ME MORANDUM

To: Deron Muehring, City of Dubuque

From: Eric Thompson, P.E. & Pat Ready, J.R., P.E.

Subject: Dubuque Comprehensive Sanitary Sewer Master Plan – Recommendations for Future RDII Investigations

Date: June 29, 2009

1. Introduction

Most sanitary sewer systems are designed for the peak diurnal wastewater flows with an allowance for infiltration and inflow. Typically, however, the infiltration and inflow allowance used in the original design of older sewer systems is significantly below the wet weather flows these systems actually experience. It is not uncommon for wet-weather peak flows to be an order of magnitude larger, or ten or more times the peaking factor, than the average daily flow of wastewater. Such large peak flows are primarily due to the numerous defects in the collection system caused by system deterioration and illegal connections over the years. In addition to excessive infiltration and inflow, a sewer system capacity can be taxed by population growth resulting in flows that exceed design flows.

Most capacity-related Sanitary Sewer Overflows (SSOs) are generally wet-weather related events. This memorandum documents the findings of a flow-metering study conducted on the trunk lines of the publicly owned sanitary sewer system in the City of Dubuque. The metering study included the installation of six flow meters at eleven locations throughout the City for a period of 11 months. Data collected from the flow meters was compared to data collected from three rainfall gauges owned and operated by the City. This data was used to determine the system response to rainfall events (wet weather) in terms of inflow and infiltration (RDII) and was used to characterize and prioritize portions of the sewer system for additional RDII studies. Upon completion of more localized studies, it is anticipated that the City of Dubuque will undertake RDII reduction projects to reduce wet weather flows within the sanitary sewer system.

2. City of Dubuque Flow Metering Program

During 2006 and 2007 the City of Dubuque operated six flow meters installed at eleven locations throughout system of sanitary sewer interceptors. **Table 1** below documents the dates and durations of the installation of each meter while **Map-1** on the following page identifies the location of each meter installation site.

Table 1
Summary of Flow Meter Installations
City of Dubuque Comprehensive Sanitary Sewer Master Plan Project

Meter	Location	2006				2007						
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July
1	Catfish Creek - North Fork Basin	19						14				
2	Catfish Creek - Middle Fork Basin	19						15				
3	Catfish Creek Basin	19						1				
4	Granger Creek Basin	18										24
5	32nd Street Basin	19										24
6	32nd Street Basin	19						14				
7	Kaufman Ave. Basin - South	19										24
8	Garfield Collector Basin	19			28		8-19					
10	Kaufman Ave. Basin - Sout							15				24
11	West Locust Basin - West										8-22	
12	1st Street Basin							29				24

The flow meters were area-velocity style meters and collected data for flow depth and velocity at 15-minute increments. This data was converted internally by the meter to produce volumetric flow rates, also on a 15-minute incremental basis.

The City of Dubuque operates three continuously recording rain gauges. These gauges are tipping-bucket gauges that record data at 5-minute increments with a minimum depth measurement of 0.01 inches. Installation of the rainfall gauges occurred in winter of 2006/2007 with data supplied for this study starting January 1, 2007. Rainfall data was obtained from the Iowa State Climatology Bureau for events prior to January 1, 2007. The data provided by the Climatology Bureau was incremental hourly data.

Rainfall data was reviewed to identify events of significance through a qualitative process which consisted mostly of determining whether a given event created a discernable effect on flow data recorded by the various flow gauges. There were 21 rainfall events selected through this process that occurred between September 19, 2006 and July 24, 2007, the period during which flow meters had been installed. The continuous record of flow data for each flow meter site was plotted against the corresponding record of rainfall data from the nearest rain gauge to the flow meter as determined by a Thiessen polygon method. The Wet Weather Flow (WWF) response (Rainfall Dependent Inflow and Infiltration, or RDII) observed in the flow record for each meter was characterized as presented in **Tables 1 and 2** below. The Dry Weather Flow (DWF) for each meter was determined by observing data from repeated weeks (Sunday through Saturday) occurrences where there was no rainfall occurring and where there was no apparent RDII response from antecedent rainfall events.

