Implementations of Geographic Information Systems on Sewage Management for Water Resources Protection

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Abstract: Taipei Watershed Management Bureau (WRATB) is a government agency entitled for water resources protection at two major watersheds in order to provide drinking water for about four millions population in Taipei on a sustainable basis. At WRATB, there are two major public sewage treatment facilities which can convert sewage in each watershed into an acceptable state before they were discharged into rivers. More than 82% of household wastewater have been collected and treated by the two public sewage systems. However, households at remote area still need more effective sewage management prescriptions. The objective of this paper is to implement geographic information systems in order to provide more effective approaches that sewage management can be easier and cost effective. ArcIMS was implemented for Internet browsing and map server of those sewage facilities on personal computers, laptop computers. In the open field, ArcPAD was implemented with personal digital assistant (PDA) such that compact flash type's global positioning systems (GPS) and digital camera can be utilized with PDA. All sewage facilities digital files were convert into ArcMap format files. MapObjects and visual BASIC were used to create sewage application modules to meet every single technician personal flavor. ASP.NET was implemented for Internet database manipulations of all sewage databases. Mobile GIS was the key component of GIS applications in the open field for sewage management on a basis of house by house. Houses at remote area, which can not cover by the two public sewage systems, were managed by PDA and laptop computers with GPS and digital camera. Sewage management at Taipei Watershed Management Bureau is easier both in the open field and in the office. Integration of GPS, GIS, and PDA makes sewage management in the open field much easier. ArcIMS, MapObjects, ASP.NET and visual BASIC make sewage management can be done in the office and over Internet.

Keywords: Geographic information systems, sewage management, GPS.

1. Introduction

Water quality and quantity is one of very important issues that should be pursued at Taipei Watershed Management Bureau. In order to supply high quality of drinking water on a sustainable basis, water resource protection has to look into all aspects of solutions. There are two major public sewage treatment facilities have been constructed and managed to convert sewage of the two watersheds into an acceptable state before they were discharged into rivers. Household wastewater is subjected to be managed by the two public sewage systems. Households at remote area still need more effective sewage management prescriptions.

The objective of this paper is to implement geographic information systems for sewage management such that water resource protection can be easier and effective.

2. Material and Method

Sewage management has to deal with a lot of maps and databases. Domestic and community wastewater has to look into on a single household basis because it is the main pollution source at WRATB. Existed sewage pipeline network has not covered more than 85% of all household. Maintenance of established sewage facilities and extending collecting pipelines to every single household are the two major problems to be solved.

1) Material

The two major sewage treatment facilities have been created into the databases separately. Sewage collecting pipeline systems including house maps have been created as well. Their map scales are in the range of 1:500 to 1:5000. All maps have been converted into topographic coordinates in order to overlay with maps in the databases. Maps are converted into ArcMap format. Attributes are manipulated into relational database format.

2) Method

Commercial GIS software such as ArcIMS, ArcView,

and ArcPAD are the major items to provide GIS functions for sewage management. Programming languages such as Visual Basic, ASP.Net and ADO.Net are used for development of application modules, data manipulations, creation of hyperlinks among maps and their associated attributes. The major ingredients of the whole prescriptions for sewage management are build-to-order and configuration of application modules for single technician both in the open fields and in the office.

Personal digital assistant (PDA) is a very useful and convenient device for field operations. ArcPAD is designed for PDA operations but is also good for personal computer implementations. GPS can work independently with or without PDA. Embedded visual Basic is needed for development of more application modules with PDA. A PDA connected to a GPS device is desired at WRATB. All PDA are running with Windows Pocket PC operating system.

ArcIMS was purchased and used for both Internet operations and intranet operations of sewage management. Databases were mainly created by Excel. They have to convert into Microsoft SQL server and some of them were stored as Internet HTML file format for quick web browsing. With ASP.Net and ADO.Net, traditional database manipulations can be done on web pages.

MapObjects were published by ESRI and come up with several different software languages such as, Visual Basic, Visual C++, Delphi, and so on. With a little bit of programming, MapObjects can provide GIS functions with personal flavor. Some of sewage application modules were created with MapObjects.

3. Results and Discussion

1) Household Inventory

Every single household has been investigated and their basic information was created into the databases including address, wastewater collected or not, landowner, types of pipelines, and so on. Which village is also a key component for sewage management.

2) Pumping Station and Sewage Treatment Facilities

Pumping stations including location, number of pumps, capacity, and horse powers were ready for data manipulations and inquiry. More detail information still need to be input into the databases.

The two public sewage treatment facilities are the major components of the whole systems. How to keep them operation on 24 hours a day, and day after day is the top priority. All hardware must keep in good condition and spare parts have to be reached at sufficient amounts and in a short time frame. GIS in this regard is providing some supporting functions in order to make the whole process of sewage treatment facilities can be smooth as long as possible.

