Chapter 22

Wastewater Information Management System: Flow Modeling and Sewer Connection Permit Applications

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The City and County of Honolulu, Department of Wastewater Management (DWWM) is charged with the wastewater service of approximately 900,000 persons living on the Island of Oahu. Effective management of the wastewater system by DWWM is being aided through construction of an island-wide wastewater information management system (WIMS).

Modules within WIMS automate to a large extent the standard procedures for managing system inventory, estimating flows, and evaluating system hydraulics and capacity. The use of the various modules within WIMS results in speedier evaluation of basin flows and impact of new sewer connections, improved project evaluations. It also provides a means to account for system-wide impacts that it was not practical to account for in the past. This chapter outlines two new modules developed for WIMS: the Sewer Flow Analysis System (SFAS) and the Sewer Connection Application System (SCAS). Figure 22.1 shows the interconnection between SFAS, SCAS and other modules within WIMS.

SFAS and SCAS use the ArcInfo geographic information system (GIS), commercial packages for data management and hydraulic modeling, and customized computer programs to complement other components of WIMS. The two new WIMS modules integrate several different information management technologies:

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Figure 22.1 Wastewater information management system: City and County of Honolulu.

- Database management is used to record, evaluate, and manage new sewer system connections.
- Database management and spreadsheets are used to analyze extensive flow monitoring data and to calibrate the flow estimating and routing models.
- GIS is used to manage sewer system connectivity and inventory, and identify all the wastewater facilities impacted by new sewer connection permits.
- A custom GIS tool-set is used to define sewer system collection system basins and the basin characteristics based on population estimates, land-use, and traffic analysis zone data.
- The GIS layers are used in combination or separately to estimate current and future wastewater flow for defined basins or the system contributing to a wastewater pump station, flow monitor area, or treatment plant.

- Dynamic and kinematic hydraulic models are constructed from the GIS generated data and analyzed for historical or design storm events.
- Model results are analyzed in the model package or through links to the WIMS infrastructure database for generation of a sewer capacity table for use in SCAS and for display and analysis of results. SFAS results are used for evaluation of new sewer connection applications and for management of the sewerage system.

22.1 System Complexity

The creation and integration of SFAS and SCAS had to be completed between July 1, 1995, and a deadline of December 31, 1995 set by Consent Decree between the City and County of Honolulu and the U.S. Environmental Protection Agency (EPA). CH2M HILL's team worked collaboratively with diverse groups at the DWWM in developing the SFAS and SCAS modules of WIMS. Time was spent in determining and refining a system that meets the needs of the City and County staff who are charged with management of the various Department programs. It was also important to become familiar with the needs of DWWM, the various business processes within the DWWM, and the WIMS system already in place. CH2M HILL is the third consultant working on WIMS and will be continuing development of the modules in cooperation with DWWM staff. The first two consultants set up the WIMS framework prototype modules for SFAS and SCAS and other WIMS modules.

The sewerage system contains over 1,300 miles (2000 km) of main sewers, 79 pump stations, eight treatment plants, and over 250 flow splits and other hydraulically challenging features. A large proportion of the sewer system is below sea level. Approximately 9,500 individual sewers, consisting of sewers 10 inch (254 mm) and larger, are analyzed in the flow routing model. About 500 individual inflow basins contributing flows are created using the GIS and database tools developed. The largest single hydraulic model constructed consisted of over 4,800 pipes. Figure 22.2 illustrates the complexity of the system, showing the Kailua-Kaneohe area of Oahu and the tool tracing sewers within the basin for later processing for flow estimation and export of sewer data for the hydraulic model.

Challenges met by the City/Consultant team included:

- Identification of data errors, and data gaps, and the correction of these data deficiencies. This represented approximately a correction of about 15% of the physical systems built and the completion of the representation of the entire sewer system connectivity for adequate construction of sewer basins for flow estimation.

Figure 22.2 Example of Sewer Traces and Model Creation.

- Generation and calibration of representative flow estimates from a large amount of flow data for a range of hydrologic conditions.
- Dynamic hydraulic modeling of a complex system with flow splits, backwater effects, and adverse sloped sewers.

22.2 Sewer Flow Analysis System (SFAS)

For most of this century civil engineers have used the same basic procedures for estimating wastewater and storm induced inflow and infiltration and linking the cumulative flows to hydraulic and flow routing models. Impacts from new developments and system retrofitting and repair are a common theme for evaluation by most communities. Before SFAS, the City estimated flows and calculated the capacity of its sewer lines using several manual methods, spreadsheets, and a static wastewater flow accumulation model. Not all of these methods provided consistent results, which caused uncertainty in estimating capital improvement projects. With SFAS, sewer system subbasins are created automatically from the sewer network maps in the WIMS and the subbasins are overlaid with population and other demographic data to estimate flow at any point in the wastewater system. The City uses the flow basins to determine realistic flow rates generated from a variety of sources, accounting for differences in the residential populations, number of hotel rooms, employment in the commercial areas, and major point discharges in each subbasin. Figure 22.3 shows a typical screen for the calculation of sewer flows.

Hydraulic modeling, using XP-SWMM, is linked to the GIS to route both wet and dry weather flow through the selected sewerage system. The SFAS module and hydraulic model will be used for planning new projects, evaluation of existing system hydraulics and capacity, and to enhance infiltration and inflow reduction analysis.

The creation of the model pipe data, flow files, and production of model results and transfer back to the GIS environment results in the production of numerous files. These files are managed and interpreted through the use of Microsoft Access database tables and queries and several custom-constructed programs, such as PSSCRAT which converts comma separated files to binary files suitable for reading by XP-SWMM.

