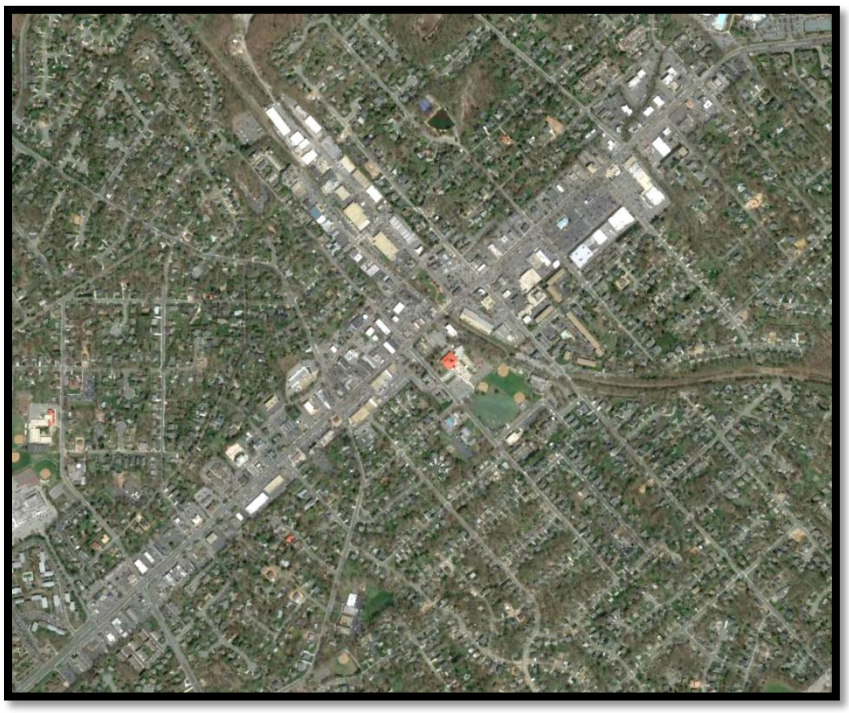
SEWER SYSTEM STUDY:
MAPLE AVENUE COMMERCIAL DISTRICT CORRIDOR DEVELOPMENT

TOWN OF VIENNA, Virginia



FINAL REPORT

March 2016

Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

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I. INTRODUCTION

Whitman, Requardt, and Associates (WRA) has conducted a sanitary sewer capacity study for the Town of Vienna to analyze the present and future flows generated by the development along the Maple Avenue (Route 123) Commercial District. The study also included a limited inflow and infiltration (I&I) analysis based on sewage flow data provided by the Town. The Maple Avenue Commercial District is expected to experience rapid growth which will increase the sanitary loading on the receiving sewer infrastructure. This study evaluates the current sewer capacity and identifies the pipeline segments which will need capacity improvements. In the absence of an existing sewer model, WRA utilized the data from the current Town of Vienna GIS to develop a hydraulic model to analyze existing and projected flows from the Maple Avenue Commercial District.

II. BACKGROUND:

For the analysis, the Town of Vienna and Fairfax Water provided the following information:

- Town of Vienna GIS Shapefiles
- WaterGEMS V8i Water Model
- Town of Vienna Sewer System Maps
- Town of Vienna Historic Water Wholesale Purchase Data
- Town of Vienna Billing Records
- Town of Vienna Water Consumption Records
- Town of Vienna Sewer Meter Records

The following assumptions were made during the analysis:

- An estimate of 30% sewage increase in flow was used because Town's population and employment and population projection data was unavailable for the study period.
- 90% of the water demands is converted to sewer flow.
- I&I investigations were limited due to data and scope constraints. I&I observed at the flowmeter site was applied evenly to the contributing area.
- SewerCAD software was utilized to create the Sewer model.
- Only major pipes in the sewer system were modeled in consultation with the Town.
- Capital Improvements assume no reduction in system I&I.

Sewer System Mapping and Scope of Modeling Effort:

WRA reviewed the GIS data and created sewer systems mapping showing the four major sewer sheds, pipe sizes and manhole locations. The major sewer sheds in the Town are NE (Creek Crossing), NW (Northside), SE (Vienna Woods) and SW (Nutley St) and are delineated based on the GIS pipe network of the existing sanitary sewer system. The sewer sheds to the North discharge to the DC Water's Blue Plains Advanced Water Reclamation facility via the Potomac Interceptor along the Potomac River. The sewersheds to the south discharge to Fairfax County's sewer system and eventually to County's Noman Cole Treatment Plant. The flow on all sewersheds is metered. WRA met Town of Vienna staff to discuss the scope of the modeling effort and it was decided that the modeling should be limited to major sewer pipe segments (generally 10-inches and more) in all four sewer sheds. A sewer system map showing the

sewer sheds and the major pipes is attached as **Appendix A**. This exhibit also shows the Maple Avenue Commercial District Corridor. **Table 1** below shows contributing land area and parcels for each sewershed.

Table 1: Contributing Area and Parcels

Sewershed	Contributing Area (AC)	Contributing Parcels
NW - Northside	1055	1575
NE - Creekside	973	1135
SW - Nutley St	590	1045
SE - Vienna Woods	879	1867

Data Analysis and Calculation of Existing Flows:

WRA reviewed the pertinent information including customer quarterly water billing records. The billing data was helpful to determine an average demand and a corresponding average daily flow for customer meters based on zoning. Once an average daily flow was calculated, it was totalized based on the actual count of the accounts in the area contributing to a flow node. In commercial areas, the quarterly billing data was compared to the water model demand data in the vicinity of the sanitary sewer loading area and totalized flows were assigned to those sewer flow nodes. Diurnal patterns were created based on the sewer meter data and added to the model flow nodes. The billing and flow meter data used to calculate the sewer flows is included in **Appendix B**.

Population Projection and Sewer Flows:

Forecasting population data was not available for analysis so in order to simulate future flows for the Maple Avenue Commercial District, WRA and the Town of Vienna agreed that it would be appropriate to place a 30% increase on all present flows within the Maple Avenue Commercial District development scenario. It was assumed that the flows elsewhere in the town would not increase due to the type of zoning and proposed development.

