Chapter 19

GIS Based Hydraulic Model Pictures the Interceptor Future

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This chapter assesses the hydraulic capacity of the Chartiers Creek Interceptor of the Allegheny County Sanitary Authority (ALCOSAN) to convey dry and wet weather flows under the existing and anticipated ultimate future development conditions. The assessment was performed by developing a hydraulic model of the interceptor system using U.S. EPA's computer program Storm Water Management Model (SWMM). The model consisted of 56 tributary sewer subareas, 75 sewer segments, 96 manholes, 34 orifices, and 34 weirs/outfalls. The input data for the model were extracted from a Geographic Information System (GIS) of the watershed. The watershed GIS consisted of data layers of digitized subareas, soil associations, and census tracts; present and future land use; and USGS Digital Elevation Models (DEMs).

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19.1 Introduction

Established in 1946, The Allegheny County Sanitary Authority (ALCOSAN) is by far the largest of all the sewerage systems in Allegheny County, Pennsylvania and serves more than half of the local municipalities, through a series of interceptor lines and a sewage treatment plant. The Chartiers Creek watershed, shown in Figure 19.1, is one of the largest watersheds in Allegheny County, enveloping all or portions of 23 municipalities, including the City of Pittsburgh, twelve boroughs and ten townships. More than 90% of the watershed is served by Chartiers Creek Interceptor. Of the 56 tributary areas shown in Figure 19.1, 22 have combined sewers. Most of the separate sewer tributary areas contribute wet weather inflow to the interceptor. The service area includes urban, suburban, and rural areas. The area is approximately 148 square miles of rolling hills, whose development ranges from very dense commercial, residential, and industrial areas; sparsely developed rural and agricultural areas; lightly to extensively strip mine disturbed areas; to varying size tracts of undeveloped forested areas. The elevation within the six 7.5 minute USGS quadrangles covering the area ranges from 690 to 1,500 feet above mean sea level.

The interceptor ranges in size from 24 inches to 45 inches. The ALCOSAN sewage treatment plant is located on the east bank of the Ohio River. The interceptor flow is conveyed to the treatment plant through a 54-inch underground tunnel that passes under the Ohio River. Most of the service areas tributary to the interceptor have diversion chambers. If operating correctly, a diversion chamber should permit all dry weather flows and a limited amount of wet weather flows to enter the interceptor.

The watershed is expected to undergo significant development in the future. Recently, a new interceptor serving several developing communities has been connected to the ALCOSAN interceptor, raising concerns about the interceptor's hydraulic capacity to convey the future flows. This paper addresses a case study (Shamsi, 1991) that assessed the hydraulic capacity of the Chartiers Creek Interceptor of ALCOSAN to convey the dry and

Chartiers Creek Interceptor Study
Existing Service Areas

Figure 19.1: Existing service areas.

wet weather flows under the existing and anticipated ultimate future development conditions.

19.2 Watershed Geographic Information System

This study developed and analyzed a GIS for the Chartiers Creek watershed in order to provide input to the watershed SWMM. The geographic data set that was created consisted of digital components that would allow preprocessing, analysis, and display using techniques commonly referred to as remote sensing and GIS analysis. An analysis of the terrain, hydrography, soil associations, land use, census properties, and locations of major trunk and interceptor sewers was conducted to develop the watershed GIS.

19.2.1 Technical Approach

The software used in this project was primarily ARC/INFO, a vector based GIS, and ERDAS, an image processing and raster based GIS. Additional programs were written whenever needed for data format changes or the creation of a product for which the methodology was not available in either of the commercial packages. This included the determination of percent slope averages, the creation of the percent impervious and developable/non-developable images, and the construction of tabular output.

The vector data format is a topologically constructed set of points, nodes, lines, and polygons which define locations, boundaries, and areas. A raster format is a regular grid of uniform size cells, with a data value associated with each cell. The reason for using both kinds of data processing and handling formats is to take advantage of the best features of each. Data entry of vector information is more easily performed using a file digitized into the vector format. All GIS layers except the elevation data were initially digitized in vector format from their

respective base maps utilizing ARC/INFO. The resulting polygon topology was then converted to raster format for GIS analysis.

