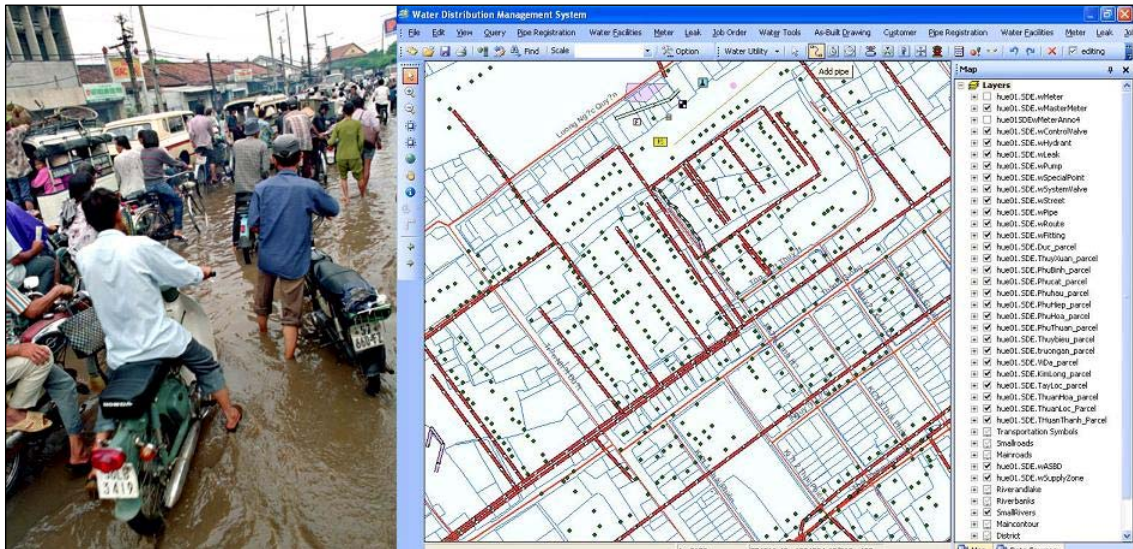


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## GUIDELINES ON ASSET DOCUMENTATION

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Ministry of Construction – Hanoi

*in cooperation with*

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# 1 INTRODUCTION

## 1.1 *The rationale of Asset Documentation*

The objective of this document is to explain “asset documentation” (AD) to the participating provincial wastewater operators. Asset Documentation is an essential asset management support component, including the documentation of the type, location and condition of the Company’s fixed asset, the operation and maintenance schedules, and the records of executed operation and maintenance works, include its related cost and required resources. It describes the main principles for the operators to implement the new Asset Management and detail all the phases of the work related to wastewater, network, construction, planning, activities, maintenance, customers, billing, and for these also describe the interface between the different departments in the Company.

Asset Documentation must guide the Company to gather existing information in order to structure and centralize it, then define the tools and processes to maintain this information up-to-date, to finally analyze and share it according to the responsibilities.

Today the context is the institutional changes, the new Decree which will be promulgated in the next months concerning Wastewater Management, the need of promoting customer value, as part of the engagement for complete and good services, the research of good accountability or the way to find a sustainable economic situation. This last point includes the fact that operators will have to apply and collect new tariffs, customer contract including engagement from customer to operator and vice-versa.

Finally, the Asset Documentation is a tool to Support Continued Development of Asset Management, in a best practices way for long term management, through the new technology GIS (Geographic Information System).

This Guideline takes into account:

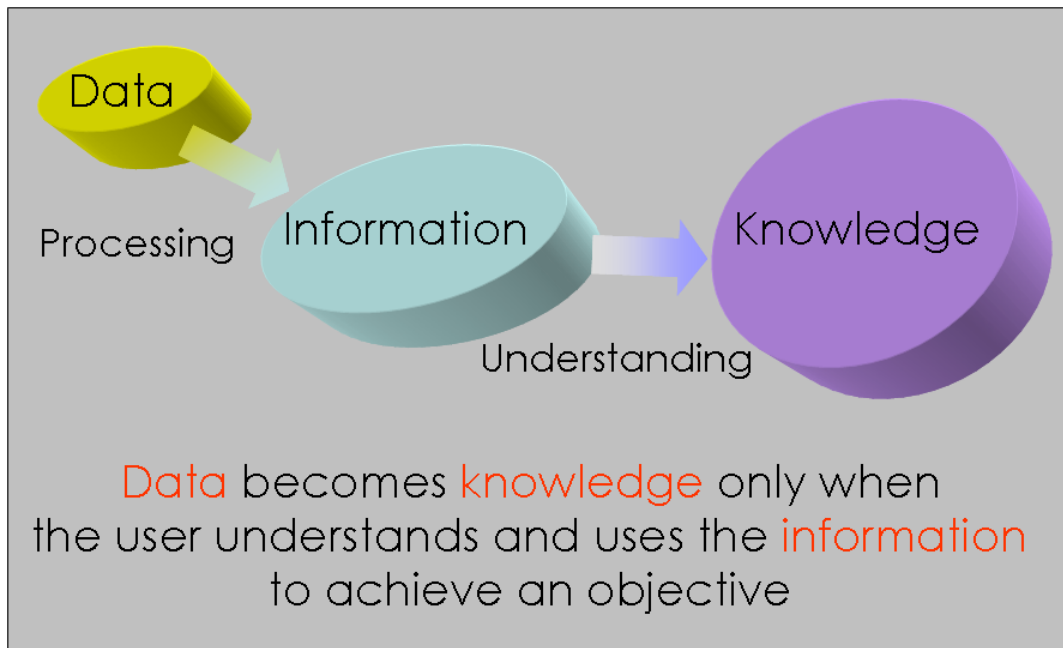
- What needs to be achieved?
- What are the best practices?
- Key Actions for Members and Officers.

## 1.2 *Application of GIS for Asset Management*

### 1.2.1 Definition of GIS

A Geographic Information System (GIS) is a system for managing spatial data and associated attributes. In the strictest sense, it is a computer system capable of integrating, storing, editing, analyzing, and displaying geographically-referenced information. In a more generic sense, GIS is a "smart map" tool that allow users to create interactive queries (user created searches), analyze the spatial information, and edit data.

## 1.2.2 Applications of GIS in Asset Management



**Figure 1: From Data to Knowledge**

### Planning and Engineering

Wastewater and Water companies use GIS to map the full extent of their water systems and link them to a database defining each element including pipe segments, valves, pumping station, services, and system appurtenances.

GIS provides you with an intelligent database so that job planning, equipment inventory, and flow analysis become an automated procedure integrated into one system.

### Construction

Wastewater and Water organizations are often responsible for constructing and/or overseeing the development of new facilities and replacement of old facilities. GIS aids them in tracking information related to projects, permits, construction work order management, inspections, as-built, and so forth.

### Asset inventory

Keeps up to date information concerning the asset, wastewater facilities, in order to have a relevant picture of the real situation.

Image integration features in GIS allow utilities to store and display images in conjunction with a footage reading and a description of the pipe defect (roots, grease, and other problems). Maps, drawings, and pictures can also be associated with valves, manholes, drop inlets, and other features to provide valuable information to the user.

### Activities: Operation and maintenance

Many utilities have discovered the value of GIS for improving day-to-day operations. GIS can be used to closely model utility networks and integrate other related types of data such as

raster images and CAD drawings. GIS spatial selection and display tools allow users to visualize scheduled work, ongoing activities, recurring maintenance problems, and historical information.

The topological characteristics of a GIS database can support network tracing and can be used to analyze specific properties or services that may be impacted by such events as stoppages, main breaks, drainage defects, and so forth. GIS can perform many other operations and maintenance tasks, including work order and warehouse inventory management, SCADA ...

### Customer services

Improve the customer relationship, satisfaction and management to store all relevant information related to each customer like contact information, type of customer. The history of each customer for further analysis, contract if exist, etc.

GIS provides solution to easily implement Complaints Call Center, in order to register all complaints with detail information such as customer information, type of the complaint and its location. From this, managing the activities to check or solve the problems, even analyzing the situation in term of leakages, for example, is possible.

### Financial Management: billing system

Finance and Administration provides the central administrative oversight to support the planning and operational activities of the organization. Budget forecasting, facility inventory analysis, customer billing, and other key administrative functions can be enhanced through the implementation of an integrated, enterprise wide GIS solution.

### Material/Inventory management

Stock-keeping and administration: to improve the activities in order to know what the list of material available is, anticipate for investment or estimate cost of operations, etc.

### Sharing the information

GIS is very flexible and can import as well export a numerous different format of data (Workstation, AutoCAD, Oracle Spatial, MapInfo, ASCII, etc.). For advanced system, GIS provides all the interfaces to communicate with other system or technologies such as GPS, SCADA, Hydraulic simulation software, external Billing system, etc.

### Advertising

GIS help any Company to provide publication, communication document for public understanding (tariff, planning, report on activities, etc.) and help the Company in its relation with customers or event authorities to prove the benefit in term of environment, flooding, customer services, etc.

### Management information system (MIS)

The power of GIS is to centralize a lot of information into one database with both geographic and text information for all the domains of intervention of the Company. Later on, GIS provides a full panel of analysis tools for better understanding of situation or better planning for future extension and all other activities, like replacement.

For that, GIS allows the company to create multitude of:

- Calculation,
- Statistical analysis,
- Thematic analysis on map,
- Report for listing,
- Performance Indicators for decision-making reports

### 1.3 Benefits for the Service Provider (Company)

#### 1.3.1 General benefits

**More up-to-date asset:** Any information related to pipe, wastewater facilities, leak, customer, complaint... could register to system easily, so other staff, other department or manager always have a current status of the system/company.

**More accurate information:** before, company could use as-built drawing in AutoCAD file or paper format for management, and they do not have accurate position of pipe/manhole. But now with GIS system, they will know exactly where the pipes and manholes are, where the pipe damage location is. Talking about network model accuracy, GIS also help company to build better, more accurate network model. There will be not existing errors such as duplicate, under shoot, over shoot information... See illustration:

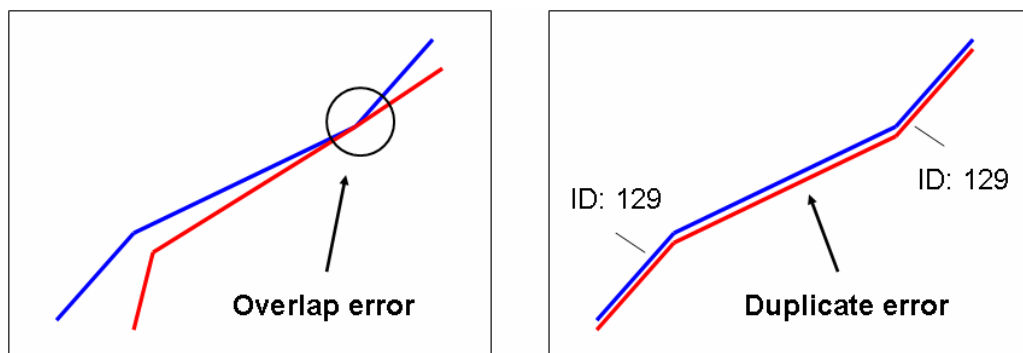


Figure 2: Illustration of Topological errors

**Increased the productivity:** pipes can be registered faster with GIS, customers located faster, and leakages located faster. The GIS provide a full automation with GPS. The job / activities designing and management are easier and faster...

**Improve sharing and coordination between groups and departments** with GIS system, technical department could have customer information, billing information for designing job / activities. Business department could see the pipe network to answer customer questions. Planning department could have all of information related for next 6 months planning, 1 year planning. The management board could have a lot of report to see how the company developing... every staff could access to system to take out information. The user management will take care who could have which information or report...

**Better asset management:** this enables to company to know where the pipes are after 5 year, 10 year, also others information such as who made that pipe, with which material, O&M information... There is no loss in the information, and the system allows the user to know where the deleted pipes are.

**Better maintenance planning:** the system could report to company that how many kilometers of pipe should be clean in next month, how many pump to maintain in next month. If the number of customers changes in the quality and quantity, the system also known that and the report will be change in parallel and automatically.

