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2019 DRAFT: SRF PROJECT PLAN
LONG TERM CORRECTIVE ACTION PLAN
FOR IMPROVEMENTS TO THE
Wayne County Rouge Valley Sewage Disposal System

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Acronyms

AM – Asset Management

AMP – Asset Management Plan/Program

CSO – Combined Sewer Overflow

DWSD – Detroit Water and Sewerage Department

FDD – Footing Drain Disconnection

FOA 2117 – Final Order of Abatement 2117

GLWA – Great Lakes Water Authority

HGL – Hydraulic Grade Line

H/H – Hydrologic/Hydraulic

LTCAP – Long Term Corrective Action Plan

LS1A – Lift Station 1A

MACP – Manhole Assessment Certification Program

MDEQ – Michigan Department of Environmental Quality

NPDES – National Pollutant Discharge Elimination System

RTB – Retention Treatment Basin

RTU – Remote Terminal Unit

RVSDS – Rouge Valley Sewage Disposal System

SCADA – Supervising Control and Data Acquisition

SSO – Sanitary Sewer Overflow

STCAP – Short Term Corrective Action Plan

WCDPS – Wayne County Department of Public Services

WRRF – Water Resource Recovery Facility

WTUA – Western Townships Utilities Authority

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1 EXECUTIVE SUMMARY

1.1 *INTRODUCTION*

The Rouge Valley Sewage Disposal System (RVSDS) transports wastewater collected by 12 municipalities in Wayne County and 1 municipality in Oakland County to the regional wastewater system and Water Resource Recovery Facility (WRRF) owned by Detroit Water and Sewerage Department (DWSD) and operated by the Great Lakes Water Authority (GLWA). The RVSDS is owned by Wayne County and operated by its Department of Public Services (WCDPS). In 1989, Wayne County and the Michigan Department of Environmental Quality[1] (MDEQ) entered a Final Order of Abatement #2117 (FOA 2117), most recently amended in July 2015, to resolve Sanitary Sewer Overflows (SSOs) in compliance with the revised MDEQ SSO Policy. Numerous studies and system improvements have been completed over the years in order to meet the revised regulatory requirements. An initial comprehensive system-wide evaluation was completed in 2007. This study led to the development and implementation of a Short Term Corrective Action Plan (STCAP) completed in June 2012. Work subsequently began on the development and implementation of a Long Term Corrective Action Plan (LTCAP). Work has been completed under Phase 1 of the LTCAP, which included additional flow metering and continued system inspections. Phase 2 of the LTCAP includes the development of recommended capital improvements to address SSOs and to ensure operational efficiency, structural integrity, hydraulic capacity and longevity of the system; these necessary improvements are identified and evaluated in this Project Plan submitted to MDEQ for funding consideration under the State Revolving Fund (SRF). The RVSDS Work Plan for the LTCAP is provided in Appendix B.

The planning level cost estimate for the recommended alternative is approximately $50 million during the first five years (see Section 4). Additional investments will likely be necessary for locally owned wastewater assets tributary to the RVSDS in order to continue reductions in inflow/infiltration from local collection systems.

1.2 REGULATORY REQUIREMENTS

This SRF Project Plan is a component of the RVSDS LTCAP which is a required component of the Fourth Amended Final Order of Abatement #2117 (FOA 2117), (AACO-000031). The WCDPS has worked very closely with the MDEQ to keep them informed of significant findings during the system investigations and as system improvements have been implemented. Wayne County also submits Annual Progress Reports for FOA 2117 to MDEQ and RVSDS communities. The MDEQ has carefully reviewed the findings and worked with WCDPS to implement reasonable adjustments to the schedule for completing the requirements of FOA 2117, where they determined it was warranted. Table 1-1 shows the key remaining milestones, as defined in the Fourth Amendment to FOA 2117.

[1] As of April 22, 2019, the Michigan Department of Environmental Quality is now known as Environment, Great Lakes and Energy. This report was written before the official name change. All references to the MDEQ, also references EGLE.

Table 1-1: FOA 2117 – Key Remaining Milestones (As Defined in the Fourth Amendment to FOA 2117 and the November 2015 LTCAP Work Plan)

Milestone	Completion Date
Submittal of LTCAP Strategy and Schedule	06/29/2016
Extended Flow Metering Period	07/1/2017
Submittal of LTCAP/SRF Project Plan	06/29/2019
Completion of Capital Projects – Full Compliance	12/30/2022

1.3 PREVIOUS INVESTIGATIONS AND IMPROVEMENTS

In performing the STCAP and LTCAP implementation, monitoring, and evaluations, several issues have been identified and addressed. Although this has resulted in extensions to schedules and additional short-term costs, it has also resulted in a better understanding of system performance during large wet weather events. This has led to a more comprehensive, yet more focused understanding of the critical needs for system improvements. The most recent asset management efforts have focused on the inspecting and repairing manholes within the 1-year and 2-year floodplain of the Rouge River, cleaning and televising siphons and restrictions, adding vents to minimize hydraulic deficiencies, and flow monitoring in key locations. The wet weather monitoring team was formed to better understand system performance during storm events. Information about the RVSDS within Wayne County's Geographic Information System (GIS) is continuously updated as new projects are completed.

1.4 HYDRAULIC AND HYDROLOGIC MODEL STATUS

A Hydrologic and Hydraulic (H/H) model) of the RVSDS service area and wastewater assets was developed in EPA SWMM for a 25-year, 24-hour storm event. The model has been calibrated and validated with flow meter data from 2013 through 2017. The WCDPS has a long-established flow and rainfall monitoring program for the RVSDS, which provides data for evaluating system performance. A summary of the H/H modeling analysis completed for the RVSDS is included in the Appendices section of this report.

1.5 IDENTIFICATION OF POTENTIAL SYSTEM IMPROVEMENT ALTERNATIVES

During the development of the LTCAP, locations within the RVSDS were identified where improvements are needed to remediate SSOs for the design storm event and/or provide better operational efficiency, structural integrity, and hydraulic capacity of the RVSDS assets. For example, segments of the interceptors that have historically been suspected of having insufficient hydraulic capacity to convey the 25-year, 24-hour design event include:

1. Middle Rouge Interceptors from Merriman Road downstream to LS1A, and
2. Inkster Arm, with observed SSOs at the Bell Branch, north of 5 Mile Road.

Initial recommendations for system improvements are outlined in the documents "Work Plan for Long Term Corrective Action Plan (November 2015)" and "Long Term Corrective Action Plan: Project Plan Summary (August 2018)" submitted to MDEQ. The recommendations for system improvements were organized into four components:

1. Asset Management (AM)
   - Remove River Inflow
   - Address Hydraulic Capacity and Structural Integrity
   - Optimize Combined Sewage Overflow (CSO) Capture via Operational Modifications
   - Lift Station 1A (LS1A) Screening Improvements / Lower Rouge Interceptor Isolation
2. Wet Weather Storage
   - Middle Rouge Interceptor Storage
3. Ancillary Projects
   - Line Connection Siphon (Lower Rouge Interceptor)
   - Resolve Boundary Conditions at RVSDS Connections to Great Lakes Water Authority Northwest Interceptor
   - Wet Weather Flow Control for RVSDS Inkster Arm
4. Community-Specific Projects
   - Hydraulic improvements to local connections to the RVSDS

1.6 APPROACHES TO SYSTEM IMPROVEMENT ALTERNATIVES

Alternatives for system improvements were developed with each representing a different scenario of future conditions. The goals of each alternative are to eliminate SSOs from RVSDS during the design storm, primarily by eliminating wet weather inflow and infiltration into the system, and to provide system integrity and longevity. The alternatives represent varying levels of success in achieving these goal, and present options for addressing the remaining issues. The potential alternatives assessed in this SRF Project Plan are summarized in Table 1-2.

