GIS and Asset Management: a Cost Efficient Enterprise Solution

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Abstract: Utilities are facing significant challenges and opportunities in developing cost effective business processes for managing infrastructure and assets. Central to that task is the development of accurate and easily accessible asset related information. Whether it is cost, criticality, condition, life expectancy, or decision support - GIS tools and technologies are at the core of the design. This paper will explore building an Asset Management System by expanding the existing water model, which facilitates the horizontal assets, to integrate our vertical assets on top of it. This combined data structure provides a GIS-centric data management system. In addition, we are expanding to the area of business process improvements and implementing it on ESRI mobile technology to allow the field crews to create work orders on assets seamlessly in the field. Last but not least, GIS provides tools to make cost efficient business decision.

Introduction

In recent years, most of the public agencies have been working on some level of the GIS implementation for its unique capability of combining large amount of information from disparate sources and formats. The introduction of government regulation such as the Governmental Accounting Standards Board 34 (GASB34) brings more attentions to the GIS centric data management. Otay Water District has been working on the enterprise level GIS implementation for the past 10 years. The purpose of this paper is to share our experience on expanding the existing GIS architecture to accommodate the needs for the District's Asset Management program. We would also like to share our thoughts on how to plan and design an enterprise wide information sharing platform to increase the efficiency and improve day to day business processes.

Background

Otay Water District (OWD) is a publicly-owned water and sewer service agency, more specifically, a California special district. The District is located in south San Diego County and encompasses approximately 125 square miles with a parcel base of approximately 60,000 parcels. Otay facilities serve the water and/or sewer service needs of approximately 186,000 people living in the surrounding communities. The District is responsible for the design, construction, operation, maintenance and update of potable water, reclaimed water and wastewater facilities within its boundary.

Otay also owns and operates a wastewater collection and reclamation system, providing public sewer service to approximately 5,000 homes and businesses within the Jamacha drainage basin. Through a dedicated pipeline system, the reclaimed water is transported into the eastern Chula Vista area where it is used to irrigate a golf course, elementary and high school playing fields, public parks, roadway landscapes and various other approved uses.

Enterprise Strategies

Any enterprise can develop its own strategy regarding the use of information. Many businesses choose a decentralized strategy that allows different elements of the enterprise a fair degree of autonomy in choosing tools and technologies to manage information. At the Otay Water District, we have chosen to emphasize and leverage as much as we can the enterprise integration strategy whereby the role of information is managed as a corporate asset and has in place the necessary controls and processes to achieve that goal. Central to this approach is a control document that is the District Strategic Plan. The strategic plan contains all of the key initiatives that the District will engage in and is endorsed by both the entire management team and the Board of Directors. It is presented in advance of the operating and capital budgets and is the foundation for all actions that we do.

Part of this plan is a set of defined initiatives that hopefully will achieve this goal. Having an enterprise approach to GIS has been at the center of this District's approach for the last ten years.

Asset Management as an Enterprise Strategy

What is new over the last two years is the emergence of the discipline of asset management as a unifying concept that provides an opportunity to utilize enterprise GIS as the technical foundation for "enterprise asset management".

Asset management as the ESRI water-wastewater web page points out (add link) does span the water utility business processes very effectively. By investing in enterprise asset management as a foundational strategy for the District, we hope to reposition our GIS support assets as the primary support for the definition and maintenance of all enterprise asset information. This in theory elevates the role of GIS in the business and provides clarity and purpose to the responsibilities of this function. What this means from a GIS support perspective is that GIS is becoming merged into the higher role of enterprise asset management and GIS rather than an end in itself is becoming one of the key technologies to achieve a higher level of enterprise efficiency and effectiveness.

The Changing Role of GIS

There are many implications to this change in direction. First, the skill set and training of GIS analysts and technicians needs to be broader and embrace the principles of lifecycle asset management. Second the technical architecture of GIS must be expanded to more easily embrace the totality of the District's assets including the "vertical" assets in detail that now tend to be represented only as a point on the map (pump station, reservoir, and treatment plant). Another key element that is quite involved but beyond the scope of this paper is decision support and how GIS along with modeling is critical to achieve this goal.

Traditionally, the asset management system information pertaining to the financial value of the utility network assets like present value, cost of maintenance, depreciation value

and salvage value is maintained in a separate database. GIS is a versatile tool to maintain and update location information for water utility network assets. **"**GIS-centric asset management standardizes data and allows interoperability, providing users the capability to reuse, coordinate, and share information in an efficient and effective manner by making the GIS geo-database the asset registry". [2]

At Otay Water District, in full consideration of the business needs for Otay's Asset Management, it was decided to integrate Otay Asset Management system with GIS since both are stored in standard Relational Database Management System (RDBMS).

