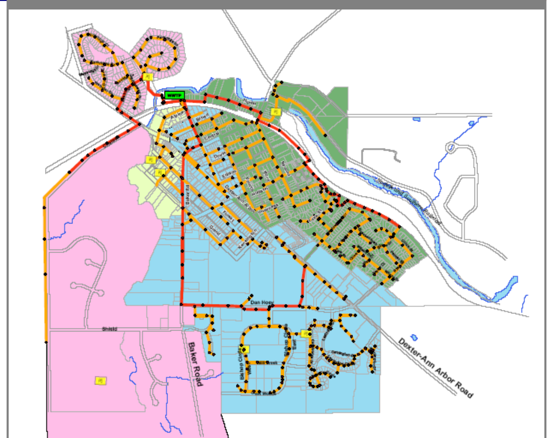
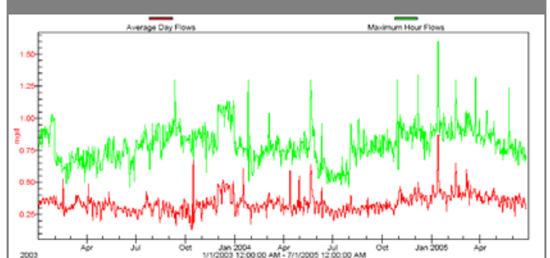
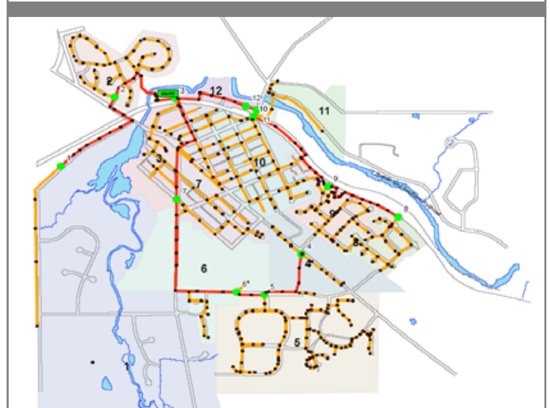
Village of Dexter
Sanitary Sewer Capacity Analysis

September, 2005







Prepared for:
Village of Dexter

Orchard, Hiltz, and McCliment, Inc.

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Abbreviations

MDEQ	Michigan Department of Environmental Quality
MGD	Million Gallons Per Day
MOR	Monthly Operating Records
SCADA	Supervisory Control and Data Acquisition
DWWTP	Dexter Wastewater Treatment Plant
REU	Residential Equivalent Unit
GIS	Geographic Information System
RDII	Rain Dependent Inflow and Infiltration

I. EXECUTIVE SUMMARY

An engineering study was performed for the Village of Dexter in 1996, which established the existing sanitary sewerage flow rates into the Village wastewater treatment plant using MOR flow data between years 1993 and 1996. This average flow rate subsequently formed the starting point for a capacity tracking spreadsheet. Between 1996 and 2004, several new proposals and permit applications to the MDEQ ware made and their corresponding flows tracked with this spreadsheet. In 2004, theoretical calculations indicated that the wastewater treatment plant might have reached its available capacity. In an effort to revise the existing flows entering the wastewater treatment plant with more recent MOR data and assess the remaining capacity in the sanitary sewer system, this study was performed.

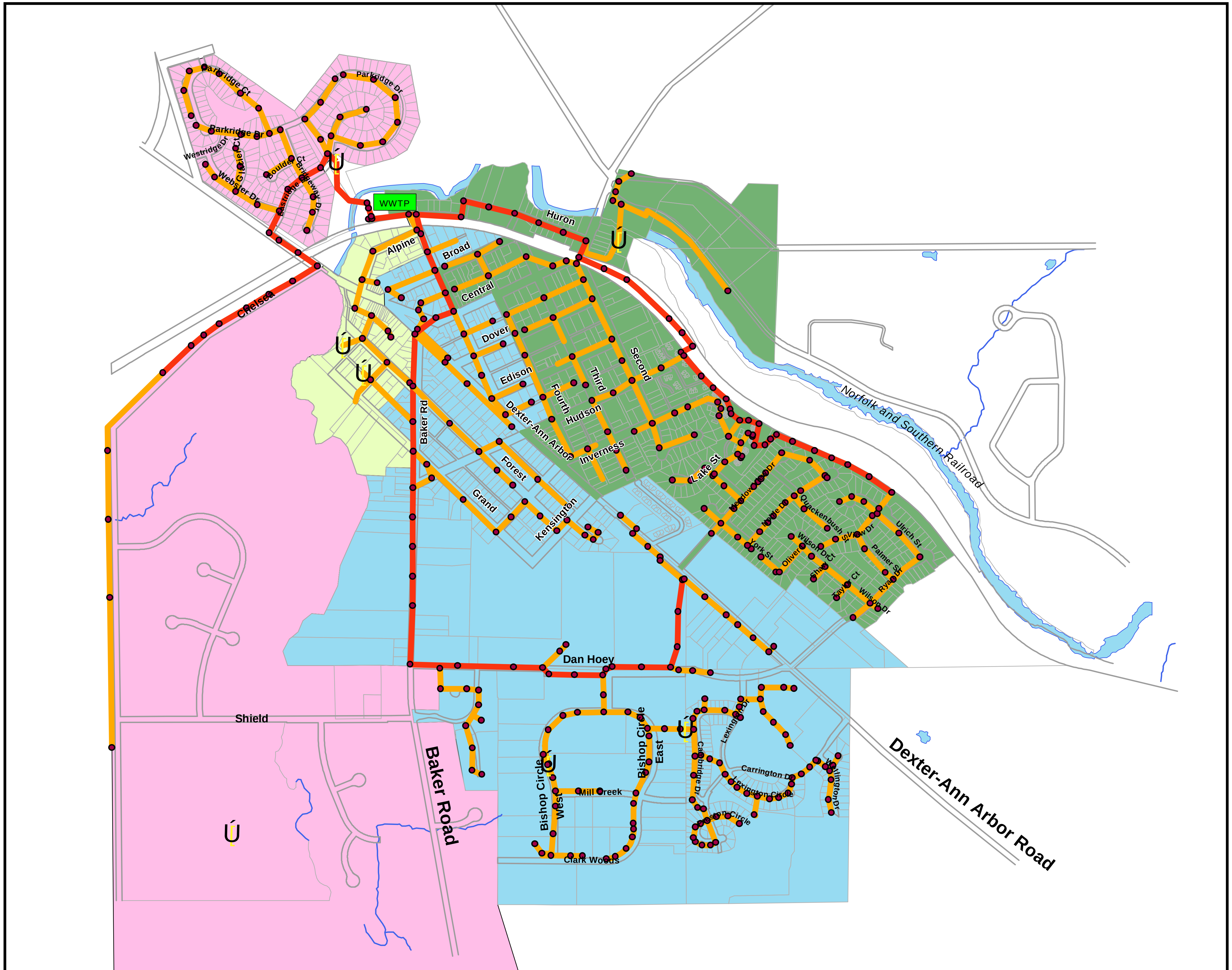
The overall conclusion is that the Village of Dexter sanitary sewer system is under the influence of inflow and infiltration effects. An approximately 10 year 24 hour frequency storm is predicted to cause the flows into the wastewater treatment plant to reach the maximum treatment plant capacity of 1.3 MGD. However, using data from dry periods in the summer, the actual, maximum sanitary sewage flows are approximated as 0.4 MGD in magnitude. Therefore, the amount of inflow and infiltration in the system is estimated as approximately 300% depending on the season and the amount of daily precipitation.