**Better visualization:** with GIS system, user could have a complex view with pipe network map plus other information such as pipe material, year of install, water flow... so the engineer could make decision more accurate (Spatial selection and display tools allow users to visualize scheduled work, ongoing activities, recurring maintenance problems, and historical information).

**Could integrate much information:** with GIS system, company could manage much information such as: pipe inspection movie/photo, as-built drawing scanning, designing document such as AutoCAD file, the system could also connect with SCADA system if need... (Dynamic segmentation and image integration features allow utilities to store and display images in conjunction with a footage reading and a description of the pipe defect (roots, grease, and so forth). Maps, drawings, and pictures can also be associated with valves, manholes, drop inlets, and other features to provide valuable information to the user).



**Figure 3: Photo of pipe inspection activity**

**Enable to do storm analyst:** with GIS system, user could build 3D model, and then they could do GIS analyst to know where the flooding are, and how the flooding area will change if they change in the surge system... And analyst how big is flood will effect in quantity and quality information.

**Enable to do network tracing and reporting:** The topological characteristics of a GIS database can support network tracing and can be used to analyze specific properties or services that may be impacted by such events as stoppages, main breaks, drainage defects, and so forth.

**Better finance and administration:** Finance and Administration provides the central administrative oversight to support the planning and operational activities of the organization. Budget forecasting, facility inventory analysis, customer billing, and other key administrative functions can be enhanced through the implementation of an integrated, enterprise wide GIS solution.

**Easily track information:** this system can be used to track the condition and maintenance history of assets such as water mains, valves, hydrants, meters, storage facilities, sewer mains, and manholes.

### 1.3.2 Daily operations benefits

The Benefits for Wastewater Company can also be summarized in two kinds of benefits: short term benefits, it means in daily activities, and long-term benefits after several years, once the GIS will be completely integrated in the working process and the functionalities use at 100%.

Benefits using a GIS application in Wastewater:

- In-time replacement
- Asset availability in accordance to needs
- Customer complaints tracking
- Reduce leakages
- To attend to pipe repairing, in-time replacement
- Make plan, design network system
- Improve day-to-day operations
- Better knowledge of project activities with geographic view
- Manage personnel better
- Fast consultation for information: no waste of time for a lot of operations, like find the corresponding as-build drawing to a feature (pipe, valve, etc.), customer location, etc.

### 1.3.3 Long-term benefits

Benefits using a GIS application in Wastewater:

- Population and demand projections
- Water quality monitoring
- Cleaner environment
- Wastewater system master planning
- Reduction in break-downs
- Better customer service (includes Complaint tracking)
- Lower operational cost
- Adopted advanced and cost reducing technologies
- Calculation of real cost of service
- Better Asset Management
- Calculate service fee
- Lower operation cost
- Apply new technology to management
- Cleaner environment

- Monitor content in waste water
- Greatly improved asset accounting & management
- Better quality in network: quality will be improve through maintenance management, it means less deterioration, less replacement or repair operations to do in the future
- Better customer care service



**Figure 4: Benefits cycle with Asset Documentation through GIS**

## 2 SETTING UP THE SYSTEM

### 2.1 Internal Organization Structure

A clear organizational structure is required within the Wastewater Company in order to execute Asset Documentation. For a realistic approach, an **Asset Documentation Center** must be created under the Technical Department, because main parts of the system will be related to the Technical staff responsibilities and activities. Then this department will have to keep close relation with other departments to share the information regarding specific aspects of the Company, like customers, billings or planning.

The Asset Documentation reference 4 departments, but more could be included in the same approach if necessary:

- Technical
- Planning
- Customer
- Financial

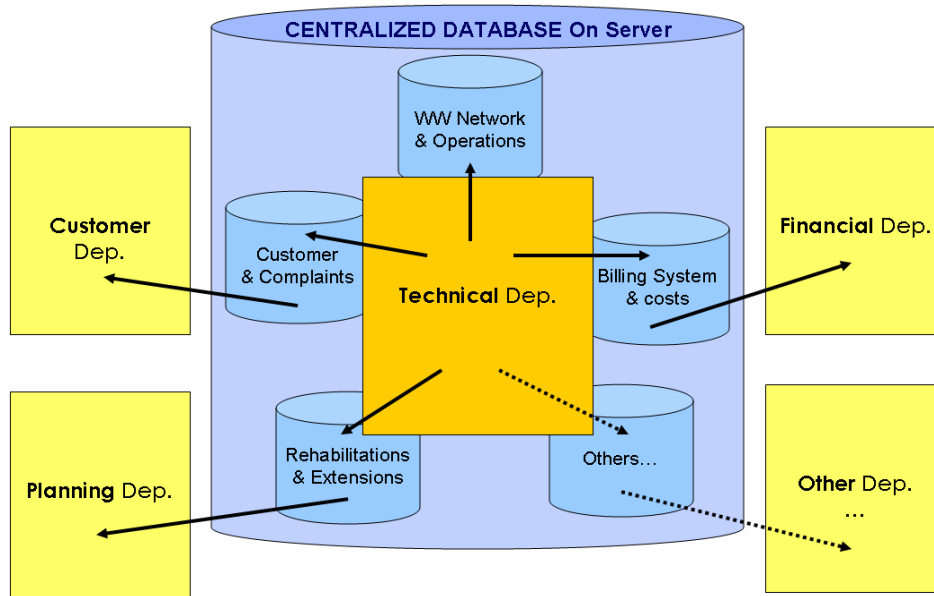


Figure 5: Organizational Structure of Asset Documentation Center

The Technical department is fully in charge of the Asset Management (wastewater network and facilities) and the Operations Management, but has also to work with other responsibilities. Therefore, an organization through subsection provides a better management.

#### Technical department functions and tasks description:

- **GIS Administration:** LAN network, hardware, software, and this for all the Company.
- **Wastewater pipes and facilities registration:** operator who maintain the information on the GIS database by directly create/update the data (real-time registration) or by importing existing CAD information)

- **Operation/Maintenance registration:** operator who maintains the information related to complaints, leakages, replacement, repair, etc. The operator is also responsible for schedule management for maintenance operation such as flushing, inspection, etc.
- **Construction:** field team in charge of field work for new construction or operation of pipe, facilities, house connection, valve replacement, etc.
- **Report management:** operator to provide thematic or statistical analysis on wastewater pipe and facilities, and also for operations/maintenance.
- **Material/Inventory:** The technical department is linked to the Warehouse in order to maintain up-to-date information concerning the stocks of material. This will be use in the Operation/Maintenance scheduling for example.

**Planning department functions and tasks description:**

- **Planning:** operators and engineers design plans for extension through project, including cost estimation, feasibility, and project life-cycle management.
- **Report management:** operator to provide visualization of planned project, budget estimation on months or years, etc.

**Customer department functions and tasks description:**

- **Customer management:** registration, information management, contact.
- **Complaints:** call center for complaints registration, and reporting / analysis.

**Financial department functions and tasks description:**

- **Billing System:** bill printing, collection, debt management, etc. In case it's collected by water supply Company, this sub-section is responsible for relation to the WS Company.
- **Report management** for billing analysis and history.

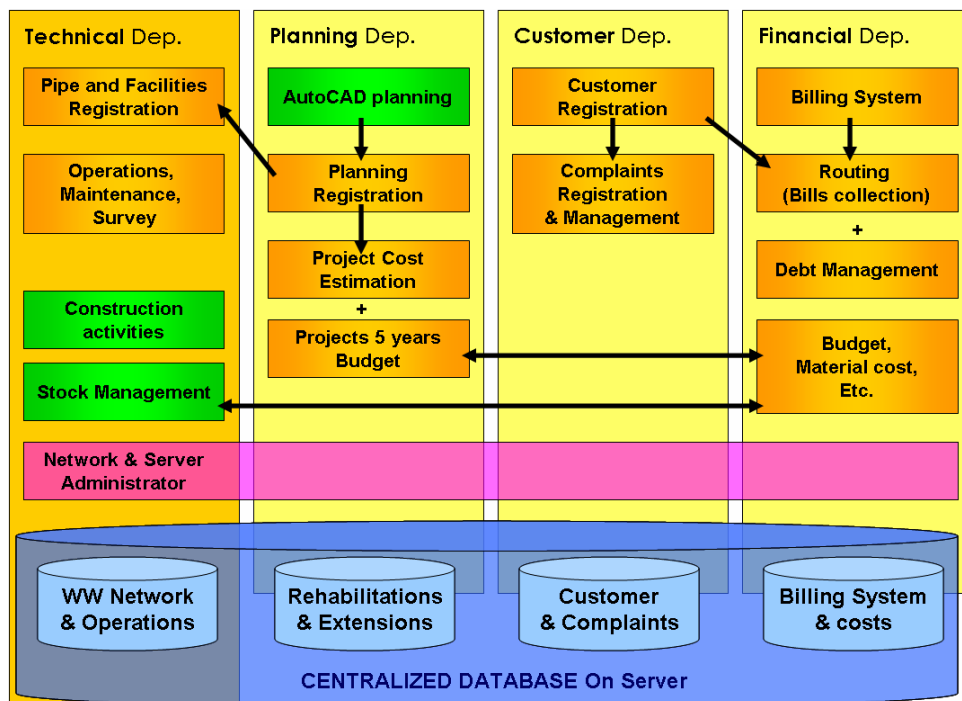


Figure 6: Illustration of relation between departments

All department concerned by the Asset Documentation Center will have to determine data format and requirements as an initial action.

Standard Operation Procedures (SOP) must be clearly defined to explain the relation between the sub-section and the department. Company will also have to identify SOP on data gathering and processing. To assure an efficient work in the Company, everybody should be able to answer these questions:

- Who define the process?
- Who start the process?
- Who take part of the different steps of the process?
- How to apply the process?
- How to validate one step of the process?
- How to control the process?

Each process can be within one department or define as transversal process.

### One example - Field survey for house connection gathering data:

- Technical staff starts the process providing the area to survey
- 1 operator, regarding this area, prepares and prints all the necessary A3 maps at 1:2000 scale.
- 1 team is in charge of the work on the field using the printed map as support, and then informs the technical staff when the work is done.
- Technical staff registers the new information in the GIS database.

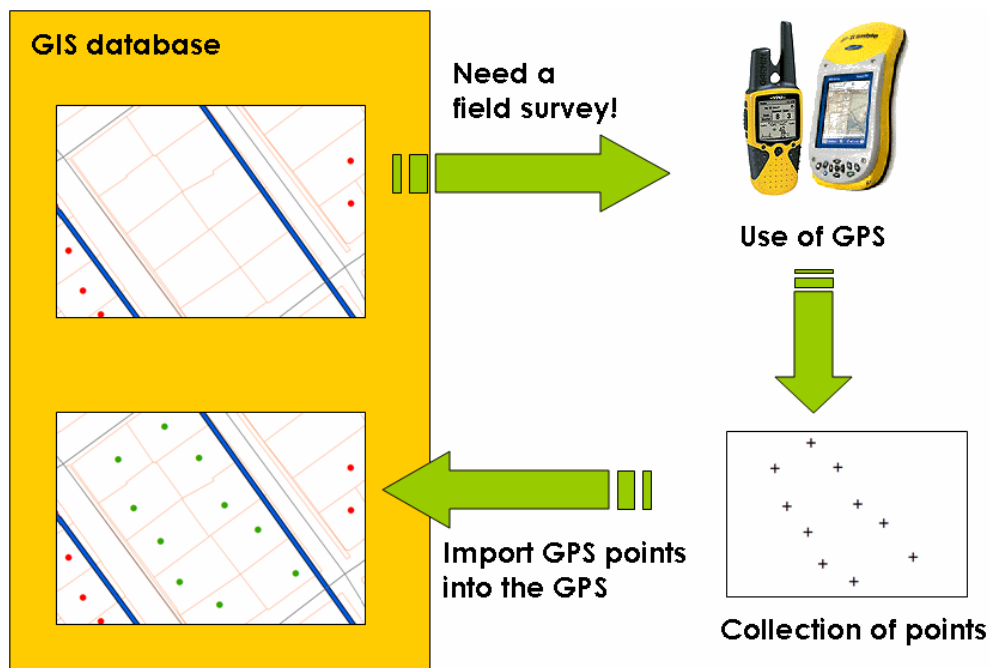


Figure 7: Field survey for house connection using GPS

## **2.2 Staffing Requirements for Data Acquisition and Data Management**

The default configuration which could be adapted to each Wastewater Company depends of its requirements and size. In fact, a company with 5,000 house connections for 100 km of pipe network doesn't need the same number of surveyors or computer operators than the company who will deal with 60,000 house connections for 500 km of pipe network.