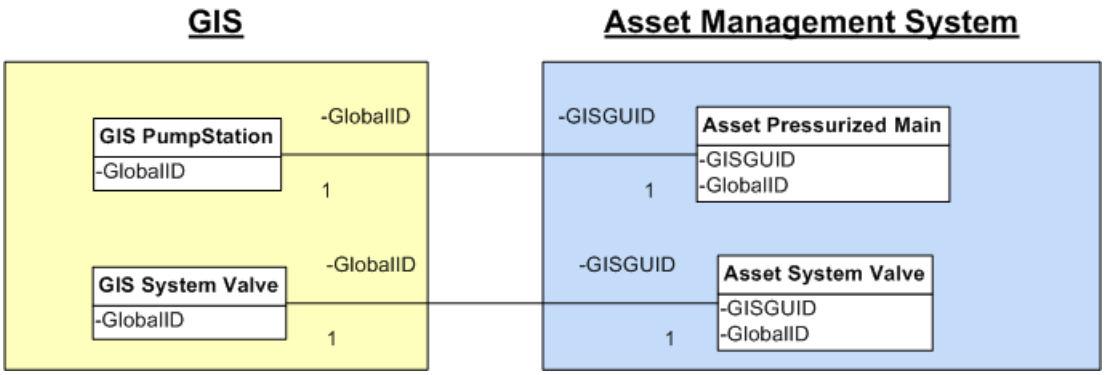
The Integration in Concept

GIS is an excellent tool to maintain information on horizontal assets like the main pipes, service laterals, meters, hydrants, and valves. Those facilities constitute the majority of a utility network but not all of its assets. For example, a water treatment plant is represented as a point feature in GIS. However, it contains many other important vertical assets like the tanks, pumps, motors, and electric equipment within the treatment plant constituting their own sub network. A similar argument can be made for the pump stations.

There are different levels of system integration within the water utility industry. Some agencies choose to have the separate data models for their GIS and CMMS system. One of the systems takes the inititave to synchronize the facility data to another system to reach the goal of system integration. There is also the new trend to try to integrate the systems through web services that, in theory, the detail data mapping process can be ignored.

At Otay, we've been working on improving the GIS platform and are confident that our existing GIS data structure is the foundation to meet our business needs. We choose the most direct way to integrate the horizontal GIS assets with the asset management system.

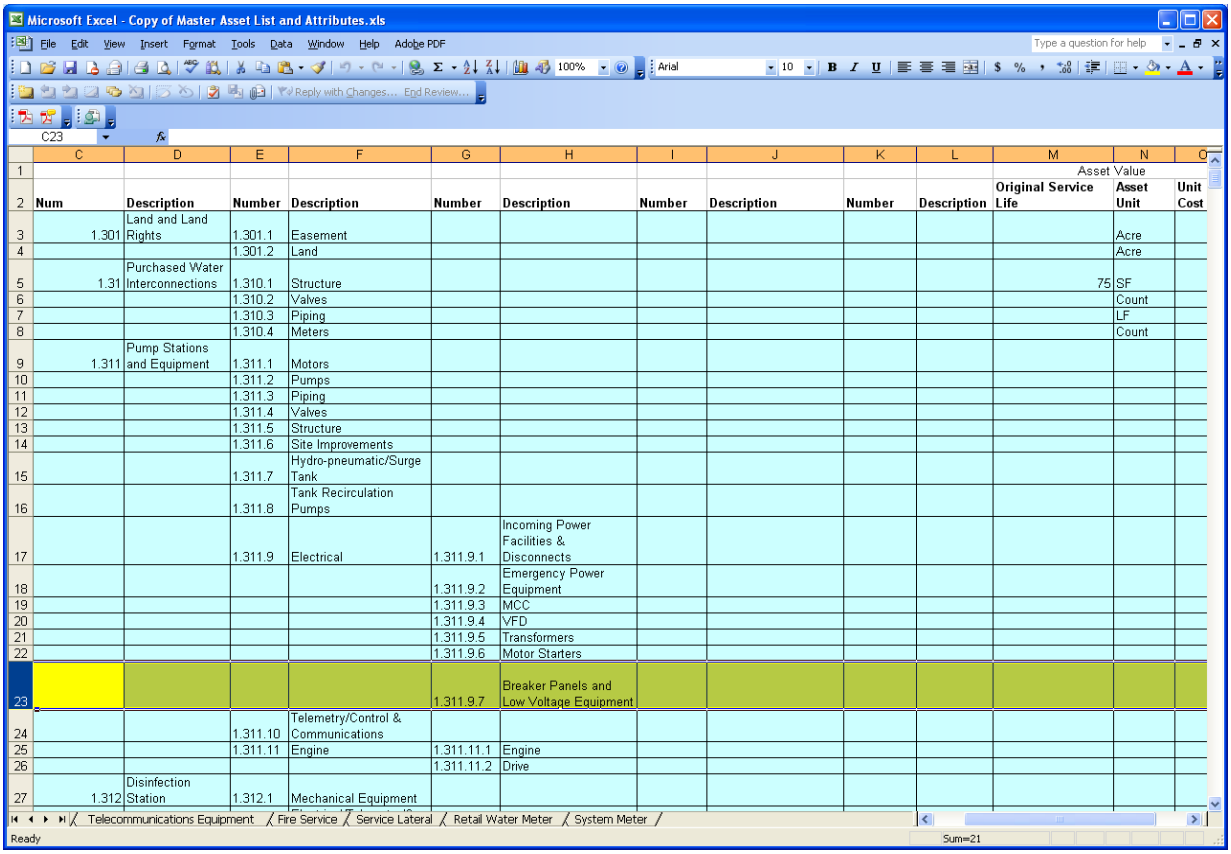
The following E-R diagram shows the basic idea that how the GIS feature classes (like Pressurized Main and System valves) would have corresponding tables in the asset management system:



The design took the advantage of the SQL platform we chose across the board. The asset mange data tables are separate tables reside inside the GIS database cluster server with keys to the GIS Geodatabase. This design will create the flexibility for other applications to access the asset management data but not necessary to go through GIS gateway.