Table 1
Flow Meter Data
DWF, WWF and Peaking Factors

			Meter Location										
			1	2	3	4	5	6	7	8	10	11	12
A	DWF (cfs)	DWF	1.41	0.50	0.27	0.03	0.57	1.62	0.19	1.43	3.52	0.48	0.20
B	WWF (cfs)	Event 1: Sept. 21-22, 2006	2.12	0.76	0.45	I.D.	1.14	1.98	0.27	2.14			
B		Event 2: Oct. 10-11, 2006	N.F.D.	N.F.D.	N.F.D.	N.F.D.	N.F.D.	1.78	N.F.D.	N.F.D.			
B		Event 3: Oct. 21, 2006	2.52	N.F.D.	0.53	I.D.	0.96	2.03	0.33	2.09			
B		Event 4: Oct. 28, 2006	N.R.D.	N.R.D.	N.R.D.	N.R.D.	N.R.D.	N.R.D.	N.R.D.	N.R.D.			
B		Event 5: Nov. 10, 2006	2.25	0.80	0.31	I.D.	0.76	I.D.	0.31	1.85			
B		Event 6: Nov. 26, 2006	1.87	0.56	0.29	I.D.	1.07	1.54	0.42	1.65			
B		Event 7: Nov. 27-28, 2006	3.19	1.29	0.98	I.D.	1.76	2.43	0.38	2.16			
B		Event 8: Nov. 29, 2006	2.74	1.09	0.80	I.D.	1.58	2.43	0.36	2.34			
B		Event 9: Dec. 20-21, 2006	2.83	1.23	0.78	N.F.D.	1.63	I.D.	0.33	2.36			
B		Event 10: Mar. 21, 2007				I.D.	0.74		I.D.		5.01		N.F.D.
B		Event 11: Mar. 30, 2007				I.D.	0.58		I.D.		5.26		1.45
B		Event 12: Apr. 3, 2007				I.D.	1.83		0.33		7.35		2.50
B		Event 13: Apr. 24, 2007				I.D.	1.49		0.33		5.93		2.41
B		Event 14: May 31, 2007				I.D.	1.00		0.22		4.59		I.D.
B		Event 15: June 1, 2007				I.D.	I.D.		0.65		7.73		1.89
B		Event 16: June 2, 2007				I.D.	0.89		0.31		6.31		3.28
B		Event 17: June 21, 2007				I.D.	0.94		0.29		7.13	0.85	N.F.D
B		Event 18: July 3, 2007				I.D.	1.94		1.89		14.66		1.89
B		Event 19: July 16, 2007 A.M.				I.D.	0.76		0.45		10.29		0.65
B		Event 20: July 16, 2007 P.M.				I.D.	0.62		0.29		5.28		0.85
B		Event 21: July 17-18, 2007				I.D.	3.68		2.87		20.48		2.14
C	Peaking Factor	Average Peaking Factors:	1.77	1.91	2.19	I.D.	2.28	1.25	3.11	1.46	2.37	1.76	9.47
D		Max. Instantaneous Peaking Factor:	2.26	2.58	3.63	I.D.	6.45	1.50	15.13	1.65	5.82	1.76	16.38
E		Peak Hourly Volumetric Peaking Factor:	1.41	1.26	1.38	I.D.	1.65	1.27	5.10	1.36	2.19	1.64	12.06

Table 2
Comparison of Wet Weather Flow Responses for Each Metershed

Metershed	Average Peaking Factor	Max. Instantaneous Peaking Factor	Peak Hourly Volumetric Peaking Factor	10-State Standard Peaking Factor	Sewershed Area (ac)	Parcels per Acre (#/ac)	MHs per Acre (#/ac)	Pipe Length Per Acre (ft/ac)	Pipe Length (ft)	Inch-Miles of Pipe (in-miles)	RDII (Max Inst.) (gpd)
1	1.77	2.26	1.41	**2.99**	2,451	1.66	0.04	8.39	20,564	2,496	826
2	1.91	2.58	1.26	**3.57**	2,661	0.34	0.04	12.56	33,406	5,802	144
3	2.19	3.63	1.38	**3.68**	2,808	0.23	0.04	12.14	34,102	5,849	108
4	I.D.	I.D.	I.D.	**4.42**	394	0.01	0.02	6.00	2,361	333	I.D.
5	2.28	**6.45**	1.65	**3.31**	1,088	1.72	0.07	16.16	17,576	2,722	874
6	1.25	1.50	1.27	**3.44**	1,954	0.69	0.04	8.35	16,312	2,351	668
7	3.11	**15.13**	**5.10**	**3.50**	319	3.51	0.08	15.48	4,936	561	3,308
8	1.46	1.65	1.36	**3.62**	1,078	0.74	0.05	13.32	14,353	2,162	705
10	2.37	**5.82**	2.19	**3.04**	1,133	3.18	0.08	18.36	20,804	3,834	3,453
11	1.76	1.76	1.64	**3.43**	443	3.06	0.09	16.17	7,161	771	712
12	**10.52**	**18.20**	**12.06**	**3.43**	313	4.37	0.08	17.08	5,351	691	3,069

Table 1 contains Dry Weather Flow (DWF) and Wet Weather Flow (WWF) responses for 21 rainfall events collected during the metering period of September 2006 to July 2007. The data is summarized according to instantaneous peak, which can be indicative of 'inflow' portions of I/I and hourly and volumetric peak for the worst event, which can be indicative of infiltration components.