So the staffing requirement is described here as an indication, mainly for profile and organization, but its number should be appropriate to the company needs.

For a realistic approach, persons responsible for Field Survey should be different than persons responsible for Data Management. That is why it is presented separately. But for small size Companies, this organization could cost more, so it is possible to merge the profile in order to have only one responsible for field survey work and data management.

The staff requirement concerns only the daily activity of the Company, and excludes the first phase of Data Acquisition for the Database construction. This first phase can be a huge work when a lot of data need to be survey and the best solution for Companies is often to outsource this work.

### **2.2.1 Data Acquisition (field work)**

Regarding the wastewater pipe network and facilities:

- The staff responsible for Data Acquisition should come from the Construction team, with 2 persons in charge of data collection using GPS, printed map or predefined printed form.
- For example these persons have to collect data during an operation for maintenance (photo of the pipe, deterioration of the pipe, other related information...)
- **Profile:** These persons should have good technical knowledge for Wastewater work, and if possible mapping knowledge.
- Then training will be given in GPS, Mapping, Methodologies and GIS concepts.

Regarding the customer management and billing system:

- 1 person should be responsible for the location of customers / house connection, and related information.
- **Profile:** This person should have at least mapping knowledge.
- Then training will be given in GPS, Mapping, Methodologies and GIS concepts.

For both, profile with Computer manipulation skills is an advantage, because all new technologies will be integrated faster.

### **2.2.2 Data Management (office work)**

Regarding the wastewater pipe network and facilities:

- 2 persons should be responsible for Data Management and work in relation with the Responsible of field work.

- **Profile:** These persons should come from Construction Engineering, with specialization in Water Supply or Wastewater domains. They should have knowledge in Computer manipulation, and the knowledge of AutoCAD will be a big advantage, because they will integrate faster and easily the Pipe registration through GIS.
- Then training will be given in GIS concepts, use of GIS application (Pipe registration, integration of As-Built Drawings, analysis, report)

### Regarding the customer management and billing system:

- 1 person should be responsible for the Customer Management and Complaints Management, and work in relation with the Responsible of field work.
- **Profile:** This person should have good Communications skills because she will be the interface between customers and the Company (Complaints registration).
- Then training will be given in GIS concepts, use of GIS application (Customer registration, complaint registration, analysis, report)

## **2.3 Training Requirements for Data Acquisition and Data Management**

All staff who will have first approach of GIS software will need a standard ESRI training to acquire Cartography (mapping) and GIS concepts. And then, another training adapted to the GIS solution applied to the Wastewater domain.

For each Wastewater Company the team will have different profiles. Even if all the users have the same needs in term of concepts and GIS users, the training will take care of this organization. For a realistic approach, the training is divided in 3 categories:

1. Field staff for Data Acquisition
  - Mapping concept: use of printed map
  - Use of GPS, for gathering data on-site
  - Apply methodology: return information, plan intervention, etc.
2. Computer operator
  - User training on the Customized GIS application
  - Consultation, updation for wastewater facilities, customers, base map
3. Chief Engineer
  - Analysis & reporting modules
  - Advanced functions like export to Hydraulic model

### **2.3.1 Step 1: Introduction to GIS**

- All the categories should follow the first training for basic GIS concept:
- What is Cartography and GIS?
- How to start the GIS application and how is it organize?
- Define queries GIS database,
- View data and information map or graph.

### Example of corresponding skill achievements:

- View geographic objects and data tables

- Working with spatial data
- Query objects by logic mathematics
- Seeking objects by spatial operation
- Use thematic map, print a map

### **2.3.2 Step 2: Data Acquisition for Field team**

For the staff which is responsible for field work, including survey (sub-section “Construction”):

- Reading of map (legend, scale, locate information in the field, etc.)
- How to use GPS? (best practices to obtain accurate coordinates)
- Methodology for using GPS to collect specific information (Which points need to be surveyed, How to manage complementary information with GPS points, etc.)
- How to import the GPS data into the database, or transfer the information to the technical operators.

### **2.3.3 Step 3: Data Management through GIS**

The training on the Wastewater GIS application will be organized according to the Operation System structure (see 3. *SYSTEM OPERATION*):

- Database
- GIS Core application
- Data acquisition of existing assets
- Data transfer of new KFW assets
- Wastewater Management
- Operation and Maintenance
- Customer management
- Planning
- User Management
- Data reporting & analysis
- Data sharing

Example of skill corresponding achievements:

- Register new pipes on the network with associated valves information, using the Wastewater Editor toolbar
- Define a new operation for pipe replacement, using the Operation Editor toolbar
- Work with *geometric network* rules
- Use planning for preventive maintenance operations
- Use advanced analysis and reporting tools
- Export selected data to another format
- Manage the customer and billing information
- Manage the complaints and leakages information

## **2.4 Office Requirements**

Each department has different responsibilities regarding the asset documentation, and some part the asset needs some specific treatment like be sure the information can not be diffuse (customer name and addresses for example, or all financial asset).

Secondly, each department is organizing with hierarchical responsibilities with Director; Engineer; Team Leader, and all technical staff. And this organization should be visible through the office organization.

That is why the office should be organized by room dedicated for each department or main subsection. The space allocated to each department will depend of the staff size, but to be sure everybody will have enough space for computer, map (A0 as-built drawing), report uses, the Company should apply the ratio of 5 sq.m per person.

Detailed requirements by department:

<b>Technical room</b>	1 Server for Database, LAN network to other rooms, LAN network materials, etc. 1 computer for GIS application All screens should have a size minimum 17" 1 desk for each computer 1 desk in order to work on the printed map (A0 format) 1 A3 or A4 printer
<b>Planning room</b>	1 computer dedicated to GIS application 1 computer dedicated to As-Built Drawings (AutoCAD) All screens should have a size minimum 17" 1 desk for each computer 1 desk in order to work on the printed map (A0 format) 1 A3 printer + 1 A0 plotter 1 set of ranged maps of As-built drawings
<b>Customer room</b>	1 computer for GIS application 1 A4 printer for listing or reporting
<b>Financial room</b>	1 computer for GIS application and/or Billing management 1 specific printer for billing
<b>Direction</b>	n/a
<b>Meeting room</b>	n/a
<b>Warehouse</b>	n/a

## **2.5 Technologies**

### **2.5.1 ESRI**

ESRI was founded as Environmental Systems Research Institute in 1969 as a privately held consulting firm that specialized in land use analysis projects. The worldwide headquarters of ESRI are anchored in a multi-campus environment in Redlands, California.

In May 2004, ESRI released ArcGIS 9, the next generation of its integrated software products for building a complete GIS. Two new products were included in this major release: ArcGIS Engine, for embedding GIS functionality into desktop and field applications, and ArcGIS Server, a centrally managed framework for serving enterprise GIS applications.

Today, ESRI GIS products are poised for even greater growth. Innovations in computer technology allow sophisticated GIS operations to be performed in the field on a personal digital assistant (PDA), on desktops, and throughout the enterprise. Faster and cheaper computers, network processing, electronic data publishing, and easier-to-use tools are fueling rapid growth in the desktop arena. Private businesses are adopting GIS technology as a decision support tool. And with the introduction of live mapping applications to the Web, anyone with a computer has access to the benefits of GIS technology.

With 11 regional offices in the United States, more than 75 international distributors, and users in more than 200 countries, ESRI stands ready to meet the needs of its user community and to set the standards for the GIS industry.

### 2.5.2 ArcGIS technology

ArcGIS is an integrated collection of GIS software products for building a complete GIS. ArcGIS enables users to deploy GIS functionality wherever it is needed in desktops, servers, or custom applications; over the Web; or in the field.

#### ArcGIS Framework

- **Desktop GIS:** ArcGIS Desktop GIS software products are used to compile, author, analyze, map, and publish geographic information and knowledge. ArcGIS Desktop is a scalable suite of GIS products that starts with ArcReader and extends to ArcView, ArcEditor, and ArcInfo — the most powerful GIS product available today. Each product exposes progressively more GIS capabilities. An extensive collection of desktop extensions provides additional capabilities.
- **Server GIS:** ArcGIS Server, ArcIMS, and ArcSDE are used to create and manage server-based GIS applications that share GIS functionality and data within organizations and many other users on the Internet. ArcGIS Server is a central application server that is used to build server side GIS applications that run in enterprise and Web computing frameworks. ArcIMS is a scalable Internet Map Server for publishing maps, data, and metadata over the Web using standard Internet protocols. ArcSDE is an advanced spatial data server for accessing geographic information in relational database management systems.
- **Developer GIS:** The ESRI Developer Network (EDN) is a program that provides software developers with the resources needed to build a wide range of custom GIS solutions. EDN subscribers will receive the latest versions of ArcGIS Engine Developer Kit, ArcGIS Server, ArcIMS, ArcSDE, and ArcWeb Services, with a license that expires when their EDN subscription expires.
- **Mobile GIS:** ArcPad coupled with a wireless mobile device that is location enabled is widely used for data collection and GIS information access in the field. ArcGIS Desktop

and ArcGIS Engine running on laptop and Tablet PC computers are being used for field tasks that require GIS data collection, analysis, and decision making.

- **GIS Web Services:** ArcWeb Services offer a cost-effective way to include mapping and location services in Web-enabled applications. Because data storage, maintenance, and updates are handled by ESRI, ArcWeb Services eliminate the overhead of purchasing and maintaining large datasets. An ArcWeb Services subscription provides you with instant access to imagery and aerial photos, real-time weather and traffic incidents, extensive demographic data, and much more. We can use ArcWeb Services in ArcGIS, or we can use them to build unique Web-based applications.

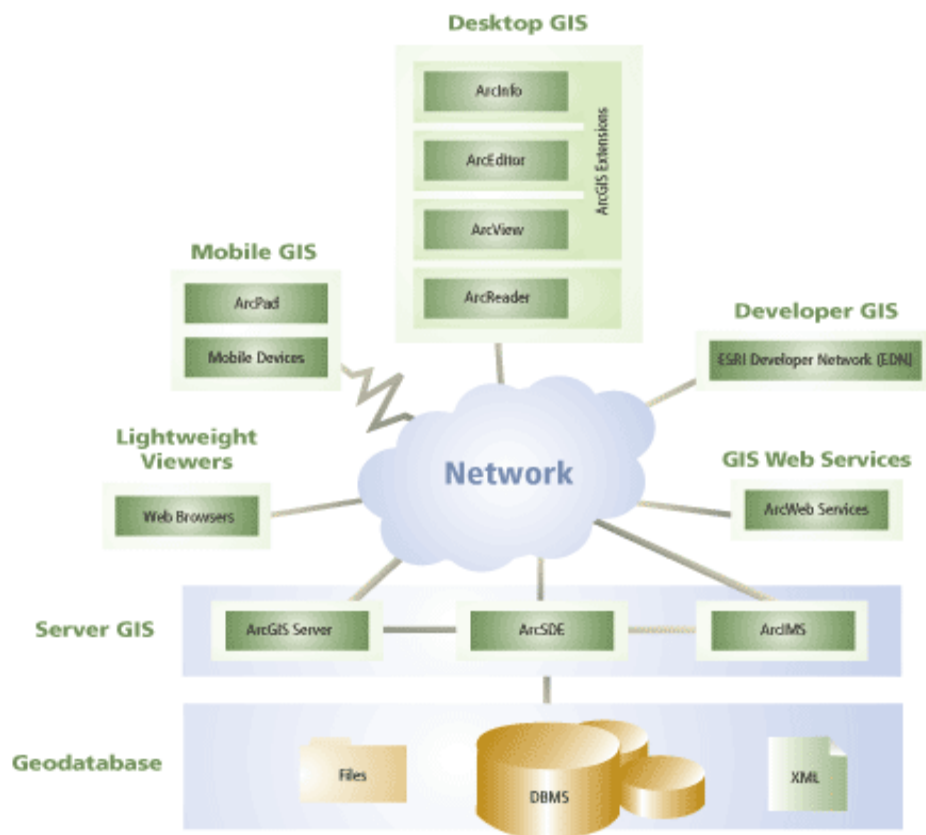


Figure 8: ESRI products organization

### 2.5.3 Geodatabase Technology

All these software products utilize Geodatabase technology — the core ArcGIS geographic information model and data management functions. The Geodatabase is used to represent things of interest in the real world in ArcGIS and store them in a database. The Geodatabase implements business logic as a set of tools for accessing and managing GIS data.