III. MODELING & ANALYSIS:

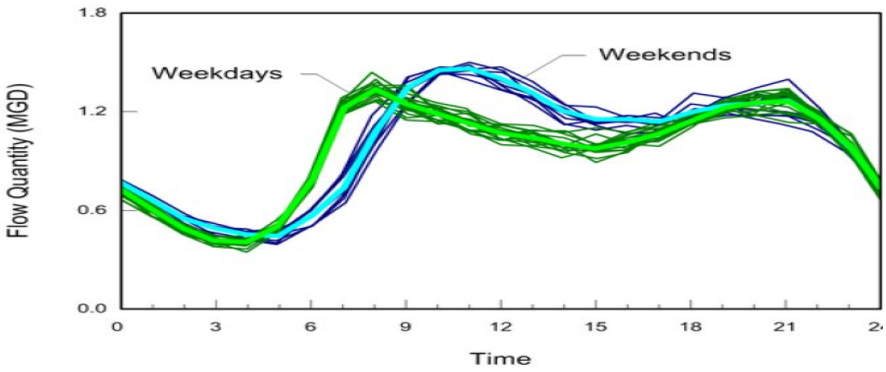
Model Creation, Data Quality and Sanitary Loading Assignments:

The initial step in the study included the development of a hydraulic model for the sewer system. Bentley SewerCAD software was used to create the sewer model by importing the shapefile data from the GIS into the modeling software to create the pipe network. The shapefile data included attribute data such as pipe size, material, and manhole size and invert information which was transferred to the model database.

Through the model development process, the quality of sewer data was enhanced. After input of the geometric and sewer attribute data in the model, the data quality was verified to ensure there were no anomalies in the data. A detailed memo was sent to the Town highlighting the observed data issues and additional information was provided by the Town to supplement the missing and erroneous data. The model connectivity was also verified after the data issues were resolved.

The base scenario of the model simulated the existing conditions of both geometry and flows based on current water billing data. To calculate the flows, the entire town was divided into sanitary loading areas discharging to a specific model node on the sewer network. An average flow was calculated for the entire loading area based on the historic billing data and then applied to the model node. The SewerCAD model

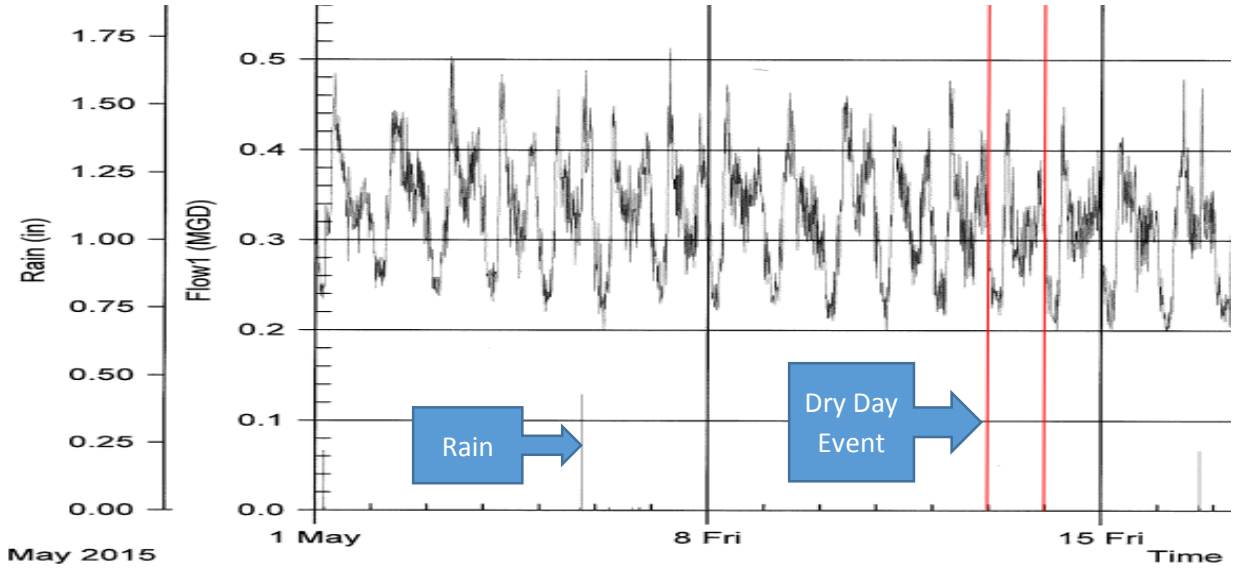
allows assigning a diurnal pattern to the sanitary loading on the model node. This feature helps analyze flows during periods of peak water demand. An example of a typical diurnal pattern in shown in the figure below.



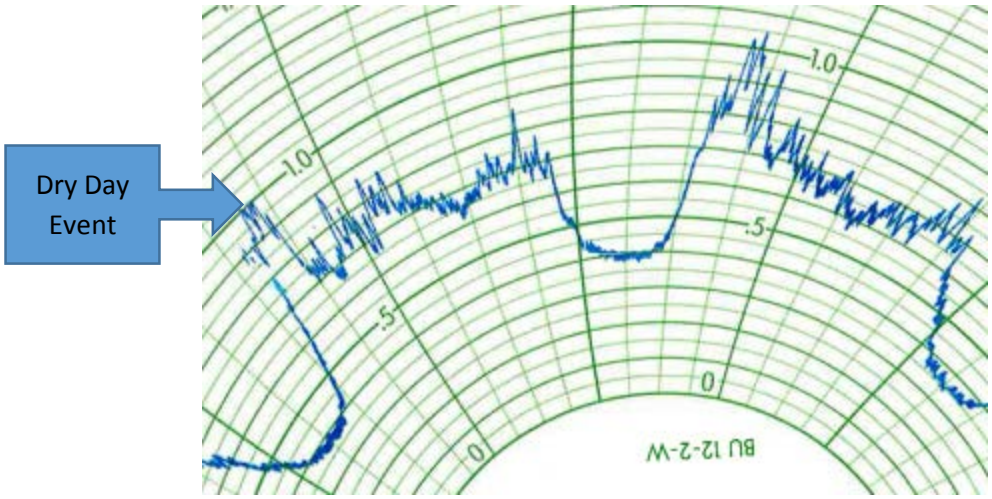
The diurnal pattern for each sewershed was developed by evaluating the data from each flow meter at the four discharge locations and selection of a common "dry-weather" day. The "peaks" and "valleys" in the recorded data were compared to the recorded average flow to create the unitless diurnal pattern. The peak flows were observed at 9:00 AM in the morning.