Satellite, elevation imagery, and overlays for GIS cross-tabulation are appropriately dealt with in raster format wherein every cell of a given layer/image is registered to the corresponding cell of every other layer. The GIS analysis of the watershed and subareas was done in raster format utilizing ERDAS software. The SPOT image and the DEMs were initially in raster format. Each data set or information layer was co-registered to common coordinates, so that every raster grid cell matched its corresponding cell in other layers.

19.2.2 GIS Analysis and Results

Land use classes were derived from a manual interpretation of the SPOT image. Each land use class was assigned a percent impervious value. These value were based on the Soil Conservation Service (SCS) estimates for similar land use types. Certain open space land use types were assigned a zero percent impervious value. Table 19.1 summarizes the watershed land use classes and their percent impervious values.

19.2.3 Summary of Themes by Subarea

The final GIS analyses were performed on raster information layers with the following themes: subareas, percent slope, slope greater than 20 percent, slope less than or equal to 20 percent, land use, impervious area, soils, and census tracts. The area of each subarea was the basic theme against which the various other themes were summarized. The ERDAS "Summary" function, as well as an in-house written function called "Sumave," were utilized.

Table 19.1: Watershed land use and percent imperviousness.

Land Use	% impervious	% of study area
High Density Residential	52	2.5
Medium Density Residential	28	21.5
Low Density Residential	16	4.2
Commercial	85	0.6
Industrial	72	2.9
Open Wooded	0	33.2
Urban Disturbed	0	0.9
Rural Disturbed	0	6.8
Strip Mine, Quarry, Oil Well	0	5.2
Open Space	0	3.0
Open, Non-wooded	10	18.1
Major Roadway	100	1.1

The following tables were produced:

- 19.1. A subarea table showing area in acres, percent slope and mean percent imperviousness of each subarea. These values were used in SWMM to compute subarea wet weather flows.
- 19.2. A soil association table showing percent of various soil associations in each subarea prepared by digitizing SCS soil association maps. This table was used to determine subarea infiltration parameters for stormwater runoff modelling.
- 19.3. A census tracts table showing percent of various census tracts in each subarea prepared by digitizing U.S. Census Bureau census tract maps. Census tract data for population, number of dwellings, number of persons per dwelling, market value of housing units, and family income were obtained from the 1980 census data. Subarea percentage of census tracts and census tract percentages in

subareas were applied to total tract values to estimate weighted mean subarea values. Mean subarea values computed in this manner were used in the watershed SWMM to estimate subarea dry weather flows.

The following color, raster, ARC/INFO maps were produced:

1. Existing service areas (Figure 19.1)
2. Present land use (Figure 19.2)
3. Census Tracts (Figure 19.3)
4. Soil Associations (Figure 19.4)
5. Future land use (Figure 19.5)

19.2.4 Determination of Future Developable Land

The present land use map (Figure 19.2) shows that substantial watershed area is still undeveloped, especially to the west of Chartiers Creek. In order to model ultimate future development in the watershed, six additional subareas were outlined as shown in Figure 19.5. These subareas were based on topography roughly following the natural surface water drainage basins on undeveloped land. By overlaying the vector land use layer and the vector "greater than/less than or equal to 20 percent slope" layer, a map coverage resulted showing existing developed areas, and future developable and non-developable areas. Based on the criterion that future development can occur only on 20 percent or less slopes of non-developed and non-strip mined areas, the nonqualifying classes were eliminated resulting in a vector layer of future developable land shown in Figure 19.5.

The six future subareas were superimposed on the Watershed GIS future land use map to compute for each future subarea the area with slopes steeper than 20 percent and strip mines. This area and area already developed was subtracted from the total future area to compute future developable area in each future subarea. Future subareas outlined in this manner, therefore, are based on the assumption that each and every developable parcel

of land will be ultimately developed. Table 19.2 shows how the developable land area of future subareas was calculated.