The Geodatabase logic is accessible in:

- Client software products (ArcGIS Desktop)
- Server product configurations (ArcGIS Server)

- Embedded custom products (ArcGIS Engine)
- Mobile products (ArcPad, ArcGIS Desktop, ArcGIS Engine)

### **2.5.4 ArcGIS Engine – to customize GIS**

ArcGIS Engine is a developer product for creating custom GIS desktop applications. ArcGIS Engine includes the core set of components from which ArcGIS Desktop products are built. With ArcGIS Engine you can build stand-alone applications or extend existing applications to provide focused spatial solutions to both GIS and non-GIS users. ArcGIS Engine provides application programming interfaces (APIs) for COM, .NET, Java, and C++. These APIs not only include detailed documentation, but they also include a series of high-level visual components that make it easy for even the casual programmer to build an ArcGIS application.

With ArcGIS Engine users can have:

- Standard GIS framework, ArcObjects, on which the ArcGIS family is built
- Cost-effective deployment requiring only an ArcGIS Engine Runtime or ArcGIS Desktop license per computer
- Developer controls available in ActiveX, .NET, and Java that simplify application development
- A choice of standard developer languages including COM, .NET, Java, and C++ as well as a choice of Windows, Linux, and Solaris computing platforms
- Extensive developer resources including object models, utilities, samples, and documentation

### **2.5.5 Proposal technology for Wastewater**

From above overview of ESRI technology, it is suggested that Wastewater Companies in Vietnam use ESRI technology ArcGIS Engine to develop a global Wastewater information System. This technology was already used with success to develop a lot of system for Vietnamese users such as:

- WDMS system for Water Supply distribution network management, Customer management, billing system, ...
- WesMapper system for UNICEF, this will deploy for whole Vietnam for environment collecting and monitoring.
- Chembase II: system for underground water quality monitoring.

Proved benefits from these existing GIS application:

- ESRI products and especially ArcGIS Engine are very strong architecture, and it is easy to extent the application for future needs,
- It minimize the deployment cost,
- It is updated and improved by ESRI frequently.

## 2.6 Physical Design

### 2.6.1 Hardware Requirements

- **4 PC:** the minimum of 4 PC is needed in order to use all the GIS modules. (1 more if the user needs one Server)
- **LAN Network:** it is a standard network in order to connect the PC together, with maybe other network using servers.
- **A3 Printer:** for mapping purpose and field survey / activities, it important to use an A3 Printer in order to print map with accurate and complete information.
- **A0 Printer:** for mapping purpose and As-Built Drawings, it important to use an A0 Printer in order to print large area map with accurate and complete information.

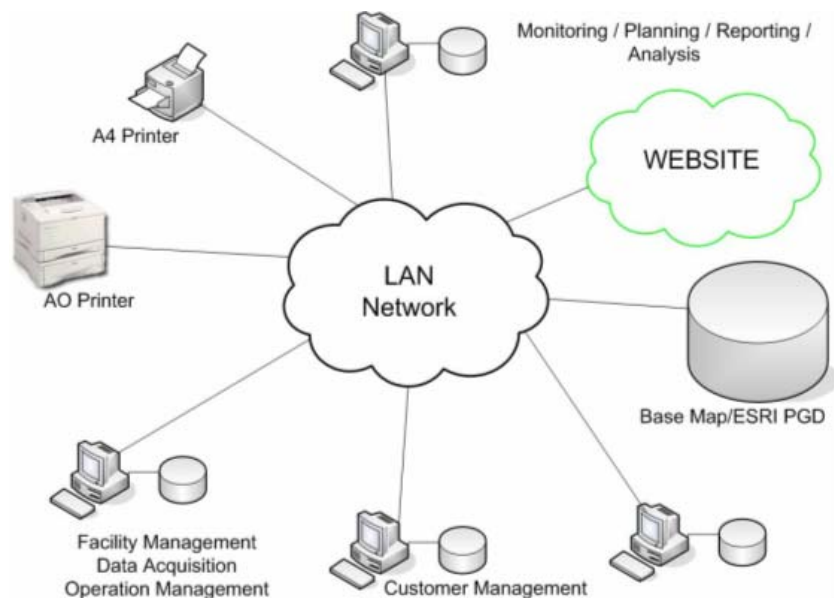


Figure 9: Physical design

### 2.6.2 Software Requirements

Standard configuration for the PC:

- **Microsoft Windows XP:** OS
- **RDBMS:** database system support the ESRI Personal Geodatabase format (Microsoft Access...)
- **ArcGIS Engine runtime version 9.2:** ESRI common objects library
- **.Net Framework version 2.0:** development environment

### 2.6.3 GIS configuration

Wastewater Information System will be built on client architecture using two parts encompassing ArcEngine and .NET framework. This model is an innovative architecture, with Plug-in programming techniques, independence in components allows system more flexible in integrating with other systems, components and easy to develop in the future.

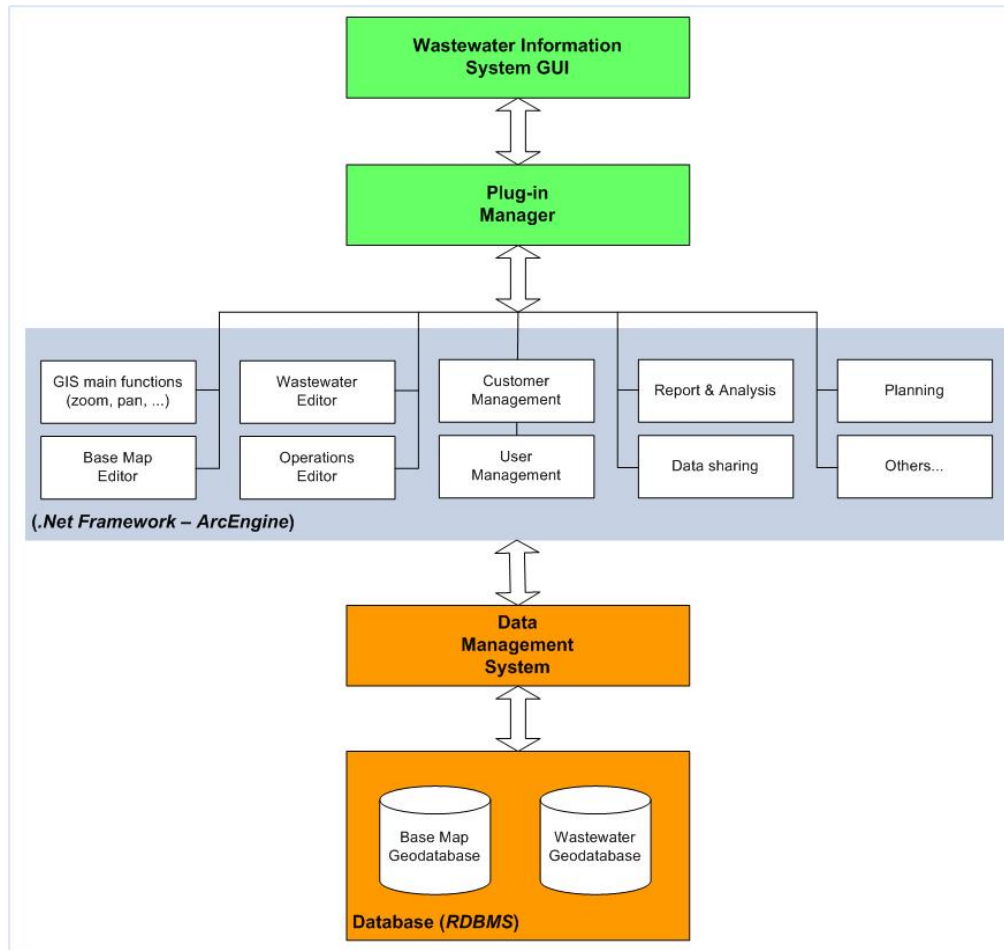


Figure 10: GIS development structure in 3 levels

Plug-in architecture is often used in application, it allows:

- To extend an application's functionality without the need to re-compile and distribute it to customers.
- To add functionality without requiring access to the original source code.
- To adapt to new rules/needs for the application that change frequently

Wastewater Information System will include Microsoft .NET win-forms as user interface layer, RDBMS as database layer, and plug-in components as business layer. This model help the system pave a way to extend its capability of portability by running the database system on one platform and the user interfaces on another.

In user interface sides, the system will take advantages of .NET framework in self-determining of assemblies so that it has a kernel in center and some just-in-time loaded modules around. Besides, this architecture can make maintenance or customization tasks easier with lower cost in future.

### Why an approach with ArcGIS Engine Technology?

The ArcGIS Engine Developer Kit is not a product for end users; it is designed for people who are developing applications. The developer builds applications based on ArcGIS Engine and delivers those programs to end users. The ArcGIS Engine Developer Kit is a set of mapping components and developer resources that lets programmers add dynamic mapping and GIS capabilities to existing applications or build new custom mapping and GIS solutions.

It is flexible in order to create customized interfaces for maps. Developers can use one of several industry-standard, interactive development environments to create unique applications or combine the ArcGIS Engine components with other software components to create advanced GIS applications.

ArcGIS Engine provides an alternative to general software applications and allows:

- Develop sophisticated GIS logic,
- Develop advanced tools for analysis and reports,
- Select only relevant GIS functions and not the full-featured GIS products
- Automate frequent operations

For the end-user side, there is the ArcGIS Engine Runtime which contains the core ArcObjects to enable the execution of a custom ArcGIS Engine application and must be installed with the customized application:

- Standard ArcGIS Engine Runtime provides the core functionality of all ArcGIS applications.

The following licensed extensions can be added for more functionalities: Geodatabase Update extension, Spatial extension, 3D extension, Network extension, Data format Interoperability...

## ***2.7 Equipment Requirements for Field Survey***

The field survey can be very different from one Company to another, depending of the advancement in data collection. Company who maintain already a lot of information with AutoCAD software, for example, have less work to do in field survey. But even considering this point, it is recommended for each Wastewater Company to have the following material:

### One GPS, which can be use to collect different kind of information:

- Referenced points on existing landmark in order to assure the good reference of the base map (base on street map, parcels for example)
- Collect pipe network and facilities location (pipe, valve, etc.)
- Collect house-connection (related to customer information)

With the GPS equipment is included the GPS device or all software, cables in order to connect the GPS on computer for easy import. It is recommended to acquire a GPS with NEMA standard, which is easy to connect on computer through COM port.

One A3 printer, which correspond to the other part of the field survey:

- It is more efficient to work with A3 format which allow users to have more relevant information on the map with a satisfied visualization (very often, the A4 allow also printing a lot of information, but it's not so clear).
- It is an important aspect, because by default, for field survey you can consider that the more relevant map scale is 1:500 which it means that 1 cm on the map represent 5 meters on the field.

### ***2.8 Data Model & presentation of Data Dictionary***

What is a Data Model? And why do we need a data model?

Data Model is a method to organize the data by themes (hydrology, wastewater facilities, land use, etc.) and to define rules between data as it exists in reality, for example:

- One administrative zone can not overlap another administrative zone
- Each pipe must be connected to another pipe minimum
- One valve must be on one pipe end-point
- Etc.

If the user applies all these rules in the database structure, a good Data Model will assure him that the data are safe (protection against wrong data), he doesn't have double information or data without link (valve without pipe for example), etc.

The Data Dictionary is written for each data and gives detailed information like description of the attributes, type of data, list values, etc.