Model Calibration:

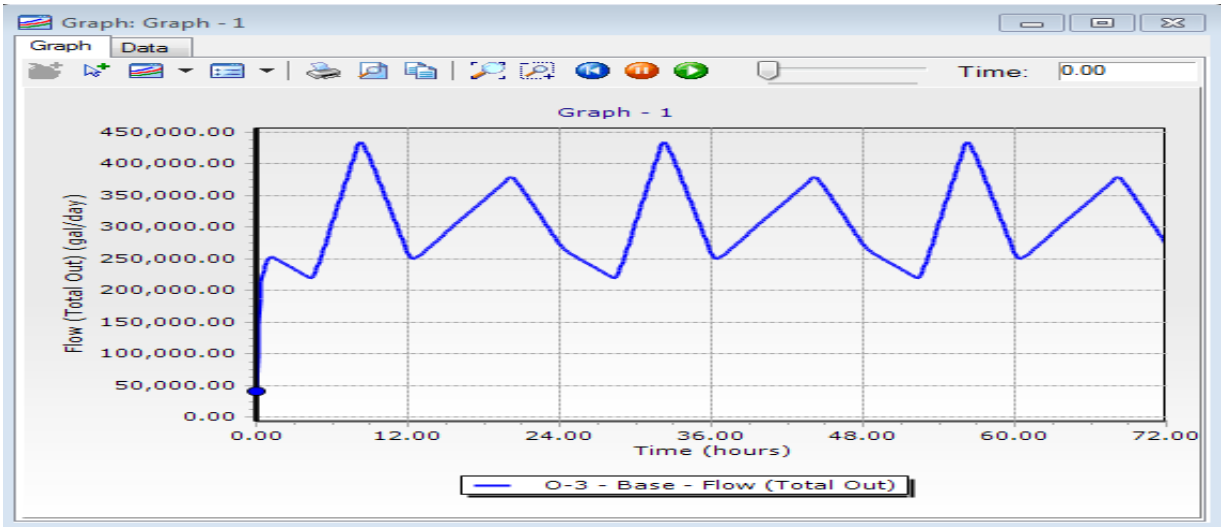
The accuracy of the updated existing conditions model was verified by comparing the simulated flow from the model to the recorded data from the flow meters located at the discharge point of each sewer shed. The model calibration involved a series of iterative steps to adjust the diurnal pattern and in some cases the flow at the nodes in the model. The data that was chosen for the "dry-weather" event during May 2014 and May 2015. The figures below shows an example of the flow data from the Nutley Street meter in the SW sewershed on May 13, 2015 and a from the Northside meter in the NW sewershed on May 8, 2014, which was used to establish the "dry weather" baseline for the respective sewershed.



The "dry weather" meter data is included in **Appendix B**.



The SewerCAD model calculations settings were modified to run the model for an extended period of 72 hours. As an example, the model results for the Nutley Street meter location are shown in the figure below.



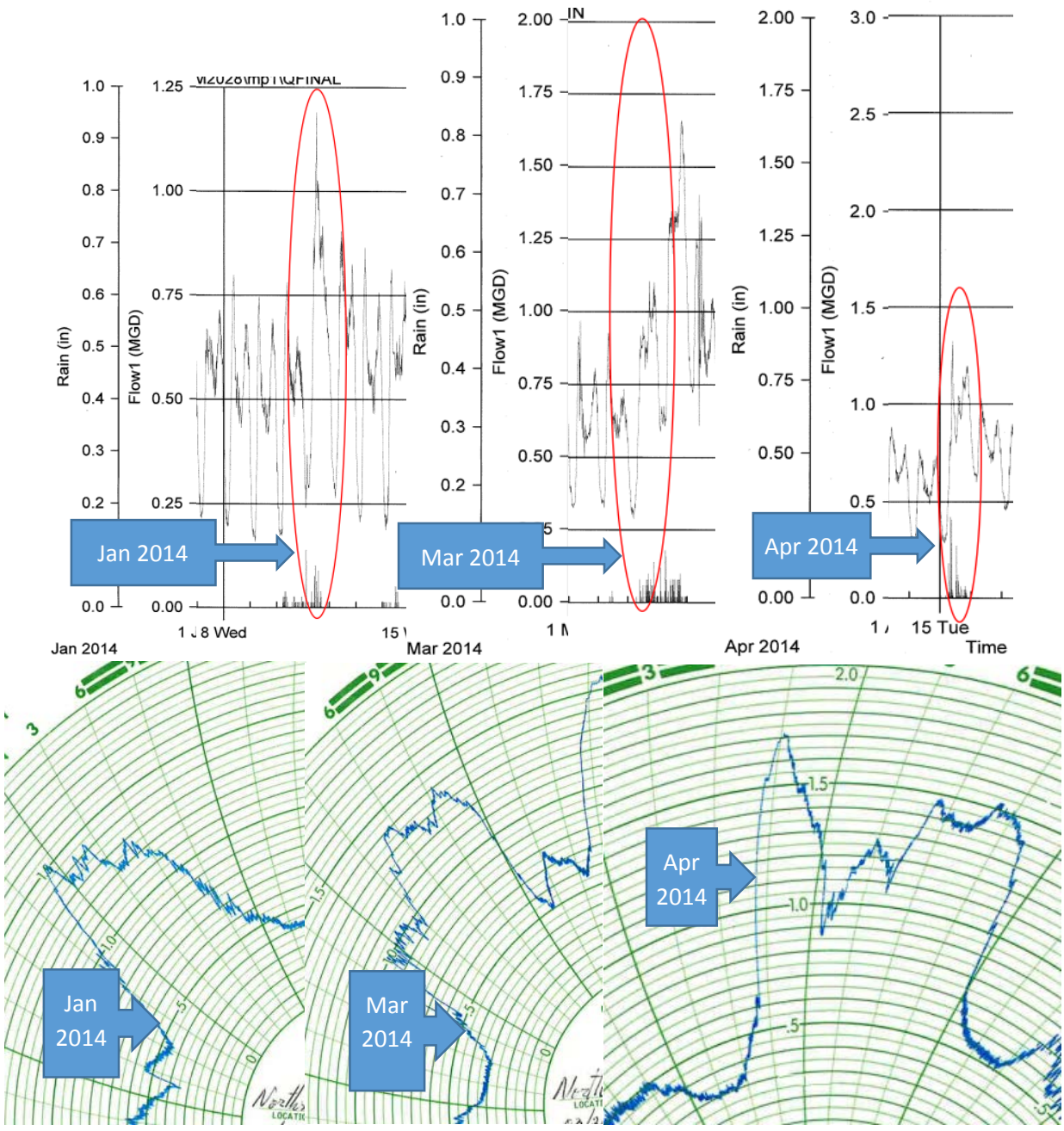
It is to be noted that the model "peaks" and "valleys" closely match the flow values recorded at the sewer meter locations and the model is calibrated for a typical "dry-weather" scenario within the scope of the modeling assumptions. Additional calibration may be required if the Town plans to conduct flow monitoring within each sewershed or specific area of interest.

