Detroit Water and Sewerage Department

Wastewater Master Plan

DWSD Project No. CS-1314

Diurnal Flow Analysis of Wastewater Treatment Plant Influent

Technical Memorandum
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Diurnal Flow Analysis of Wastewater Treatment Plant Influent

1. Introduction

Hourly flow data at the Wastewater Treatment Plant (WWTP) have been reviewed to determine the peak hourly flow that might be expected at the plant during dry flow days. Previous reviews of the flow data at the WWTP have indicated that the plant's capacity will be adequate to handle the average daily dry flow and the peak month dry flow; however, the flow varies continuously throughout any one day. This memo summarizes the analysis of hourly flow to determine the peak hourly dry flow that might be expected at the plant under current conditions and for projected future flows.

2. Existing Flow Data Analysis

Hourly flow data with dry days defined were available for the time period of 11/1/97 through 7/31/02. Dry flow days were determined using criteria as established for the GDRSS Metering and Flow Balance program (CS-1249). The data reviewed consist of hourly data provided by DWSD to the CS-1249 project team. The data include total pumping at Pump Station 1 and at Pump Station 2. An estimate of the amount of recycle was also provided.

The data were first grouped to determine an average daily (diurnal) variation in flow at the plant by month. Review of this data indicates that the highest flow months are February through May. The chart in Figure 1 presents the diurnal curves for these months for the five years of records reviewed. Each curve represents the average flow by hour for all the selected dry days for a given month. As shown in the chart, the flows can vary by more than 200 MGD during the course of the day, depending on the month reviewed. One can also observe that the low flow occurs around early to mid-afternoon.

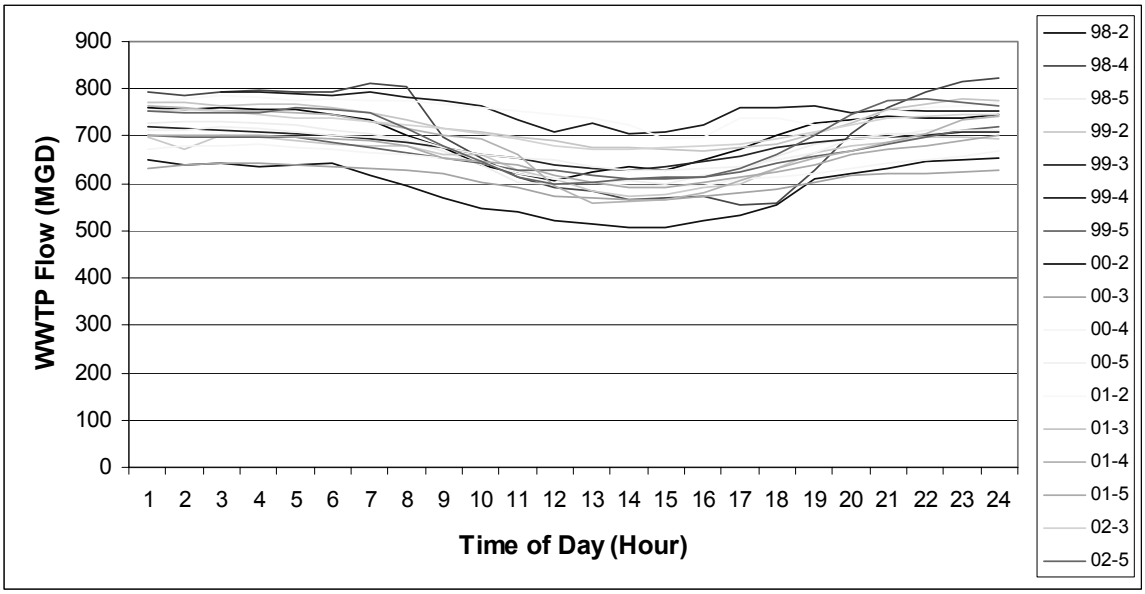

Figure 1. Average DWF Diurnal by Month (total pumped, for months of February through May for years 1998 through 2002)

To review the variation for individual days, the top 20 dry days based on maximum hour flow for the day are presented in Figure 2.