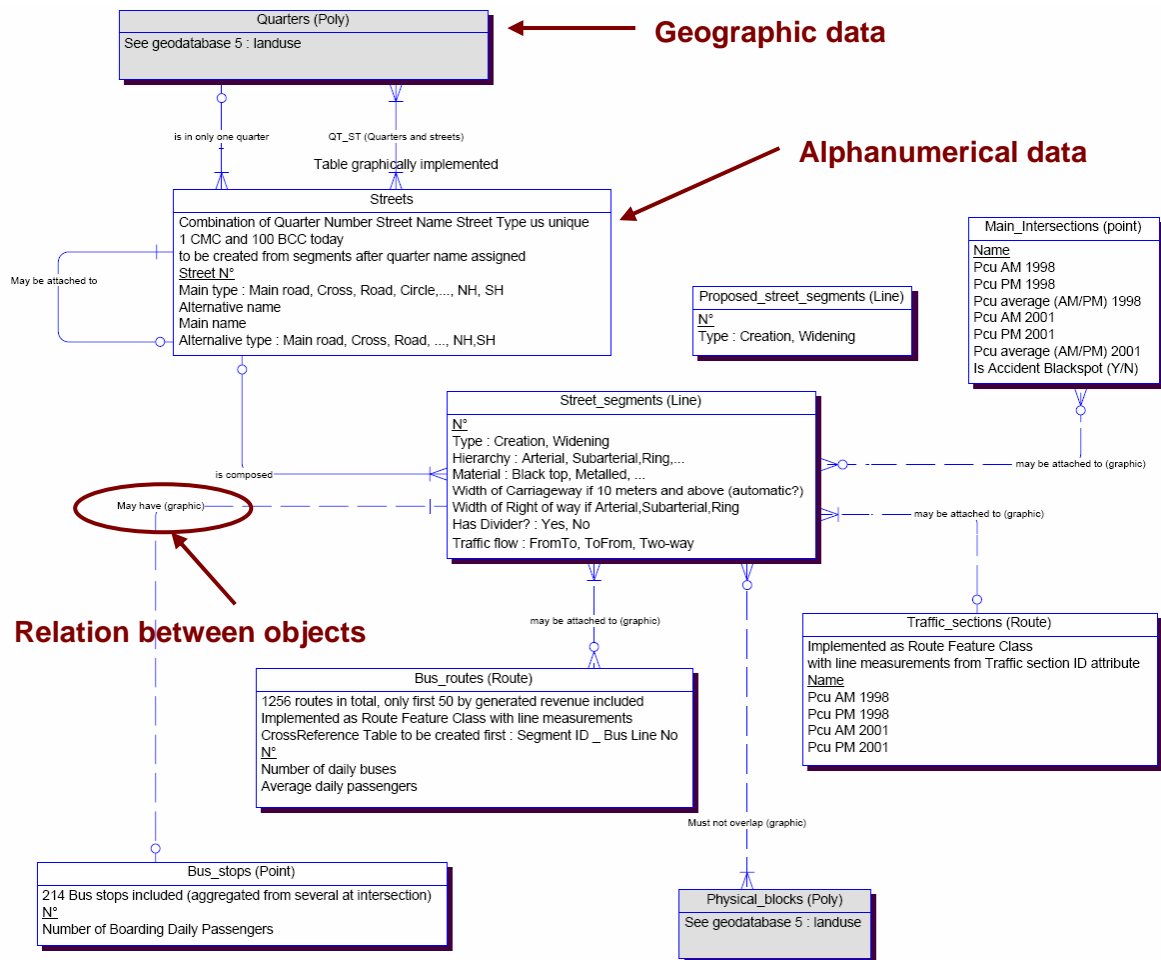


Figure 11: Conceptual Data Model illustration

In annex (see 4.2. GIS Database Dictionary), the Data Dictionary presents all relevant information that corresponds to the Wastewater Company needs. This Data Dictionary tries to be as complete as possible, but should be customize according to the specific requirements.

Name of the Theme		
Name of the data	Description	Type of geometry: Surface, Line or Point

Figure 12: Data Dictionary tables description

## 2.9 Implementation risks and risk mitigation

As all GIS system, or more generally all Asset Documentation Center, there are some potential risk for a successful implementation. The following table gives some brief explanations for the different kind of risks the Wastewater Company could face:

<b>Data</b>	Availability of the information (like accurate Base Map...) Inaccurate coordinates for asset
<b>Requirement</b>	Consultant and end user can not talk together Costs are not well estimated (capital costs like hardware, software, data, staff and recurrent costs like maintenance, staff), so not enough funds Interoperability with other products is missing The final requirements can not be defined There are too many requirements in the final project document
<b>Lacks</b>	Lack of skills (for example in training: user need to understand and use the information to achieve an clear objective) Lack in Human Resource Lack of coordination and standardization Facilities are not enough
<b>Management</b>	The project not have support from top management Organizational structure is not adapted (problems in daily workflow...) Do not have right policy for the system (about rights, responsibilities, operations, salary...)
<b>Software</b>	Application is not updated Crash (related to testing phase) Data losses
<b>Hardware problems</b>	GPS is missing or not working CPU (performances are slow and limited...) Printer (A0 or A3 missing, bad printing quality...)
<b>Other</b>	Delay in payment for consultant

### 3 SYSTEM OPERATION

#### 3.1 Operation of the System

The logical design for a Wastewater GIS solution is organized in modules. There are 2 basic modules which are the Core of the solution, then 10 modules (or plug-ins) which can be added one by one:

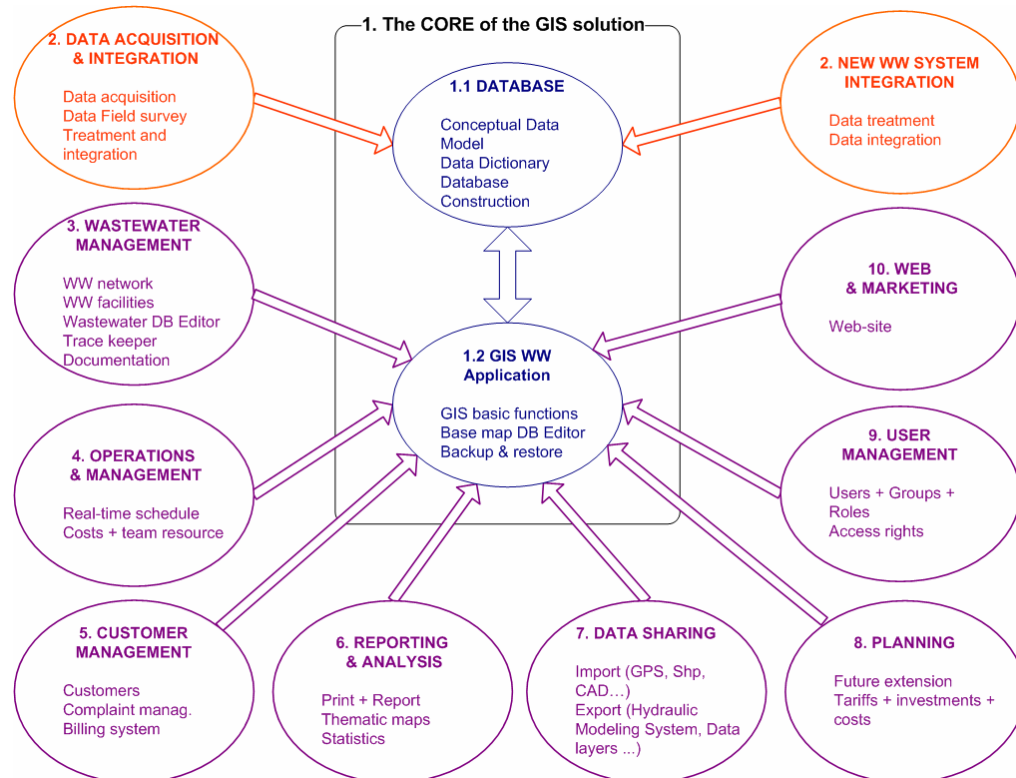


Figure 13: System operation by modules

##### 3.1.1 Database

The first module of the Core application is the Spatial Database. This module contains 3 main parts:

- **Conceptual Data Model (CDM):** the first step is to design the organization of the database by themes (Hydrology, administrative boundaries, wastewater, etc.) and then list all the data contain in each theme. The CDM define also all the relationships between the data.
- **Data Dictionary:** the second step is to write the Dictionary for each data which give detailed information like description of the attributes, type of data, domains, etc.
- **Database construction:** once the database is design, it is easy to create it whatever the RDBMS is (Oracle, SQL Server, MS Access, ...)

The Coordinate System defined for the GIS database must be WGS 84 UTM, which is common choice, when operators need to work with GPS. Then of course, it is always possible to import in this Coordinate System data which come from other source (VN2000 for example).

### 3.1.2 GIS Core application

The second module of the Core application is the GIS Application. It is customized GIS software, which contains the same basic functions than all other GIS software:

- Map view: the main frame, where the user can see his data and work on it,
- Menu items: all the functionality are accessible here,
- Toolbars: The main important functionalities are organized by toolbar and can be load/unload if necessary,
- Navigation toolbar: GIS basic functions like zoom in/out, pan, select, info tool, etc.
- Data source / Layer management: the user can manage his connection to the database to add/remove data, and then define all the properties on his layers (visibility, symbology, labels, display name, etc.),
- Geographic information like scale and X,Y coordinate system,

This application will allow the user to:

- Open a connection to the database and load data
- Visualize/Consult his data or map,
- Update the Base Map layers (data stored in the Base Map databases like Hydrology, Administrative boundaries, Topography, etc.) in term of geography and attributes. For this part, he will use the Base Map objects Editor toolbar,
- Do the backup and restore the database for safe and exchange purpose
- Select his data using spatial or alphanumeric query,
- Print his current view (page with the map, title, legend, scale, date, north icon, etc.)
- Save the current map into a file (map document) which stores the visible layers and all the properties, current scale, current selection, etc. Then the user can load a map document.

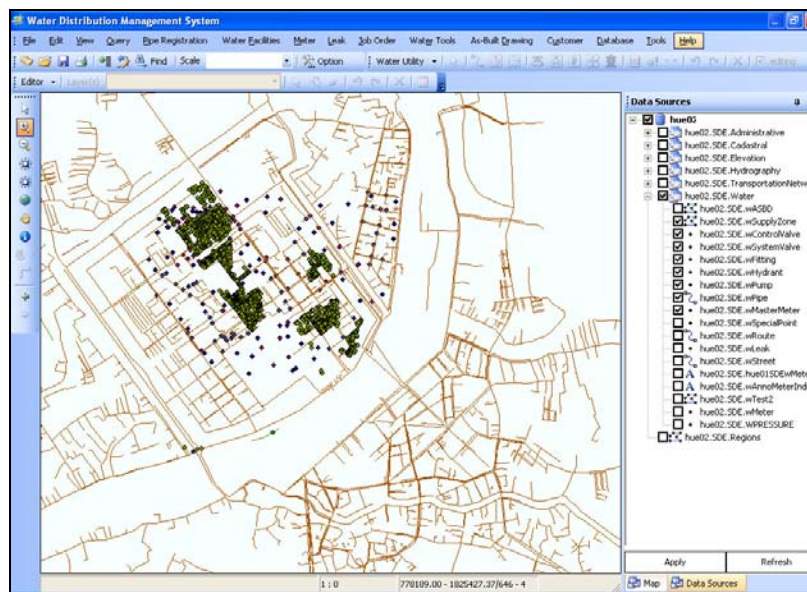


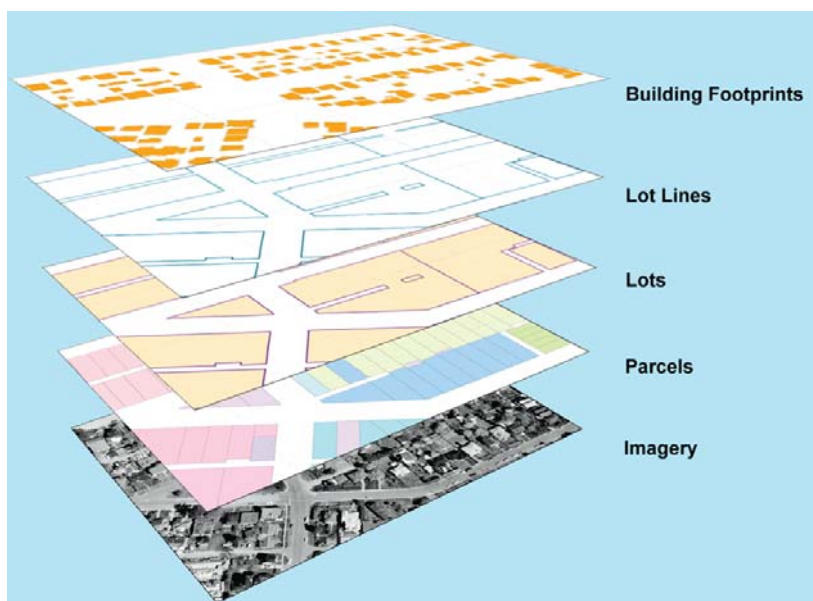
Figure 14: GIS user interface illustration

### 3.2 Data acquisition of existing assets

The data acquisition concerns 3 different domains: Base Map which will be use as reference, background, locate information or analysis boundary; the existing Wastewater Network and Customers.