3) Sewage Pipeline Network in the Open Fields

Sewage pipeline network in the open fields is the key component that GIS can contribute something in sewage management. Layout maps of pipeline network for every village were stored as GIS databases. A GPS device and a PDA can browse the right sewage maps for a desired place for field operations and data manipulations. Almost all manholes have been located with the help of GPS and their location maps were overlaid with different map layers. Hyperlinks between important sewage pipeline network and their associated attributes can be done smoothly in GIS software.
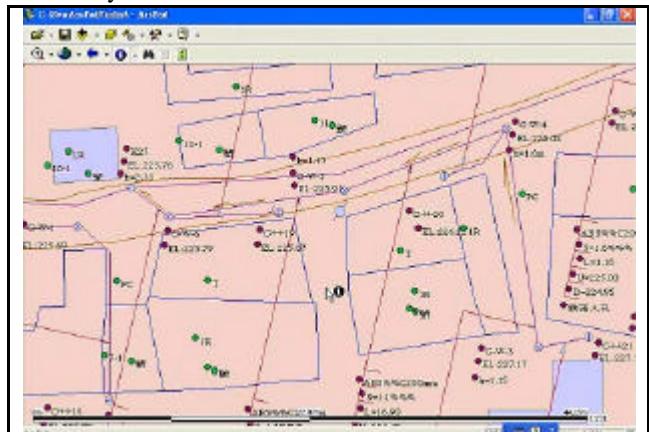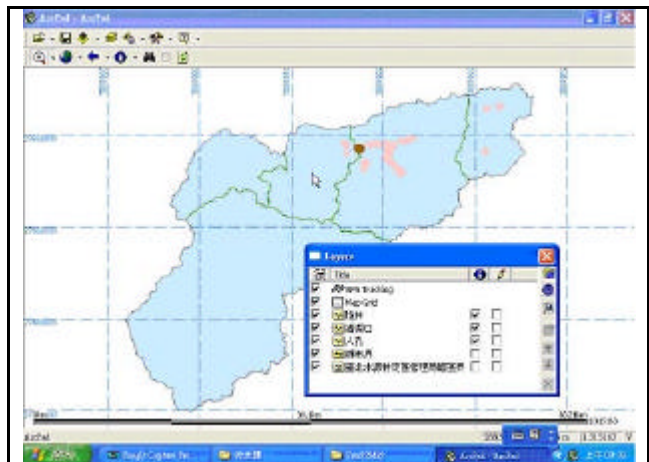

Fig. 1. One portion of sewage maps.

Fig. 2. Manholes overlaid with a township map.

4) Regions that Wastewater has been Collected

Those regions that their wastewater has been collected were managed more like routine works. Maintenance is the most part of jobs done every. Hot springs discharged by hotels and resorts are hot issues to be managed recently. Sewage maps are not the only required maps for management. Parcel maps, house maps, road systems, and contour maps are overlaid quite often. Summary reports usually are a must. Visual Basic is very good for table automatic generation using Microsoft Excel and automatic report generation using Microsoft Word. To convert those information in Excel and Word into databases, Visual Basic is also a very good programming

language.

5) Regions that Wastewater has not been Collected

How to collect the household and public wastewater at remote area with effective management prescriptions is a real challenge at WRATB. Uncollected household has been investigated house by house. GIS can answer so many "what if" questions in order to come up with very good management prescriptions for a specific region. Maps overlay and buffering analysis of GIS can do a nice job in this regard [1]. Budget concern and efficiency can be met simultaneously as well. A long-term project for these regions that wastewater to be collected has been reviewed with the help of GIS and GPS. How many houses to be collected at a given village or region and where are they can be answered quickly by GIS, with the help of maps to show their locations and tables to indicate attributes.

6) PDA for Open Field Operation and Web Browsing

PDA is a very convenient device for open field operation of sewage management, especially, with the help of GPS. Although, it has RAM only 64 MB but power supply good for 12 hours job is quite useful. High resolution color images such as 2 meters and 0.5 meters are no problems to put into PDA as background for field inspection. Some free software can compress one color image from 144 MB into 3 MB such as ECW [2]. ECW is good for ArcView, ArcIMS, and ArcPAD. High resolution satellite images and 0.5 meters resolution orthomaps are very good information to update household databases.

PDA can not use for web browsing without some sorts of cell phone functions such as PHS and GPRS. Two ways communication between servers in the office and PDA in the open fields brings real-time mobile GIS into sewage management. Although, large amount of data manipulations in this manner is confined to bandwidths of PHS and GPRS, a good combination of PDA, GPS, and GIS is very useful for sewage management at WRATB.

4. Conclusions

Taipei Watershed Management Bureau is entitled for water resource protection in order to provide high quality of drinking water for about four millions populations in Taipei. Sewage management is one of many types of jobs has to be done day after day at WRATB. With the help of GIS, GPS, and PDA, sewage management can be done in the open fields and in the office almost identically. Web browsing and mobile GIS are two typical functions that sewage management can be done with more personal flavor. Commercial GIS software is not easy to customize in this manner. With a little bit of programming, application modules for sewage management can be organized in task-oriented and personalized modules. GIS implementations for sewage management at WRATB is not confined to examples mentioned here. More research on GIS implementations for water resource protection are planned in the near future.

References

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