Table 19.2: Future subareas.

Sub Area ID	Area (Acres)	Area w/ steep slopes & strip mines (Acres)	Area already developed (Acres)	Developed Area (Acres)
600	1,415.6	613.4	444.8	357.4
610	19,775.4	3,632.5	2,254.8	13,888.1
620	1,240.4	87.0	73.4	1,080.0
630	2,399.3	539.6	46.3	1,813.4
640	7,245.0	1,698.1	1,037.5	4,509.5
650	3,920.6	511.7	1,663.7	1,745.2

19.3 Hydraulic Model of the Interceptor

The U.S. EPA's SWMM (Huber and Dickinson, 1991) was developed in the early 1970's and has been continually maintained and updated. It is perhaps the best known and most widely used of the available urban runoff quantity/quality models. SWMM simulates dry weather sewage production and wet weather flows on the basis of land use, demographic conditions, the hydrologic conditions in the watershed, meteorological inputs and conveyance/treatment characterizations. Based upon this information, SWMM can be used to predict combined sewage flow quantity and quality values. SWMM also provides the ability to perform detailed analyses of conveyance system performance under a wide range of flow conditions. As such, it is well suited to this study and is the model of choice for use in most combined sewer overflow feasibility studies.

The use of SWMM to model the Chartiers Creek watershed to assess the available capacity of the Chartiers Creek interceptor will be particularly advantageous for the following reasons:

1. SWMM represents the best means of producing estimates of current dry and wet weather flow rates from a service

Chartiers Creek Interceptor Study
Present Land Use

Derived by Manual Interpretation of Spot Image 8/15/87

Figure 19.2: Present land use.

Chartiers Creek Interceptor Study
Census Tracts

Census Tracts
County Boundary
Subcatchments
Interceptor
Watershed Boundary

Figure 19.3: Census tracts.

Chartiers Creek Interceptor Study
Soil Associations

Figure 19.4: Soil associations.

Chartiers Creek Interceptor Study Potential Development

Developable Lands

Present Land Use and Slope < 20%

- Open-Wooded
- Urban Disturbed
- Rural Disturbed
- Open Non-Wooded
- Woodland
- Agricultural Activity

Non-Developable Lands

- Presently Developed,
Strip Mines, or
Slopes > 20%

Figure 19.5: Future land use.

area as large and diverse as the Chartiers Creek watershed. Flow estimates can be prepared based upon current land use conditions, topography, interceptor sewer characteristics, and selected meteorological conditions. The model can be calibrated against measured flow rates.

2. SWMM represents the best means of modelling the performance of the interceptor conveyance system under a range of dynamic flow conditions.
3. The use of SWMM provides a ready means of accounting for anticipated future development characteristics in an assessment of available capacity.
4. Using SWMM, it will be possible to assess capacity in response to wet weather input. This characteristic can be very useful for subsequent analyses related to abatement of combined sewer overflows (CSOs).
5. The watershed SWMM developed under this study can be expanded to model water quality and assess the effectiveness of a range of CSO abatement or treatment options.
6. Future CSO and system monitoring data expected to be collected in compliance with the Pennsylvania Department of Environmental Resources' CSO strategy can be used to improve calibration of the model.

19.3.1 Modelling Strategy

SWMM is flexible enough to allow different modelling approaches to the same area. An approach which adequately describes the service area and accurately computes and routes the flows at reasonable computing time and effort should be adopted.