GIS Data Model for Asset Hierarchy

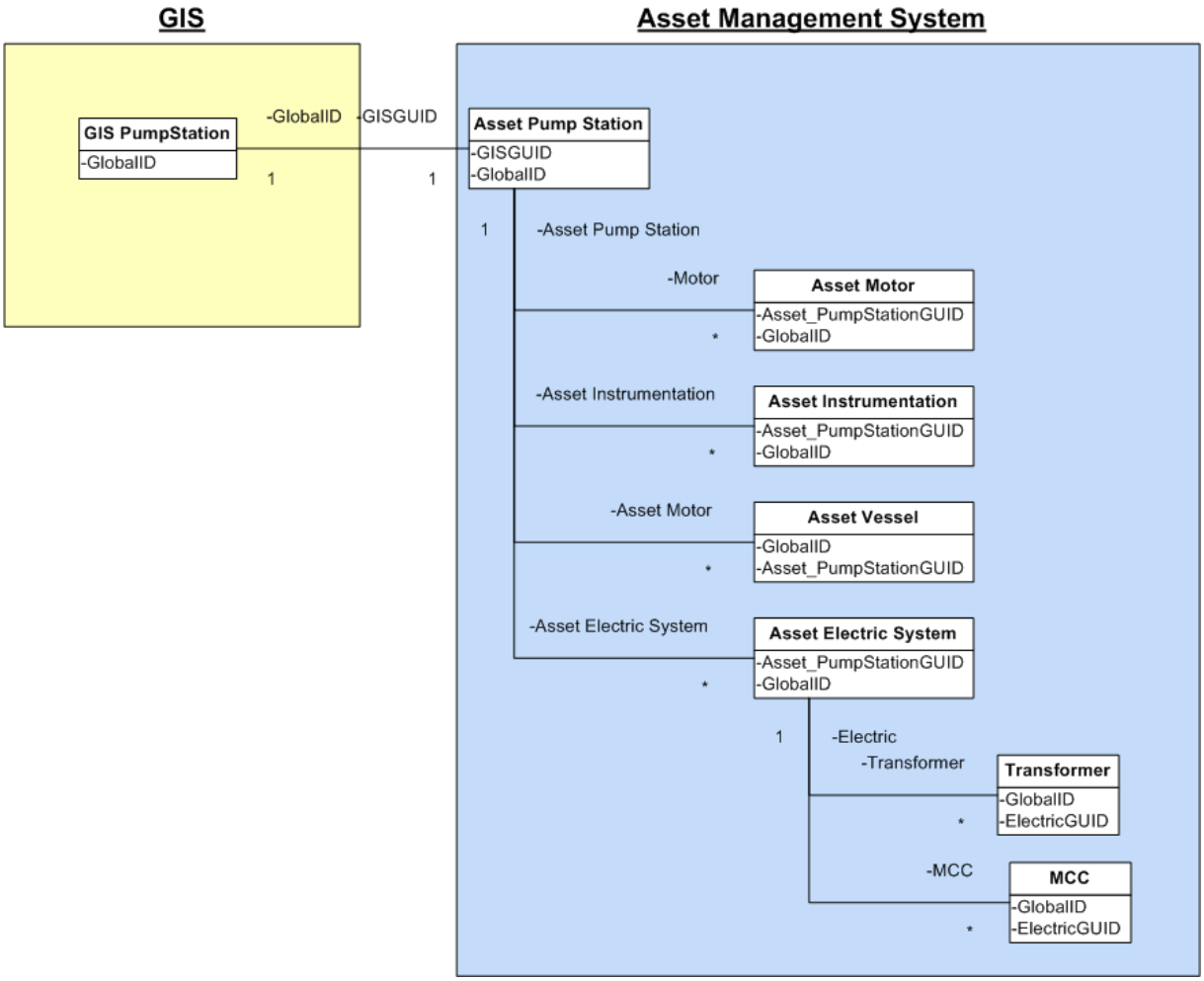
The District contracted to an engineering consultant firm to conduct the "Baseline Asset Management Assessment". The study reviewed the existing district data, general preventive maintenance practices and established a fixed asset hierarchy/account structure. The following figure is the part of the "Asset Account Detail Structure" delivery.