Note that there is some risk in assessments using instantaneous peaks when compared to average daily DWF values because the actual instantaneous peaking factor may appear reduced if the rainfall occurs at night during a diurnal trough in flows.

Also note that the 'worst' case rainfall event was the July 16 to 18 rainfall event. This event fell according to the following distribution:

65-hr (Total Event Duration) = 5.8 inches, Approximate return frequency = 22-yrs
24-hr = 4.25 inches, Approximate return frequency = 9-yrs
12-hr = 4.04 inches, Approximate return frequency = 14-yrs
6-hr = 3.87 inches, Approximate return frequency = 22-yrs
2-hr = 2.78 inches, Approximate return frequency = 10-yrs

So, instantaneous peaks may be higher than what might be expected for the City given that the design service level that the City decided upon was the 5-yr event.

Map-2 on the preceding page identifies the portion of the City tributary to each meter location. The 'metershed' drainage area was used to determine data presented in Table 3 regarding the number of parcels per metershed, the total length of pipe per metershed, and the inch-diameter-miles of pipe per metershed.

Table 3 contains a summary of the calculated peaking factors from Table 2 and provides comparison data from various peaking-factor evaluations discussed in section 4 including the 10-State Standards and EPA RDII evaluation methods. Data in this table is useful for comparing metersheds based on system composition and response to wet weather events. The data shows that metershed 5, 7, 10, and 12 have unusually high instantaneous peaking factors and meters 7 and 12 also have unusually high volumetric peaking factors.

Note that according to data presented in section 4 below, it might appear that the RDII values shown on the far-right column of Table 3 appear to be within allowable levels. However, this data is presented for comparison purposes only since the data that was used to determine sanitary sewer length and inch-diameter-miles was from unverified legacy-GIS data.

3. Observed Sanitary Sewer Overflows

Map-3 on the following page shows areas where the City has recorded events that resulted in sanitary sewer overflows. This is restricted mostly to the Upper

Catfish Branch (meter 1) and the W. Locust area (meter 11). The issues with the Catfish branch should be addressed by the recent system improvements as was validated in the modeling completed for the Comprehensive Sanitary Sewer Plan.

Unfortunately meter 11 has consistently poor data so there is no way to assess I/I problem magnitude in this areas from the meter study.

4. Historical Excessive Infiltration / Inflow Criteria

The following is a select list of criteria developed by the EPA for evaluation of whether sanitary sewer systems are experiencing excessive infiltration and/or inflow. This list was taken directly from *Sanitary Sewer Overflow Solutions, American Society of Civil Engineers, April 2004*.

EPA Program Requirements Memorandum (PRM 78-10, 1978)
Established 1500 gpdidm (gallons-per-day-per-inch-diameter-mile)as non-excessive leakage allowance, perform a cost effective analysis to determine if the leakage is possibly excessive and qualifies for investigation.

Draft Program Requirements (PRM 80, 1980)
Proposed 3000 gpdidm as non-excessive allowance, maximum of 30% infiltration removal for use in cost-effective analysis.

EPA Handbook: Procedures for Investigating Infiltration / Inflow, (EPA 68-01-4913, 1981)
Non- Excessive Allowance Ranges
2,000 – 3,000 gpdidm for sewer lengths greater than 100,000 lf
3,000 – 5,000 gpdidm for sewer lengths between 50,000 and 100,000 lf
5,000 – 8,000 gpdidm for sewer lengths between 1,000 and 50,000 lf

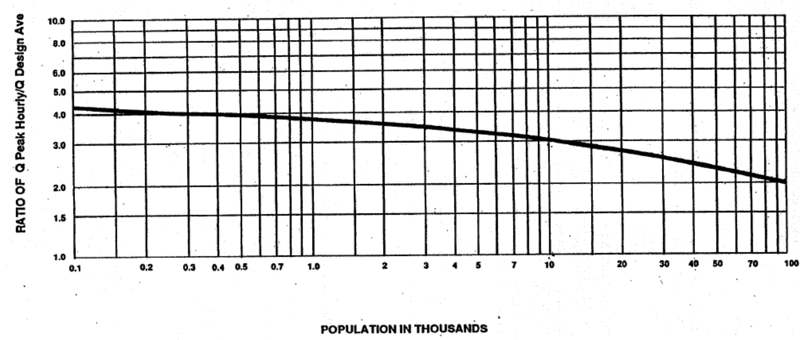
EPA Handbook: Facilities Planning, 1981
Non- Excessive Allowance Ranges
2,000 – 3,000 gpdidm for sewer lengths greater than 100,000 lf
3,000 – 6,000 gpdidm for sewer lengths between 10,000 and 100,000 lf
6,000 – 10,000 gpdidm for sewer lengths less than 10,000 lf

EPA Handbook: Sewer System Infrastructure Analysis and Rehabilitation (EPA 625/6-91/030, 1991)
Non-Excessive Infiltration
Preceding year's 7-14 day high ground water wastewater flow less than 120 gpcpd.
Non-Excessive Inflow
Total daily average storm flow less than 275 gpcpd.
No operational problems in collection system and WWTP.