After a review of the data, maps, and literature available to complete this study the following modelling strategy was adopted:

1. Run SWMM's Transport Block to generate sanitary flows (dry weather flows) in all the subareas.
2. Use Transport block to model flow division (an approximate way to separate dry weather flows from combined flows) from the areas where detailed modelling of diversion chambers in the Extran Block is not feasible.
3. Enter the entire amount of sanitary sewage flow to the diversion chambers.
4. Run SWMM's Runoff Block to generate stormwater runoff (wet weather flow) in all the subareas.
5. For combined sewer subareas, enter the entire amount of runoff to the diversion chambers. For separate sewer subareas, enter only a fraction of total runoff to the diversion chambers to account for uncontrolled infiltration and inflows (I/I flows). This fraction will be determined by comparing the modeled and measured flows from separate subareas.
6. Import wet weather flows from Runoff Block into the Transport Block and combine them with the dry weather flows. Enter the combined flows to diversion chambers.
7. Use SWMM's Extran Block to regulate the dry weather flows entering the interceptor and route them through the interceptor.
8. Study interceptor response (capacity, surcharging, manhole flooding, etc.) from the Extran output.

19.3.2 SWMM Schematic Diagram

It is highly recommended that a sewer system schematic diagram be prepared prior to model building. A schematic diagram is developed by discretization, a procedure for the mathematical abstraction of the physical drainage system. For the computation of hydrographs, the drainage basin may be conceptually represented by a network of hydraulic elements, i.e. subareas, sewers, manholes, and diversion chambers. Hydraulic properties of each element are then characterized by various parameters, such as size, slope, and roughness coefficient. The schematic diagram for the study watershed is shown in Figure 19.6.

19.4 Precipitation and Flow Monitoring

Site selection for monitoring rainfall and flow was made in conjunction with the general arrangement of the watershed, delineated subareas, and the interceptor sewer system in order to maximize the extent and value of the data collected for use in calibration of watershed SWMM. Flow monitoring is necessary for several reasons. One reason is that hydraulic characteristics of the collection system may need to be confirmed or corrected. Another reason is that the flow monitoring provides necessary calibration and verification data to develop a mathematical model of the interceptor. Rainfall duration and intensity is so variable that parts of the collection system may be dry while others are deluged. Knowing that rain occurred only in a part of the collection system can have major implications on the hydraulic loading of the interceptor. Rainfall data coupled with flow monitoring data close the loop and establish cause and effect.

The determination of feasible locations for installing raingauges was based upon a combination of factors such as watershed topography, shape of the watershed, and availability of space. The objective was to distribute the raingauges in such a manner that most of the watershed storms can be captured. This objective requires that each raingauge cover approximately an

equal watershed area without leaving any watershed area uncovered. Since the eastern half of the watershed accounts for most of the service area, three raingauges were uniformly distributed in this part. The western half of the watershed was covered by one gage because it covers a relatively small service area. These locations are shown in Figure 19.1. Measurements were taken for four months.

The determination of feasible locations for installing flow monitors was based upon a combination of factors such as type of flow (separate or combined), location with respect to the interceptor, and access. It was decided to install three flow monitors to sample a typical combined sewer service area, a typical separate sewer service area, and the interceptor. The flow monitoring locations are shown in Figure 19.1. Flow monitoring was also conducted for four months.

19.5 Model Calibration

Model calibration consists of adjusting model parameters (for example, imperviousness, or roughness) until the predicted output agrees with measured observations. For example, the modeled hydrograph may be adjusted to agree with the measured hydrograph. Parameter estimates should fall within reasonable ranges of known values in order to enhance confidence in model results. This is easier for physically measurable parameters such as area, elevation and slope and harder for more abstract parameters such as imperviousness, depression storage, and roughness. As a result, the former are often fixed during the calibration and the latter are varied. It is often necessary to account for an unmodelled effect by varying a parameter beyond its normal range. In general, rainfall/runoff parameters and dry weather flow base infiltration rate estimating coefficients are adjusted to calibrate model output against measured conditions.

SWMM calibration was performed by comparing model outputs from Runoff, Transport, and Extran blocks to measured flow rates. All the three SWMM blocks Runoff, Transport, and

Figure 19.6: SWMM schematic diagram.

Extran were calibrated separately. Runoff and Transport block input parameters were calibrated against measured wet and dry weather subarea flows, respectively. Extran block input parameters were calibrated against measured interceptor flows both under dry and wet weather flow conditions. Only the Extran block calibration is described here.