Table 1-2: Project Alternatives for RVSDS LTCAP

Alternative 1	Asset Management Plan is fully implemented, including local wet weather flow reduction projects to the point that no further projects are necessary
Alternative 2	Asset Management Plan is fully implemented, although local wet weather flow reductions were not sufficient enough to eliminate all SSOs for the design event. Additional storage along the Inkster Arm and the Middle Rouge Interceptor is necessary.
Alternative 3	Decentralized storage only (no asset management). Install several storage facilities along the Middle Rouge Interceptor as well as storage on the Inkster Arm.
Alternative 4	Conveyance and Centralized Storage only (no asset management). Conveyance and centralized storage projects include construction of large interceptors to convey the design event to JC 2-8 and store the wet weather volume at a single location at the downstream end of the Middle Rouge Interceptor, near LS1A.
Alternative 5	Conveyance and Treatment. Same as Alternative 4, but with a localized Water Resource Recovery Facility.

1.7 KEY RECOMMENDATIONS

Alternative 1 represents the most cost-efficient approach to controlling SSOs and to ensure operational efficiency, structural integrity, hydraulic capacity and longevity of the system; and thus Alternative 1 is the recommended alternative (See Section 4 for alternative descriptions and Section 5 for a detailed description of Alternative 1). Alternative 1 focuses on a system-wide Asset Management Plan, including the removal of river-dependent inflow, sewer pipe inspection and rehabilitation, junction retrofits, optimizing combined sewer overflow (CSO) regulator flows to the RVSDS, and improvements to LS1A. This alternative also addresses a hydraulic bottleneck on the Lower Rouge Interceptor. Asset Management (AM) is a critical component of effective utility management that focuses on the long-term operability through targeted but ongoing investments in key system assets. For the RVSDS, the AM components include:

- River inflow reduction (Wayne County and local system components)
- Sewer system rehabilitation and hydraulic improvements (Wayne County and other local system components that exist within the Middle Rouge floodplain)
- CSO regulator flow control from combined sewer service areas, and
- Operational improvements at RVSDS Lift Station 1A (LS1A)

The AM efforts have begun and will continue to ramp up as the County is able to adjust sewer rates to RVSDS communities to meet the defined revenue needs. Beyond the first five years, the impacts of these system improvements will be measured; if additional controls are needed to address SSOs, then Alternative 2 will be implemented, which includes targeted wet weather storage along the Inkster Arm and the Middle Rouge Interceptor.

1.8 COST APPORTIONMENT AND AFFORDABILITY

The Alternative 1 costs are intended to be treated as a common-to-all cost that will be allocated to all RVSDS communities using the same cost apportionment methodologies used to establish rates for existing operation & maintenance (O&M) and capital improvement projects. This strategy was discussed among the RVSDS customer communities in 2017 and 2018. All existing RVSDS customers concurred that this is the appropriate cost apportionment strategy.

The representatives of the RVSDS communities participated in a series of Long-Term Corrective Action Plan (LTCAP) cost allocation meetings from August 2017 through March 2018:

- August 16, 2017
- September 20, 2017
- November 1, 2017
- January 8, 2018
- March 21, 2018

The goal of this work group was to discuss various potential methods to allocate the costs as recommended in this Project Plan and communicate a method to Wayne County for implementation.

The likely projects to be recommended in the SRF Project Plan were presented to the RVSDS communities; these projects comprised of four components:

1. Asset Management Projects (Alternative 1)
2. Ancillary Projects (Alternative 1)
3. Wet Weather Storage Projects (Alternatives 2, 3, and 4)
4. Community-Specific Projects

The Asset Management and Ancillary Projects components (Alternative 1 in this Project Plan) focus on restoring and maintaining system integrity and modifications that are intended to reduce or eliminate the need for wet weather storage. The representatives of the RVSDS communities agreed that costs for these components of the LTCAP should be allocated common to all, either within the RVSDS sewer rates or in a manner similar to the RVSDS sewer rates.

Determination of a cost allocation method for the Wet Weather Storage Projects has been deferred. The representatives of the RVSDS communities felt that this was appropriate since the projects outlined in Alternative 1 of this Project Plan have the potential to significantly impact the need for, size of, and location of any wet weather storage. As the wet weather storage projects become more well defined (2023 and beyond), the representatives of the RVSDS communities intend to reconvene to discuss cost allocation for these types of projects.

Costs for the Community-Specific Projects component (e.g., line connections – see Section 5) are to be allocated to the community served by each Community-Specific Project.

Summary of Conceptual Costs

The conceptual cost estimates for Alternatives 1-5 in this Project Plan are detailed in Sections 4 and 5 and cover the anticipated costs over the 20-year planning horizon. The likely cost scenarios, based on the recommended Alternative, are as follows:

- Years 1 – 5: Additional $10.3 million per year (5-year average) above the current annual expenditures

- Years 6 – 10: Additional $2.5 million per year above the current annual expenditures ***(if no wet weather storage is needed)***

  OR

- Years 6 – 10: Additional $11.9 million per year (5-year average) above the current annual expenditures ***(Alternative 2: wet weather storage is required)***

- Years 11 – 20: Additional $1.7 million per year above the current annual expenditures (ongoing Asset Management activities)

The existing annual expenditures for the RVSDS, as detailed in the proposed Rate Package (FY2019/2020), are approximately $57.5 million per year. Based on the recommended projects in the Project Plan, the fixed charges will increase by different amounts each year, based on the timing of key components of Alternative 1. These expenditures will have the following approximate impact on rate increases:

- Years 1 – 5: 7.3% rate increase*
- Years 6 – 10: 4.3% rate increase* (no wet weather storage)

  OR

- Years 6 – 10: 20.7% rate increase* (Alternative 2: wet weather storage)
- Years 11 – 20: 3.0% rate increase*

* *These increases reflect the components of this Project Plan only and do not reflect additional rate increases due to increased disposal costs paid to the GLWA.*

The rate increases listed above assume that the cost allocations will be assigned to RVSDS communities similar to the methodology outlined in the FY2019/2020 Proposed Rate Package for the RVSDS. See Section 5 for a cost allocation table by municipality.

Affordability

During the cost allocation outreach effort in 2017-2018, feedback was sought on whether any of the RVSDS communities have any affordability issues as related to the EPA guidance on water/sewer rate affordability. Based on the feedback we received, there are concerns about individual communities and their current burden with respect to sewer rates as compared to median household income.

Based on feedback received from the City of Inkster, they have previously coordinated with the MDEQ on their financial capability and the City of Inkster demonstrated that they were a High Burden Community, based on a Residential Indicator score of 2.1% and permitted financial capability score of 1.33.