The day with the highest maximum hourly flow is June 29, 2000, with a maximum flow of 1036 MGD. This rate would exceed the secondary capacity at the plant, which is projected to be 930 MGD (with recycle). The flows for this day appear to be a bit of an anomaly, though, as it also has the lowest hourly flow as well. The variance in flow is likely due to an operation of some control within the system or at the plant that held flows back in the system for several hours.

The next highest maximum flow day is June 9, 2001, with a maximum flow of 902 MGD, which would not exceed the projected secondary capacity of 930 MGD. The rest of the days' maximum flows are at or below 860 MGD.

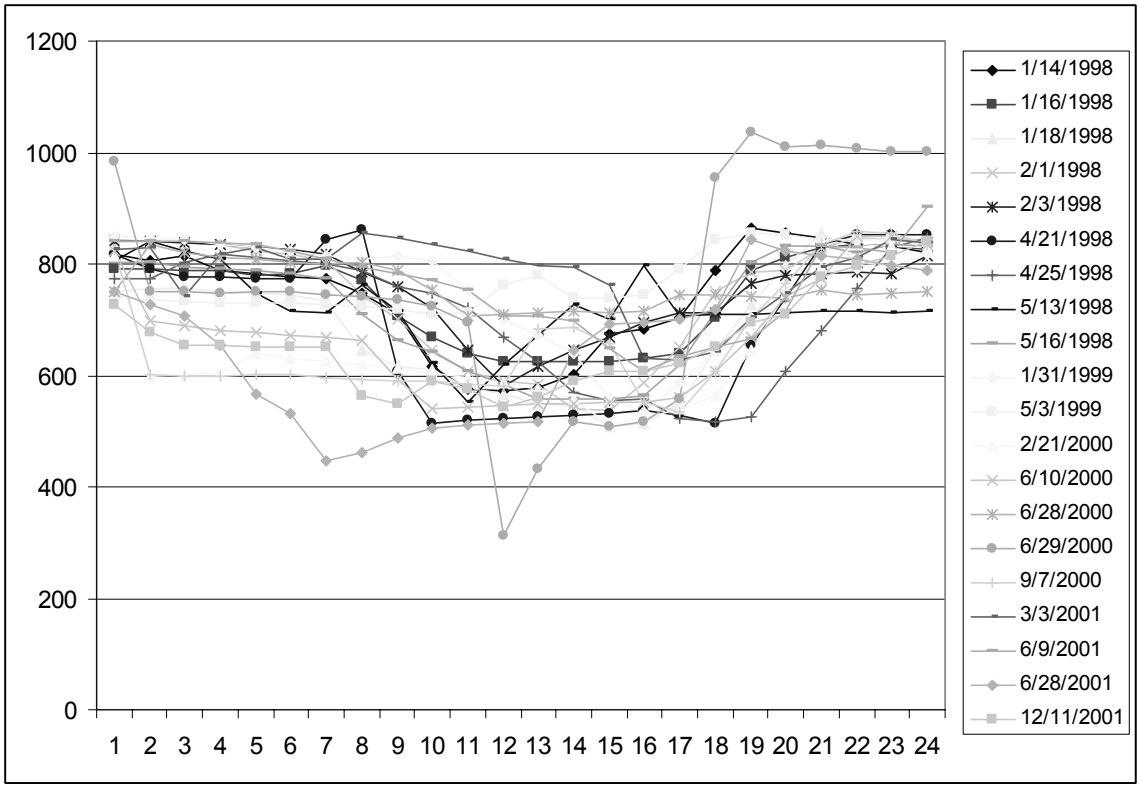

Figure 2. DWF Diurnal for Top 20 Days by Maximum Hour Flow (Total Pumped)

3. Average Peaking Factor

To investigate the variability in the diurnal flows, a peaking factor representing the maximum hour flow divided by the average flow for each dry day in the period of record was calculated. In this case, the plant flows without the recycled flows were used. DWSD provided recycle flow data based on direct meter measurements. These recycle flows were subtracted from hourly total pumped flows for peaking factor calculations.

The resulting factors were plotted versus the average daily flow to discern whether the peaking factor varies with the amount of the average daily flow. The results are presented in Figure 3. As can be seen, the peaking factor tends to be smaller as the average flow for a day increases. A correlation was made so that a peaking factor for any average flow can be calculated.