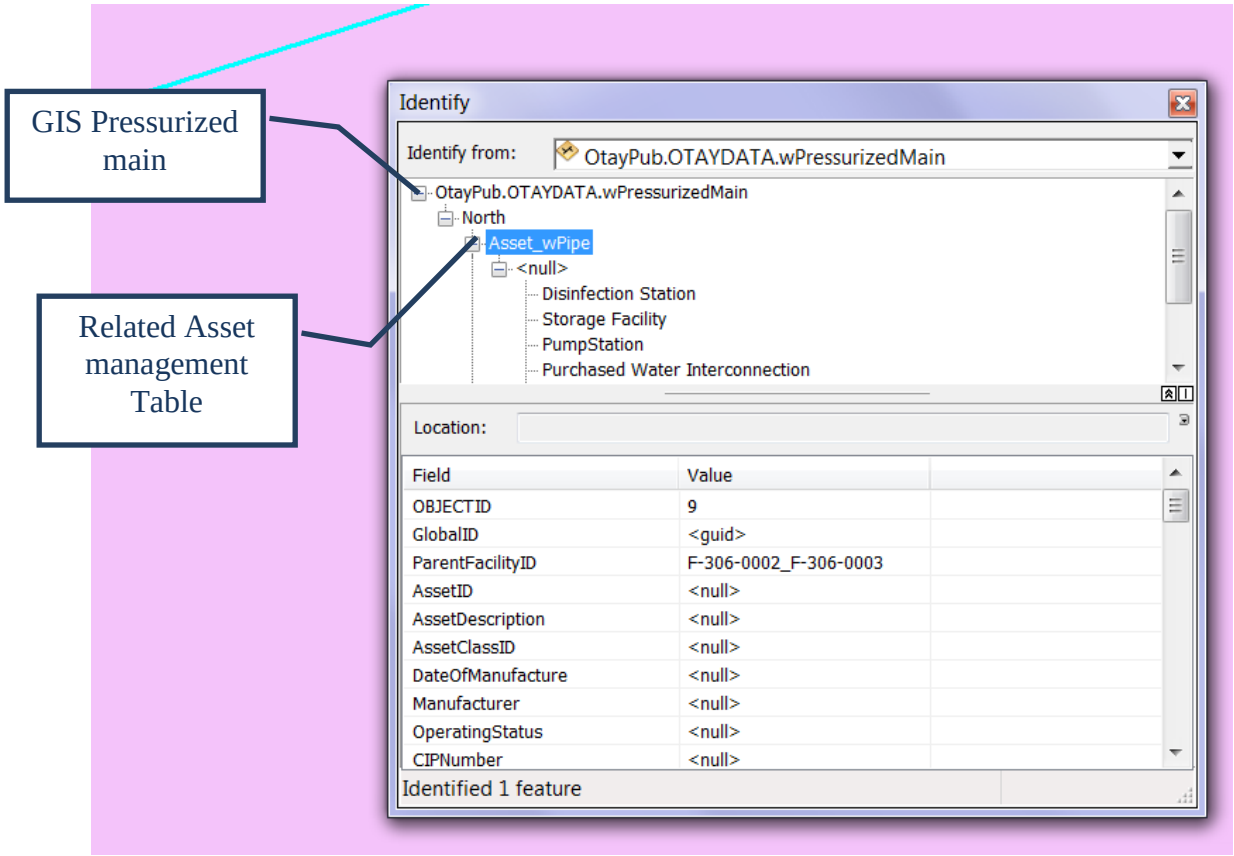
	C	D	E	F	G	H	I	J	K	L	M	N	O
1												Asset Value	
2	Num	Description	Number	Description	Number	Description	Number	Description	Number	Description	Original Service Life	Asset Unit	Unit Cost
3	1.301	Land and Land Rights	1.301.1	Easement								Acre	
4			1.301.2	Land								Acre	
5	1.31	Purchased Water Interconnections	1.310.1	Structure							75	SF	
6			1.310.2	Valves								Count	
7			1.310.3	Piping								LF	
8			1.310.4	Meters								Count	
9	1.311	Pump Stations and Equipment	1.311.1	Motors									
10			1.311.2	Pumps									
11			1.311.3	Piping									
12			1.311.4	Valves									
13			1.311.5	Structure									
14			1.311.6	Site Improvements									
15			1.311.7	Hydro-pneumatic/Surge Tank									
16			1.311.8	Tank Recirculation Pumps									
17			1.311.9	Electrical	1.311.9.1	Incoming Power Facilities & Disconnects							
18					1.311.9.2	Emergency Power Equipment							
19					1.311.9.3	MCC							
20					1.311.9.4	VFD							
21					1.311.9.5	Transformers							
22					1.311.9.6	Motor Starters							
23					1.311.9.7	Breaker Panels and Low Voltage Equipment							
24			1.311.10	Telemetry/Control & Communications									
25			1.311.11	Engine	1.311.11.1	Engine							
26					1.311.11.2	Drive							
27	1.312	Disinfection Station	1.312.1	Mechanical Equipment									

Otay's GIS staff along with an individual contractor creates the UML data diagram based on the above mentioned concept and the account detail structure spreadsheet. The newly created vertical asset data structure then is integrated with the existing GIS data model.

To demonstrate how vertical assets can be integrated with GIS, a pump station is selected. The pump station in GIS is represented by a point feature. However, in reality, the pump station contains other important assets that are not represented in GIS such as motors, vessel(s), and an electric system. The electric system, in turn, may consist of one or many other assets like a transformer and a MCC board. The following E-R diagram shows the integration of the GIS feature classes with their corresponding asset management system data.