In addition, the following standard is recommended in the publication, *Recommended Standards for Wastewater Facilities, Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2004.* This document is commonly referred to as the '10-state standards.'

Chapter 10 Engineering Reports and Facility Plans
11.243 Hydraulic Capacity for Wastewater Facilities to serve New Collection Systems.
a. The sizing of wastewater facilities receiving flows from new wastewater collection systems shall be based on an average daily flow of 100 gallons per capita plus wastewater flow from industrial plants and commercial facilities.
b. The 100 gal/cap/d figure shall be used which, in conjunction with a peaking factor from Figure 1, is intended to cover normal infiltration for systems built with modern construction techniques.

FIGURE 1.
RATIO OF PEAK HOURLY FLOW TO DESIGN AVERAGE FLOW



Q peak hourly: Maximum Rate of Wastewater Flow (Peak Hourly Flow)
Q design ave: Design Average Daily Wastewater Flow
Source: Q Peak Hourly/Q Design Ave $= \frac{18 + \sqrt{P}}{4 + \sqrt{P}}$ --- (P = population in thousands)

Fair, G.M. and Geyer, J.C. "Water Supply and Waste-water Disposal" 1st Ed., John Wiley & Sons, Inc., New York (1954), p. 136

5. Success of I/I reduction Programs

Although it is feasible to identify sources of I/I, it can be difficult to estimate the magnitude of individual sources and the potential success rate of rehabilitation projects on I/I reduction. The Environmental Protection Agency's (EPA) *Evaluation of Infiltration/Inflow Program Final Report, 1991* extensively evaluated the productiveness of I/I analysis and sewer rehabilitation. The first finding of the report says: "The EPA program was implemented to eliminate excessive I/I - generally this has not been accomplished." This stresses the caution that should be applied to I/I or Sanitary Sewer Evaluation Survey (SSES) estimates. They are not precise calculations. In many cases, I/I has continued to be excessive following rehabilitation. The limited success in removal of I/I is due to the multitude of opportunities in which I/I can enter the sanitary sewer system. Flow reductions are generally overstated because difficulties in estimating I/I arise when accounting for year-to-year environmental variations.

According to the EPA, the largest I/I sources in rehabilitated sewers are house service connections and non-rehabilitated pipe joints. While replacement of the sanitary sewer mains undoubtedly help reduce I/I into the sanitary sewer system, excessive RDII flows may continue to be a problem following completion of the improvements.

Experience in other communities the size of Dubuque indicates that I/I are typically only reduced by 10 to 15% through improvements to the public sanitary sewer system. A more comprehensive approach that also addresses laterals and sump pump cross connections will improve the likelihood of higher levels of reduction.

6. RDII Contributions from Public vs. Private Sewer Systems

Experience analyzing RDII in sanitary sewer systems shows that a variable amount of flow comes from private services. Determining the quantity based on past experience is not valid for estimating RDII in the City of Dubuque. There are two reasons for this; the first is that, generally speaking, there is too much variability from system to system; quantifying RDII amounts is difficult unless each service is metered. Since that is not feasible, smoke and dye testing is used to determine which services are contributing to large quantities of I/I. This can determine inflow from illegal cross connections of sump pumps, roof drains, and floor drains, or from old and deteriorated service laterals. It will assist in showing which particular private connections are the ‘big offenders’ but will not provide quantitative data suggesting ‘how big’.

The second reason that past experience cannot be applied to Dubuque is simple due to the fact that there is limited data available describing the complete extent of the sanitary sewer collection system. For example, under a previous engineering study, the City surveyed the entire trunk interceptor system and the first pipe segment for branch sewers, so there is a high level of confidence in the data describing the manholes and pipe connections for 62 miles of the sanitary sewer system. However, there is virtually no data available on the condition of pipes between manholes. The City also has a GIS database of information containing geometric descriptions of approximately 200 additional miles of branch lines, but there is little data beyond alignment, length, and diameter in this database. Presumably all the information in this system relates to publicly owned sewers, but that is not clearly indicated. There is currently no information available regarding the location, length, diameter, or condition of privately owned systems that connect to the public system.