For Base Map, data can be organized in 6 Database Themes:

- **Hydrology:** river, lake, pond, dyke ...
- **Administrative boundaries:** province, town, district, socio-economic data, demography, other divisions ...
- **Topography:** DEM, elevation point, contour lines, geology ...
- **Transportation:** street centerline, railway, supporting facilities (bridge, etc.) ...
- **Land Use:** parcel/cadastral layer, buildings, street block ...
- **Raster:** satellite image, aerial photo, historical map ...

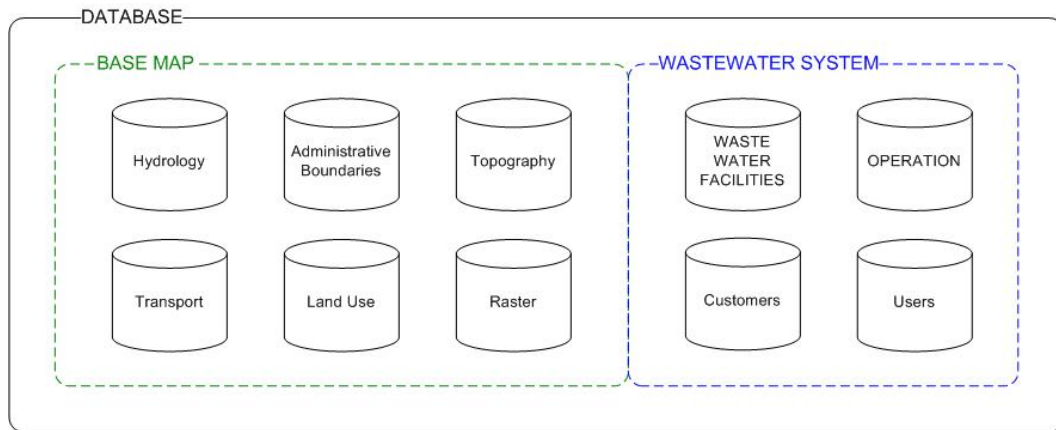


**Figure 15: Construction of Base Map Database**

First, the methodology should concentrate on data collection, from internal documents (existing CAD files...) or with other public bodies which already have some information, paper maps, and digital data. The data collection will focus only on relevant data and complete information. It is sometimes a lot of waste of time when people try to collect all the existing data, but part of it is not relevant at all or incomplete and difficult to use in the future.

The second step will be the data treatment (format conversion, georeferencing, geoprocessing, digitalization, rubber-sheeting, etc.) in order to obtain GIS compliant information, and then integrate it into the corresponding database.

If the Wastewater Company can obtain Aerial Photo or Satellite Image, so it is easier to perform some digitalization in order to create some new information layer, like rivers, drains, building blocks, etc. These raster could also be used to re-adjust some CAD layers to obtain very accurate base map.



**Figure 16: Database organization by themes**

For the Wastewater network and Customers, which are 2 specific Databases, the data acquisition depends directly of the existing situation.

In this case, the methodology is the field survey in order to collect detailed information on the location (geography) and attributes for all the features of the network (pipes, pumping stations, house connection, valves, manholes, drains, basins, etc.).

The House Connection corresponds to the location of a customer. It is part of the Wastewater network database. The Customer personal information will be part of the Customer database (see Customer Management module).

The field surveys can be done using GPS or manually (paper map) depending of the data accuracy needed in result.

For all the data acquisition process which will integrate the Wastewater’s team participation, we will define and provide all the methodology documentation.



Figure 17: Base map & Wastewater databases

### 3.3 Data transfer of new KFW assets

For each Wastewater Company, a New Wastewater System has been drawn by Kfw, in a CAD format. If it is possible and easy to convert an AutoCAD drawing data to a GIS compliant data, nevertheless we need to do a treatment on this data, because in this kind of drawings, some information are not part of a GIS database and are only drawing.

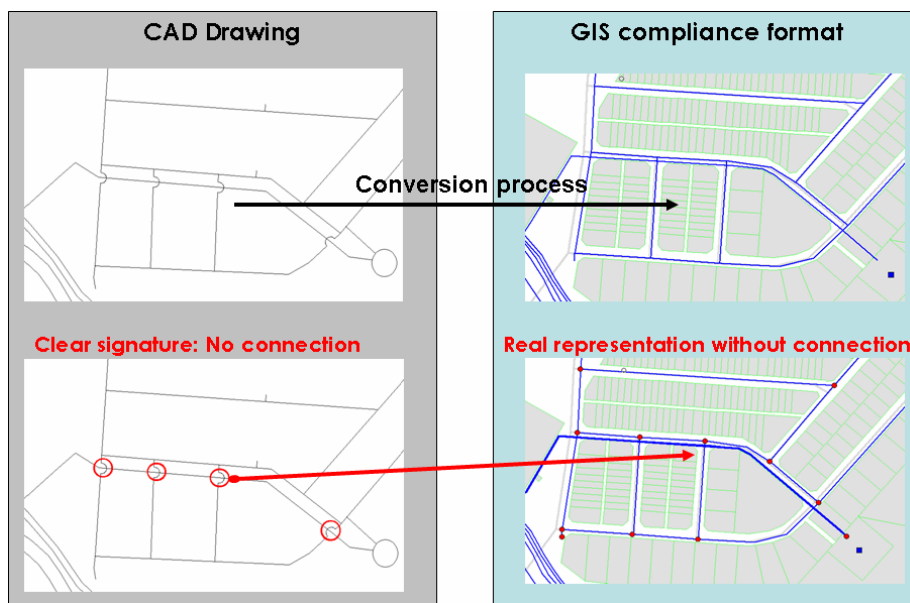


Figure 18: AutoCAD drawings conversion to GIS

So the integration will consist of several steps for each data:

- Convert the AutoCAD drawing data into a GIS compliant format,
- Check the Geographic Coordinate System,
- Check the GIS compliance in term of geography (geometry of features, intersection, gap, snap, etc.) and attributes (fields format, attribute values, etc.),
- Split or gather together the data in order to fit with the Data Model,
- Quality control,
- Integrate the data into the database.

### 3.4 Data management

#### 3.4.1 Wastewater Management

This module will allow the user to:

- Visualize Wastewater network and facilities,
- Register and maintain information using the Wastewater Facilities Editor toolbar. The user will be able to add and delete each feature and modify the Geometry and Attributes.
- Use the Trace keeper plug-in (explain below)
- User pre-defined symbology for the layers (so it will be easier to understand the map)
- Define linked documentation



Figure 19: Registration of Wastewater network with Valves

Figure 20: Registration of Wastewater pipe with Attributes information

The Trace keeper plug-in:

This add-on will keep a trace for all the actions on the Wastewater facilities. So it will be possible for the supervisor to know exactly for a specific feature:

- Who has created it?
- When it was added?
- When it was modified and by whom?
- Which information was modified? (Geometry, values of attributes)
- And it will keep trace of all the old information (geometry, deleted vertex, different values for one attribute, etc.).

**3.4.2 Operation and Maintenance**

This module contains:

- Preventive maintenance & Operations management
- Real-time schedule management for: checking, flushing, replacement, leakage detection, reparation, etc.
- Definition of the costs and team resource
- Linked to the Complaint management (see Customer Management)

### Example of Preventive maintenance procedures:

- Have to define the preventive maintenance operation for each feature: pipe (interceptor, pressure pipe, etc.), pumping station, service line, outfalls, etc.
- Then for each feature, there is an operation records table linked, which give information to know for each operation : planned dates (frequency), execute unit, type of operation (flushing, visual control, cleaning, etc.), date of execution, comments on the results (see some erosion, advanced age of the pipe, etc.), photo of the feature.
- In some case, the comment will create a planned operation in order to repair a leakage or replace an old pipe for example...
- The system can show some analysis: where are the pipes or other features that the team needs to clean this month, etc.
- Automatic alert to inform the team of the preventive maintenance to do this week (frequency and kind of alert will be defined).
- A specific print function of the preventive maintenance operation, including photo and information of the feature (pipe, pumping station, etc.), will be a support for the team to go on the field (to locate and recognize the feature)

### Example of Operation procedures:

- Origin: complaint (form Complain Management) or preventive maintenance comments
- For each operation the information are: begin-end dates, executive unit, feature concerned by operation, type of operation (replacement, etc.), cost estimation, location.
- Each operation must be located by a point, line or area: point if it's on a specific feature like a Fitting, line if it's on a specific pipe and area if it's a global operation which can include several features.
- The system can show some analysis: where are the leakages (from complaint or preventive maintenance comment), where the recent replaces pipes are, etc.
- Automatic alert to inform the team of the operation to do this week (frequency and kind of alert will be define)
- Close each operation once the work is done, so it is easy to know and manage the pending operation (complaint, leakage, routine, etc.)
- A specific print function of the operation, including photo and information of the feature (pipe, pumping station, etc.), will be a support for the team to go on the field (to locate and recognize the feature)

### **3.4.3 Customer management**

The Customer Management will keep a dynamic link to the House Connection feature in the Wastewater facilities Database. So it will be very easy for the user to access to the Customer information from the map or from an alphanumerical list. With this module, the user will be able to add, modify or delete a Customer.

The user will be able also to perform Satisfaction surveys for the customers, save the information, and then perform analysis and report.

### Based on the Customer Management, there are 2 systems:

- **Complaint system:** recording, processing, analyzing and reporting through Call Center or Online web services.

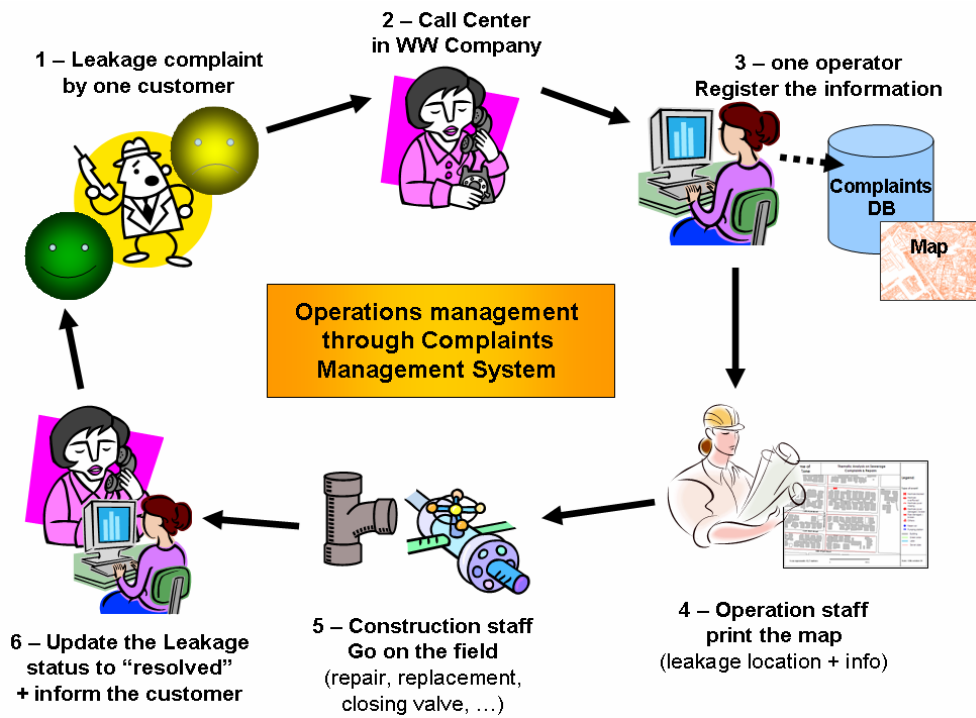


Figure 21: Work-flow for Complaints Management

- **Billing system:** if the Wastewater Company wants to apply a specific tariff and tax collection, this system will allow her to manage the bill history, status and organize the routing for tax collection.

