects Internet Map Server 2.0(MOIMS)™

MOIMS is a server application that enables custom applications developed with MapObjects 2.0™ to be shared and executed in an intra/internet browser application. This software allows custom applications to be shared throughout a corporation, or potentially by customers over the World-Wide-Web. MOIMS also permits remote users to visualize and query data in a distributed mapping application, such as routing and emergency response. MOIMS is tightly integrated with ESRI's free GIS data client ArcExplorer™. Using ArcExplorer, users can download data, create custom map compositions, and save them to their local hard drive.

ESRI ARC Internet Map Server(ArcIMS)™

ArcIMS is a true client-server architecture that enables custom applications developed with any of ESRI's GIS data products to be shared and executed in an intranet browser application. This software allows custom applications to be shared throughout a corporation, or potentially by customers over the world-wide-web. ArcIMS also permits remote users to visualize and query data in a distributed mapping application, such as routing and emergency response, as well as redline and mark up GIS layers and submit their comments to a "redlining" layer for all users to see.

ESRI ArcExplorer™

ArcExplorer is a GIS data explorer capable of working locally with its own data sets, or as a client to Internet or Intranet data and map servers. ArcExplorer is built using MapObjects components. As a stand-alone application, ArcExplorer allows users to query a wide variety of industry standard data sources.

Enterprise RDBMS

In addition to the GIS software, the City will need to employ an enterprise database software package (Oracle, Informix, SQL Server) to administer the graphic and tabular data that will be housed on the GIS server(s).

The City is currently utilizing Microsoft's SQL server database in a variety of applications. Considering the City's current investment in SQL Server (capital and training costs), it is recommended to embrace this RDBMS software as part of the overall GIS solution. ESRI's ArcInfo 8 and Spatial Data Engine will interface with SQL Server 7.0. If the City decides to move to another RDBMS platform in the future, the GIS data can be migrated at that time.

Customized Software Options

Various COTS programs and ESRI extensions will support the majority of the City's Focus Applications. However, even with the COTS packages, some level of customization will be required to tailor the

software to the City's specific needs and GIS data model. This customization can be performed using ESRI's various development tools, as described in the preceding section.

The required interfaces with the City's legacy AS400 applications will require a variety of customized software solutions. The City's Information Technology Department has previously developed certain custom applications to access data from the AS400 and translate it into an ODBC compliant format. These applications should be evaluated and considered as part of the application development process.

Recommended Hardware Configuration

The City's selected hardware components should fit seamlessly within the previously established information technology framework. This framework is typified by high-end data servers and PC workstations (operating within the Microsoft Windows NT environment) and high capacity network/communication devices. Employing this hardware configuration approach will ensure the selected components will adequately serve the needs of the planned GIS, while maximizing the City's investment in its current information technology backbone. The recommended hardware configurations are as follows:

Servers	Current dual Pentium II class server (or better)
	512 MB RAM (or higher)
	2 – 4 18 GB (or higher) SCSI drives
	Windows NT Server Operating system
Map Maintenance Systems	Current Pentium II class processor (or better)
	256 MB RAM (or higher)
	1 – 16 GB EIDE drive
	Windows NT Workstation operating system

Desktop Systems	233 MHz Pentium processor (or better) 64 MB EDO RAM (or higher) 1.5 GB EIDE drive (or higher) Windows NT Workstation (or Windows 95/98) operating system
Field Systems	233 MHz Pentium processor (or better) 96 MB EDO RAM (or higher) 2.5 GB EIDE drive Windows NT Workstation (or Windows 95/98) operating system
Field Data Collectors	MIPS RISC Processor 16 MB RAM (upgradeable); 16 MB ROM (upgradeable) MS Windows CE 2.1 operating system

Network Considerations

In order to support the GIS, the City's network must provide for the high-speed data transfer between the City's various GIS users and campuses. The existing network's available bandwidth (the amount of data that can be transmitted across the network) must be evaluated and analyzed for any existing or potential deficiencies. Since the GIS implementation will introduce a significant amount of new data and network traffic, certain upgrades to the existing network may be required. The following considerations will need to be addressed:

1. Does the existing network have the capacity to handle the new GIS data and traffic that will be introduced?
2. What are the financial ramifications for any required network upgrades, and how do they fit within the City's overall IT plan?

Wide Area Network Solution

The following diagram illustrates a Wide Area Network (WAN) that accesses a centralized server or GIS data warehouse:

DIAGRAM

Implementing the GIS in this manner would require the WAN to support significantly high data transmission rates, especially in the transfer of digital imagery such as digital orthophotography. Public Switched Telephone Network (PSTN) T1 type connections, providing 1.5 Mbps (1 Megabyte every 5.3 seconds) of data transfer capability, is the minimum capacity required for remote sites to maintain adequate performance of GIS software. PSTN T3 type fiber optic lines provide increased bandwidth and quicker access times, and are preferred over the T1 type lines. This level of remote access capability is necessary to ensure the desired GIS performance levels across the City's WAN.