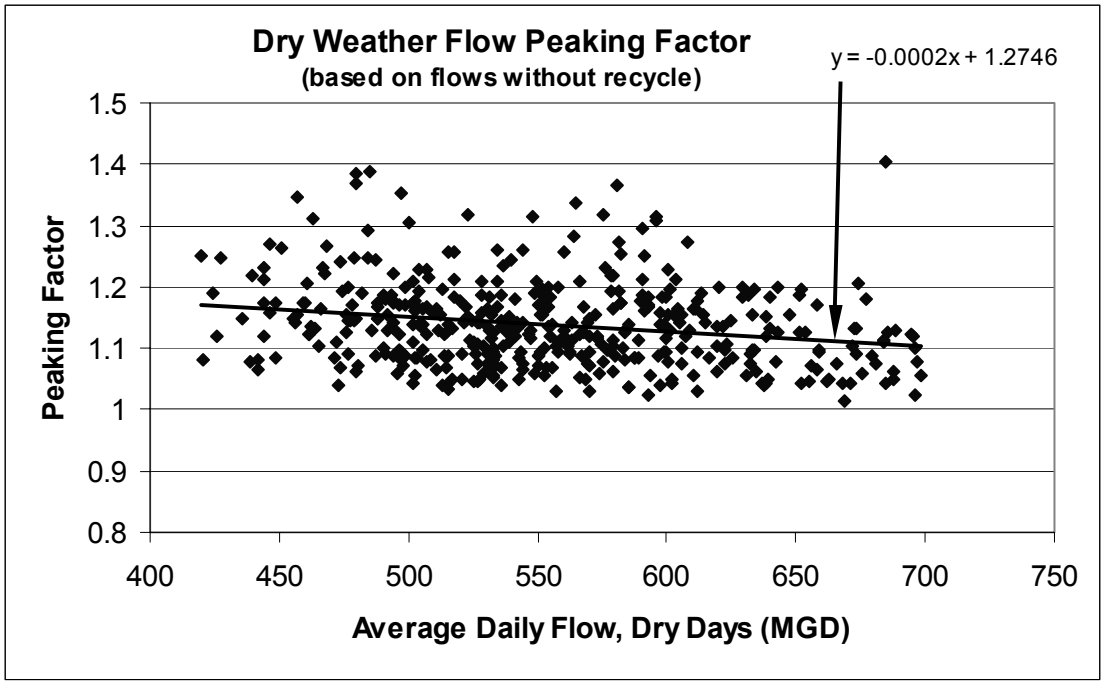

Figure 3. Dry Weather Flow Peaking Factor (based on flows without recycle, calculated as Max. Hour Flow / Avg. Daily Flow)

4. Projected Future Flow

Projected future flows were developed as part of the WWMP flow needs assessment. The development of these flow projections is described in the technical memorandum Flow Needs for DWSD Customers through 2050. A summary of the results is provided in Table 1. Flow projections were made from a 4-year average record (1998 through 2001) and from the year 2001 data, which was the highest flow year of the four years. The average daily dry flow for the 4-year record versus the year 2001 is 549 MGD versus 605 MGD. The projected annual average daily flows for the year 2050 are 580 and 635 for the 4-year and the year 2001 projections, respectively. The projected peak month dry weather flows are 631 MGD and 714 MGD, respectively.

These rates include flows from the Western Township Utility Authority (WTUA). Flows from this area potentially may be diverted in the future, which would reduce these projected rates

Table 1. Projection of Areas, Populations, and Waste Flows within DWSD Service Area