The proposed cost allocation framework and the presence of at least one municipality with affordability limitations may impact the scope and schedule of projects as recommended in this Project Plan.

Future Rate Package

The cost allocations described in this document are based on the recently submitted FY2019/2020 Rate Package, adjusting for the removal of flows from Plymouth Township, Northville Township, and Canton Township, pending termination of services to WTUA communities.

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2 PROJECT BACKGROUND

2.1 INTRODUCTION

The RVSDS transport wastewater from a service area approximately 215 square miles in size located in all or part of 12 municipalities in Wayne County (Dearborn Heights, Garden City, Inkster, Livonia, Northville (City), Plymouth (City), Redford Township, Romulus, Van Buren Township, Wayne, Westland and the Wayne County Airport Authority) and 1 municipality in Oakland County (City of Novi)

The RVSDS discharges wastewater to the regional wastewater system owned by the Detroit Water and Sewerage Department (DWSD) and operated by the Great Lakes Water Authority (GLWA) for transport, treatment, and disposal. The RVSDS is managed by the Wayne County Department of Public Services Environmental Services Group ("WCDPS" or "Wayne County"). A map of the RVSDS interceptor system is shown in Appendix A.

2.1.1 CULTURAL RESOURCES

There are no known historical or archaeological sites located within the project area. The existing system is located in areas disturbed by previous construction activity. New construction would likely take place within areas of previous disturbance. Eleven Native American communities were contacted to solicit input on the locations of historical sites.

2.1.2 NATURAL ENVIRONMENT

The project area is located in a predominately urban setting in the metropolitan Detroit area. Parks and green spaces are scattered throughout the area. The natural features of the project area are outlined below.

Wetlands

Numerous wetlands are present in the project area. The wetlands were mapped based on data from the Michigan Resource Information System (MIRIS), National Wetland Inventory (NWI), and NRCS soils. If any projects are within a wetland, application for appropriate permits will be submitted to the MDEQ.

Coastal Zones

The project area is entirely outside the Great Lakes Coastal Zone Region, as mapped by MDEQ.

Floodplains

The RVSDS roughly parallels the Lower Rouge River and the Middle Rouge River, and many components are located within the 1- and 2-year floodplain of the rivers. If a construction project occurs within the 100-year floodplain, application for appropriate permits will be submitted to the MDEQ.

Natural or Wild and Scenic Rivers

According to the Natural Rivers Unit of the Land and Water Management Division of MDEQ, there are currently no natural or scenic rivers within the project area.

Major Surface Waters

The Rouge River and its tributaries (Middle Rouge and Lower Rouge) are the primary waterbodies in the project area. Several small lakes and ponds are scattered throughout the area.

Recreational Facilities

Several recreational facilities are present in the project area including Hines Park, Nankin Mills Recreation Area, Elm Grove Recreation Area, Wayne County Dog Park, Merriman Hollow Park, Sherwood Recreation Area, Perrin Recreation Area, Nolar Bend Recreation Area, Parr Park, Helms Haven Recreation Area, Parkland Recreation Area, Bell Creek Park, Lower Rouge Parkway and Rouge Park.

Topography

The project area is located on a flat glacial lake plain. The topography generally slopes east, following the flow of the River Rouge and its tributaries (Lower and Middle Rouge). Elevations range from approximately 810 feet (above mean sea level) in Northville to about 590 feet in Dearborn Heights.

Geology

According to the Soil Survey of Wayne County Area, Michigan (USDA, 1977), the geologic material of Wayne County is predominantly glacial drift with underlying dolomite bedrock. Small pockets of shale bedrock and sandstone are present along the east edge of the County.

Soils

The soils in the project area vary widely. The predominant soils include a Cohoctah fine sandy loam (Hydrologic Soil Group A/D), Thetford loamy sand (Hydrologic Soil Group A/D), Ceresco-Sloan complex (Hydrologic Soil Group B/D), and Sloan silt loam (Hydrologic Soil Group B/D). *It should be noted that the RVSDS service area is an urban environment, where the USDA soils data presented herein may have been altered due to likely soil disturbance and compaction during urban development.*

Agricultural Resources

The project area is located in a highly urbanized environment. There are no significant agricultural resources within the project area.

Flora and Fauna

There are no known threatened or endangered species present in the areas impacted by proposed improvements in the project area. The existing species are typical of urban environments. Endangered species reviews will be performed on an as-needed basis for specific projects as they are selected for design and construction.

Air Quality

Air quality in the area can become a concern during the summer months. High temperatures and stagnant air periodically results in elevated levels of ozone and other pollutants. The RVSDS does not contribute significantly to any air quality issues. System vents and non-airtight components release gases from the system, but likely do not account for any impacts to the ambient air quality.

2.1.3 LAND USE

The land use within the project area is a mix of developed residential, industrial, commercial and green spaces in northwest Wayne County and a small segment of southwest Oakland County. The project area roughly parallels Edward Hines Drive along the Middle Rouge River, and Michigan Avenue along the Lower Rouge River. Numerous parks are situated within the project area. Any significant changes to the area would be of the redevelopment and reconstruction type. Land use data for each of the RVSDS communities is shown in Table 2-1 below. The data shown includes portions of the communities not serviced by the RVSDS.

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Table 2-1: Land Use for Communities Within the RVSDS Service Area

Developed Land (acres)	Dearborn Heights	Garden City	Inkster	Livonia	Northville	Novi	Plymouth	Redford Twp	Romulus	Van Buren Twp	Wayne	Westland
Commercial	10,357	218	266	2,032	368	1,973	186	390	74	176	357	1,712
Government/Institutional	8,705	238	271	2,024	541	1,390	93	485	0	431	214	681
Industrial	13,512	63	135	2,537	418	1,341	99	427	689	2,239	783	530
Airport	4,954	0	0	0	0	0	0	0	4,881	0	0	0
Multiple-Family Residential	2,531	26	105	165	289	381	56	22	0	29	98	675
Single-Family Residential	58,634	2,250	1,800	10,171	5,223	7,388	535	3,379	799	1,597	1,066	5,675
Total Developed	98,692	2,796	2,578	16,928	6,839	12,473	968	4,703	6,444	4,471	2,517	9,274
Undeveloped Land (acres)												
Parks, Recreation and Open Space	8,405	68	36	1,515	2,332	1,124	14	64	0	199	99	250
Transportation Corridor/Utilities	22,434	888	889	4,085	1,135	2,762	312	1,864	109	898	741	2,084
Agricultural	1,553	0	0	0	0	19	0	0	0	463	0	0
Water	640	0	0	16	301	160	1	4	8	47	0	5
Total Undeveloped	33,032	955	925	5,616	3,768	4,065	327	1,933	117	1,608	840	2,338

*Source: SEMCOG 2008 Land Use data *(does not include Northville Township, Plymouth Township, and Canton Township, as only small components of these communities upon execution of the planned termination of RVSDS service to WTUA)*

2.2 POPULATION DATA

In order to effectively plan and design RVSDS projects that will maintain the desired level of service in the future, a population project was analyzed for year 2040. Existing populations and future populations were previously developed as part of the master planning process for the RVSDS. These are summarized in the following documents.