Microsoft Access was used extensively to query data files, particularly in identifying inconsistent physical data such as pipe offsets or large slope changes. The databases were used to generate the physical data input files for XP-SWMM and the flow interface file. Figure 22.4 shows the Microsoft Access tables for manhole and conduit data and Figure 22.5 shows examples of the query to produce model input files.

Figure 22.3 Creation of sewer basins and flow estimates.

The screenshot shows a Microsoft Access database named 'MASTXP4'. The 'Table: MasterConduits' is displayed with the following data:

LINK	USNODE	ZP1	DSNODE	ZP2	LEN	DEEP	ROUGH	NKCLASS	Basin
000000	1		1					0.013	HN
1000737	27432710	-0.97	27500001		9999.99	2301.2	9999.99	0.013	1.KK
1001043	27510215	-8.61	27510797		-10.41	145.74	10	0.013	1.KK
1001046	27510797	-10.41	27510799		-19.49	11	18	0.013	1.KK
1001059	32590220	19.85	33550027		17.92	286.5	15	0.013	1.WM
1001066	33550134	0.19	33550719		-0.85	345	18	0.013	1.WM
1001083	32540011	20.86	32540273		17.42	200.34	12	0.013	1.WM
1001182	29530792	-2.4	29530815		-3.38	245	12	0.013	1.KK
1001394	30510162		18 30510161		16.6	116	12	0.013	1.KK
1001395	30510005		22 30510162		19	56	12	0.013	1.KK
1001411	29550007	-11.05	29550094		-12	47	10	0.013	1.KK
1001430	21290528	859.62	21290773		859.56	40	36	0.013	1.WH
1001432	21300142	894.9	21301655		893.61	170.68	10	0.013	1.WH
1001434	21301010	869.8	21301656		869.05	270	12	0.013	1.WH
1001436	21301336	868.1	21301657		866.75	173.46	18	0.013	1.WH

The 'Table: MasterNodes' is also displayed with the following data:

CONCEPT	NODE	ISAPID	GRELEV	Depth	Xcoord	Ycoord	Basin
100032	14230002	PK01AA0001	15.6	8.77	461076.25	149742.1875	PK
100033	14230003	PK01O00000	15.7	8.46	461034.625	149723.9688	PK
100080	14230050	PK01AA0003	17.6	10.01	461329.3125	149447.0313	PK
100109	14230079	PK01AA0004	22.05	10.65	461475.875	149312.2813	PK
100120	14230080	PK01AA0005	25.2	11.13	461596.125	149257.7344	PK
100122	14230092	PK01AA0006	23.65	11.53	461740.875	149247.7813	PK
1001489	14230124	PK01AA0002	16	9.15	461130.2468	149628.4919	PK
100501	14240136	PK01AA0007	25	13.88	461980.0625	149273.5	PK
102320	19300605	WW15-G0034	982	970.23	489949.5	126404.7031	WH
102381	19300666	WW15-G0033	981.1	968.81	489919.7813	126284.5	WH
102477	19300762	WW15-G0032	981	969.12	489957.5938	126070.8906	WH
102501	19300786	WW13-G0009	993.6	990.85	491355.25	126016.0781	WH

Figure 22.4 Example of manhole and conduit tables.

22.3 Sewer Connection Application System (SCAS)

In the SCAS system, applications for a new sewer permit (for example), are processed on line to facilitate locating the connection point to the sewer system and, depending upon the sewer basin, to facilitate the estimation of sewer flow generated from the new development.

SCAS will allow the City to process sewer connection application forms, store and track the sewer application data, and effectively manage the system by producing warnings whenever sewer capacity is reaching critical levels. The SCAS tool-set then checks for sufficient flow capacity in all downstream wastewater facilities (Figure 22.6), and issues sewer connection permits and payment receipts if sufficient downstream capacity is available. Figure 22.7 shows the interconnection between SFAS and SCAS.

The capacity status of every sewer reach and pumping plant is stored in a capacity allocation table. As new permits are approved, the SCAS allocation table is updated to reflect the erosion in available capacity. When capacity reaches pre-set limits, notification of these triggering flows is automatically issued and

Figure 22.5 Example of query to generate model input.

Figure 22.6 On-line sewer trace to check for capacity.

planning functions for correction of the capacity deficiencies can be started. Use of the capacity allocation table improves WIMS' response and eliminates the need to run the dynamic model for each sewer connection.

Wastewater flows from new connections are estimated by using a set of land use and equivalent population values calibrated from a detailed analysis of flow monitors located throughout the system. With SCAS, the City will effectively manage growth and better understand the cumulative effects of new connections on the sewerage system.

Figure 22.7 Relationships between SFAS and SCAS.

22.4 Conclusions

The sewer flow analysis and sewer connection application system modules provide the City's engineers with a standardized methodology to estimate flows and the capacity of their sewerage system, to make intelligent decisions about whether or not to approve a sewer connection permit, and to trigger facility plan updates.

These modules offer several advantages for wastewater management:

- the adoption of standard and proven civil engineering practices with modern computer information management systems to provide timely analyses and to allow consideration of system-wide impacts;
- rapid review of sewer connection applications that allows new connections when unused capacity is available, and identification of those parts of the system that prevent the acceptance of new flows when unused capacity is not available;
- better management of the collection system by using up-to-date flow monitoring data, and current land use and demographic data;
- more effective sewer infrastructure improvements by the consideration of system-wide impact and the use of consistent flow estimating and evaluation procedures; and
- optimization of sewer system operation by developing and testing alternative system operations procedures and scenarios.

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