Maple Ave Commercial District Corridor Development Scenario:

Once the calibrated "dry-weather" model was established, another scenario was created to simulate the additional flows anticipated by the Maple Avenue Commercial District Corridor redevelopment. The projected 30% additional sanitary sewage loading was applied to the exiting sewer flow nodes in the Maple Avenue Commercial District to calculate the future flows at the four meter locations.

Wet Weather/Inflow and Infiltration (I&I) Scenario:

The scope of this report did not include an indepth wet weather/ I&I investigation, however, a few observations are worth mentioning. The review of the rain and flow data at the metering site (since 2013) revealed that the Town has experienced significant I&I. The year 2014 has been recorded as a "wet year" with numerous rain events spanning over several days. The wet weather events in January, March and April 2014 exceeded the peaking factor of 2.25 X average flow in the two southern sewersheds and 3.00 X average flow in the two northern sewersheds. The "wet- weather" flows from the Vienna Woods meter (SE sewershed) and Northside meter (NW sewershed) are shown in the figures below.



A wet weather scenario was simulated for all sewersheds to identify capacity constraints within the existing sewer network. This was accomplished by adding the additional flow due to I&I to each flow node. This additional flow was derived by utilizing a multiplication factor observed at the flow meter at that sewershed during a routine wet weather event. The "wet weather" meter data is included in **Appendix B**.

IV. MODEL RESULTS:

A summary of the model results for the existing condition dry weather scenario is presented below:

Table 2: Existing Conditions Dry Weather Sanitary Flows

Sewershed	Location of Flow	Average Flow (MGD)	Maximum Flow (MGD)
NW (North Side)	By W&OD Trail just north of Mill St NE	0.71	1.05
NE (Creek Crossing)	E St. NW and Creek Crossing Rd NE	0.17	0.25
SW (Nutley Street)	Nutley St SW and Marshal RD SW	0.31	0.43
SE (Vienna Woods)	Behind 532 Walker St SW	0.55	0.81

A summary of the model results for the Maple Ave Commercial District Corridor development dry weather scenario is presented below:

Table 3: Maple Ave Commercial District Corridor Development Dry Weather Sanitary Flows

Sewershed	Location of Flow	Average Flow (MGD)	Maximum Flow (MGD)
NW (North Side)	By W&OD Trail just north of Mill St NE	0.76	1.12
NE (Creek Crossing)	E St. NW and Creek Crossing Rd NE	0.18	0.26
SW (Nutley Street)	Nutley St SW and Marshal RD SW	0.31	0.43
SE (Vienna Woods)	Behind 532 Walker St SW	0.55	0.81

A summary of the model results for the existing conditions wet weather scenario is presented below:

Table 4: Existing Conditions Wet Weather Sanitary Flows

Sewershed	Location of Flow	Average Flow (MGD)	Maximum Flow (MGD)
NW (North Side)	By W&OD Trail just north of Mill St NE	1.41	2.08
NE (Creek Crossing)	E St. NW and Creek Crossing Rd NE	0.34	0.49
SW (Nutley Street)	Nutley St SW and Marshal RD SW	0.47	0.65
SE (Vienna Woods)	Behind 532 Walker St SW	0.78	1.12

A summary of the model results for the Maple Ave Commercial District Corridor development wet weather scenario is presented below:

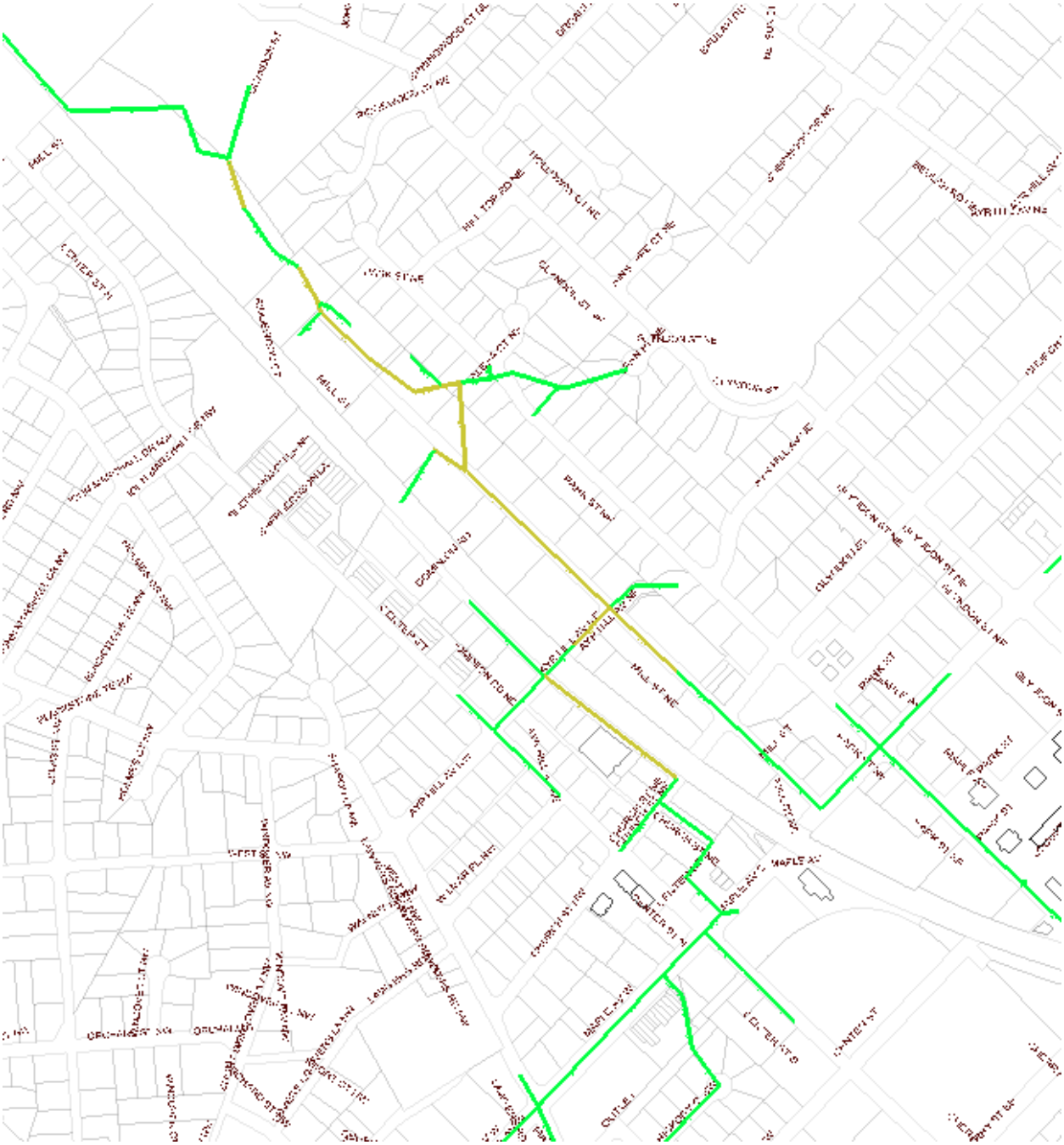
Table 5: Maple Ave Commercial District Corridor Development Wet Weather Sanitary Flows			
Sewershed	**Location of Flow**	**Average Flow (MGD)**	**Maximum Flow (MGD)**
NW (North Side)	By W&OD Trail just north of Mill St NE	1.52	2.24
NE (Creek Crossing)	E St. NW and Creek Crossing Rd NE	0.36	0.53
SW (Nutley Street)	Nutley St SW and Marshal RD SW	0.47	0.65
SE (Vienna Woods)	Behind 532 Walker St SW	0.78	1.12