Existing Populations

The 2010 Census population of the RVSDS service area is roughly 404,849 residents and the estimated 2015 SEMCOG population is 400,528. See Appendix F for additional details on population projections.

For H/H modeling of the RVSDS, the future population growth was considered, but determined not to be a factor; this is primarily due to the impacts of projects declining populations in the service area. The hydrologic/hydraulic model was developed based on 2010 Census data. Based on the projections for an overall reduction in RVSDS population over the next 25 years, the existing populations were used as a more conservative (higher) estimated baseflow. Table 2-2 lists the estimated and projected populations within the RVSDS service area. The majority of communities are projected to experience a decline in population from 2015 to 2040, except City of Novi and Van Buren Township.

***Table 2-2*: Existing and Projected Residential Populations within the RVSDS Service Area**

Municipality	2010 Census	Year 2015 SEMCOG Estimated Population	Year 2040 SEMCOG Projected Population
Dearborn Heights*	37,287	36,004	35,278
Garden City	27,692	25,709	25,010
Inkster	25,369	23,806	20,612
Livonia	96,942	96,589	92,353
Northville	2,739	2,570	2,360
Novi*	51,096	53,816	53,569
Plymouth	9,132	8,940	8,369
Redford Township*	44,354	42,921	39,054
Romulus*	2,429	2,275	2,297
Van Buren Township*	6,122	6,627	6,428
Wayne	17,593	17,213	16,250
Westland	84,094	84,058	78,602
Total	**404,849**	**400,528**	**380,182**

* *Information is provided for the part of the municipality in the RVSDS Service Area (does not include Northville Township, Plymouth Township, and Canton Township, as only small components of these communities will remain within the RVSDS service area upon execution of the planned termination of RVSDS service to WTUA) (note: future growth in Canton Township, Northville Township, and Plymouth Township will not impact the RVSDS, as these communities discharge primarily to the Western Townships Utility Authority (WTUA) system. Wayne County and WTUA are currently negotiating termination of RVSDS services to WTUA.*

2.3 ECONOMIC CHARACTERISTICS

Economic statistics for each of the RVSDS communities are shown in Table 2-3 and below, which includes the median household income and the percentage of individuals 18 or older below the poverty level. Table 2-4 shows the employment data for each of the RVSDS communities. The data shown represents the entire municipality, including portions not served by the RVSDS.

Table 2-3: Median Household Income for Communities Within RVSDS Service Area

Municipality	Median Household Income[1]	Individuals below poverty level[1]
Dearborn Heights*	$47,794	19.2%
Garden City	$54,619	10.8%
Inkster	$32,379	33.2%
Livonia	$74,882	5.4%
Northville	$107,500	5.8%
Novi*	$88,667	5.7%
Plymouth	$80,104	4.5%
Redford Township*	$52,177	17.0%
Romulus*	$46,724	18.7%
Van Buren Township*	$56,955	10.4%
Wayne	$42,055	23.8%
Westland	$46,230	14.6%

[1] *Source: 2013-2017 American Community Survey 5-Year Estimates*

**Information is provided for the part of the municipality in the RVSDS Service Area (does not include Northville Township, Plymouth Township, and Canton Township, as only small components of these communities will remain within the RVSDS service area upon execution of the planned termination of RVSDS service to WTUA)*

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Table 2-4: Employment Data for RVSDS Communities

Category	Dearborn Heights		Garden City		Inkster		Livonia		Northville		Plymouth		Redford Twp		Romulus		Van Buren Twp		Wayne		Westland		Novi	
	2015	2045	2015	2045	2015	2045	2015	2045	2015	2045	2015	2045	2015	2045	2015	2045	2015	2045	2015	2045	2015	2045	2015	2045
Natural Resources & Mining	75	76	30	23	32	20	238	197	7	7	30	25	55	47	65	31	72	46	21	20	127	93	155	159
Construction	998	997	741	732	255	256	5,088	5,077	54	53	424	422	1,291	1,290	1,287	1,293	481	484	534	532	1,309	1,299	2,166	2,446
Manufacturing	230	123	474	234	234	161	9,493	6,180	98	43	1,103	707	4,102	2,150	3,978	3,697	2,455	2,347	5,836	3,545	1,405	1,019	3,958	2,944
Wholesale Trade	661	705	123	128	146	146	4,117	4,675	36	35	89	96	952	978	1,643	1,533	984	1,074	307	329	1,229	1,265	3,188	3,218
Retail Trade	2,107	1,462	1,325	836	450	313	9,314	9,627	264	228	655	596	1,986	1,347	1,359	3,045	1,440	1,443	821	706	5,006	3,282	9,469	7,510
Transportation & Warehousing	737	511	229	166	395	216	2,318	2,393	125	44	96	76	551	479	18,027	18,523	2,115	2,442	939	886	853	609	736	783
Utilities	2	2	1	-	-	3	39	30	-	-	-	-	125	71	5	8	86	68	5	3	5	12	173	157
Information	112	77	105	40	61	41	1,232	1,250	45	7	249	93	150	226	226	251	58	616	117	178	307	193	815	718
Financial Activities	1,146	950	671	673	302	243	7,148	6,680	697	687	1,227	1,184	1,035	944	1,252	1,538	617	849	424	377	1,800	1,599	4,982	5,157
Professional, Scientific & Technical Services	648	716	268	330	284	299	7,632	8,723	421	464	653	714	1,093	1,252	839	1,515	2,392	4,635	350	437	1,023	1,284	5,835	8,540
Management of Companies & Enterprises	128	147	51	60	34	39	3,419	3,902	19	14	39	63	99	106	45	123	295	973	30	53	145	164	483	852
Administrative, Support & Waste Services	1,403	1,589	712	810	623	702	5,820	6,620	177	202	602	678	1,407	1,603	1,536	1,753	983	1,121	1,181	1,341	1,956	2,212	4,012	4,460
Education Services	1,235	1,267	688	697	354	361	4,281	4,327	178	176	293	297	1,134	1,156	745	750	313	315	898	910	1,826	1,855	1,812	1,936
Medical Facilities	1,402	1,847	1,247	1,637	549	725	8,530	11,233	478	630	884	1,168	1,507	1,983	679	890	440	579	1,006	1,325	2,900	3,811	4,668	6,699
Hospitals	30	123	1,904	1,961	71	113	2,775	2,846	-	4	9	29	68	161	33	65	9	39	1,417	1,468	537	587	1,986	2,037
Leisure & Hospitality	2,024	2,156	868	949	333	364	7,780	8,548	464	506	1,088	1,189	1,831	2,002	4,029	4,615	1,279	1,393	704	768	3,820	4,081	6,511	7,446
Other Services	1,435	1,408	781	772	459	451	5,534	5,365	372	363	1,008	1,128	1,435	1,420	971	961	508	508	665	648	2,308	2,264	2,152	2,069
Public Administration	463	444	104	103	693	678	1,241	1,203	130	126	162	160	536	519	771	742	134	130	665	641	651	639	758	749
Total Employment	**14,836**	**14,600**	**10,322**	**10,151**	**5,275**	**5,131**	**85,999**	**88,876**	**3,565**	**3,589**	**8,611**	**8,625**	**19,357**	**17,734**	**37,490**	**41,333**	**14,661**	**19,062**	**15,920**	**14,167**	**27,207**	**26,268**	**53,859**	**57,880**

*Source: SEMCOG, 2045 Regional Development Forecast / Data by Community *(does not include Northville Township, Plymouth Township, and Canton Township, as only small components of these communities remain within the RVSDS)*

Total Employment

2015 842,923

2045 880,667

2.4 EXISTING FACILITIES

The first segments of the RVSDS interceptor system were built in the 1930s, with additions in the 1960s and 1980s. Today the RVSDS interceptor system includes nearly 93 miles of sewers ranging in size from 30 inches to 102 inches. The average dry weather flow for the RVSDS is approximately 60 cfs, which is measured at the RVSDS outlet meters to the GLWA (formerly DWSD) system at three different connection points, each with a maximum allowable flow limit for discharges to GLWA. The 2015 average annual flow rate from RVSDS to GLWA was 85 cfs, with an estimated maximum monthly average flow rate of 145 cfs.