Extran block is based on physical properties of the interceptor conveyance system including sewers, manholes, and diversion chambers. Accurate information about the length, slope, and size of the sewers was obtained from the construction drawings. However, Manning's roughness coefficient for the sewers cannot be determined with full certainty and may be adjusted during the calibration process. The diversion chambers' geometry was determined from the construction or as-built drawings. However, SWMM's capability to model flow division in a diversion chamber is based on simplifying assumptions. For example, diversion chambers are treated as storage elements where water level rises or drops depending on the size of orifice opening for dry weather flow to the interceptor or the width and height of the overflow weir for combined sewer overflows. Conveyance within a chamber due to sloped bottom troughs is not accounted for. A diversion chamber is assumed to have a flat bottom with uniform cross section throughout its depth. Last but not least, partial openings due to orifice plates cannot be modeled. Thus, discrepancies between modeled and observed interceptor flows are likely. These discrepancies can be reduced by adjusting the parameters controlling the dynamics of flow in diversion chambers such as orifice coefficients, weir coefficients, and cross sectional area of the chambers.

19.5.1 Dry Weather Flow Calibration

Figure 19.7 shows the interceptor calibration for dry weather flows. The modeled interceptor dry weather flows were compared against the measured mean flows of May 28 and June 25 flows. The flow averaging was performed to account for two

typical types of interceptor dry weather flows. The first type of dry weather flows (June 25) are found during prolonged dry weather periods and peak at about 24 cfs. The second type of dry weather flows (May 28) are found after substantial rainfall events and peak at about 28 cfs. The latter type of flows include effect of wet weather infiltration on dry weather flows.

It can be seen from the plots in Figure 19.7 that modeled dry weather flows match the observed flows quite satisfactorily. The difference between the modeled and observed average daily flow and volume is less than two percent, which indicates a satisfactory calibration of the SWMM for dry weather interceptor flows. This degree of calibration was attained by the following SWMM parameter values:

- Manning's "n" = 0.013
- Diversion chamber orifice coefficient = 0.65
- Diversion chamber weir coefficient = 3.00
- Manhole/diversion chamber area = 50 ft²

19.5.2 Wet Weather Flow Calibration

The interceptor tributary subarea flows are regulated in the diversion chambers. The diversion chambers allow a limited quantity of flow to enter the interceptor and divert any flows in excess of this amount to the receiving waters. If properly designed and maintained, this limited quantity is approximately 3.5 times the average dry weather flow rate. Improper design and lack of maintenance may cause the diversion chambers to allow more or less wet weather flows to enter the interceptor than set by this standard. Furthermore, some separate sewer tributary subareas have no diversion chambers and are referred to as having direct connections with the interceptor. These subareas are not always 100 % water-tight and some quantities of wet weather flow are able to infiltrate into the interceptor. Thus, interceptor flows increase during the storm events and corresponding interceptor flows are called wet weather flows. In conclusion, the

TIME (HOURS)	OBSERVED FLOW			MODELED FLOW (CFS)
	June 25, 91	May 28, 91	MEAN	
	(CFS)	(CFS)	(CFS)	
0	21.05	25.63	23.34	22.30
1	20.60	25.63	23.12	21.96
2	19.09	24.46	21.78	21.00
3	18.25	22.85	20.55	19.41
4	15.85	21.49	18.67	17.51
5	14.39	21.05	17.72	15.91
6	13.21	18.88	16.05	15.80
7	13.05	18.25	15.65	16.81
8	13.70	17.83	15.77	18.55
9	16.82	18.88	17.85	21.77
10	18.88	22.85	20.87	27.07
11	21.27	25.63	23.45	29.10
12	23.08	27.75	25.42	27.36
13	23.77	27.98	25.88	25.77
14	23.31	27.98	25.65	25.09
15	23.08	27.51	25.30	24.13
16	21.49	26.80	24.15	23.04
17	20.83	25.63	23.23	22.58
18	20.60	25.16	22.88	22.59
19	20.60	24.46	22.53	22.57
20	20.60	24.46	22.53	22.20
21	20.38	24.93	22.66	22.50
22	20.60	24.93	22.77	22.90
23	20.60	25.63	23.12	23.03
TOTAL	465	577	521	531
VOLUME	1,674,360	2,075,940	1,875,150	1,911,420
MEAN	19.38	24.03	21.70	22.12
% DIFFERENCE IN VOLUME				1.93
% DIFFERENCE IN MEAN FLOW				1.93