In order to determine the current amount of sanitary sewerage entering the wastewater treatment plant while accounting for inflow and infiltration effects along with operation of pump stations in the Village sanitary sewer system, the average of the maximum hour flow data entering the wastewater treatment plant for the past 2½ years was determined. This amount was estimated as 0.8 MGD. Since the maximum treatment plant capacity is 1.3 MGD, it is estimated that currently, only approximately 62% of the available treatment plant capacity is being utilized.

Using the above-mentioned base flow along with information on the sanitary sewers in the Village, a capacity-tracking tool was developed. This tool has the capability to track both wastewater treatment plant and sanitary sewer pipe capacities. When 0.8 MGD maximum flows were distributed in the major trunk sewers of the sanitary sewer system (see Figure E1), it was determined that, on average, only 15% of the available pipe capacity was utilized.

It is recommended that the Village continue pursuing its current manhole and sanitary sewer pipe rehabilitation program. It is also recommended that the Village implement a flow monitoring program in order to more accurately define the level and potential location of inflow and infiltration areas (e.g. prediction of 25 year-24 hour storm response of the sanitary sewer system). Also, this flow-monitoring program is hoped to aid in demonstrating the effectiveness of the sanitary sewer rehabilitation program that the Village has steadily been performing.

Finally, it is recommended that the Village receive approval from the MDEQ for using the updated tracking tool developed as part of this study. This tracking tool not only approximates available treatment plant capacity but also available capacity of trunk sewers that were modeled.



Village of Dexter

Legend

- Structures
- Pump Stations
- Modeled Sanitary Sewers
- Sanitary Sewers

Sanitary Sewer Districts

- East
- Southeast
- Southwest
- West

Figure E1

Existing Sanitary Sewer System Overview

0 440 880 1,320 Feet

September 2005

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II. INTRODUCTION

An engineering study was performed for the Village of Dexter in 1996, which established the existing sanitary sewerage flow rates into the Village wastewater treatment plant using MOR flow data between years 1993 and 1996. This average flow rate subsequently formed the starting point for a capacity tracking spreadsheet. Between 1996 and 2004, several new proposals and permit application to the MDEQ ware made and their corresponding flows tracked with this spreadsheet. In 2004, theoretical calculations indicated that the wastewater treatment plant might have reached its available capacity. In an effort to revise the existing flows entering the wastewater treatment plant with more recent MOR data and assess the remaining capacity in the system, this study was performed.

The purpose of this memorandum is to outline the procedures that were used for analyzing the available capacity in the Village of Dexter sanitary sewer system and wastewater treatment plant. Also, the assumptions and steps involved in the development of a sanitary sewer capacity analysis tool are explained.

Figure 1 shows an overview of the existing sanitary sewer system and portions of the major trunk lines that were utilized in the capacity analysis tool. The locations of major pump stations and the existing wastewater treatment plant are also depicted. The subsequent sections provide detailed information and assumptions that were used in the analysis of sanitary sewer flow capacities in the Village system.

III. SANITARY SEWAGE FLOWS

The wastewater treatment plant design capacity based on the 1977 plant design drawings and 1999 plant update drawings is as follows:

- Average Day Design Flow: 580,000 gallons per day (0.58 MGD)
- Maximum Hour Design Flow: 1,300,000 gallons per day (1.3 MGD)

The total amount of sanitary sewage flow entering the wastewater treatment plant was obtained from Monthly Operating Records (MOR). This information was used to determine the average day and maximum hour sanitary sewage flows in the Village of Dexter. Subsequently, these flows were compared with the wastewater treatment plant capacity.

A) MONTHLY OPERATING RECORDS (MOR)

MORs between January 1, 2003 and June 26, 2005 were analyzed. Flow data recorded were daily average and maximum flows. Daily precipitation data was recorded as well. Figure 2 shows the variation of average and maximum flows for the above mentioned time period. The average day and maximum hour flows are defined as follows (based on how they are recorded on the MOR's):

Average day flow: This is defined as the total volume of flow entering the wastewater treatment plant on any given day. The original measurements are recorded in million gallons.

Maximum Hour flow: This is defined as the highest flow rate entering the wastewater treatment plant (in MGD) on any given day.