The allowable peak wet weather flow to GLWA for the design event has not yet been determined, due to the need to further evaluate flow meter data and the resolution of ongoing master planning efforts for GLWA's collection system; however, the County's maximum allowable flow rate to GLWA is currently 378.8 cfs with a verbal agreement with GLWA/DWSD to return to the previous flow limit of 444.5 cfs. The ability of GLWA to accept a peak flow of 444.5 cfs from the RVSDS is in question. Known hydraulic constraints in the downstream GLWA interceptors and wastewater treatment plant may prevent the collective of RVSDS discharge points from flowing at the combined maximum allowable flow limit.

Wastewater discharged by local communities into the RVSDS is typical of municipal sewage.

Interceptors

The existing RVSDS consists of two major interceptor corridors, the Middle Rouge Interceptors (located along Edwards N Hines Road and the Middle Branch of the Rouge River) and the Lower Rouge Interceptors (located along Michigan Avenue and the Lower Branch of the Rouge River). These interceptors serve a network of smaller interceptors and trunk sewers. Local sanitary collector sewers are owned and operated by the local communities within the RVSDS service area. Appendix A shows the RVSDS service area, interceptor network, and major facilities.

The Middle Rouge Interceptor system runs along the Middle Branch of the Rouge River from the City of Northville to the City of Dearborn Heights. The Middle Rouge Interceptor system consists of three branches, the Middle Rouge Interceptor Relief (MRIR), Middle Rouge Parkway Interceptor Extension (MRPIE), and Rouge Valley Interceptor (RVI). Flow from the MRIR is transported to LS1A in Dearborn Heights, where it flows by gravity (and is pumped during wet weather) to the GLWA Northwest Interceptor. The MRPIE flow into the Northwest Interceptor by gravity. The GLWA Northwest Interceptor transports the wastewater to the GLWA's Water Resource Recovery Facility (WRRF). Wastewater from the RVI flows through the GLWA Oakwood Interceptor Arm to the WRRF.

The Lower Rouge Interceptor system runs along Michigan Avenue and the Lower Branch of the Rouge River from Canton Township to Dearborn Heights, ultimately flowing into the GLWA Oakwood Interceptor to the GLWA WRRF.

Combined Sewer Overflow Control and Flow Management Control Facilities
In the 1990s, projects were implemented by some communities in the RVSDS service area to address uncontrolled combined sewer overflows (CSO), including sewer separation in Garden City, Livonia, Wayne, and Westland, and the design and construction of CSO Retention Treatment Basins (RTBs) in Dearborn Heights, Inkster, and Redford Township. The CSO RTB facilities dewater stored wastewater to the RVSDS interceptor system. Additional storage facilities operated by communities in the RVSDS which serve to equalize and manage their wastewater flows into RVSDS. Wastewater storage and/or treatment facilities which are authorized to discharge to RVSDS include:

Wayne County Owned or Operated Facilities:

- Dearborn Heights CSO RTB (2.7 MG)
- Inkster CSO RTB (3.1 MG)
- Livonia Equalization Basin (2.2 MG)
- Redford CSO RTB (1.9 MG)

Local Owned and Operated Facilities:

- Inkster Middlebelt CSO RTB (1.9 MG), City of Inkster
- Van Buren Township Equalization Basin (1.4 MG), Van Buren Township
- Pond 3W at Detroit Metropolitan Airport Wayne County Airport Authority,
- Wayne Equalization Basin (2.54 MG), City of Wayne

Four combined sewer overflow Retention Treatment Basins (RTBs) provide wet weather storage and dewater into the RVSDS following wet weather events: Redford CSO RTB, Inkster CSO RTB, Inkster Middlebelt CSO RTB, and Dearborn Heights CSO RTB. The CSO RTBs (with the exception of the Inkster Middlebelt CSO RTB, which is not currently fully in service) were constructed in the mid-1990s and put into service in the late 1990s. The Redford and Dearborn Heights CSO RTBs are located on the Middle Rouge Interceptor (see Appendix A for RTB locations). The Inkster CSO RTBs are located on the Lower Rouge Interceptor. Together, the CSO RTBs, exclusive of the Inkster Middlebelt CSO RTB, which is not fully in operational, eliminated over 18 CSO outfalls and service a combined area of 1,724 acres.

The RTBs have a collective storage and treatment capacity of over nine million gallons. All discharges from the RTBs (except for Inkster Middlebelt CSO RTB) are treated discharges that meet effluent standards defined in the NPDES permit issued to each facility. Each of the three RTBs has a permitted outfall along the Middle/Lower Branches of the Rouge River. These only discharge treated effluent, as necessary, during wet weather.

Following wet weather events which partially or fully fill the RTBs, stored flows are dewatered and discharged to the RVSDS after the event peak flow has receded.

Lift Station 1A (LS1A)
LS1A provides pumping capacity for the downstream end of the RVSDS during wet weather, which is necessary to counteract the downstream hydraulics in GLWA's system

and to ensure that the RVSDS can discharge at the proposed maximum allowable peak flow rate of 444.5 cfs (although LS1A's firm capacity is only a portion of the 444.5 cfs limit). LS1A was built in the 1990s to address the reduced capacity of the interceptor system outlets due to the hydraulic surcharging of GLWA's Northwest Interceptor. The lift station is located on the Middle Rouge Interceptor between Edward N Hines Drive and Ford Road in Dearborn Heights.

CSO Regulators

There are 34 combined sewer regulators within the communities of Dearborn Heights, Inkster, and Redford in the RVSDS service area. These regulators were built to control flows into the interceptors and divert wet weather flows into alternate wastewater facilities (typically combined sewers, CSO outfalls, and, more recently, CSO RTBs).