Figure 19.7: Dry weather flow calibration.

interceptor wet weather flows include only that portion of the total subarea wet weather flow that is allowed by the diversion chamber to enter the interceptor, and any wet weather contribution of direct connection separate sewer subareas.

Figure 19.8 shows the interceptor calibration for wet weather flows. The modeled interceptor wet weather flows were compared against the measured flows of June 11, 1991. It can be seen from the plots in Figure 19.8 that modeled wet weather flows match the observed flows satisfactorily. The difference between the modeled and observed peak flow and volume is 5.5% and 7.7% respectively, which indicates a satisfactory calibration. This degree of calibration did not require any further adjustment of the model parameters established under dry weather flow calibration.

19.6 Interceptor Capacity Analysis

The following five type of flows were considered under present and anticipated future development conditions:

- Dry weather flows,
- 2-year, 1-hour wet weather flows,
- 25-year, 1-hour wet weather flows,
- 2-year, 24-hour wet weather flows, and
- 25-year, 24-hour wet weather flows.

The capacity analysis was performed by comparing the maximum simulated flows in various sewer segments of the interceptor to their full flow capacities. The full flow capacity is defined as the maximum flow that can be conveyed by a sewer without surcharging, and it is estimated from sewer size, slope, and roughness. If a sewer is surcharged, the flow becomes pressurized and the sewer can convey more flow than its full flow capacity with or without manhole overflows and street flooding. Surcharged sewers causing manhole overflows and street flooding are unacceptable.

TIME (HOURS)	RAINFALL (INCHES)	OBSERVED		MODELED	
		FLOW (CFS)	VOLUME (CF)	FLOW (CFS)	VOLUME (CF)
19	0.00	22.17	39,906	24.32	43,776
20	0.75	22.17	79,812	24.06	87,084
21	0.10	32.65	98,676	32.77	102,294
22	0.25	45.44	140,562	44.15	138,456
23	0.00	46.78	165,996	49.36	168,318
0	0.00	46.41	167,742	49.17	177,354
1	0.15	45.44	165,330	48.85	176,436
2	0.05	41.00	155,592	48.17	174,636
3	0.00	43.48	152,064	48.64	174,258
4	0.20	44.85	158,994	48.60	175,032
5		44.85	161,460	48.49	174,762
6		45.96	163,458	48.06	173,790
7		44.20	162,288	40.19	158,850
8		43.48	157,824	38.15	141,012
9		43.48	156,528	36.79	134,892
10		42.71	155,142	32.71	125,100
11		42.71	153,756	30.92	114,534
12		41.88	152,262	27.27	104,742
13		41.00	149,184	24.69	93,528
14		34.91	136,638	23.49	86,724
15		31.50	119,538	22.88	83,466
16		29.16	109,188	22.59	81,846
17		27.98	102,852	22.40	80,982
18		27.98	100,728	22.40	80,640
SUM	1.50		3,305,520		3,052,512
% DIFFERENCE IN VOLUME					-7.7
% DIFFERENCE IN PEAK FLOW					5.5

Figure 19.8: Wet weather flow calibration.

19.6.1 Present Conditions

The present flows were simulated by running the calibrated SWMM with the existing tributary subarea characteristics. Figure 19.9 shows a plot of maximum dry weather flows versus interceptor capacity for all the interceptor segments modeled in SWMM. The maximum sewer flows reported here represent the peak flows simulated by the watershed SWMM. Figure 19.9 shows that the peak interceptor dry weather flow from the entire watershed is 35.7 cfs. Since the peak flows are less than the full flow capacity in all the interceptor segments, it is demonstrated that the interceptor has adequate capacity to transport the present day dry weather flows from the watershed.