Item	Decade					
	2000	2010	2020	2030	2040	2050
Sewered Area (acres)	505,230	534,356	543,006	551,656	556,694	561,731
Residents	3,018,021	3,054,234	3,088,911	3,123,588	3,180,574	3,237,560
Employees	1,716,599	1,812,809	1,851,587	1,890,364	1,909,624	1,928,885
SIU Employees	185,186	185,186	185,186	185,186	185,186	185,186
SIU Flows (MGD)	44.85	44.85	44.85	44.85	44.85	44.85
Equivalent Population*	4,594,959	4,693,646	4,753,503	4,813,360	4,882,853	4,952,346
Sanitary Flow [=77gpd*eq.pop] (MGD)	354	361	366	371	376	381
Projected from 4-Yr Avg. (1998-2001)						
Dry Weather I/I (MGD)	195	197	197	198	198	198
Average Dry Weather Flow (MGD)	549	558	563	568	574	580
Average Flow (MGD)	669	679	684	690	695	701
Peak Month Dry Weather Flow (MGD)	599	609	614	619	625	631
Peak Month Flow (MGD)	720	730	736	741	747	752
Projected from Year 2001 Meter Data						
Dry Weather I/I (MGD)	251	252	253	253	253	254
Average Dry Weather Flow (MGD)	605	614	619	624	629	635
Average Flow (MGD)	724	734	739	744	750	756
Peak Month Dry Weather Flow (MGD)	683	692	698	703	708	714
Peak Month Flow (MGD)	885	896	901	906	912	918

*Eqv. Pop.= Residents+[Emp.-SIU Emp] * 50/77+SIU Flow/77

To determine the peak hour flow rate for these projected flows, the correlation from Figure 3 was used to calculate peaking factors for these flows. The calculated peaking factors and resulting peak hour flows for average day and peak month are provided in Table 2 for the year 2001 projection only. The resulting peak hour flows in the year 2050 are 729 and 808 MGD, respectively.

This peak hour flow rate is without recycle flows. At the projected rate of 808 MGD, the plant could handle an additional flow of up to 122 MGD before the secondary treatment capacity of 930 MGD would be reached.

Table 2. Peak Hour Flows as Projected from Year 2001 Data

	Decade					
Item	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Average Dry Day						
Average Dry Weather Flow (MGD)	605	614	619	624	629	635
Peaking Factor*	1.154	1.152	1.151	1.150	1.149	1.148
Peak Hour Dry Flow (MGD)**	697	707	712	717	723	729
Peak Month Dry Day						
Peak Month Dry Weather Flow (MGD)	683	692	698	703	708	714
Peaking Factor*	1.138	1.136	1.135	1.134	1.133	1.132
Peak Hour Dry Flow (MGD)**	777	786	792	797	802	808

*Peaking Factor from correlation shown in Figure 3

*Peaking Factor times dry weather flow (average or peak month)

5. Extreme Flow Review

A frequency distribution of peak hour flow was also generated to look at the potential for exceeding the secondary capacity at the plant on a percent basis. This chart is shown in Figure 4 for all dry days of the data analyzed. Other than the outlier discussed earlier, 100% of the peak hour flows are less than 812 MGD.