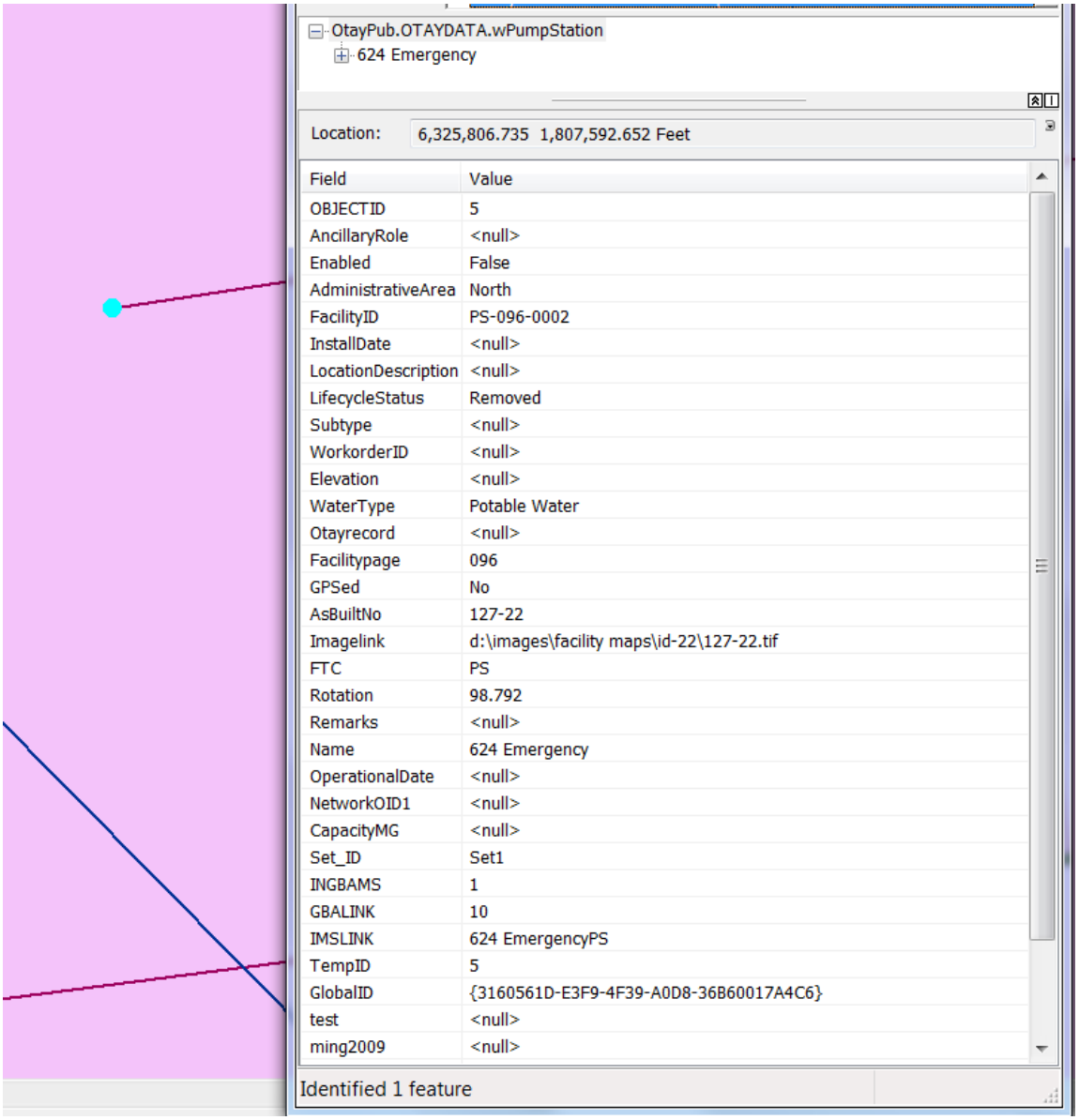


The Asset Management table was created in the same GIS RDBMS using native RDBMS SQL Statements and then registered the new table with the Geodatabase in ArcCatalog.
A GIS relationship is then established between the GIS feature class and the Asset Management table and related through a common GlobalID as shown below:

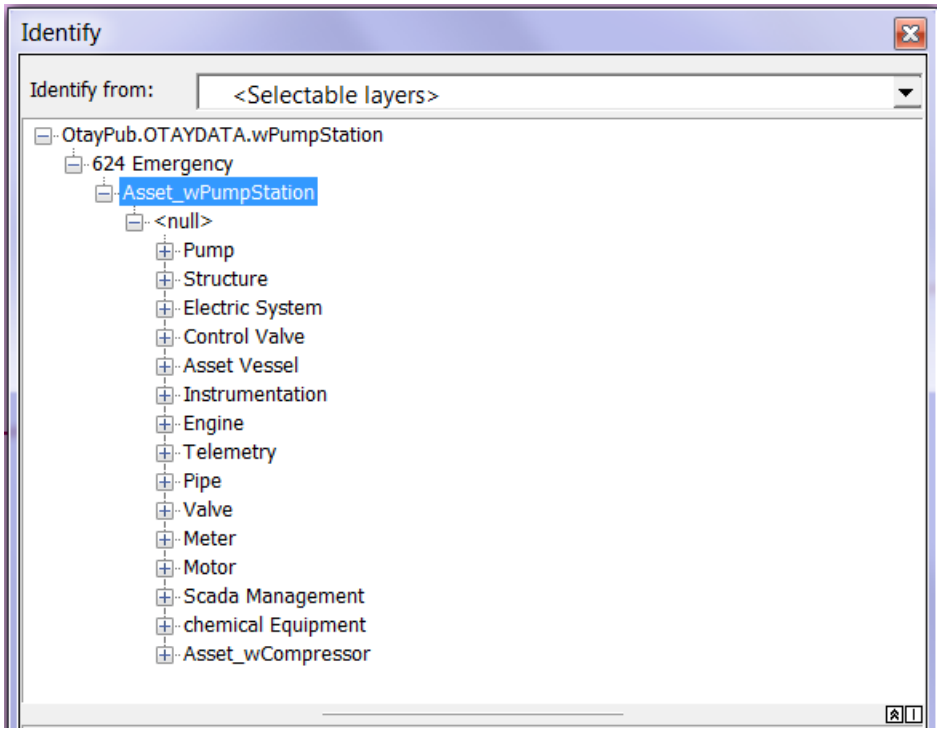


This process can then be repeated to cover all GIS feature classes. However, with the present state of GIS software and technology, GIS has not been used extensively to capture the information within pump stations and treatment plants graphically

The following figures demonstrate how the pump station looks like in GIS, then how the associated asset management pump station table looks on its own, and then how the above GIS pump station would look when associated with its asset management tables.