As noted from the data in the tables above, in existing conditions dry weather scenario, the Maple Avenue Corridor Development (in the NW sewershed) adds 0.05 MGD to the average flow of 0.71 MGD and 0.07 MGD to the peak flow of 1.05 MGD. In the existing conditions wet weather scenario, the NW sewershed experiences the most significant increase in flows (i.e. 0.70 MGD for average flow and 1.03 for peak flow). The wet weather impact is worsened in the Maple Ave Corridor Development scenario.

Sewer model results and hydraulic profiles are included in **Appendix C**. A graphical depiction of the results is noted below:

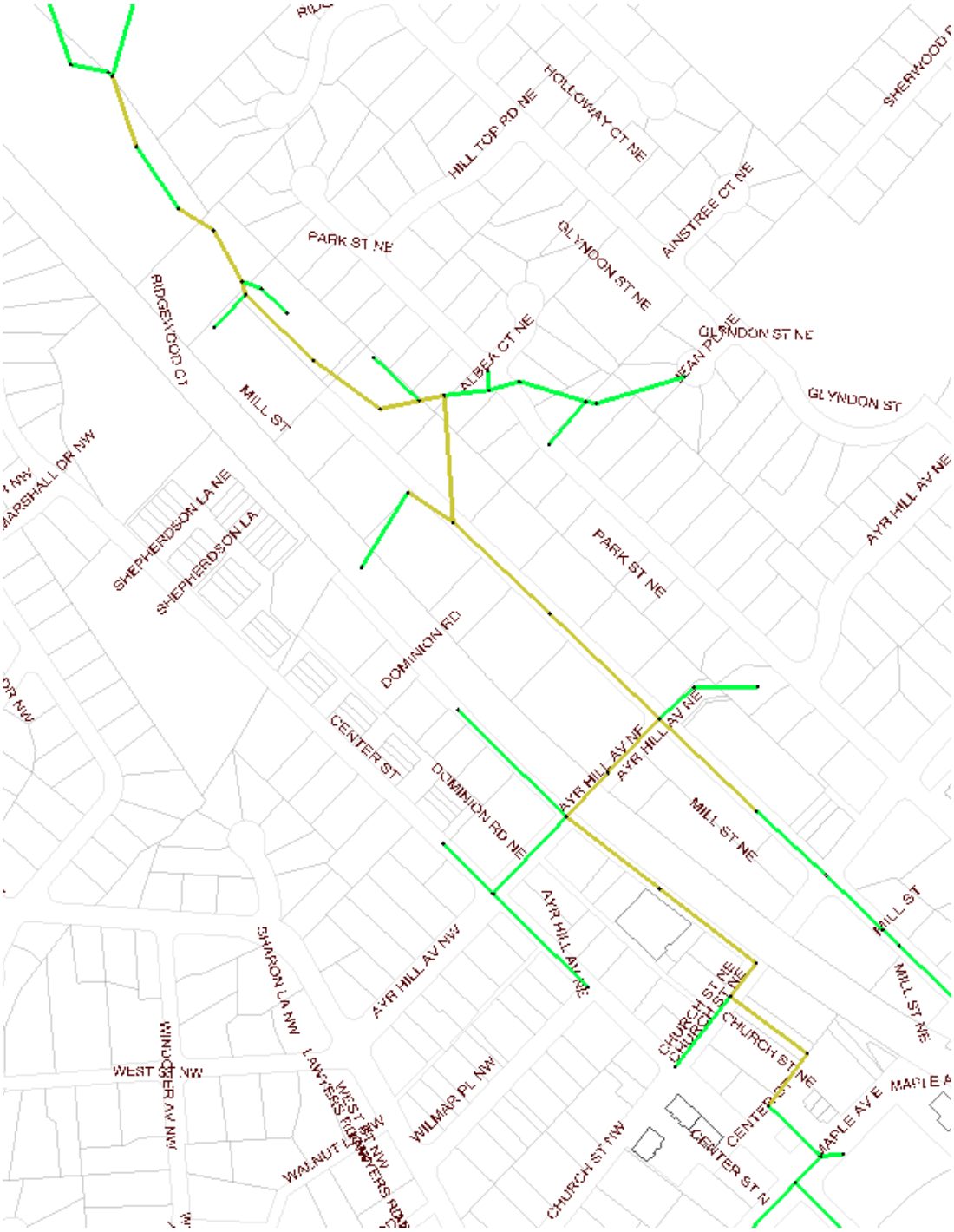
NW sewershed: The figure below shows a color coded graphic of the sewer network in an existing condition dry weather scenario. The yellow line type indicates that the sewer flow has exceeded 50% the available pipe capacity.