7. Alternatives for investigating Infiltration and Inflow

It is assumed that, because the City of Dubuque owns several flow meters that the City will continue flow metering within areas of concern. Beyond this additional flow monitoring, the existing sewer system can be further evaluated by various observation techniques, in order to quantify the extent of impact throughout various priority areas. Observation techniques include physical surveys, manhole inspections, smoke testing, dye testing, and televising. Each is discussed further below:

a) Physical Survey

A physical survey of the sewer system is performed to isolate obvious problem areas and to determine the general condition of the sewer. The physical survey includes above ground evaluations and observations to evaluate such conditions as topography, streets, alleys, access to manholes, etc. Potential problem areas, such as waterways, river crossings, natural ponding areas, etc. are also identified. This activity is similar to that conducted for the sanitary sewer interceptors as part of the survey tasks of the Comprehensive Sanitary Sewer Master Plan project recently completed by the City.

b) Manhole Inspection

Manhole inspections include examining the physical conditions of manholes and documenting observations made. Manhole defects are documented, including:

- Broken, Cracked or missing manhole covers
- Broken or cracked frames;
- Deteriorated or defective cones
- Deteriorated or defective wall segments
- Root Intrusion; and / or
- Deteriorated or defective pipe seals;

c) Home Inspections

Home inspections involve door-to-door canvassing to check for floor drain or sump pump connections to the sanitary sewer system.

d) Smoke Testing of Sewer Segments

Smoke testing is an inexpensive and quick method for determining and detecting sources of inflow within sewer systems. A non-toxic, non-staining low-pressure smoke is pumped through a manhole into the sewer pipe for distances up to 600 feet. Smoke plumes from manholes and from the ground indicate defects in manholes, sewer lines, and sewer laterals through which I/I may enter the sewer. Many inflow sources can be located in this manner, including:

- Roof Leaders,
- Cellar, yard and area drains;
- Foundation drains;
- Abandoned building sewers;
- Faulty sewer connections;
- Illegal connections;

- Sewer Cross connections;
- Structural damages; and
- Leaky joints

Smoke testing is also a procedure to assist in localizing the areas to televise to find the exact locations of faulty joints and pipes. This is primarily completed for public sewer mains and manholes, but can be used to determine breaks in private laterals.

e) Dye Testing

Dye testing can be used to further investigate areas of inflow when possible contribution sources did not become evident through conventional smoke testing. Dye can be added to roof drains, sump pumps, etc. and used in conjunction with televising; televising would be used to monitor the sewer mains to determine if the dye was flowing into the main sewer lines, thus showing illegal cross connections.

f) Televising

Televising is a procedure where a video camera is pulled through sewer mains and assists in determining exact locations of failures in pipes and manholes. Televising can be used alone or in conjunction with dye testing. Televising is the best way to localize the areas of infiltration.

8. Recommendations

Four problem metersheds (5, 7, 10 & 12) were identified when comparing peaking factors and metershed data. A fifth problem metershed is known due to reported complaints; that being metershed 11.

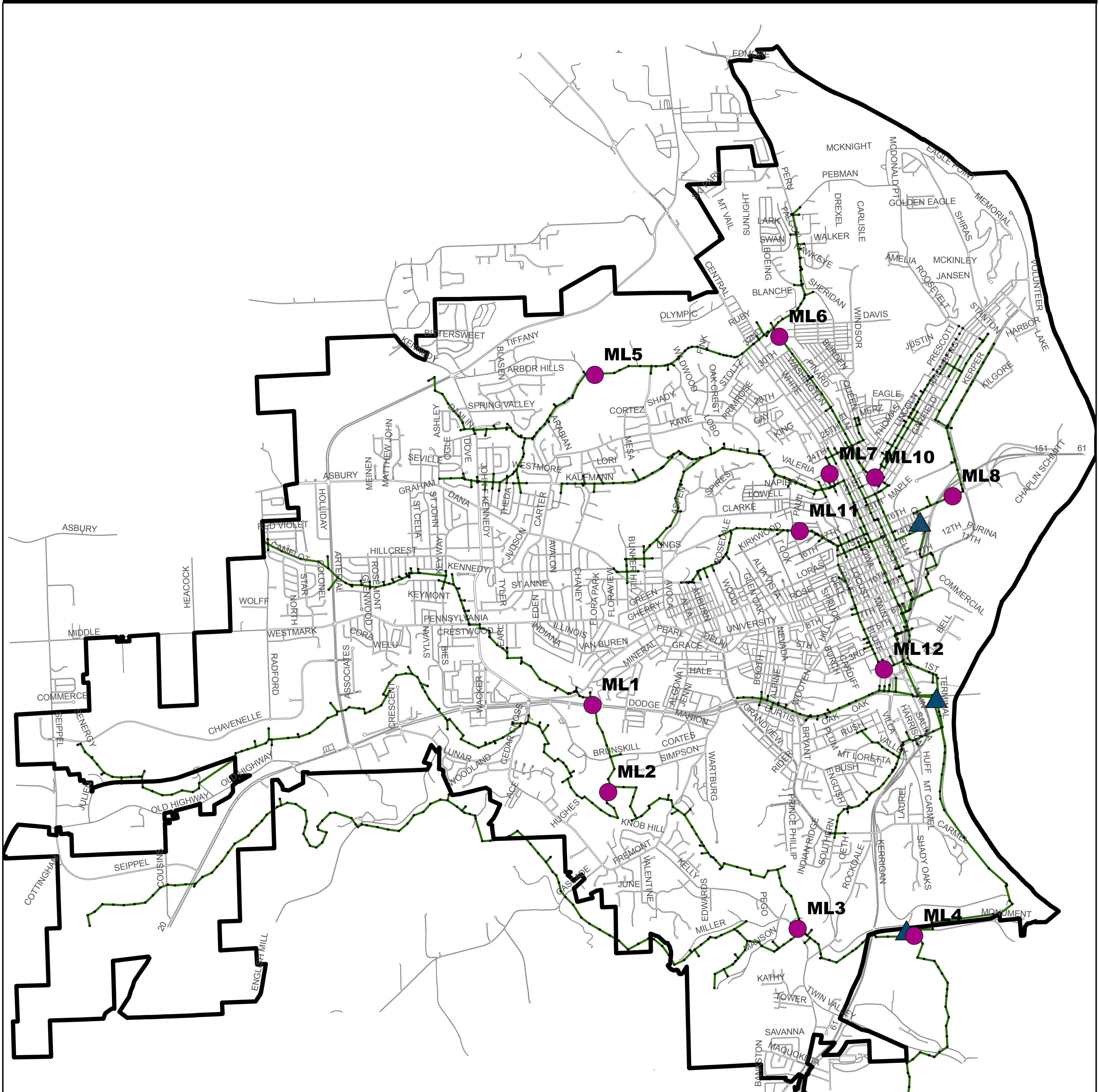
It is recommend that additional I/I studies for the previously listed sewersheds be conducted according to the following orders of priority:

#1 - Metershed 11, simply because of known problems.
#2 - Metershed 12, because of very high volumetric and instantaneous peaking factors.
#3 - Metershed 7, because of very high volumetric and instantaneous peaking factors (although less than meter 12)
#4 - Metershed 5, because of high instantaneous peaking factors
#5 - Metershed 10, also because of high instantaneous peaking factors.

In addition to redeployment of flow meters within these basins, it is recommended that the City conduct additional studies including smoke testing, televising, and, if necessary, dye testing.

It is recommended that smoke testing be utilized in each prioritized sub-basin. It is an easy, inexpensive way to determine large contributors of inflow. This should also be used in conjunction with manhole inspection and a physical survey of the sub-basins.

Once sub-basins have been prioritized it is recommended to complete televising in the biggest problem areas of each sub-basin to determine exact locations of needed repair. If further investigation is needed, dye testing should be used in a case by case basis to determine if specific storm or drain connections are illegally connected to the sanitary sewer system.



Duration of Flow Meter Installations

		2006				2007						
Meter	Location	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
1	Catfish Creek - North Fork Basin	19						14				
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8	Garfield Collector Basin	19			28		8-19					
10	Kaufman Ave. Basin - Souht							15				24
11	West Locust Basin - West										8-22	
12	1st Street Basin							29				24

Flow Meter Locations

MAP-1

City of Dubuque *Dubuque County, Iowa*

Legend

- Meter Locations
- Lift Stations
- Dubuque City Limits
- Sanitary Manholes
- Sanitary Mains
- Street Curblines