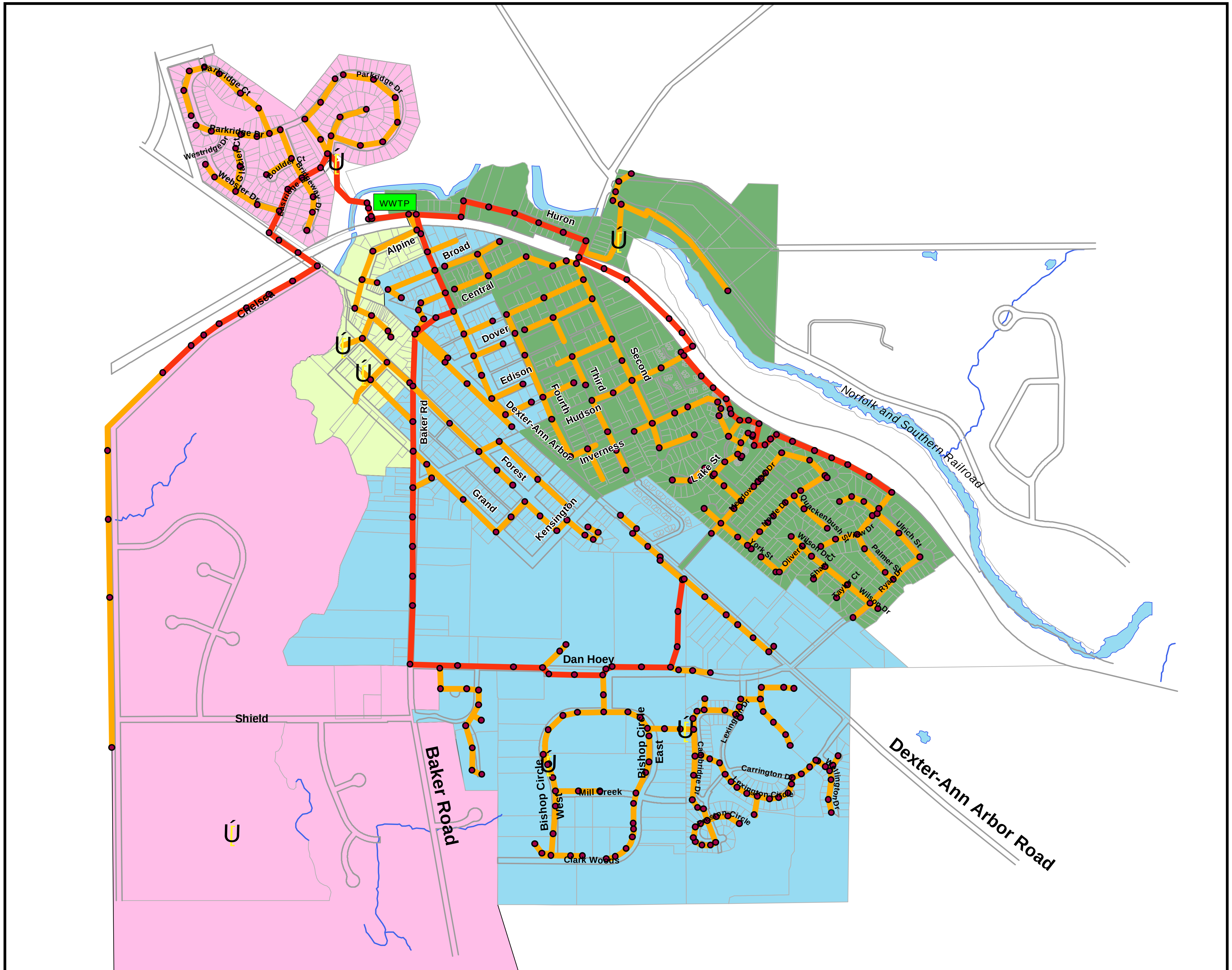

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Figure 1

Existing Sanitary Sewer System Overview

0 440 880 1,320 Feet

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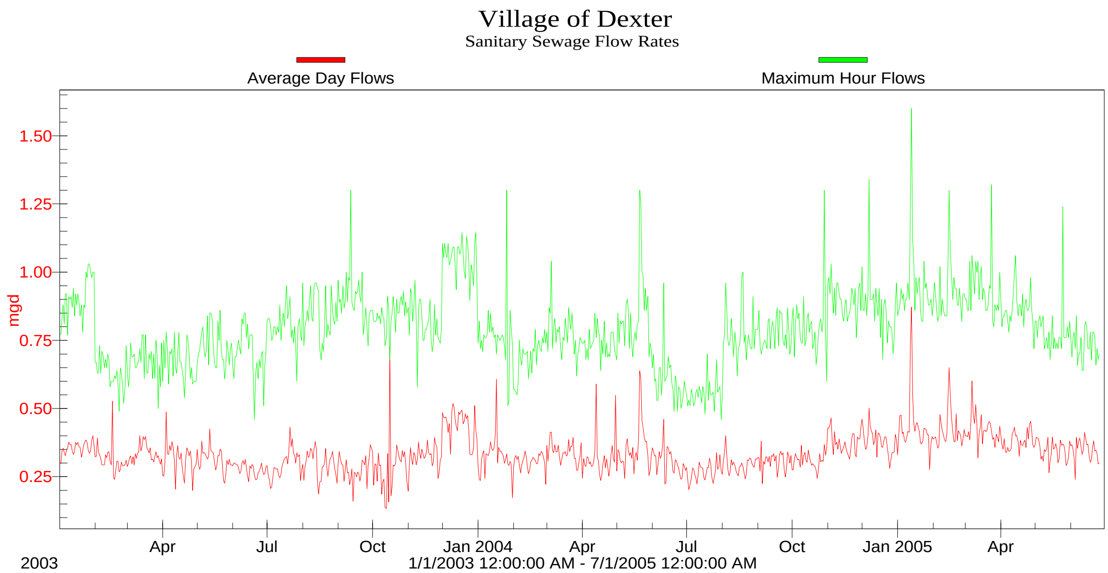
Figure 2: Daily Variation of Average and Maximum Flows



As per these MOR's, the two-year average daily flow into the wastewater treatment plant is 0.34 MGD. This value was obtained by averaging the average daily flows in the MORs over a two year time period. The average daily flow consists not only of sanitary sewer flows but also of rain induced inflow and infiltration since the flow totalizer at the treatment plant does not have a way of distinguishing between these two flows. The highest maximum hourly flow was observed as 1.60 MGD. This flow was recorded on January 13 of 2005. This maximum value consists of sanitary sewage flows and rain induced inflow and infiltration flows.