2.5 HYDROLOGIC/HYDRAULIC MODELING

The data used to development the RVSDS hydrologic/hydraulic model spanned from July 2012 to October 2016. Sewage flow data was recorded on a five minute interval and consisted of measured depth and velocity, and a computed flow rate. Flow meters undergo periodic dye-dilution testing to verify their accuracy. The information used to build the hydraulic model was derived from a variety of sources including previous modeling work, as-built drawings, field survey data, GIS data, local municipal line connection information, system inventories, reports and special studies, and O&M manuals. The hydraulic model was built primarily on an extensive review of all available as-built drawings. The RVSDS H/H model was previously incorporated into the Greater Detroit Regional Sewer System (GDRSS) model, which was a regional modeling effort and broad in scope. As part of the LTCAP analysis, the version of the RVSDS H/H models within the GDRSS model were updated and significant detail added to better represent the RVSDS. Recent improvements to the RVSDS H/H model included:

- Adding a representation for each of the pipes, regulators, siphons, manholes and interconnections in the RVSDS;
- Expanding the modeled sewer reaches to encompass the full extent of the RVSDS;
- Including existing storage facilities (equalization basin, retention treatment basins);
- Providing a representation for each customer line connection to the interceptor system; and
- Using model control rules to simulate actual operational procedures of facilities.

The boundary conditions of the RVSDS H/H model are based on recorded level data in the downstream ends of the RVSDS. Hydraulic conditions in the RVSDS are largely driven by backwater conditions from the GLWA WWRF. Wayne County is working with GLWA to obtain an estimate of the levels at the RVSDS connection points. Dry weather flow rates serve as the foundation for understanding RVSDS flows. Based on metering data and rainfall data, 2014 was selected as the appropriate period for deriving dry weather flow parameters. The average dry weather flow rate in 2014 was the highest within the analyzed timeframe. Two dry weather flow conditions were determined: the springtime high and yearly average. These values help determine the amount of groundwater infiltration a meter district may experience during wet springtime months. Wet weather conditions are equally important in the development of the hydraulic model. Any event with a duration less than 24 hours and an average precipitation depth greater than one inch was considered significant.

The significant rainfall events from 2012 – 2016 were reviewed for spatial uniformity. Further review included screening for a single peak of intensity. This results in a clear cause-and-effect relationship to be distinguished between the rainfall and the response of the sewer system. In total, nine significant events were identified for further use in the hydraulic analysis. Appendix D shows these events. The presence of river-dependent inflow has been suspected in the Middle Rouge Interceptor between Inkster Road and the Middle Rouge outlet. Meter data from the September 29, 2016 rainfall event corroborated that the inflow source was occurring predominantly between Inkster Road and Telegraph Road. Temporary line connection meters also showed evidence of inflow during this event. The Thiessen polygon method was used to compute a weighted average rainfall depth for each meter district because multiple rain gauges are present in the relatively large service area of the RVSDS. The capture coefficient is a fraction of rainfall that fell over the meter district that becomes river-dependent inflow and infiltration (I/I), which is calculated at the quotient of I/I volume and rainfall. SWMM5 utilizes the capture coefficient along with shape parameters to estimate inputs into the model. The combined sewer areas are represented in the model using subcatchment elements, which were taken directly from the previous GDRSS model. The model does not include a representation of the local sewer networks for the combined sewer district because GDRSS model parameters were found to inundate the regulators, which results in surcharge above grade. This situation is not known to be occurring in reality, so flow rate caps were applied to each of the CSO regulator. Additional details can be found in Appendix D and Appendix E.

The unit hydrograph method was used to distribute the wet weather volume over time. SWMM5 uses the RTK method for distributing the rainfall derived infiltration and inflow (RDII) generated by a sanitary system service area. The R, T, K parameters define the size and shape of the corresponding hydrograph. "R" represents the capture coefficient, "T" is the time (in hours) from the start to peak of rainfall, and "K" is the ratio of time to recession to time to peak. These parameters determine how flashy the inflow occurs. The RTK parameters were calibrated against the September 10, 2014 event, which was spatially uniform with a single peak. The resulting RTK parameters set the unit hydrograph for each meter district. An initial calibration attempt was made in summer 2015 to the September 14, 2014 event. The results of which predicted depths less than the observed depths beyond which could be accounted for by any reasonable adjustment to the hydraulic and hydrologic parameters. Some of the possible explanations included unaccounted river inflow, unknown blockages or restrictions, inadequate venting, and greater than expected losses in pipes and structures. Field investigations revealed no significant blockages. Additional permanent meters were installed along the RVSDS interceptors from Telegraph Road to Outer Drive to quantify the river-dependent inflow. A successful calibration was made to the September 28, 2016 event. This calibration required an increased Manning's roughness coefficient (from 0.014 to 0.016). This is representative of additional system losses of unknown origin, but could include any of the aforementioned explanations. A theoretical design storm was set up to represent the existing conditions during a 25-year, 24-hour design storm. The event is based on the following parameters:

- Total rainfall volume of 4 inches, distributed over 24 hours using the SCS Type 2 hyetograph;
- System wide dry weather flow rates based on 2014 average;
- RTK parameters derived from September 10, 2014 event;
- Capture coefficients based on the higher of the September 10, 2014 and September 28, 2016 events; and
- Theoretical peak river inflow correlating to the 10-year river level.

The event simulation was run and found to produce stable computational results.

2.6 FISCAL SUSTAINABILITY PLAN

Per the SRF Project Plan Preparation Guidelines, a fiscal sustainability element is required for any SRF-funded portions of the wastewater system. The requirement includes an inventory of critical assets and an evaluation of condition and performance. It also requires certification that water and energy conservation efforts are integrated into the plan. The Project Plan should also include plans for maintaining, repairing/replacing and funding the SRF-funded treatment works.

This SRF Project Plan meets the requirements of the Fiscal Sustainability Plan, as the key components have been addressed through the physical inspection of the system, the hydraulic modeling of the system, and the proposed focus on Asset Management (see Sections 4 and 5) to minimize future energy costs (through reduced pumping and wastewater treatment volumes).

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3 NEED FOR PROJECT

3.1 COMPLIANCE AND ORDERS

The RVSDS does not currently meet Michigan's 2002 SSO Policy. Periodic SSOs have been observed within the system. Multiple studies have been conducted and improvements have been implemented since 1982. Additional system improvements have been required per FOA 2117 for the RVSDS, last updated in July 2015 (ACO-000031).

The list below includes a summary of the key milestones, including prior studies and improvements implemented since 1982. This list provides a history that establishes the need for the projects listed in this LTCAP SRF Project Plan.

1982 .... Comprehensive Facilities Plan (approved by MDEQ in September 1988)

1988 .... MDEQ issues Final Order of Abatement 2117 to Wayne County for the RVSDS

1989 .... MDEQ issued 1st Amended Final Order of Abatement 2117

1999 .... Construction of Segment I facilities completed

1999- Present .... Ongoing system-wide flow and rainfall monitoring program

2002 .... MDEQ issued SSO Policy Document

2003 .... MDEQ issued SSO Clarification Statement

2005 .... Project Plan created to address RVSDS wet weather flows

2006 .... RVSDS Hydrologic and Hydraulic Modeling Analysis submitted to MDEQ

2007 .... MDEQ issued 2nd Amended Final Order of Abatement 2117

2007 .... STCAP proposed during FOA negotiations

2007-2013 .... RVSDS communities implemented various local rehabilitation projects

2007 - Present .... Annual Status Reports for FOA 2117 Compliance submitted to MDEQ

2007 - Present .... Annual Work Plans for Sanitary Sewer Operation and Maintenance submitted to MDEQ