Local Area Network Solution

An alternative to the WAN solution is to operate all network intensive GIS data sets at the LAN level. This solution will require local data servers in each department that would be capable of housing large vector and raster data sets. The following diagram illustrates the deployment of this solution:

DIAGRAM

In this scenario, large data sets, such as digital orthophotography, are stored on a local area network (LAN) server, while the point, line, and polygon features/attributes are stored on the central GIS server. Users requiring this data will be able to access it from two locations: the central GIS server (located on the WAN), and a local GIS server (located on the LAN). A benefit of this solution would be that the large file transfer requirements would be relegated to the LAN, thereby allowing the data transmissions to be isolated and switched to nodes that do not require long travel distances and multiple exchange points. This is an ideal solution for reducing networking costs, but does require an series of additional GIS servers at the LAN level.

Internet/Intranet Options

The majority of the City's GIS users fall within the "viewer" category. These users mainly require the ability to view geospatial data sets generated by a series of queries. An ideal means of providing these

users with the data they require is through an internet/intranet solution. This solution will minimize the number of GIS software packages that must be installed through the City's network, by allowing users to access the data via standard web browser software packages (Netscape, Microsoft Internet Explorer, ESRI ARC Exploer).

ESRI offers a variety of web solution packages that enable an internet/intranet solution to distributing GIS data to the City's various users. These packages allow a user to process a request for data from their desktop, using a standard web browser. The request is then processed by the GIS and web solution packages on the GIS server, and the resulting data is sent back to the user as a series of graphic images. This greatly reduces the amount of GIS traffic on the City's network.

Field Access Data Options

Several city departments have field personnel who spend a significant amount of time collecting information that will be incorporated into the City's GIS database. The City should consider the acquisition of field data collection computers to support these workflows. The data collectors will enable the field personnel to download information from a central database in the office, evaluate and update the information in the field, and automatically upload the data directly back into the GIS database upon return to the office. The need for data collectors will be evaluated on a departmental basis.

CHAPTER 3 – PROJECT SCHEDULE

System Implementation Schedule

The systematic and cost effective implementation of the City's planned GIS requires the development and adherence to a sound implementation schedule, budget, and work plan. When implementing a GIS as complex as the City's, expenditures for hardware / software, data, applications, and training must be made at the optimal times in order to ensure the systems and data do not become obsolete during the implementation process.

The implementation schedule and associated budget outline the sequence of expenditures for the following GIS components:

- System Design – Database , Hardware / Software / Peripherals, Network
- Hardware / Software / Peripheral Acquisition and Installation
- Base Mapping Development
- Digital Orthophotography Development
- Focus Application Data Development / Conversion
- Focus Application Development
- Staffing
- Training

At the time this Implementation Plan was prepared, the City had already obtained the required aerial photography. Additionally, the system design (database, hardware/software/peripherals, and network) tasks were underway, and will be completed prior to initiating the base mapping development portion of the project. It is assumed that the City will be issuing a Request for Proposals for the development of base mapping and digital orthophotography development by the first week of December, 1999; and a vendor will be selected by January 1, 2000. For these reasons, the implementation schedule begins with base mapping development, and does not include aerial photography acquisition, system design, or mapping RFP tasks.

The project implementation schedule is presented on the following pages:

CHAPTER 4 – PROJECT BUDGET

The cumulative cost of the City's planned five-year GIS implementation is approximately $_____. The cost includes the following components:

Needs Assessment – Needs Analysis; Data Survey; Management Plan; System Implementation Plan	$80,000
System Design – Aerial Photography Specifications and Quality Control; Database Design; System Selection; Software Specifications	$80,000
Aerial Photography – Ground Control; Photography; Analytical Triangulation; One update in YR 2002	$166,000
Hardware – Servers; Workstations; Field Computers	
Software – ESRI GIS Software; SQL Server RDBMS Software	
Peripherals – Plotters; Printers; Scanners; Digitizers; GPS Equipment	
Staffing – GIS Manager; Analysts; Technicians; Programmers	
Training – Baseline Computer; GIS Software; Database Administration/Programming; Field Data Collection	
Data Conversion/Development/Collection	
Application Development	
Implementation Phase Consulting	$160,000

5 – Year Project Totals:

The following sections detail the budgetary estimates for the complete implementation of the City's planned enterprise GIS.

Hardware

Software

Peripherals

Data Conversion / Development / Collection

Application Development

Staffing

Training

Additional Consulting

Other Costs

CHAPTER 5 – ADDITIONAL FINDINGS AND RECOMMENDATIONS