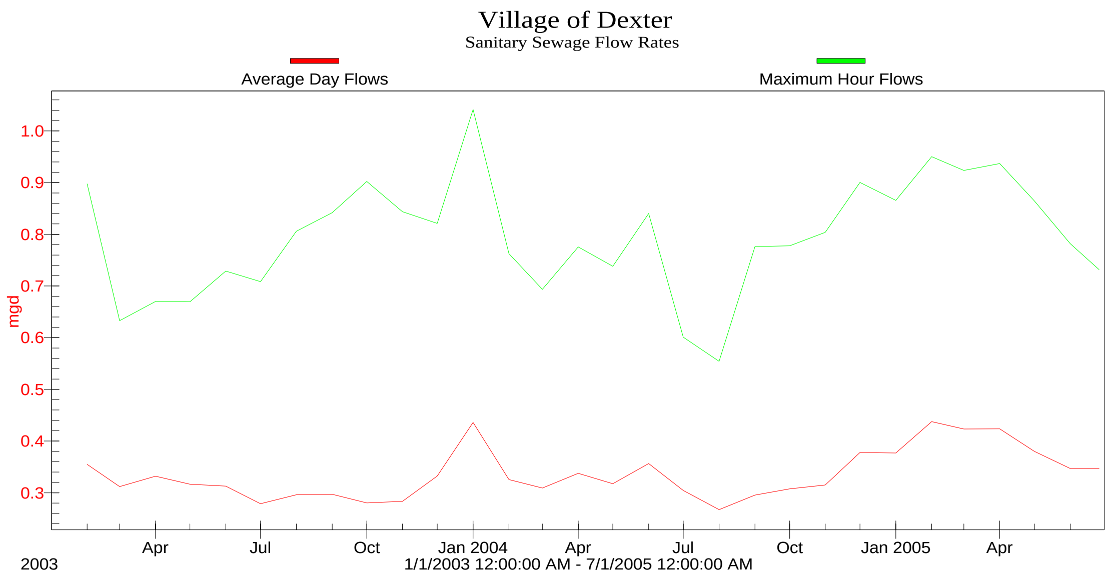
In 1996, a study was prepared by Orchard Hiltz & McCliment, Inc. entitled "The Village of Dexter Preliminary Engineering Report". In this study, MORs between approximately January of 1993 and October of 1995 were analyzed. As per this analysis, the average day and maximum hour flows into the wastewater treatment plant were 0.24 MGD and 1.5 MGD respectively.

It is important to notice that even though the average daily flow values between the 1996 study and this study have increased by approximately 46% (of the 0.24 MGD flows), the peak flows have only increased by 7%. This disproportionate increase in average day flows as compared to maximum hour flows may be indicative of rain dependent infiltration effects.

B) RAIN INDUCED INFLOW AND INFILTRATION (RDII)

Figure 3 shows the variation of average and maximum daily flows over a one-month period in order to emphasize seasonal variations in the data.

Figure 3: Monthly Variation of Average and Maximum Flows



As figure 3 indicates, seasonal variations are observed in the data. Both the average day and the monthly averaged maximum hour flows are smallest in the summer months (July – September), and then gradually increase until the highest flow values are reached in January or February. These seasonal variations are most likely the result of wet weather infiltration effects on the sanitary sewer system.

In order to get a sense for the amount of RDII, the MORs were analyzed along with daily precipitation data. This daily rain data is recorded on the MOR along with flow values. Two periods with no daily precipitation were analyzed in order to get a sense for the average dry weather flows that are not influenced by RDII. Table 1 summarizes these periods and their corresponding dry weather average daily flows.

Table 1: Dry Weather Average Daily Flows

Time Period	Total Daily Precipitation (in)	Average Day Dry Weather Flow (MGD)	Maximum Hour Dry Weather Flow (MGD)
9/8/2004 – 9/27/2004	0	0.31	0.79
1/23/2005 – 2/6/2005	0	0.39	0.90

As seen in Table 1, both the average day and maximum hour flows are higher in the month of January than in the month of September. This effect is most likely due to less ground infiltration / evaporation taking place in the winter months and therefore more snow melt and / or rain flows entering the sanitary sewer system.

Also, ground water levels may influence the observed variation in average sanitary sewage flow rates.

Figure 2 shows that within the 2½ years time period analyzed, there were three events for which the high flow rates exceeded 1.3 MGD. The dates of highest two exceedances are summarized in Table 2 along with the daily precipitation amounts at that time and the potential RDII in the system. The RDII was estimated by subtracting the average daily flow the day before the rain event from the recorded maximum flow during the rain event. A third event was analyzed for comparison purposes (May 5/19/2004 – 5/27/2004 event).

Table 2: Potential RDII Effects

Time Period	Total Precipitation (in)	Highest Daily Precipitation (in)	Previous Day Avg Day Flow (MGD)	Rain Event Max Day Flow (MGD)	Estimated Inflow Due to RDII (MGD)
5/19/2004 – 5/27/2004	4.55	3.1	0.39	1.3	0.91
12/5/2004 – 12/12/2004	N/a*	N/a*	0.39	1.34	0.95
1/9/2005 – 1/14/2005	2.1	1.0	0.39	1.6	1.21

* The Village rain gauge recorded no precipitation even though the max day data had a spike. A local rain gauge in Ann Arbor, on the other hand, recorded a precipitation amount of 1.32 inches / day. Therefore, the local Village rain gauge may have malfunctioned at this time.

As shown in Table 2, the approximated average RDII in the system is 200% except for January of 2005 where RDII values approached approximately 300% of the average day flows. Please note that the highest maximum hourly flow response was observed in a winter season. This may imply that the effects of precipitation may have been compounded by potential snowmelt and frozen ground conditions. In May of 2004, for example, the maximum flows reached 1.3 MGD for much higher precipitation than in January of 2005 for which the maximum flow recorded was 1.6 MGD. The amount of rain in May of 2004 of 3.1 inches per day corresponds approximately to a 10 year 24 hour storm event.

C) COMPARISON WITH WATER CONSUMPTION

When the Village of Dexter SCADA information was analyzed for the drinking water distribution system between the time periods of January 1, 2005 and August 1, 2005, it was determined that the daily average water consumption rate was 0.57 MGD. Assuming that the average day sanitary sewer flow is approximately 0.34 MGD, this would suggest that approximately 60% of the total water consumption is turned into sanitary sewer. This ratio is lower than the commonly accepted value of 70%-85%. Part of the reason may be that the Village has separate water meters for lawn sprinkling. Water consumption from these sprinklers may not contribute directly to sanitary sewage flows.

D) EXISTING SANITARY SEWAGE PUMP STATIONS

As shown in Figure 1, there are four major sanitary sewage pump stations in the Village. Table 3 summarizes their location and capacities. The Westridge Subdivision is located north of the wastewater treatment plant. A force main from a pump station in this subdivision is connected upstream and in close proximity to the flow meter measuring sanitary sewer flows entering the treatment plant.

Table 3: Sanitary Sewage Pump Stations

Name	Number of Pumps	Pump Type	Rated Capacity of Each Pump Station (gpm / MGD)
Westridge of Dexter	2	Submersible	320 / 0.46
Huron Street	2	Submersible	190 / 0.27
Dexter Crossing	2	Submersible	190 / 0.27
Dexter Business / Research Park	2	Submersible	230 / 0.33

E) AVERAGE DAY AND MAXIMUM HOURLY FLOWS

As indicated earlier, the two-year average of the average day flows recorded are approximately 0.34 MGD. This value includes potential RDII effects and corresponding seasonal variations in the seasonal average day flows (as indicated in Figure 2). The two-year average of the maximum flows are estimated as 0.8 MGD. This value includes potential RDII effects as well.