Existing Conditions Dry Weather Scenario



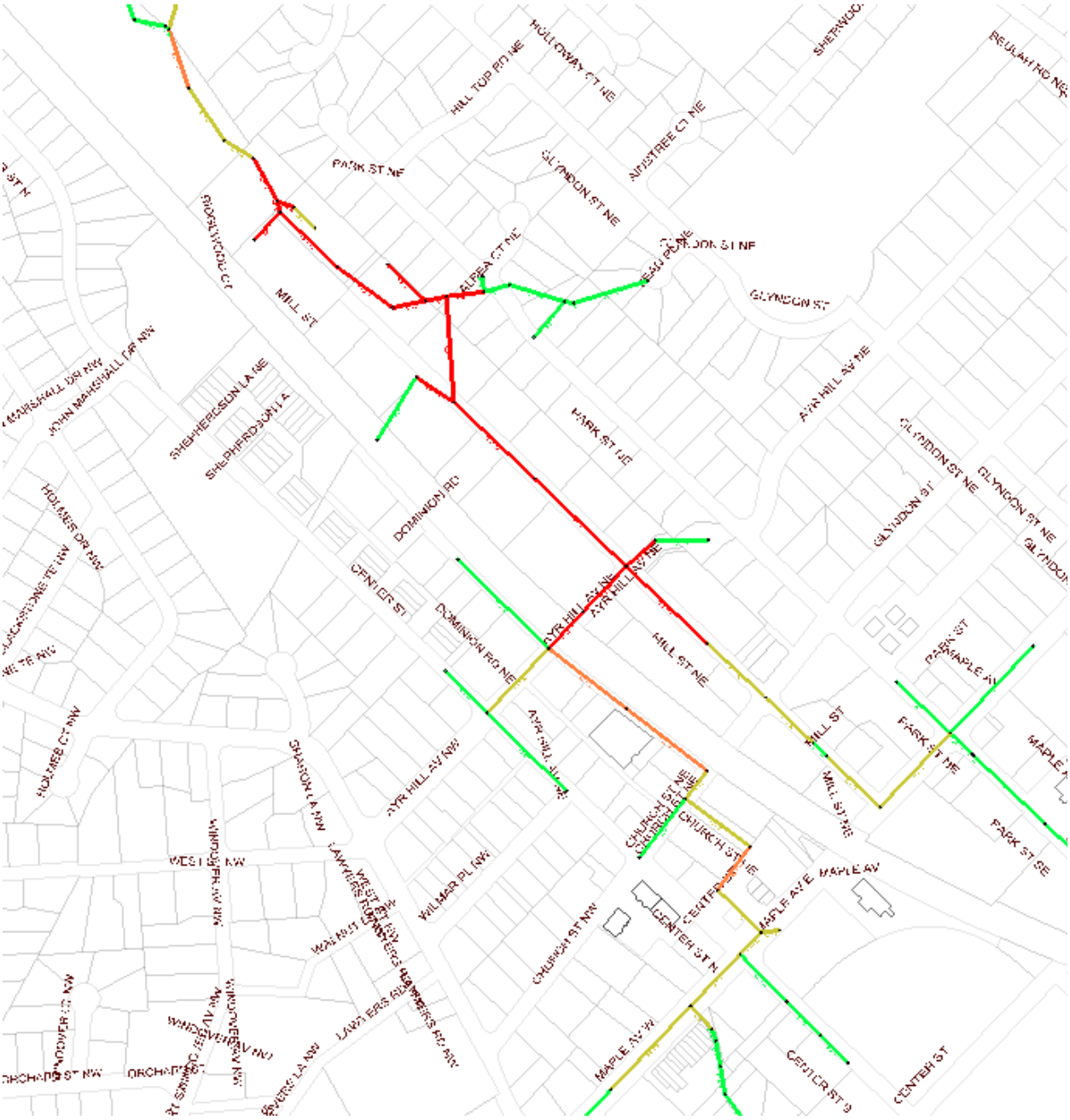
The figure below shows a color coded graphic of the sewer network for the Maple Ave Development and dry weather scenario. The yellow line type indicates that the sewer flow has exceeded 50% the available pipe capacity.

Maple Ave Corridor Development Dry Weather Scenario



The figure below shows a color coded graphic of the sewer network in an existing condition wet weather scenario. The red line type indicates that sewer flow has exceeded 99% the available pipe capacity, the orange indicates 80% exceedance and the yellow indicates 50% exceedance.

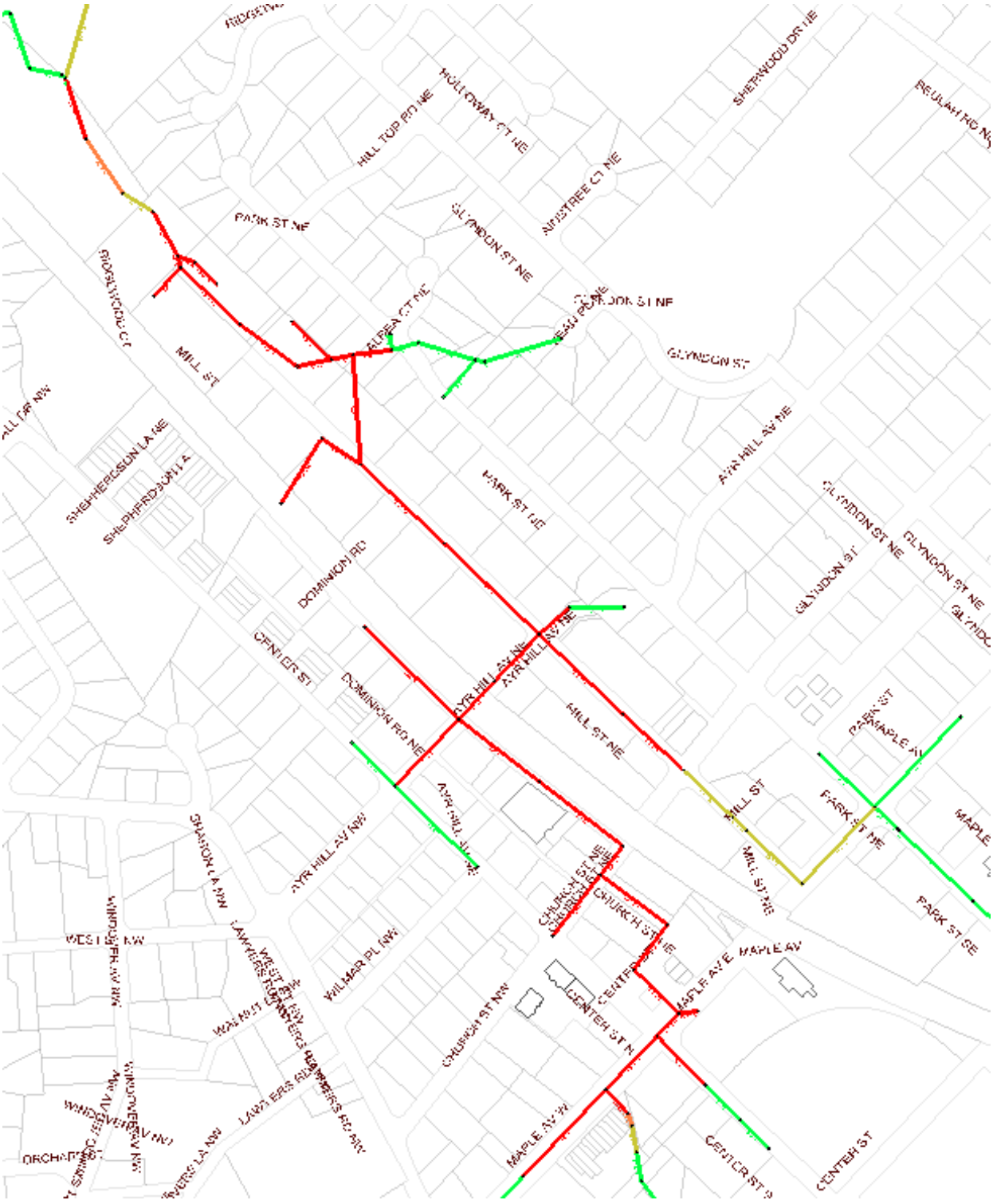
Existing Conditions Wet Weather Scenario