Feet

0 4,000 8,000

Sources:
- City Base Data

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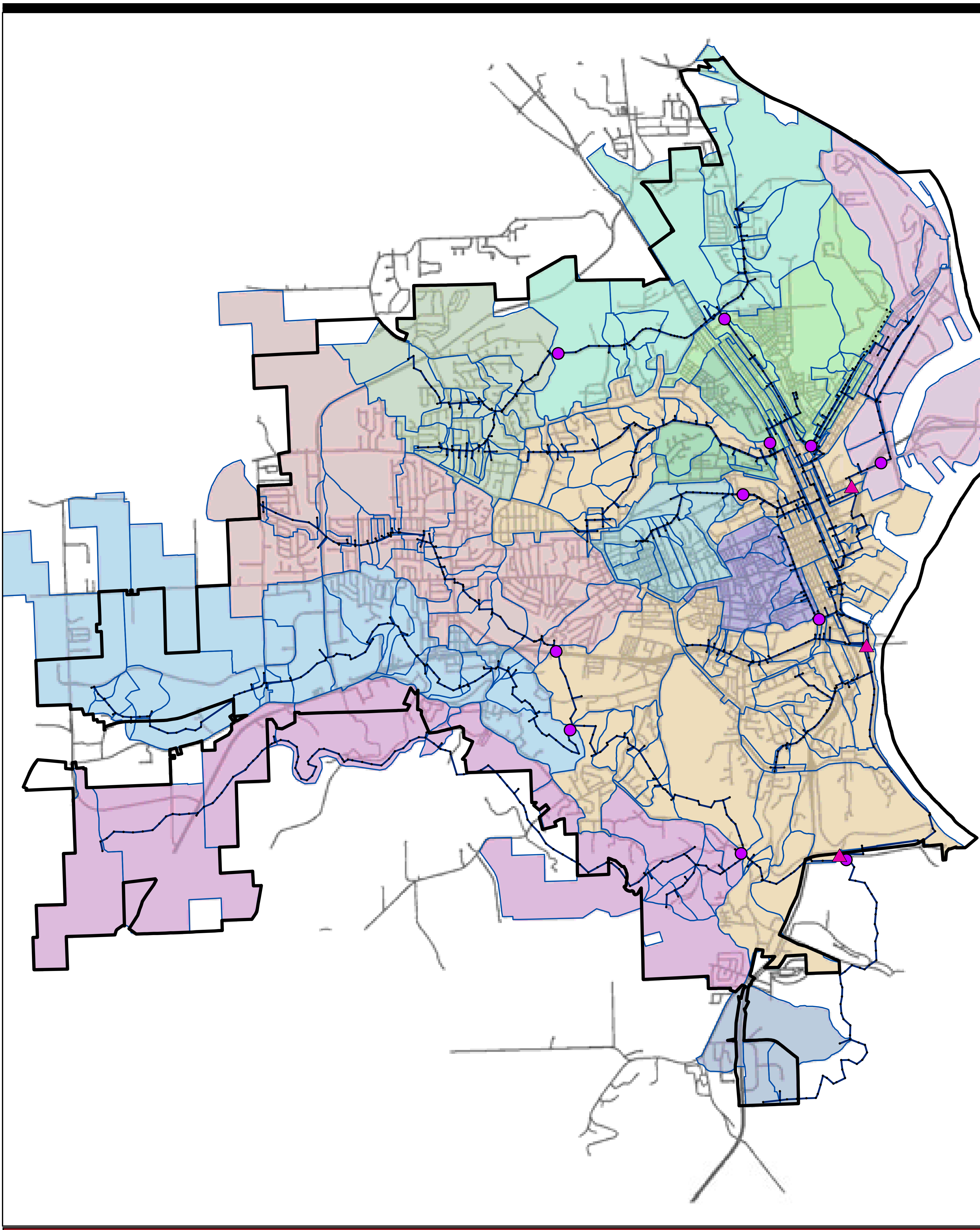

Sub-Sewersheds

MAP-2

City of Dubuque

Dubuque County, Iowa

Legend

- Lift Stations
- Meter Locations
- Dubuque City Limits
- Sanitary Manholes
- Sanitary Mains
- Sub-Sewersheds