It is important to mention that the pump station north of the wastewater treatment plant (located in the Westridge subdivision) has a direct influence on the flow meter readings at the treatment plant flow meter. Due to its proximity to the flow meter, its operation is directly observed in the average and maximum daily flow readings as a temporary spike. The pump station is rated for 320 gpm, i.e. 0.46 MGD. It is likely that the maximum flow rates shown in Table 1 are under the influence of this pump station. Figure 4 shows a metered flow chart from the wastewater treatment plant for a day in April of 2005. Please note that the flows on this chart are recorded as MGDs and the values need to be multiplied by a factor of 2 (as per the Village). The blue pen corresponds to treatment plant inflows. The red pen corresponds to outflows. This chart clearly shows temporary "spikes" in the data. Therefore, the maximum flows excluding the effects of the pump station of the Westridge Subdivision may be estimated as 0.34 MGD. This observation is an indication of the level of attenuation in the collection system. In other words, the system has much more transmission capacity than the total flows entering it. This issue is further explored in the "capacity tracking tool" section of the memorandum. Furthermore, the temporary operation of the pump station for approximately 15 minutes, only about four times during one day (Figure 4) and the resulting temporary peak flows should not be used as maximum sanitary sewer flows generated in the Village system or the Westridge Subdivision.

The MORs indicate that the treatment plant maximum hourly flow design capacity of 1.3 MGD was exceeded three times between the years of January of 2003 and June of 2005. The highest exceedance was experienced on January 13, 2005 (1.6 MGD). Figure 5 shows a flow chart of this event. Please note that the exceedance was most likely caused by potential inflow / infiltration and snowmelt conditions rather than excessive sanitary sewer flows generated in the Village. Except for this three-hour exceedance event, the highest flows into the treatment plant were below 1.3 MGD (the average flows, excluding this three hour period being below 1 MGD). The Village indicated that despite the flows exceeding 1.3 MGD, no overflow occurred in the treatment plant without the need for any system manipulation. This could potentially be explained considering the thinking process behind designing components for treatment plants. Usually, a safety factor of 25% is added to the maximum flows. If this were the case, the treatment plant could potentially be able to handle maximum hour flows of up to 1.625 MGD.

In an effort to determine a maximum flow for the purposes of tracking available capacities in the wastewater treatment plant and the sanitary sewer system, the two-year average of the maximum hourly flows was calculated. This value was estimated as as 0.8 MGD. This flow includes potential rain dependent inflow and infiltration and temporary Westridge Subdivision pump station operation effects, therefore, conservatively, reflecting the maximum hour sanitary sewer flows into the treatment plant. If this were taken as the existing maximum flow into the treatment plant, it may be assumed that only approximately 62% of the total treatment plant capacity is utilized. In the subsequent capacity analysis-tracking tool, 0.8 MGD flow was assumed as existing base conditions in the Village system.

In an effort to understand the magnitude of sanitary sewer flows generated in the Village without the influence of inflow and infiltration effects, one of the driest months in the year was examined. Figure 6 shows a flow chart for July 1, 2005. According to this flow chart, the average daily sanitary sewer flow received by the wastewater treatment plant was estimated as 0.27 MGD. The maximum hourly flow, excluding the operation of the Westridge sanitary sewer pump station, is estimated as 0.4 MGD. (With the operation of this pump station, the maximum hourly flow would be 0.66 MGD). The daily minimum flow was estimated as 0.1 MGD. In other words, theoretically speaking, if all the inflow and infiltration effects could be removed from the Village sanitary sewer system, only approximately 31% of the maximum hourly wastewater treatment plant capacity would be utilized.

Summary: The two-year average day sanitary sewer flow into the wastewater treatment plant is estimated as 0.34 MGD. This value includes RDII. The highest flow observed in the MORs is 1.6 MGD. This value was observed in January of 2005 and coincides with a wet day having a maximum precipitation of approximately 2.1 inches in 5 days. There is potentially significant amount of rain flow induced inflow and infiltration contribution in the sanitary sewer system. The maximum hourly flow entering the treatment plant (including RDII and operation of sanitary sewer pump stations in the Village sanitary sewer system) is estimated as 0.8 MGD.

Figure 4: Sanitary Sewage Flow Chart for April 7, 2005.