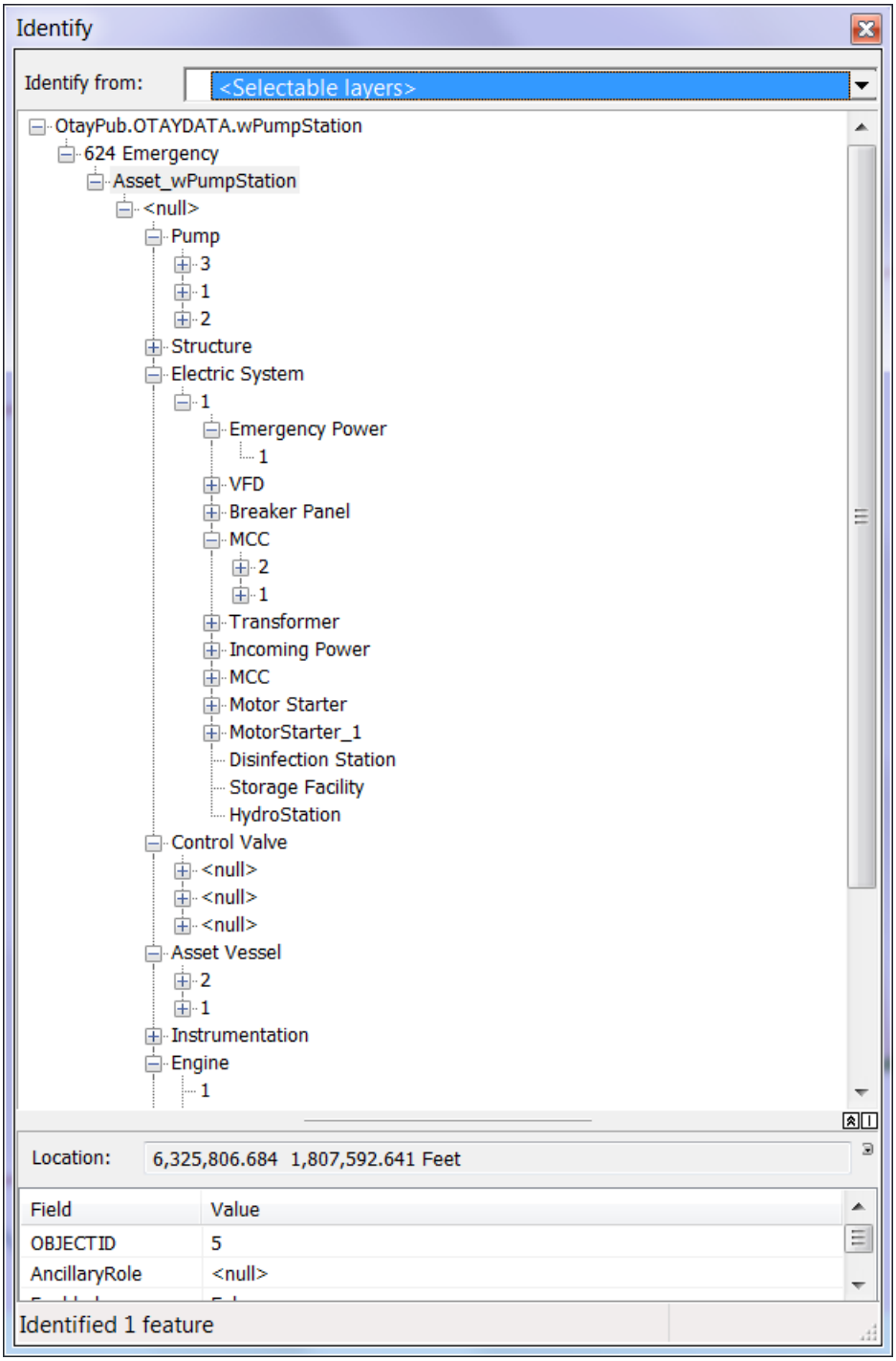


To create the Asset Management table for the pump station, a simple SQL-create statement was executed using the underlying RDBMS SQL statement and the table was registered with the geodatabase in ArcCatalog. A Geodatabase relationship was established between the GIS pump station and the Asset Management pump station just like it was done between the pressurized main GIS feature class and its corresponding Asset Management table. To satisfy the business requirements at the District, it was determined that the pump station should be related to the following tables:



The Asset Management tables listed above were created using SQL Statements in the RDBMS system. They were then registered with the geodatabase and then relationships were established between these assets and the asset pump station. The asset pump station table is related to the GIS feature class.