This existing condition wet weather scenario indicates that the existing 10-inch and 12-inch lines along the Mill Street corridor are deficient. This confirms the issue that Town has had with the sanitary sewer along Mill Street. SSO and manhole surcharging has been recorded at several locations along Mill St. based on the current modeling assumptions.

The figure below shows a color coded graphic of the sewer network with the Maple Ave Development and wet weather scenario. The red line type indicates the sewer flow has exceeded 99% the available pipe capacity, the orange indicates 80% exceedance and the yellow indicates 50% exceedance.

Maple Ave Corridor Development Wet Weather Scenario



- NE sewershed: the model scenario with the Maple Ave Commercial District Corridor development and the rainfall indicates there are no capacity issues.
- SW sewershed: the model scenario with the Maple Ave Commercial District Corridor development and the rainfall indicates there are no capacity issues.
- SE sewershed: the model scenario with the Maple Ave Commercial District Corridor development and the rainfall indicates there are no capacity issues.

Inflow and Infiltration Volumes:

In order to quantify the additional flow generated due to I&I, the model's flow hydrograph ordinates generated on the selected "wet weather" events (i.e. for January, March and April 2014) were subtracted from the ordinates on a typical "dry weather" day to compute the sewage volume generated in one day. It was noted that the selected "wet weather" events reported a total rainfall depth between 1.39 and 2.19 inches in 24 hours. This observed rainfall depth is somewhat close to 1 year return precipitation event which is estimated at 2.57 inches average during a 24 hour rainfall duration (per NOAA for the Town of Vienna). The sewage runoff volumes are calculated in **Table 6** below.

Table 6: Volume of Inflow and Infiltration (existing wet weather scenario)

Sewershed	Rain Events (IN)	Runoff Volume (MGD)	Runoff Volume (MG/YR)
NW - Northside	March 29, 2014 (1.39) April 15, 2014 (2.19)	0.69	17.25
NE - Creekside	March 29, 2014 (1.39) April 15, 2014 (2.19)	0.17	4.25
SW - Nutley St	March 29, 2014 (1.39) April 15, 2014 (2.19)	0.16	4
SE - Vienna Woods	March 29, 2014 (1.39) April 15, 2014 (2.19)	0.22	5.5

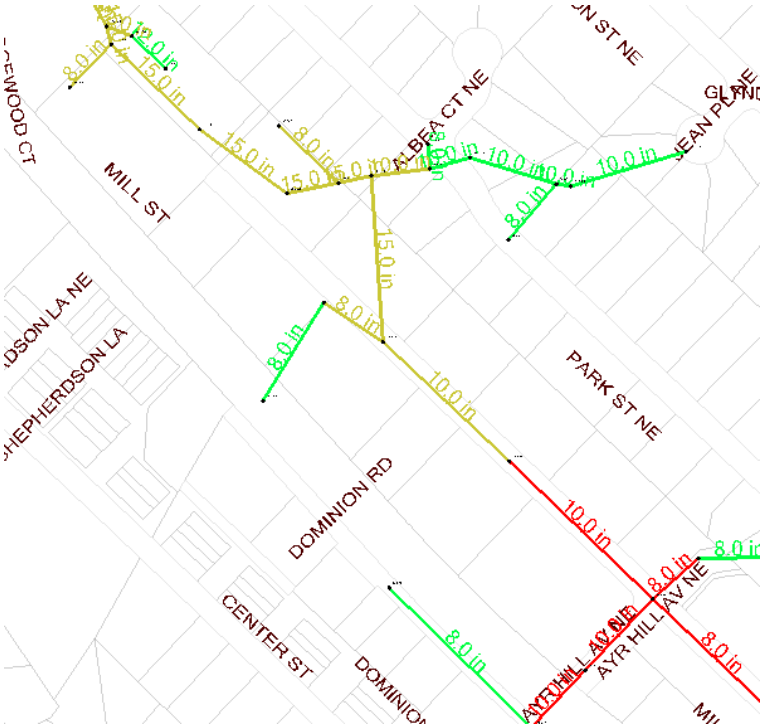
* Assumes a typical "design" rain event with a total precipitation of 2 inches/event and the totalized I&I runoff volume based on the 50-inch total rainfall depth recorded in 2014 in Town of Vienna (i.e. 25 rainfall events).

Capital Improvements:

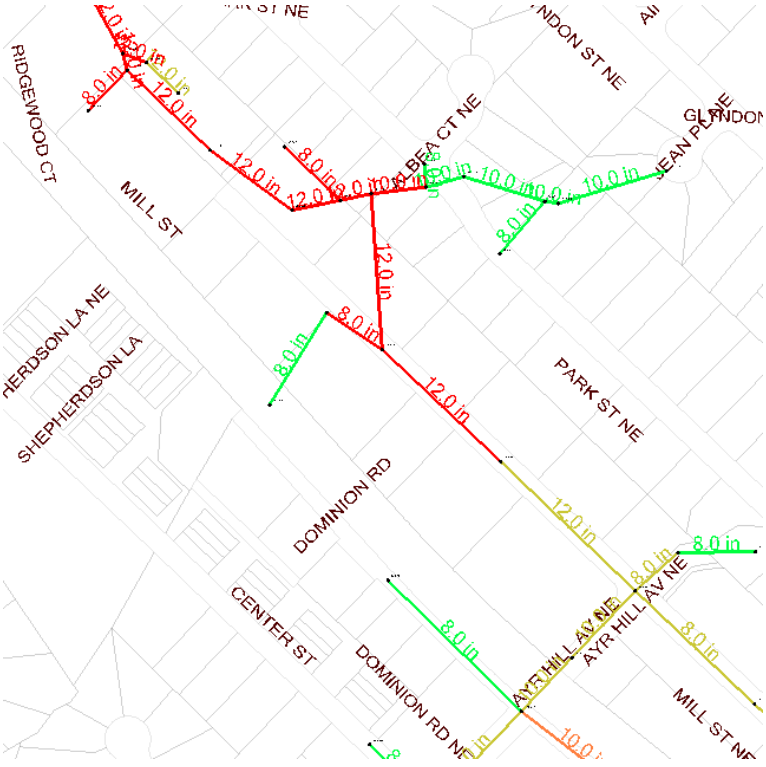
Current best engineering practice recommends sewer capacity improvements once the flows exceed 80% of capacity. Based on the model results several sewer segments in the NW sewershed experienced "surcharging" in existing conditions wet weather scenario. Surcharging is defined as the hydraulic condition in which the flow exceeds the "full pipe" capacity of the sewer.