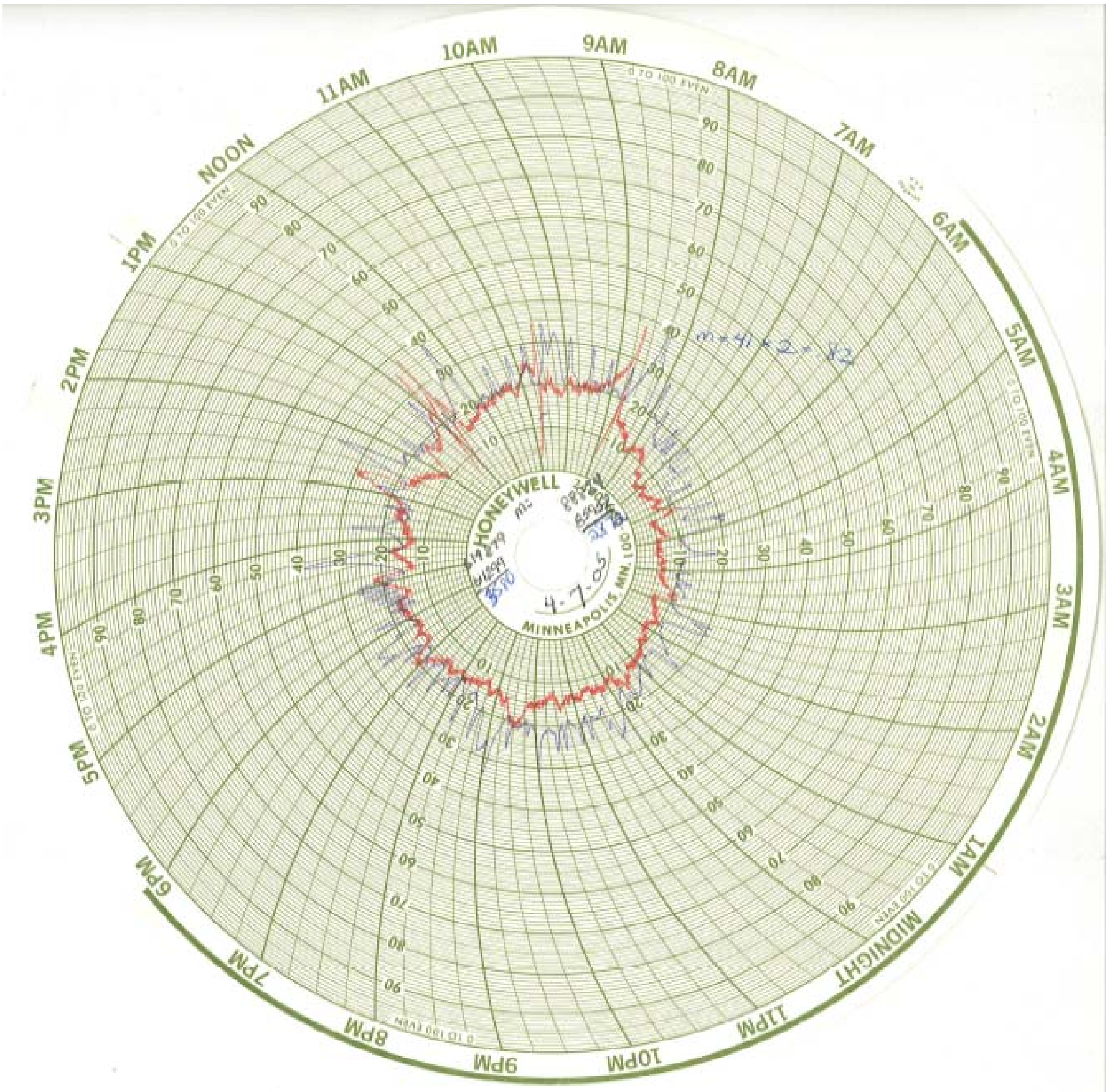
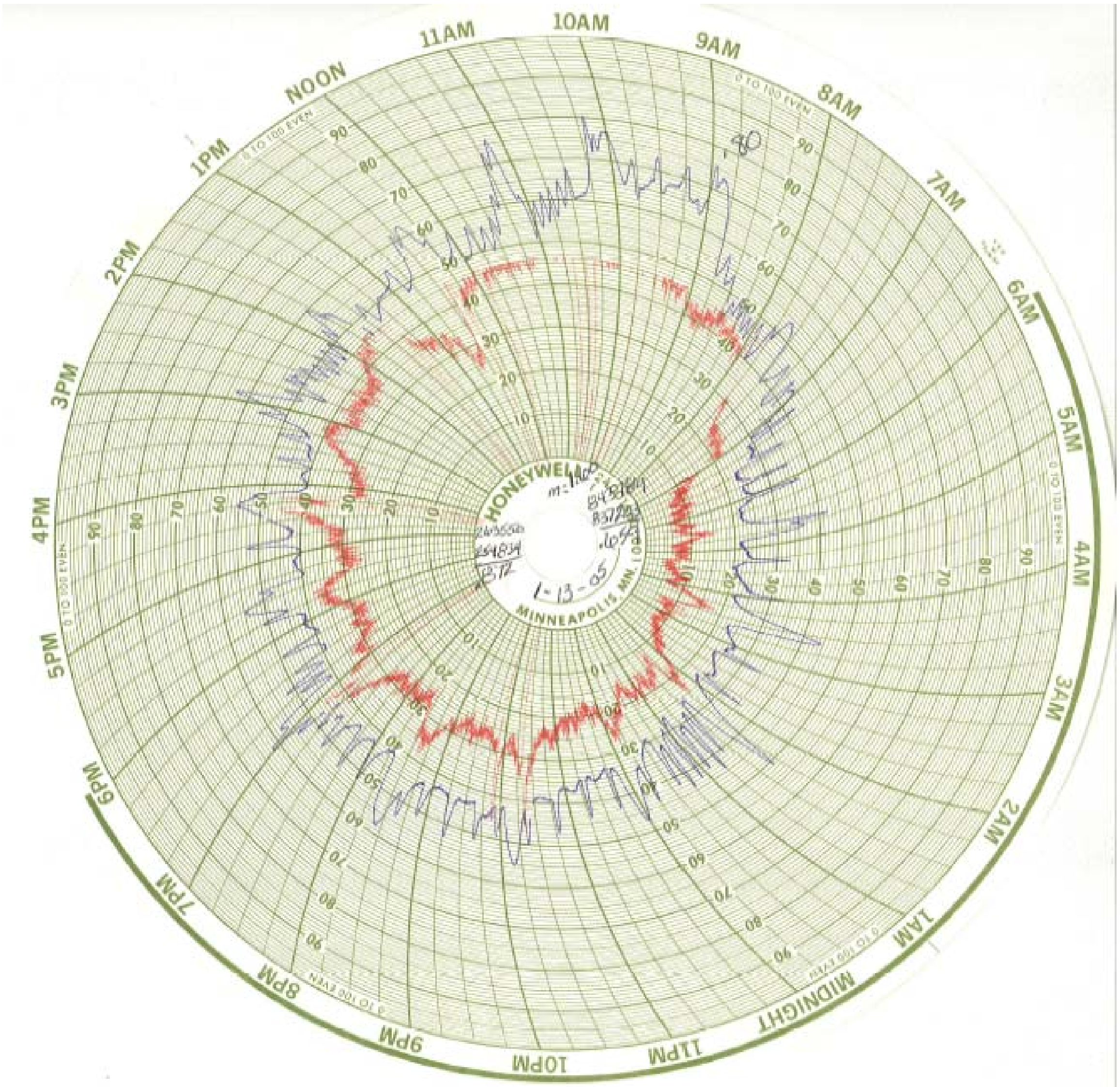