The following figure demonstrates how this particular pump station has 4 pumps, three control valves and two engines. It also shows that it has one electric system which consists of one emergency power supply and two MCC boards

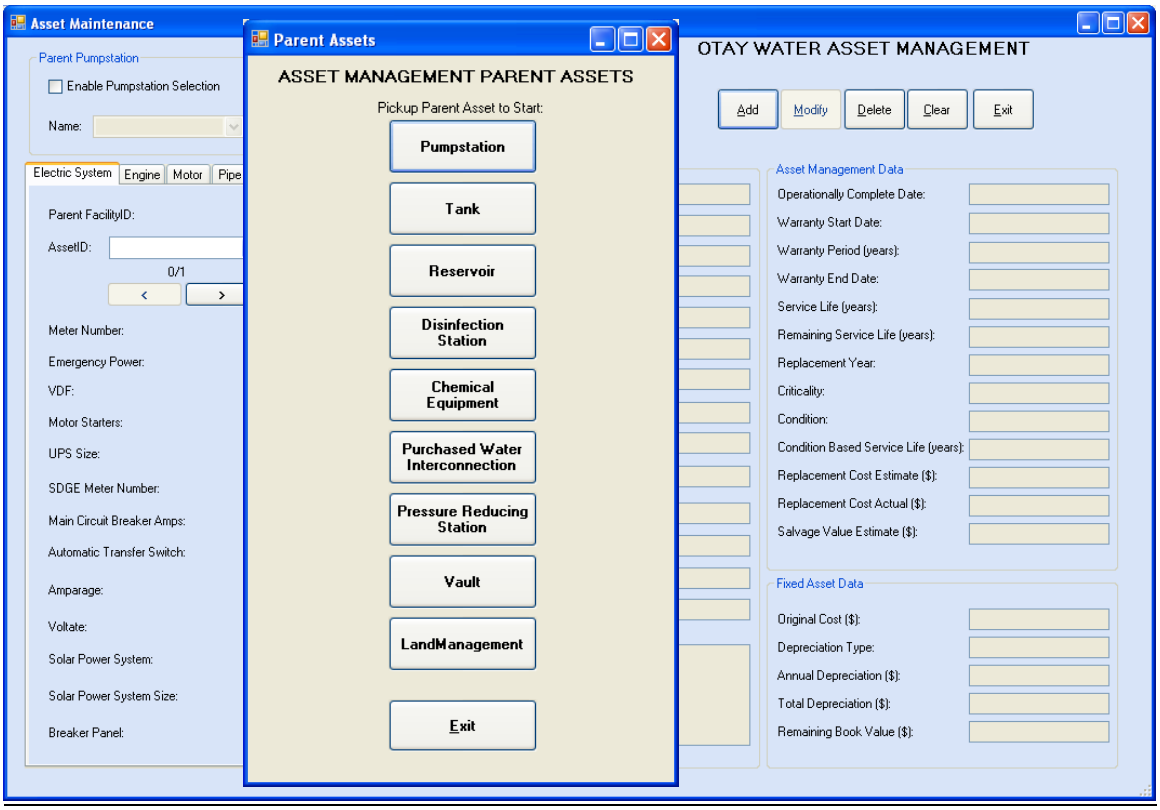


Whether GIS relationships are used or not, the primary and foreign keys need to be established to link any kind of tables and enforce integrity constraints. Creating the relationship class would only make it easier to see all this data integrated in GIS as shown above. Furthermore, these relationships can be deleted and database joins can be established at any time in and out of GIS tools and software.

Data Quality with Data Entry Tool

The vertical asset data requirement has been successfully integrated into the horizontal GIS data structure. The overall asset data structure provides the District with the single point of data storage platform. From the technical point of view, we have achieved a big milestone to expand the District's data architecture to another level. From the business side, an easy data entry form that embeds with the intelligence of database relationship is highly desired.

The GIS staff then developed an "Asset Management Date Entry Forms" using .NET technology. The entry forms provide multiple levels of hierarchies of an individual facility for the field staff to key in the asset information. The intelligent forms prevent from redundant data entry and avoid the mismatch for each level of asset registry.



GIS vs CMMS

Otay has adopted one of the Computerized Maintenance Management System (CMMS) in the market mainly as the Work Order Management tool. GIS has been the data provider for the current CMMS system. Due to the different data structure, GIS department has bee tasked to map out the two database systems and synchronized the data on the monthly basis. We've tried to integrate the two systems at the web interface level which allows the users to access through only the GIS viewer and to create the work

orders without launching the CMMS software. But there are some technical difficulties due to the Citrix Server whipping out the user profiles daily. The other drawback of the current architecture is that the end users have to memorize the long "FacilityID"s which were assigned to each asset by GIS and physically type them into the CMMS system before they create the new work orders. This process increases the chances of human errors and also discourages the field crew to link the asset when they create work orders.