Metersheds

1	6	12
2	7	Not Flowing to Meter
3	8	
4	10	
5	11	

Feet

0 4,000 8,000

Sources:
- City Base Data

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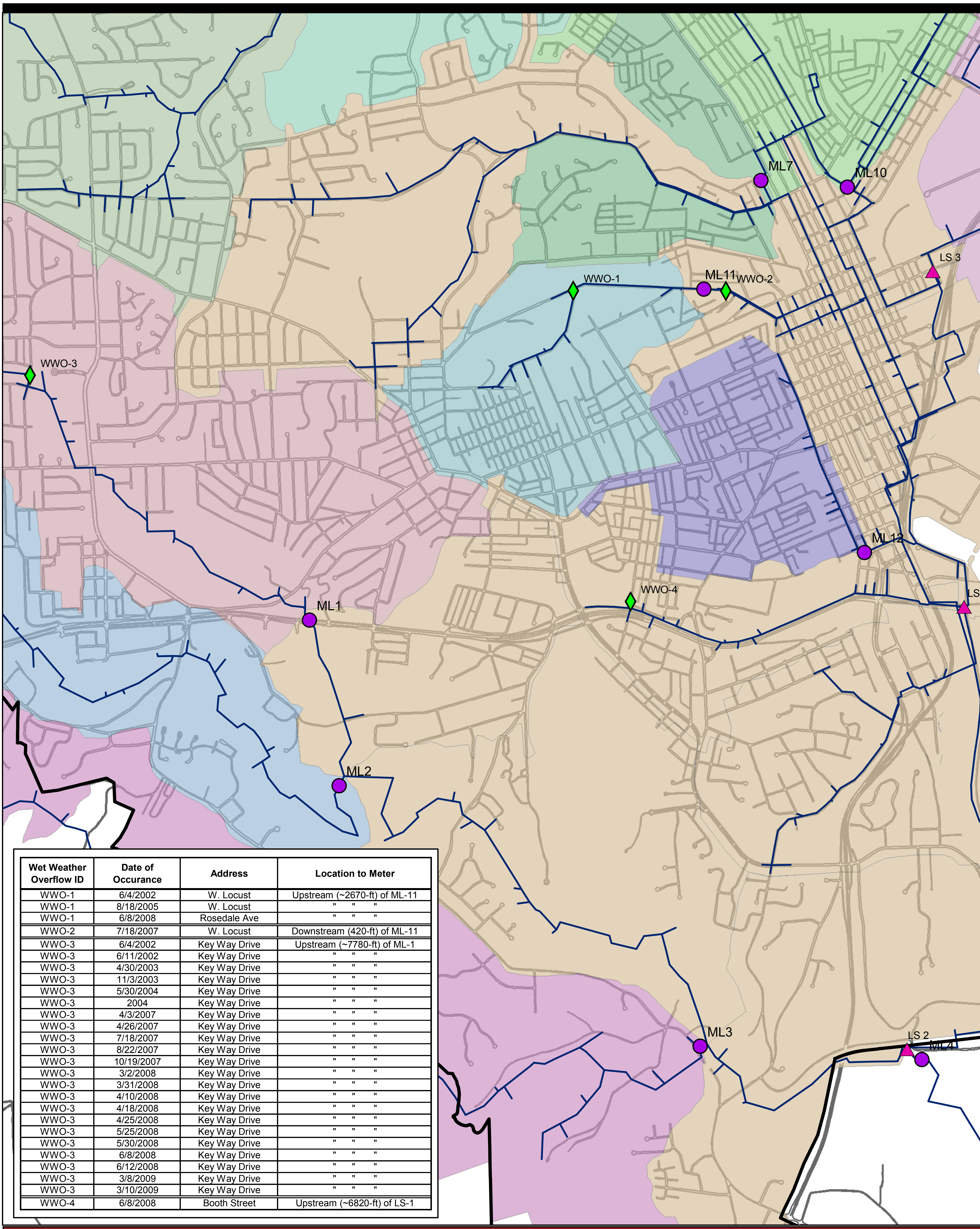

Wet Weather Overflow ID	Date of Occurance	Address	Location to Meter
WWO-1	6/4/2002	W. Locust	Upstream (~2670-ft) of ML-11
WWO-1	8/18/2005	W. Locust	" " "
WWO-1	6/8/2008	Rosedale Ave	" " "
WWO-2	7/18/2007	W. Locust	Downstream (420-ft) of ML-11
WWO-3	6/4/2002	Key Way Drive	Upstream (~7780-ft) of ML-1
WWO-3	6/11/2002	Key Way Drive	" " "
WWO-3	4/30/2003	Key Way Drive	" " "
WWO-3	11/3/2003	Key Way Drive	" " "
WWO-3	5/30/2004	Key Way Drive	" " "
WWO-3	2004	Key Way Drive	" " "
WWO-3	4/3/2007	Key Way Drive	" " "
WWO-3	4/26/2007	Key Way Drive	" " "
WWO-3	7/18/2007	Key Way Drive	" " "
WWO-3	8/22/2007	Key Way Drive	" " "
WWO-3	10/19/2007	Key Way Drive	" " "
WWO-3	3/2/2008	Key Way Drive	" " "
WWO-3	3/31/2008	Key Way Drive	" " "
WWO-3	4/10/2008	Key Way Drive	" " "
WWO-3	4/18/2008	Key Way Drive	" " "
WWO-3	4/25/2008	Key Way Drive	" " "
WWO-3	5/25/2008	Key Way Drive	" " "
WWO-3	5/30/2008	Key Way Drive	" " "
WWO-3	6/8/2008	Key Way Drive	" " "
WWO-3	6/12/2008	Key Way Drive	" " "
WWO-3	3/8/2009	Key Way Drive	" " "
WWO-3	3/10/2009	Key Way Drive	" " "
WWO-4	6/8/2008	Booth Street	Upstream (~6820-ft) of LS-1

Wet Weather Overflow Locations

MAP-3

City of Dubuque — *Dubuque County, Iowa*

Legend

- Lift Stations
- Meter Locations
- Dubuque City Limits
- Sanitary Manholes
- Sanitary Mains
- Sub-Sewersheds

Metersheds: 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, Not Flowing to Meter

Wet Weather Overflow Locations

Feet: 0, 1,800, 3,600

Sources:
- City Base Data

MSA PROFESSIONAL SERVICES — TRANSPORTATION • MUNICIPAL • REMEDIATION DEVELOPMENT • ENVIRONMENTAL

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