An approach was taken to replace the deficient pipes in (indicated in red) and upsize them to the next available size to remove or minimize the surcharging condition. In the NW sewershed, two alternatives for pipe upgrades were evaluated in the existing conditions wet weather scenario to correct the surcharging issues at Mill Street. The first alternative proposed to remove the downstream tailwater condition by upgrading the existing 12-inch pipeline segments (between Mill Street and TOV Northside Property Yard) to 15-inch size. The second alternative proposed to upsize only the existing 10-inch pipe segments to a 12-inch size along Mill Street, north of Ayr Hill Av. The proposed alternatives were simulated in the hydraulic model and it was noted that the pipe upgrades to correct the tailwater condition, though critical, did not address the immediate surcharging issues at Mill Street and Ayr Hill Ave. However, the Mill St. pipeline upsizing alternative relieved the surcharging at the same location, therefore the alternative to improve the tailwater condition was deferred into the future. The figures below shows the impact of the pipeline improvements for both pipe upsizing alternatives in Mill St Area.

Pipe Improvements Alt. 1 – Mill Street to TOV Northside Property Yard (12-inch to 15-inch) Existing Conditions Wet Weather.



Pipe Improvements Alt. 2 – Mill Street - North of Ayr Hill Av (10-inch to 12-inch) Existing Conditions Wet Weather.



The figure below shows the impact of the pipeline improvements for the Maple Street Commercial Development wet weather scenario. This scenario assumes the pipe upsizing proposed in both alternative 1 and alternative 2.

Pipe Improvements Alt. 1 and Alt. 2 – Maple Avenue Corridor Development – Wet Weather

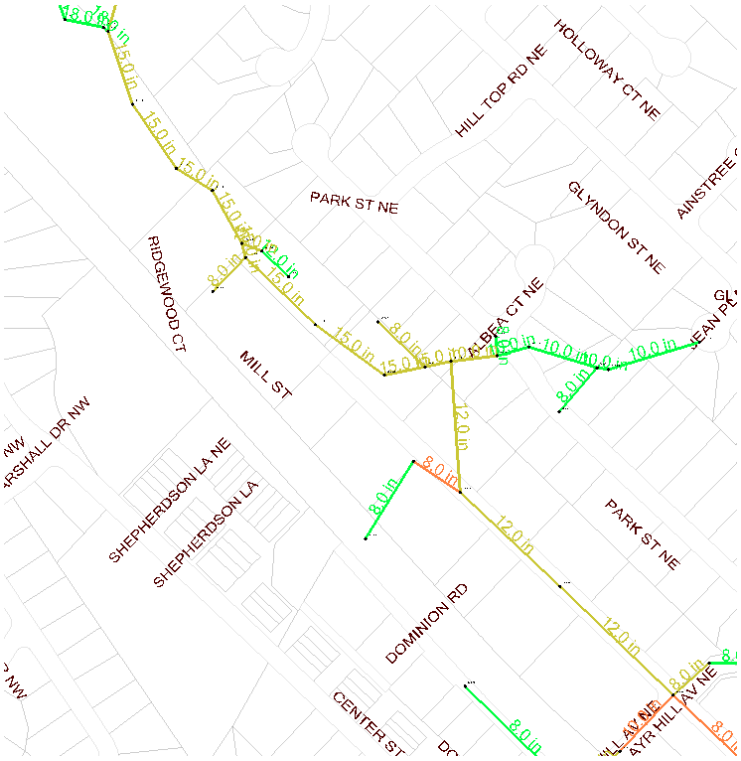


Table 7 below shows the proposed pipe size improvements for the NW sewershed to handle the wet weather flows in both existing conditions and buildout scenarios.

Table 7: Capital Improvements in NW Sewershed			
Location	**Existing Pipe Size (IN)**	**Recommended Pipe (IN)**	**Length of Replacement (FT)**
Alt. 1: Mill Street to TOV Northside Property Yard	12	15*	1,685
Alt. 2: Mill Street	10	12**	760

* Pipe improvements due to I&I and impact of Maple Ave Corridor Development. ** Pipe improvements due to I&I based on existing wet weather scenario.

V. RECOMMENDATIONS:

- I&I flows have the most significant impact on the flows in the NW Sewershed. The Town should continue to investigate sources of I&I and continue to perform targeting flow monitoring, pipe condition assessment, relining and manhole rehabilitation to control I&I.
- The Town should perform periodic sewer cleaning to ensure availability of pipeline capacity.
- The Town should inspect, repair or replace the existing flow meters at each sewershed to help maintain accurate flow records. The rain gauge should also be inspected and maintained. The Northside and Creek Crossing meter sites should be upgraded from chart loggers to digital data recorders.
- To handle the immediate I&I related issues around the Mill Street area, a 12-inch pipe upsizing is recommended for the existing 10-inch sewer main along Mill St (north of Ayr Hill Rd). A parallel relief sewer is recommended if the site conditions do not support removal and replacement of the existing line. Trenchless pipe construction methods such as pipe bursting could be considered as an alternative to open cut.
- In the NW sewershed, future sewer improvements between Mill Street and TOV Northside Property Yard are required to handle wet weather flows generated by the development of the Maple Ave Corridor. The existing 12-inch pipe should be upsized to a 15-inch size. These improvement costs should be generated by accessing an impact fee to the developers of the Maple Avenue Corridor.

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APPENDIX A

SEWERSHED MAP

VIENNA SANITARY SEWERSHED MAP

N

1 inch = 1,500 feet

NW Shed

NE Shed

SW Shed

SE Shed

Legend

Sanitary Gravity Main

DIAMETER

- 8
- 10
- 12
- 15
- 18
- 21

Sewershed

Id

- NW
- NE
- SW
- SE

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