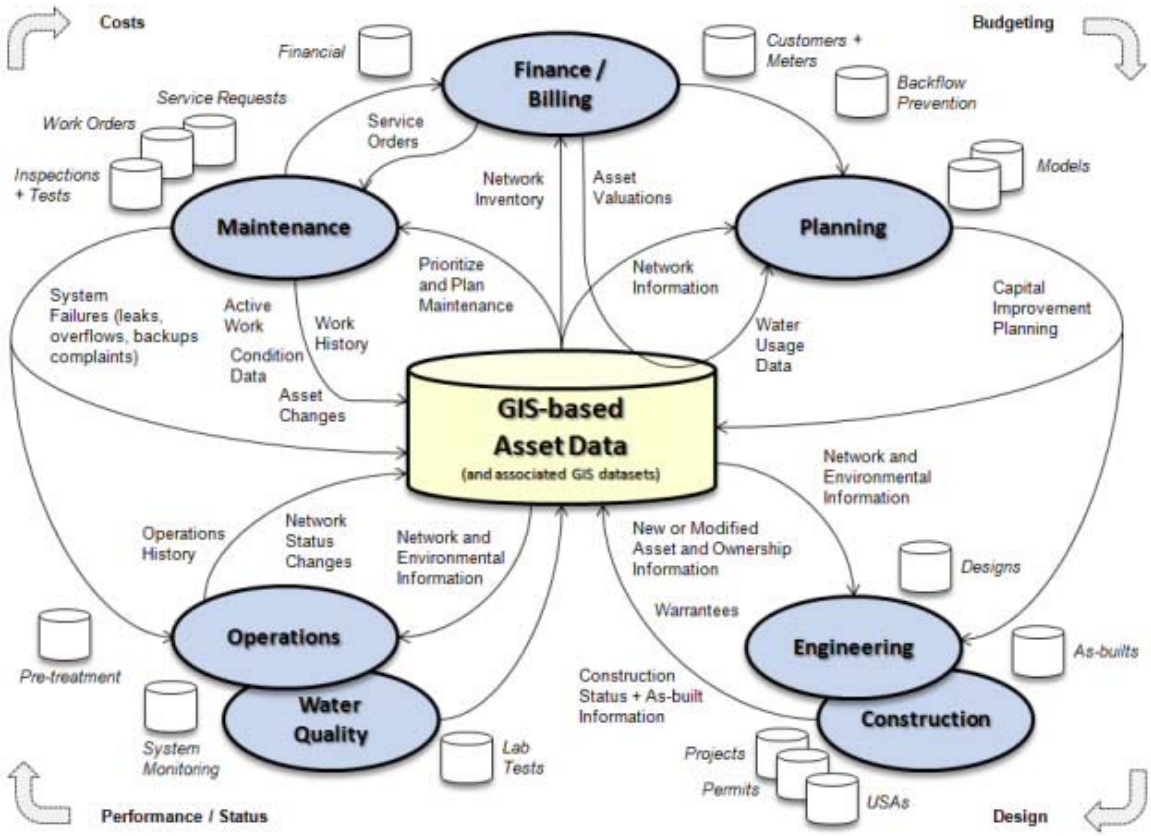
The new design which stores the vertical assets in the GIS platform, streamlines the District's data management process. The GIS and Asset Management data correlate with each other. This new data structure will reduce the data maintenance cost by removing the duplicated data from the CMMS system and will improve the efficiency by presenting only the asset information from one data source. For the long run, a GIS-centric CMMS system will further reduce the cost by reducing the chances of human error on work order categories and providing more intelligent asset related information while the users create the new work orders.

One of the benefits of the design is for the field mobile solution. The horizontal facility data was stored in a personal geodatabase in the field mobile unit. The new improvement of the vertical assets being added to the data structure provides the field crew the new opportunity to create work orders in the field "on the map". Working with the field mobile software vendor, the GIS department is able to provide the new "Hydrant Flash" and "Valve Exercise" extensions to the field crew to create the work orders and record the work activities in the field which reduce the duplicated efforts of re-entering the data at the office.

The benefit of the District's new design will also provide GIS with the real time asset conditions for further spatial analyses. Along with the unique capability of GIS's spatial components, widely available online GIS resources, the District will be able to schedule the preventive maintenance in a more scientific and realistic manner to save the overall operation maintenance cost.

Business Intelligence and Decision Making using GIS technology

Business Intelligence refers to computer-based techniques used in identifying, extracting, and analyzing business data in order to provide historical, current, and predictive views of business operations. Common functions of business intelligence technologies are reporting, online analytical processing, analytics, data and text mining, process mining, business performance management, benchmarking, and predictive analytics.[1] The ultimate goal of BI is to streamline business workflows and improve operational decision-making at the District.



Since the District is in the business of operating and maintaining networks of geographical-dispersed assets, it is recognized that many of the BI reporting functions would be organized geographically using the GIS, and a significant portion of the analytical processing and data mining will require spatial analysis utilizing GIS (e.g. develop a map of reactive maintenance hot spots, determine the total annual maintenance costs for sewer assets downstream of business X). [3]

Based on the District's focus on GIS-centric business management, it is very logical to get the important information such as criticality, condition, level of service, etc. through the geometric network and work order histories. Since the District has created the Water Resource Master Plan based on the enterprise GIS information which takes the advantage of geometric capability, the methodology for predicting the Capital Improvement Plan should be applied to the operation preventive maintenance. The District is visioning an automated operation dashboard that will accommodate the majority of the District's daily processes and will be produced based on the above diagram. The business process related to the operation and maintenance will be greatly improved based on the GIS-centric operation dashboard.

Conclusion

For the GIS-centric approach, the GIS database is the primary database-of-record for all assets. It is important to keep this thought through the design of the system, data management workflows, and data governance policies.

For the purposes of this paper, we wanted to illustrate what is involved in developing an integrated data model that effectively allows vertical assets to be contained in the geo-database architecture. This is essential if we are to use GIS as the integrating technology for District assets. Currently these vertical assets – which may be over 50% of our capital expenditures, are not in our GIS system beyond the summary "point" level. To address this change we are modifying our GIS database and UML to accommodate this need. This is but one of many modifications we will need to make but a very important and necessary change.

1 Wikipedia: Business Intelligence

2 ESRI (pending publication) *GIS-Centric Public Asset Management*, 2011 by Brian L. Haslam

3 Otay Water District Geographic Information System Five-Year Strategic Plan (draft) Brian Hoefer