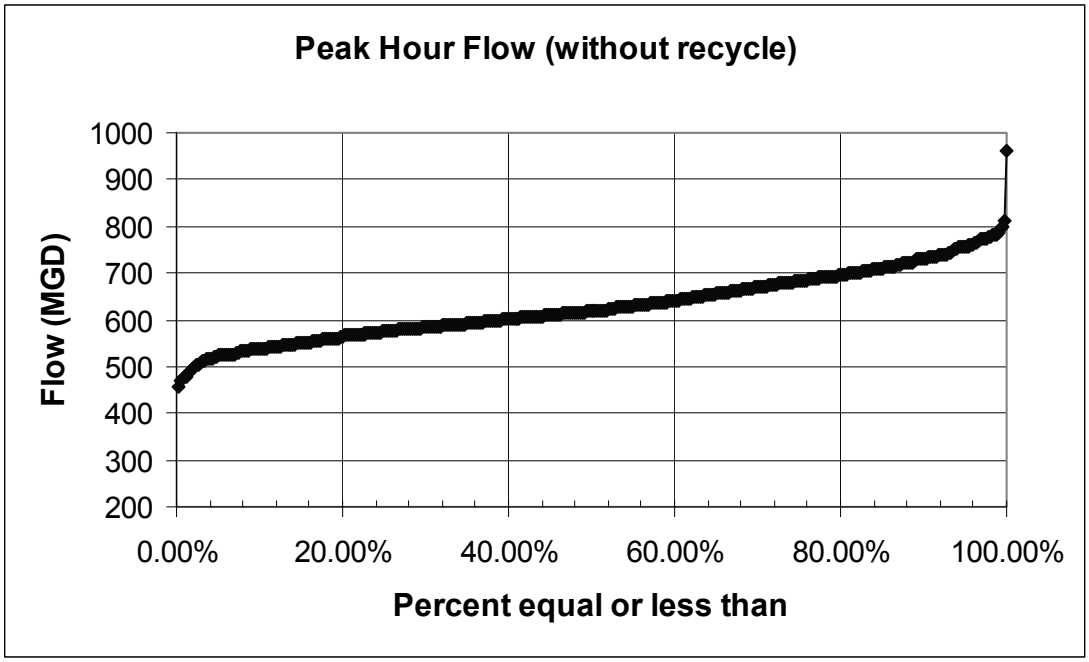

Figure 4. Cumulative Distribution of Peak Hour Flow by Day to WWTP

6. Impact of Recycle Flows

Recycle flows for the period of record reviewed varied from 27 to 115 MGD, as shown in Figure 5. More recently, the estimates of recycle flows have been improved as the recycled flow rates are now being measured using a meter that has been tested (calibrated). The recent data show recycled flows varying within the range of 50 to 70 MGD. At this range, the projected future peak hour flow with recycle would be 858 to 878 MGD. Even with the maximum recycle recorded of 115 MGD, the resulting peak flow of 923 MGD would not exceed the secondary capacity of 930 MGD.

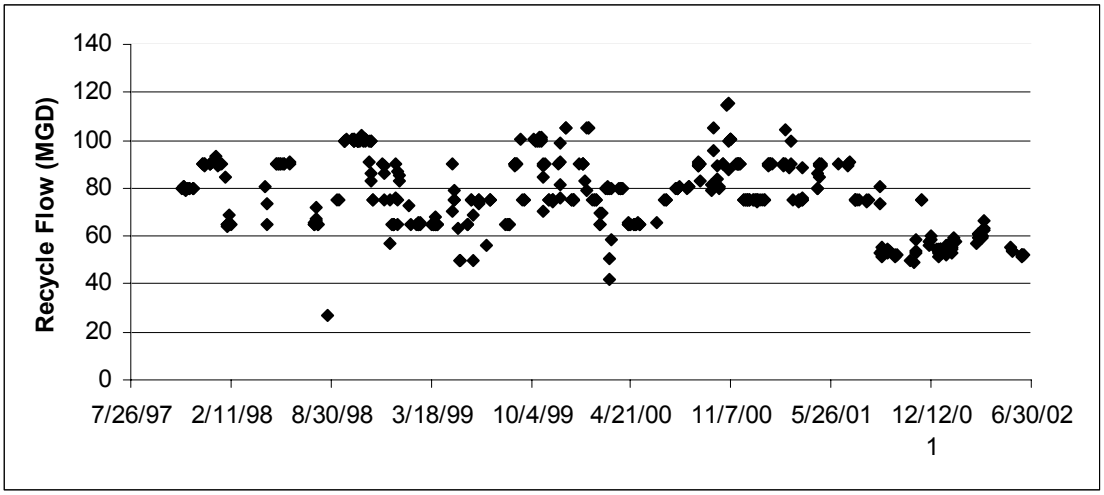

Figure 5. Recycle Flows at WWTP (dry days only shown)

7. Summary

The variation in dry flow at the WWTP has been investigated to determine if the daily peak hour dry flow will exceed the projected secondary capacity of 930 MGD at the plant. Out of five years of data, only one day classified as a dry day exceeded this limit. The diurnal flow for this one day is thought to be an anomaly as it also had several hours of very low flows, suggesting that some operational control held flows back in the system for a period of time, resulting in higher than normal flows after being released.

Projected future flows were also reviewed to determine if the plant's capacity might be exceeded by the year 2050 (the planning horizon of the Master Plan). Based on the analysis, the peak hour dry flow will be 808 MGD (including recycle). This rate will not exceed the 930 MGD secondary capacity of the plant provided that the recycled flows continue to be controlled to the rates currently seen at the plant.