2008 .... STCAP Completed, SRF Project Plan for STCAP Submitted

2012 .... Construction of STCAP completed

2012 .... MDEQ issued 3rd Amended Final Order of Abatement 2117

2012-2013 .... Evaluation of post-STCAP flow monitoring data

2012 - Present .. Publication of quarterly and annual reports summarizing RVSDS flows

2013 -Present ... Ongoing efforts to assess RVSDS and remove sources of I/I

2015 .... MDEQ issued 4th Amended Final Order of Abatement 2117

2015 .... Submittal of LTCAP Work Plan to MDEQ

2016 .... Approval of LTCAP Work Plan and revised schedule by MDEQ

2016 .... Submittal of LTCAP Project Plan and revised draft per MDEQ comments (See Appendix C)

2017 .... MDEQ approved LTCAP Project Plan (See Appendix C)

2018 .... Submittal of Long Term Corrective Action Plan: Project Plan Summary to MDEQ

3.2 WATER QUALITY

SSOs from the RVSDS typically occur during significant wet weather events, although volume and frequency of SSOs is suspected to be lower than prior to the STCAP implementation, based on pre- and post-STCAP hydrologic modeling. Additionally, the WCDPS and RVSDS communities have continued to implement sewer system rehabilitation projects. However, evaluation of the design event hydrology reveals that additional system improvements likely will be needed to meet FOA 2117 requirements.

Water quality problems, such as elevated bacteria levels or sanitary trash, could be present in the Rouge River and its tributaries downstream of the SSO discharge locations. No water quality studies specific to the impacts of SSOs from the RVSDS have been conducted, since the MDEQ considers SSO discharges to contain raw sewage, which is prima facie evidence of a water quality violation.

3.3 PROJECTED NEEDS

Data obtained from SEMCOG indicates that population in the RVSDS service area is anticipated to slightly decrease through 2040. Sewer flows within the RVSDS is expected to remain relatively constant. This assumes no major changes in climate which would lead to increased rainfall depths and intensities. Projected needs in the system, identified in Section 4, address river inflow and structural deterioration, and do not include increases in projected flows due to flat/decreasing population projections.

3.4 FUTURE ENVIRONMENT WITHOUT PROPOSED PROJECT

If no action is taken, SSOs will continue to occur. Climate change will likely increase the frequency of severe weather events. SSOs will become more frequent and water quality issues will be of greater concern to public health. Although populations within the service area are expected to decrease slightly over the next 25 years, improving the system and managing we weather flows will be necessary to combat the impacts of an aging collection system.

4 LTCAP ALTERNATIVES ANALYSIS

4.1 IDENTIFICATION OF POTENTIAL ALTERNATIVES

Multiple sets of system improvements were evaluated; the calibrated RVSDS H/H model was used to develop various alternatives to meet the regional system compliance requirements to eliminate SSO's and provide adequate storage, transport, and treatment for a 25-year, 24-hour storm event. The alternatives considered include system improvements to optimize existing transport capacities, implementation of flow reduction strategies to eliminate river inflow, decentralized wet weather storage basins at critical interceptor locations to reduce peak wet weather flow and control system surcharging to acceptable levels, and relief interceptors to transport peak wet weather flows to a central storage or treatment facility. The initial recommendations for system improvements are outlined in the documents "Work Plan for Long Term Corrective Action Plan (November 2015)" and "Long Term Corrective Action Plan: Project Plan Summary (August 2018)" submitted to the MDEQ.

The following criteria and assumptions were used to formulate these planning level alternatives:

1. Outlet capacity from GLWA is assumed available at the 3 system outlets described as follows:
   a. Oakwood Interceptor @ WC-S-1—Peak HGL = 569.2 ft NAVD88
   b. LS1A Discharge to Northwest Interceptor @ WC-S-3—Peak HGL =587.0 ft NAVD88
   c. Middle Rouge Gravity Discharge to Northwest Interceptor—Peak HGL = 587.0 ft NAVD88

2. H/H modeling results with and without river inflow elimination were used to identify critical interceptor locations requiring draw-off of peak flows to maintain acceptable hydraulic levels. Peak rates and volumes at these draw-off locations were used to size relief interceptors, storage basins, pump stations, and treatment facilities as required for the specific alternative.

3. Wet Weather Storage Basin Assumptions:
   a. Storage basin depth: 15 feet average operating storage depth
   b. Pumped flow into basins, with gravity dewatering
   c. Storage basins and pumping facilities to be located outside of Middle Rouge floodplain and readily accessible during river flooding events (river flooding is common and access above the floodplain is the only reasonable alternative)
   d. Storage basin footprints include 25-foot buffer on all sides for grading and appurtenances

4. Relief Sewer Assumptions:
   a. The prevailing slope available for the existing interceptors between draw-off locations was used for sizing relief interceptors.

b. Relief interceptors will generally follow the alignment of the existing parallel interceptors and be constructed within Hines Park in open cut except at major Road and river crossings, which would be tunneled or jacked pipe. The relief sewer for the Inkster Road Arm Interceptor is expected to require tunneling or jacked pipe construction methods due to the existing dense development along the road right-of-way corridor.

c. There are already three parallel interceptor pipes that represent the collective Middle Rouge Interceptor and adding a fourth parallel pipe is not desirable. The potential to replace an existing aging parallel interceptor with an upsized relief interceptor, if feasible, is preferred and will be further evaluated for the selected alternative during final design.

5. Asset Management (AM) Assumptions:

   a. Remove River Inflow: River inflow is still a significant issue along the lower reaches of the RVSDS where the interceptors are within the influence of the Middle Rouge and Lower Rouge floodplains. The Short Term Corrective Action Plan for the RVSDS successfully addressed river inflow from many sources. However, additional sources were identified (see Figure 4-1) that still contribute significant river inflow that must be addressed. Given the hundreds of known manholes within the influence of the 1-year and 2-year floodplains, this issue will need to be addressed in an ongoing AM program, which will include repairing up to 160 manholes and ongoing (annual) inspection of approximately 230 manholes per year (5-year cycle). The AM component will also require cooperation from RVSDS communities, as many of the local collection systems are also within the floodplain. Focusing on river inflow removal will not, by itself, address all SSOs in the RVSDS, but it can provide the most meaningful, immediate, and cost-effective impact on the system.

Figure 4-1: Manhole M-20 (Middle Rouge Interceptor) – September 29, 2017; River Level and Interceptor Level Equalized

b. Address Hydraulic Capacity and Structural Integrity: A critical section of the RVSDS, the downstream reaches of the Middle Rouge Interceptors, does not convey the amount of flow calculated from conventional hydraulic analysis. One of the contributing factors is the observed spalling of concrete on the pipe interiors; this causes not only a structural problem (such as exposed reinforcement), but it increases pipe friction which acts to reduce the hydraulic capacity. Regular inspection of the interceptors on a 5-year cycle (about 20 miles per year) will allow the County to maintain a structurally-sound system that is functioning as intended. Furthermore, potential blockages (more prevalent in siphons and pipe size changes) can be more quickly identified and addressed. Regardless of the need to address hydraulic constraints, ongoing structural rehabilitation (and occasional sewer replacement) is necessary for any aging system, and this is a core component of the RVSDS Project Plan. It is assumed that approximately four miles of sewer lining per year will be required in Years 1-5 of this Asset Management program. After the first five years, the lining quantity should be reduced to at or around one mile per year.

c. Optimize Combined Sewage Overflow Operations: There are significant combined sewer service areas in the RVSDS. Reducing the flow contribution from the combined areas to the interceptors during significant wet weather events to allow preferential flow for separate areas has been utilized successfully in other collection systems in Michigan. Typically, the reduction is offset by increased allowance of flow during non-critical periods. This strategy has been demonstrated in the hydrologic and hydraulic models for the RVSDS to have a significant impact on peak flows in the system and would be an integral part of an Asset Management program. However, this strategy will require additional control structures and an advanced logic system to optimize flows; the decentralized nature of the CSOs will require a significant investment to achieve this outcome.