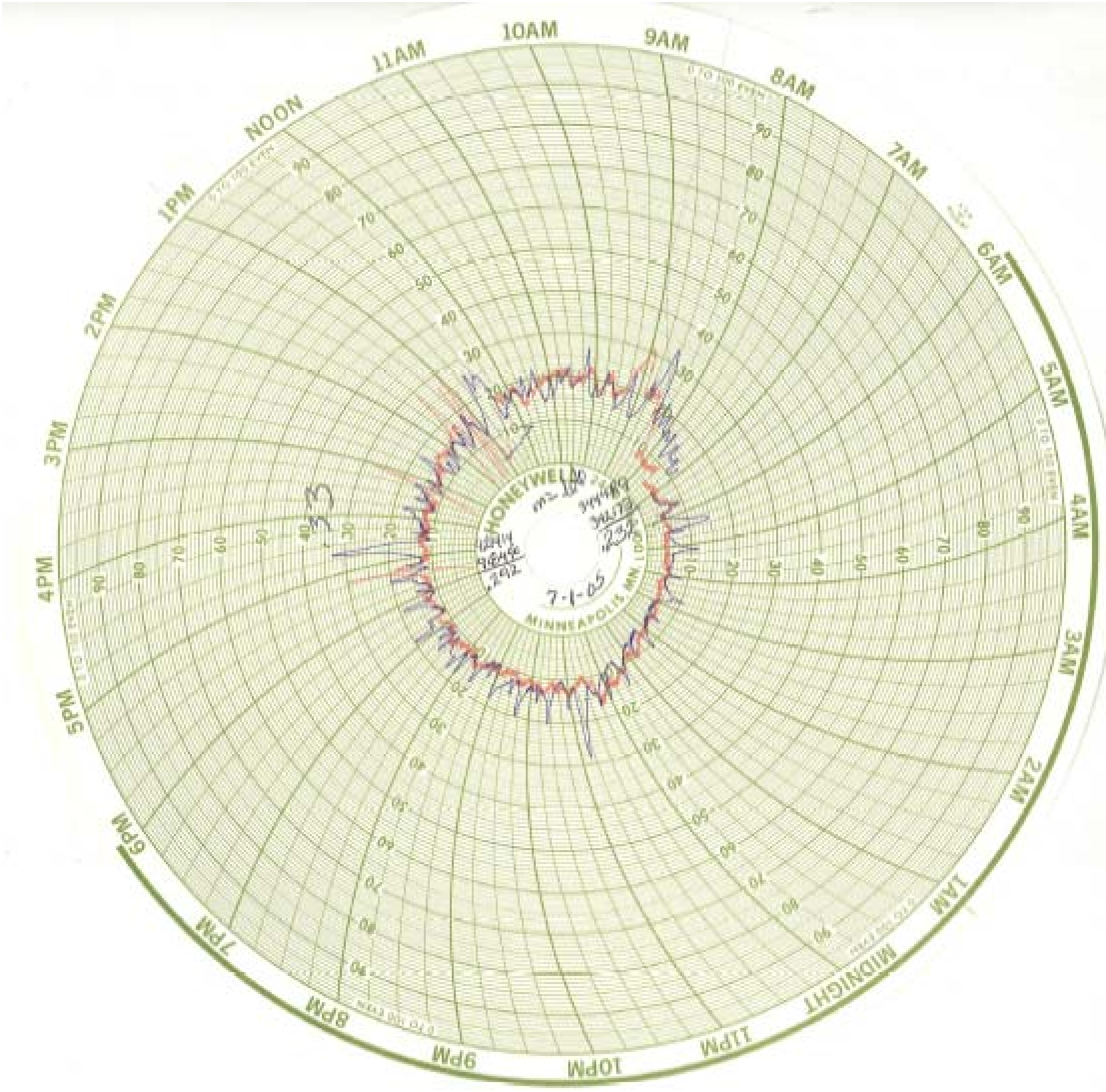