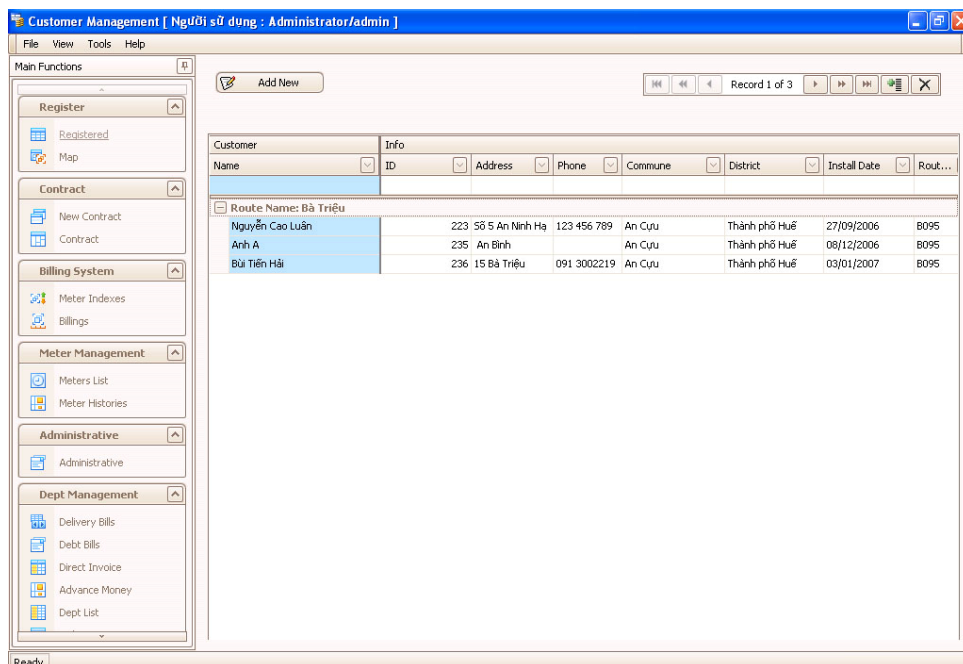


Figure 22: Invoice Management interface

### **3.4.4 Planning**

This very advanced and complex module contains:

- Extension planning on network
- Investment planning
- Tariff planning
- Costs planning
- Resources planning

This module provides planners with a sound knowledge of a network's location, characteristics and condition at present time or in near future.

### **3.4.5 User Management**

For a powerful Data Security on the Wastewater system, the Company needs to manage the users of the Wastewater GIS Application using:

- Groups: can be compared to Department organization,
- Roles: can be compared to position or responsibilities of each user,
- Users: manage all the users with password and personal information,
- Access Rights: give to the user the appropriate rights by module or sub-module.

## ***3.5 Data reporting & analysis***

The form of all reports will be determined and agreed with WW Company.

This module contains:

- Thematic maps (pre-defined maps)
- Basic Print
- Advanced print (with options and design templates)
- Statistics analysis
- Spatial analysis (by administrative boundaries for example)
- Basic Reports like detailed information on one selected features (location and information), summary list of selected features by query (list all new pipes since 6 months), etc.
- Advanced Reports (for decision-makers) like Management Indicator Panel (MIP): a monthly report with give the Key Features to the Chief engineers and Chairman.

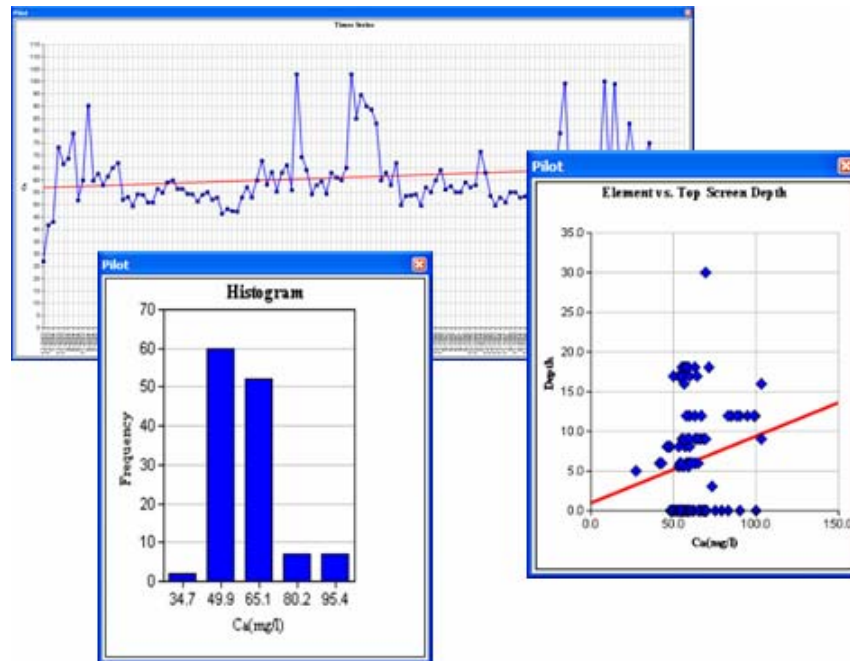


Figure 23: Example for Trend / Times series analysis

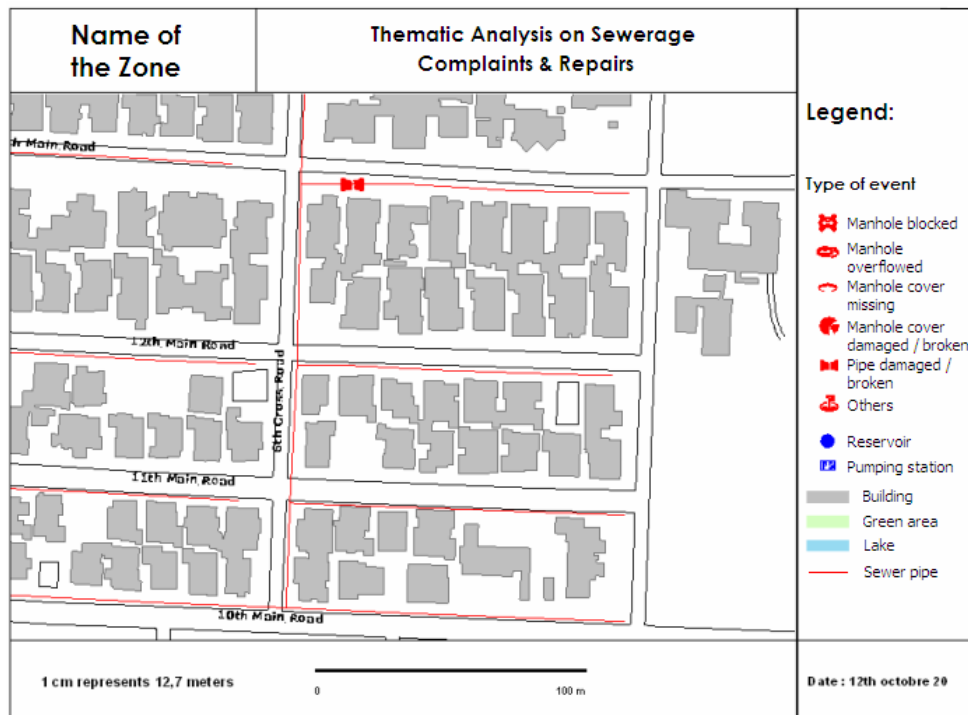


Figure 24: Example for Thematic Maps reporting

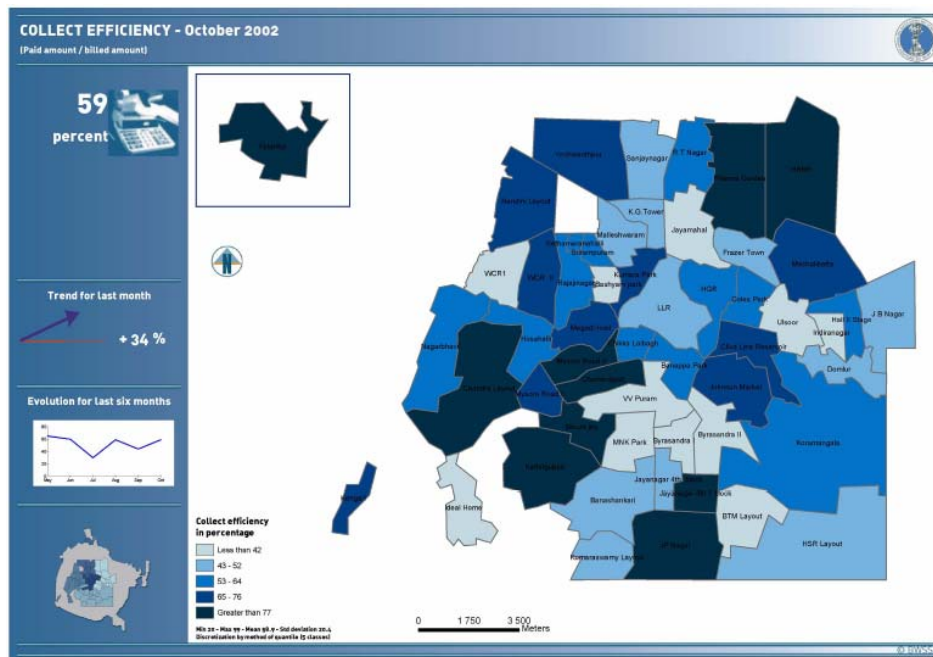


Figure 25: Example of Management Indicator Panel (MIP) reporting for all zones

### 3.6 Data sharing

#### 3.6.1 Internal

The internal shares contain all the import – export functions:

- Import GPS data like Survey points...
- Import other data formats (MIF/MID, TAB, DGN, etc.)
- Export the database to an Hydraulic Modeling System
- Export the map to an image (BMP, GIF, JPG, etc.)
- Export a selected layer to another data format

#### 3.6.2 With Public (web)

In the near future, Wastewater Companies will have to develop a dynamic web-site, link to the GIS application, for the following needs:

- Marketing: presentation of the Company and its objectives,
- Communication: give to the public some information like planning network extension, existing situation, maps illustrating network, water quality, etc.
- Public information: educate people for a good Water management
- Report information: publish some reports to show the repair damage and preventive maintenance operations, leakage resolved, etc.
- Tariff: publish a transparent information about the tariff policy

## 4 ANNEX

### 4.1 Proposed schedule

For a realistic approach, each Company should implement a GIS solution step-by-step, in order to facilitate the organization, the capacity building and the integration of this new technology in the department organization:

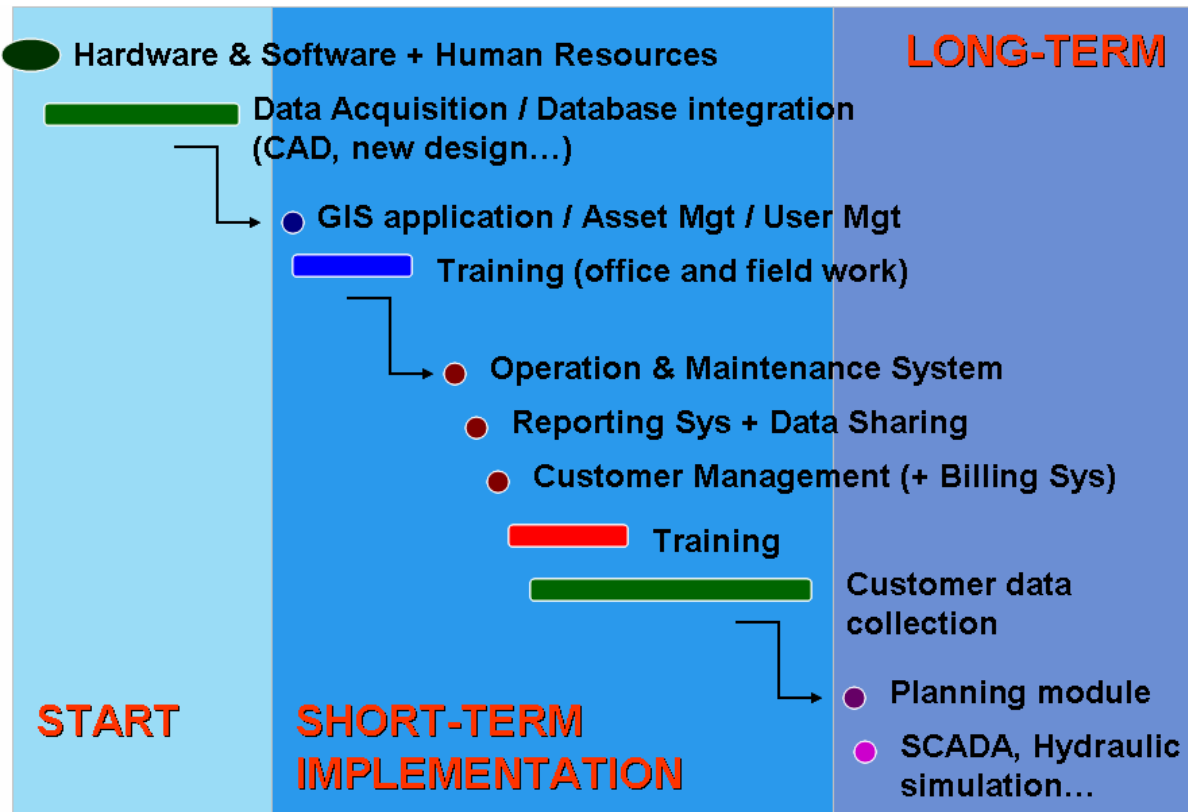


Figure 26: Schedule for implementation

## **4.2 GIS Database Dictionary**

### **4.2.1 Base map**

<b>Hydrology</b>		
Lake	Lake	Surface
River	River, stream ...	Surface and line
Moats	Moats	Line
Channel	Irrigation channel ...	Surface
Watershed	Watershed boundaries	Surface
Water facilities	Dyke, Dam (all water facilities not included in the Wastewater system)	Surface, line and point

<b>Administrative Boundaries</b>		
District	Districts/Wards contained by a town	Surface
Socio-Economic	All demographic and socio-economic information linked to the administrative boundaries (district level or town level)	Table
Other Divisions	All other divisions (for example: other Water Board boundaries)	Surface

<b>Topography</b>		
DEM	Digital Elevation Model (if available)	Raster
Elevation points	Elevation point (if available) – must be very accurate	Point
Contour lines	Contour lines (if available)	Line
Geology	Geological information on soils (if available)	Surface

<b>Transportation</b>		
Street centerline	Street centerline, with name (the street right-of-way is better used to build the Street blocks)	Line
Street name	Created from Street centerline	Annotation
Railway	Railway line	Line
Supporting facilities	Bridge, tunnel, terminal ...	Surface

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<b>Land use</b>		
Street/Land use Block	Street block (can be define from street right-of-way) with land use information if possible	Surface
Land use	Large scale information, using land specific occupation classification (residential, industrial, health public bodies, commercial, education, ...)	Surface
Landmarks	Well-known landmark (location and name)	Point and annotation
Amenities	Slum, Industries, Hospital ... (could be important to analyze the flow information)	Surface

<b>Raster</b>		
Aerial photography	Geo-referenced raster for base map maintenance	Raster
Satellite Image	Geo-referenced raster for base map maintenance	Raster
Historical map	Geo-referenced raster for archive	Raster

4.2.2 Wastewater system

Wastewater System (1/3)		
Sewer Pipe	<p>Sewer pipes network</p> <ul style="list-style-type: none"> <li>• <b>Sub-Type: combined, sanitary, gravity pipe, pressure pipe, interceptor, storm sewer, outfall pipe, force main, casing ...</b></li> <li>• Street location</li> <li>• Status: active, inactive</li> <li>• Collection system: watershed, sewer shed, sub basin ...</li> <li>• Upstream (from) ID</li> <li>• Downstream (to) ID</li> <li>• Diameter (if circular)</li> <li>• Dimensions (if not circular)</li> <li>• Dimension unit</li> <li>• Length (meter)</li> <li>• Upstream invert elevation (from)</li> <li>• Downstream invert elevation (to)</li> <li>• Slope</li> <li>• Depth (meter)</li> <li>• Pipe material: Asbestos cement, cast iron, PVC, corrugated metal ...</li> <li>• Joint length</li> <li>• Material, brand</li> <li>• Installation date</li> <li>• Digital photo</li> </ul>	Line
Service line/pipe	<p>Lateral line which connect the Customer to the sewer pipe</p> <ul style="list-style-type: none"> <li>• Diameter</li> <li>• Length</li> <li>• Material</li> <li>• Pipe type</li> <li>• Tap location</li> <li>• Installation date</li> <li>• Digital photo</li> </ul>	Line
Drains	<p>Drainage pipes</p> <ul style="list-style-type: none"> <li>• Dimension</li> <li>• Capacity</li> <li>• Material, brand</li> </ul>	Line

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<b>Wastewater System (2/3)</b>		
Pumping Station	<p>Can be a node with the sewer pipes (point object) or surface for large station</p> <ul style="list-style-type: none"> <li>• Number of pumps</li> <li>• Dimension</li> <li>• Capacity</li> <li>• Material, brand</li> <li>• Installation date</li> <li>• Digital photo</li> </ul>	Surface and Point
Treatment Plant	<p>Wastewater treatment plant (all types)</p> <ul style="list-style-type: none"> <li>• Sub-Type: Pre-treatment, Primary Treatment, Secondary Treatment, Mechanical Systems, Electrical Systems, Wastewater Laboratory, Disinfection, Sludge Treatment</li> <li>• Dimension</li> <li>• Capacity</li> <li>• Material, brand</li> <li>• Installation date</li> <li>• Digital photo</li> </ul>	Surface
Septic tank	<p>Septic tank</p> <ul style="list-style-type: none"> <li>• Depth (meter)</li> <li>• Installation date</li> </ul>	Surface or point
Manhole	<p>Manhole – Node with sewer pipes</p> <ul style="list-style-type: none"> <li>• Sub-Type: standard, drop, interceptor, overflow ...</li> <li>• Street location</li> <li>• Status: operational, planned, abandoned, buried ...</li> <li>• Number of inlets, outlets</li> <li>• Pipes in and out (invert elevation – diameter – direction [in/out] – type)</li> <li>• Cover material</li> <li>• Cover type</li> <li>• Top (rim) elevation</li> <li>• Bottom (invert) elevation</li> <li>• Depth (meter)</li> <li>• Shape</li> <li>• Diameter (if circular)</li> <li>• Dimensions (if not circular)</li> <li>• Installation date</li> <li>• Digital photo</li> </ul>	Point

## GUIDELINES ON ASSET DOCUMENTATION

<b>Wastewater System (3/3)</b>		
Valve	Node with sewer pipes <ul style="list-style-type: none"> <li>• Sub-Type: system valve or control valve</li> <li>• Installation date</li> <li>• Digital photo</li> </ul>	Point
Fitting	Pipe fitting - Node with sewer pipes	Point
Cleanout	Node with sewer pipes	Point
Outfalls	Combined sewer overflow or sanitary sewer overflow. <ul style="list-style-type: none"> <li>• Sub-Type: combined sewer overflow CSO, sanitary sewer overflow SSO</li> <li>• Installation date</li> <li>• Digital photo</li> </ul>	Line
Outlet structures	All the outlet structures of the system	Point
Inlet structures	All the inlet structures of the system	Point
Monitoring location	<ul style="list-style-type: none"> <li>• Sub-Type: flow meter, sampler, rain gauge, digital [electronic], CSO or SSO regulator ...</li> <li>• Status: permanent, temporary</li> <li>• Flow type: combined, sanitary, CSO, SSO</li> <li>• Installation date</li> <li>• Digital photo</li> <li>• Device (model no., etc.)</li> </ul>	Point
Basin	<ul style="list-style-type: none"> <li>• Sub-Type: detention pond, retention treatment pond, Infiltration, diversion chamber ...</li> <li>• Digital Photo</li> </ul>	Surface
Pollution Control	Pollution control measurements. This kind of information will be link to a table schedule-results	Point
Flooding Area	Flooding area	Surface
House connection	House connection to the wastewater System is a node on the Lateral Line. It is linked to the Customer Management.	Point

### 4.2.3 Future new wastewater system

The data of the new wastewater system is presented separately, but in the final database it will be integrate with the existing data. So for each data, we will add a new status “planned”.

<b>Planned Wastewater System</b>		
Drains	Drainage pipes <ul style="list-style-type: none"> <li>• Status = planned</li> <li>• Dimension</li> <li>• Capacity</li> <li>• Material, brand</li> </ul>	Line
Sewer pipes	Sewer pipes network <ul style="list-style-type: none"> <li>• Status = planned</li> <li>• Sub-Type: combined, sanitary, gravity pipe, pressure pipe, interceptor, storm pipe ...</li> <li>• Dimension</li> <li>• Capacity</li> <li>• Material, brand</li> </ul>	Line
Pumping Station	Pumping Station <ul style="list-style-type: none"> <li>• Status = planned</li> <li>• Number of pumps</li> <li>• Dimension</li> <li>• Capacity</li> <li>• Material, brand</li> </ul>	Surface and Point
Treatment Plant	Wastewater treatment plant <ul style="list-style-type: none"> <li>• Status = planned</li> <li>• Dimension</li> <li>• Capacity</li> <li>• Material, brand</li> </ul>	Surface

### 4.2.4 Operation & Management

<b>Operation &amp; Management - Work plans (1/2)</b>		
Leakage	<ul style="list-style-type: none"> <li>• Location</li> <li>• Type</li> <li>• Leak date</li> <li>• Source information: complaint, routine maintenance</li> <li>• Repaired by and date</li> </ul>	Point

<b>Operation &amp; Management - Work plans (2/2)</b>		
Operation "As-Built drawing"	<ul style="list-style-type: none"> <li>• Sub-Type: installation, repair of damage, replacement ...</li> <li>• Execute Unit</li> <li>• Street location</li> <li>• Operation date begin</li> <li>• Operation date end</li> <li>• Target object: pipe, pumping station, monitoring location, treatment plant, manhole ...</li> <li>• Estimated cost</li> <li>• Digital photo</li> </ul>	Surface
Preventive Maintenance	<ul style="list-style-type: none"> <li>• Sub-Type: flushing, inspection, periodic cleaning ...</li> <li>• Execute Unit</li> <li>• Street location</li> <li>• Operation date begin</li> <li>• Operation date end</li> <li>• Target object: pipe, pumping station, monitoring location, treatment plant, manhole ...</li> <li>• Estimated cost</li> <li>• Digital photo</li> </ul>	Surface
Material Cost	Cost for a new feature like pipe, pump, fitting, valve, manhole, ...	Tables
Operation Cost	Define costs for each type of operation or preventive maintenance	Table
Team resource	List of the staff that will be part of the executive units. This information could be linked to the Human Resources System	Table

#### **4.2.5 Customer Management**

<b>Customer Management</b>		
Customer	Customer who has a house connection to the wastewater System <ul style="list-style-type: none"> <li>• Customer ID</li> <li>• Street address</li> <li>• Telephone</li> <li>• Type of customer: residential, commercial, industrial, institutional ...</li> </ul>	Table
Billing	There is a billing management if the company wants to manage a wastewater tax per customer.	Table