Figures 19.9 also shows plots of maximum wet weather flows under the 2-year/1-hour, 25-year/1-hour, 2-year/24-hour, and 25-year/24-hour storm conditions. The peak interceptor wet weather flows for the four design storms are 54.5, 62.7, 59.8, and 63.3 cfs, respectively. Peak wet weather flows are greater, under certain flow conditions, than the full flow capacity in the first three interceptor segments located at the watershed outlet. Table 19.3 summarizes the interceptor capacity deficits with respect to types of wet weather flows.

Table 19.3: Interceptor capacity deficits under present wet weather flows.

Design Flow	Deficient Interceptor Segments	Capacity Deficit (cfs)
2-year/1-hour	30	3.9
25-year/1-hour	20	4.0
	30	9.2
2-year/24-hour	20	1.1
	30	6.0
25-year/24-hour	20	4.6
	30	9.1
	50	0.1

Figure 19.9: Interceptor flows under present conditions.

The previous table shows that flows resulting from the short duration (1 hour) storms are as critical as the long duration (24 hours) storms since both types of design flows cause approximately the same amounts of capacity deficits and the same maximum wet weather flows. This phenomenon can be explained by the fact that high rainfall intensity associated with the short duration storms is known to cause more severe flooding conditions. It can be seen that, under all four types of wet weather flows, sewer 30 will have the maximum capacity deficit of 9.2 cfs. Sewers 20 and 50 will have capacity deficits of 4.6 cfs and 0.1 cfs, respectively. Although interceptor capacity deficits due to surcharge interceptor segments did occur as described above, no manhole overflows (street flooding) were noted in the SWMM output. Thus, it can be concluded that the four types of wet weather flows surcharged the interceptor near the watershed outlet, but these flows were not large enough to cause manhole overflows. In other words, while the full pipe capacity of the interceptor for the above sewers is exceeded, surcharging is not severe enough to produce overflows.

19.6.2 Future Conditions

The future flows were produced by loading the calibrated SWMM with subarea data descriptive of anticipated future land development conditions in the six future subareas (600, 610, 620, 630, 640, and 650). Figure 19.10 shows a plot of future maximum dry weather flows versus interceptor capacity. It can be seen that the peak interceptor dry weather flow is 45.5 cfs, which is 27.5 percent greater than the present day dry weather flows. The peak flows are less than the full flow capacity in all the sewers except sewer 220. The capacity deficit based on full pipe flow for this sewer is 3.7 cfs. However, the model indicates that while the full pipe capacity in this segment is exceeded, no manhole overflows would be produced. Thus, despite a capacity

Figure 19.10: Interceptor flows under future conditions.

deficit, the surcharge head of the interceptor will enable sewer 220 to convey future dry weather flows. It is therefore concluded that the interceptor is adequate to handle future dry weather flows from the potential future service areas with the possibility of dry weather surcharging, provided that no major industrial development will take place and commercial and institutional growth will continue at the existing rate.

Figures 19.10 also shows plots of maximum future wet weather flows. The peak wet weather flows for the four design storms are 66.0, 70.6, 68.0, and 68.6 cfs, respectively. Peak wet weather flows are projected to be greater than the full flow capacity of the interceptor in all but a few interceptor segments where capacity was quite high already as indicated by the spikes on the capacity curve. A total of twelve modeled interceptor manholes overflowed during the course of future wet weather flows associated with 25-year/1-hour rainfall events. Since the other three types of wet weather flows also demonstrate a similar pattern, it can be concluded that the interceptor does not have sufficient capacity to convey the future wet weather flows.

19.7 Conclusions

The study concludes that under the existing development conditions the interceptor is adequate to convey the dry weather flows, but will result in a slight surcharge during wet weather conditions.

Under the ultimate future development conditions, the interceptor is expected to convey the dry weather flows with slight surcharging, and wet weather flows with moderate to severe interceptor surcharging, manhole overflows, and street flooding.

19.8 References

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