Figure 5: Sanitary Sewage Flow Chart for January 13, 2005.



Please note that the values on this chart need to be multiplied by a factor of 2.

Figure 6: Sanitary Sewage Flow Chart for July 1, 2005.



Please note that the values on this chart need to be multiplied by a factor of 2.

IV. SANITARY SEWAGE FLOW ALLOCATION

In order to determine the sanitary sewage flow distribution throughout the Village, the sanitary sewer system was divided into districts and sub-districts. Using a number of sources the flow for each district was determined.

A) SANITARY SEWER DISTRICTS

The Village of Dexter's sanitary sewer system consists of four main districts that convey sanitary sewage flow to the Dexter Wastewater Treatment Plant (DWWTP). These four main districts were sub-divided into twelve sanitary sewer sub-districts. Figure 7 depicts the sanitary sewer districts and sub-districts. These sub districts were determined based on the direction of flow and the connectivity of the sanitary sewer system.

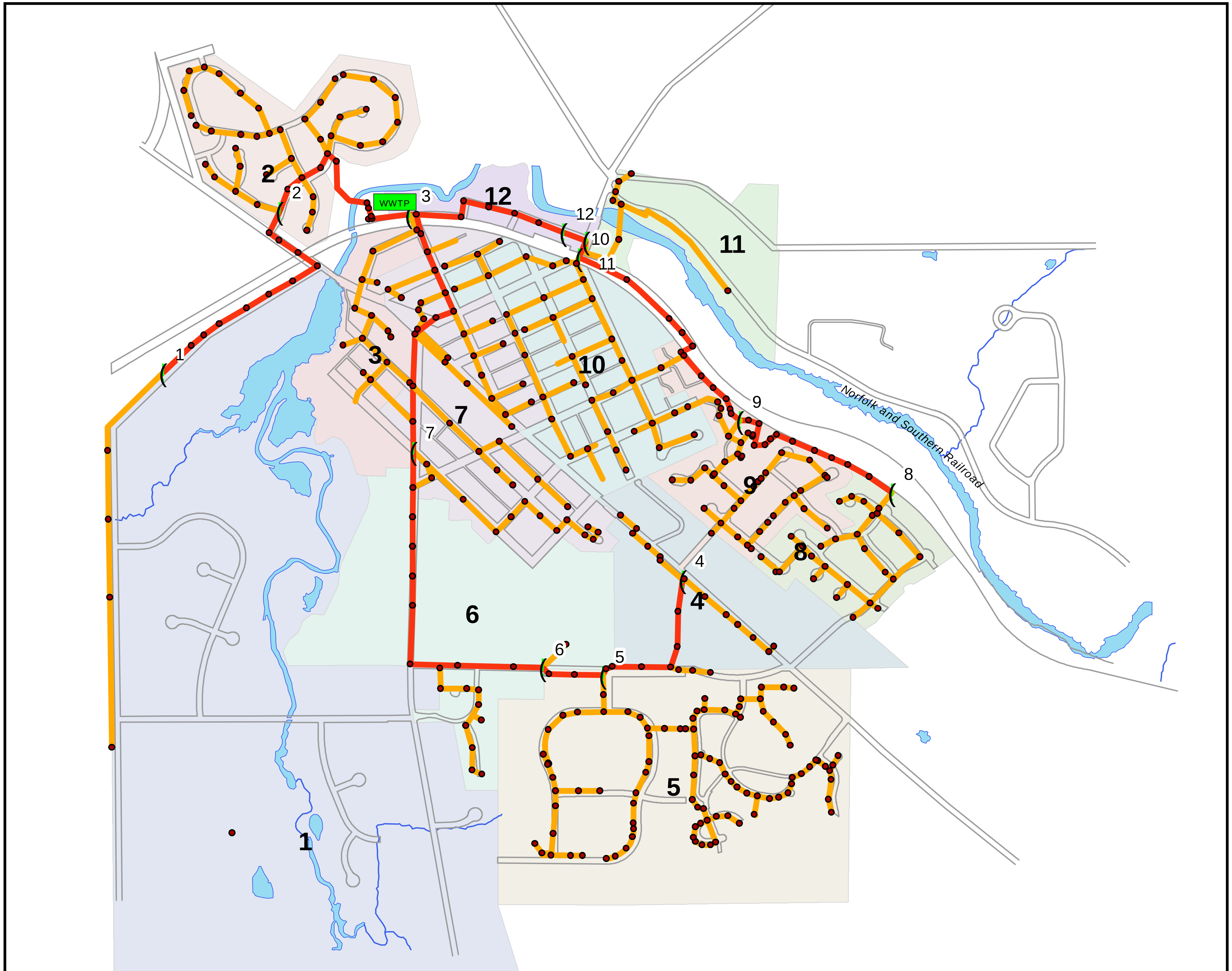
B) FLOW ALLOCATION

The following sources were used to allocate sanitary sewage flows for each district:

- Development Site Plans
- Oakland County Drain Commissioner Schedule of Unit Assignment Factors (July 1, 1998). These are the standard units that are accepted by the MDEQ for sanitary sewer flow projection purposes.
- The Village of Dexter Master Plan (April 11, 2005)
  - The average number of people per household in 2000 was 2.31.

When available, development site plans were used to determine flows within sub-districts. Industrial and commercial flows were calculated using the associated parcel areas and appropriate REU conversion factors. The REUs were calculated for Cornerstone Elementary, Bates Elementary and Mill Creek Middle Schools using estimated number of students and the Oakland County unit factors.

The ratio of each sub-district's REUs to the total number of REUs was applied to the Village's estimated maximum hourly sanitary sewage flow of 0.80 MGD to calculate the maximum hour sewage flows for each sub-district.



Village of Dexter

Legend

- (Model Inflow Manholes
- • Structures
- Modeled Sanitary Sewers
- Sanitary Sewers

Figure 7

Sanitary Sewage Sub Districts

0 425 850 1,275 Feet

September 2005

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Table 4: Sanitary Sewage Flow Allocation

District	Sub-District	Allocated Sanitary Sewer Flow (MGD)
West	1	0.041
	2	0.074
Southwest	3	0.034
Southeast	4	0.037
	5	0.315
	6	0.038
	7	0.066
East	8	0.042
	9	0.067
	10	0.056
	11	0.022
	12	0.007
Total		**0.80**

V. CAPACITY TRACKING TOOL

A capacity tracking tool was developed using the major trunk sewers shown in Figure 1. This tool utilized sanitary sewage flow information as shown above along with Village GIS and as-built data for the sanitary sewer pipes (pipe diameter, slope, inverts etc). Flows to individual sections of the sanitary sewer system were distributed by using sanitary sewer sub districts. The total flow entering the wastewater treatment plant, as observed by the MORs, is rationed out using the acreages of these sanitary sewer sub districts (Table 3).

When the maximum hour flow of 0.8 MGD was distributed through the sanitary sewer system, it was observed that the modeled trunk sewers were able to carry this flow to the wastewater treatment plant without any surcharging. When analyzing the conveyance capacities of the main trunk sewers modeled in the tracking tool (Figure 1), it was observed that on average, only 15% of the total, available carrying capacity of the system was utilized. This result implies that the sizing of some of the trunk sewers was based on conservative assumptions and engineering estimates (10 State Standards).

> *Summary: A maximum hour flow of 0.8 MGD in the sanitary sewer system, on average, utilizes only 15% of the available capacity of the piping system in the major trunk sewers that were modeled.*

VI. CONCLUSIONS AND RECOMMENDATIONS

The overall conclusion is that the Village of Dexter sanitary sewer system is under the influence of inflow and infiltration effects. In May of 2004, for example, a precipitation of approximately 10 year 1 hour frequency magnitude caused the flows into the wastewater treatment plant to reach the maximum treatment plant capacity of 1.3 MGD. However, the actual, maximum sanitary sewage flows are approximately 0.4 MGD in magnitude (estimated using flow data for June 1, 2005). If the temporary, 15-minute flow surges in the wastewater treatment plant flow meters due to operation of the Westridge Subdivision pump station were to be taken into account, this maximum flow would be approximately 0.66 MGD. Therefore, the amount of inflow and infiltration in the system is estimated to be 200% - 300% depending on the season and the magnitude of precipitation.

In order to account for the effects of pump station operation and inflow and infiltration effects, average of the maximum hour flows entering the wastewater treatment plant for the past 2½ years were determined. This flow was estimated as 0.8 MGD. Since the maximum treatment plant capacity is 1.3 MGD, it is estimated that currently, only approximately 62% of the available treatment plant capacity is being utilized. When the average sanitary sewer flow of 0.34 MGD was used as a base condition, the percentage available capacity based on the average flow wastewater treatment total capacity of 0.58 MGD was approximately 60%.

The capacity-tracking tool developed for the Village includes tracking both wastewater treatment plant and sanitary sewer pipe capacities. When 0.8 MGD maximum flows were distributed in the major trunk sewers of the sanitary sewer system, it was determined that, on average, only 15% of the available pipe capacity was utilized.

It is recommended that the Village continue to pursue its current manhole and sanitary sewer pipe rehabilitation program. It is also recommended that the Village plan implementing a flow-monitoring program in order to more accurately define the level and potential location of inflow and infiltration areas (e.g. prediction of 25 year-24 hour storm response of the sanitary sewer system). Also, this flow-monitoring program is hoped to aid in demonstrating the effectiveness of the sanitary sewer rehabilitation program that the Village has steadily been performing.

Finally, it is recommended that the Village receive approval from the MDEQ for using the updated tracking tool developed as part of this study. This tracking tool not only approximates available treatment plant capacity but also available capacity of trunk sewers that were modeled.