Regulator modifications for CSO throttling consist of adding a control gate to the interceptor sewer connection on the downstream side of the CSO regulator structure. Under normal dry weather and most wet weather rain event conditions, the control gate would be left fully open allowing the regulated flow discharge to the interceptor as designed. During significant rain events experienced in the regional system that exceed available interceptor capacity, the control gates will be closed to bypass the regulated flow to the river with the CSO discharge, thereby reducing flow in the interceptor during the critical periods. An automated control system consisting of interceptor level sensors and flow meters will be used to identify critical system conditions for closing and re-opening the gates, with automated controls via the RVSDS Supervisory Control and Data Acquisition (SCADA) System to close the gates only when necessary. The control system will include remote SCADA system access to the gate operators and interceptor monitors, with appropriate alarms to be programmed for any conditions requiring servicing by field crews.

d. LS1A Screening Improvements/Lower Rouge Interceptor Isolation: The existing manually-operated bar screens at LS1A can become blinded which makes it difficult to clean (there is no mechanical removal of debris). This can result in excessive head upstream of the pumps, which propagates upstream in the Middle Rouge Interceptor. Additionally, debris can bypass the blinded screens and damage the pumps. Improvements are necessary to ensure that LS1A continues to operate at its intended capacity. Adding a sluice gate to JC 2-8 will allow for more flows to be directed to LS1A during wet weather, thereby reducing flows (and hydraulic surcharging) on the Lower Rouge Interceptors.

6. Ancillary Projects Assumptions:
    a. Line Connection Siphon: One inverted siphon on the Lower Rouge (L-34) is suspected of having inadequate hydraulic capacity; partial clogging at this siphon occurs regularly, primarily due to the small sewer diameters at this location. Therefore, a siphon enlargement is needed at this location.

    b. Resolve GLWA Boundary Conditions: The hydraulic gradients at the outlet points from the RVSDS to the GLWA Northwest Interceptor are controlled by GLWA and have been identified as a controlling factor in the performance of the RVSDS under wet weather conditions. GLWA is addressing this issue as part of the current Wastewater Master Plan efforts. The location and sizing of wet weather storage projects (if still required after the AM efforts) will hinge on the boundary condition established by GLWA. It is anticipated that GLWA will complete the work to provide information necessary to complete this RVSDS Project Plan in 2019.

   c. Wet Weather Flow Control in the Inkster Arm: The Inkster Arm analysis shows that the flows exceed the available capacity. The City of Livonia is currently implementing a footing drain disconnection (FDD) program in this area, which will reduce wet weather flows. Depending upon the extent and success of the FDD program, the need for additional hydraulic capacity or storage in the RVSDS Inkster Arm could be reduced or even eliminated.

7. Community-Specific Projects Assumptions
   a. Hydraulic Improvements at Local Line Connections: Several line connections (locally-owned sewers connecting to the RVSDS Interceptors) do not have adequate hydraulic capacity to deliver the design event flow rates without surcharging. These projects will need to be implemented when the interceptor capacity is addressed so that individual customers can deliver wet weather flows without causing SSOs upstream of the interceptors.

Summary of Alternatives and Costs

System improvement alternatives were screened and evaluated based on the system needs and project objectives. Table 4-1 identifies the potential alternatives to achieve the goals of the LTCAP.

Alternative 1 represents the base scenario that focuses on an Asset Management Plan to repair known system deficiencies, remove known river-dependent inflow along key reaches of the interceptor, LS1A screening improvements, and optimize combined sewage overflow (CSO). Additional, Alternative 1 requires local communities to address local wet weather flow reduction projects to remove inflow/infiltration sources. The RVSDS H/H modeling analysis indicates that this alternative is achievable, but only with considerable local investments to collection systems that are not under direct control of Wayne County.

Alternative 2 reflects the scenario under which the Asset Management Plan is fully implemented but the full impact of local and regional system improvements does not fully address SSOs in the system. Additional targeted wet weather storage projects will address remaining SSOs.

Alternatives 3-5 reflect more conventional approaches to SSO control, focusing on conveyance, storage, and/or treatment, all assuming that river inflows and local system wet weather responses remain as they are today.

Table 4-1: SRF / LTCAP Project Plan Alternatives Summary

Alternative	Description	Conceptual Cost Estimate*
1	Asset Management Plan is fully implemented, including local wet weather flow reduction projects to the point that no further projects are necessary	$80 Million
2	Asset Management Plan is fully implemented, although local collection system projects are not sufficient to eliminate SSOs for the 25-year, 24-hour design event	$127 million
3	Decentralized storage only (no asset management). Install several storage facilities along the Middle Rouge Interceptor as well as storage on the Inkster Arm	$247 million
4	Conveyance and Centralized Storage only (no asset management)	$260 million
5	Conveyance (same as Alternative 4) with a localized Water Resource Recovery Facility.	$1.07 billion

** Includes contingency and engineering/legal/administration costs (see cost estimate tables at the end of this section). Based on 2019 dollars.*

4.2 ANALYSIS OF PRINCIPAL ALTERNATIVES

Alternative 1

Alternative 1 represents a scenario where the Asset Management Plan is fully implemented and local wet weather flow reduction projects are completed, such as footing drain disconnections, and other inflow/infiltration source removal. If these efforts are completed and proven successful, then no further projects are necessary.

Although the Asset Management Plan will include a more robust program in the initial five years, it will remain as a system O&M strategy into perpetuity. Fixing obvious problems that are apparent in Years 1-5 will not guarantee that they do not reappear in the future. Continued diligence in the way of manhole/sewer inspection and local collection system I/I removal will be necessary to enhance the likelihood that river-dependent inflow will be minimized, and that the system is operating as originally intended. The conceptual cost estimate includes costs related to the Asset Management Plan through the entire 20-year planning horizon.

Although this section has no figures related to Alternative 1, the Asset Management Plan components are described in full detail in Section 5 - Recommendations.

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Alternative 2

Alternative 2 consists of all activities listed under Alternative 1, but includes additional wet weather storage in the event that the Asset Management Plan does not fully address SSOs within the project area. This alternative was developed as an extension of Alternative 1 to address any remaining capacity deficiencies after implementation of the asset management river inflow reduction and related improvements. While the Asset Management program actions will largely address SSOs, some additional protection may be required. RVSDS H/H modeling results indicated that there are two potential locations where wet weather storage may be necessary upon completing Alternative 1 (illustrated in Figure 4-2).

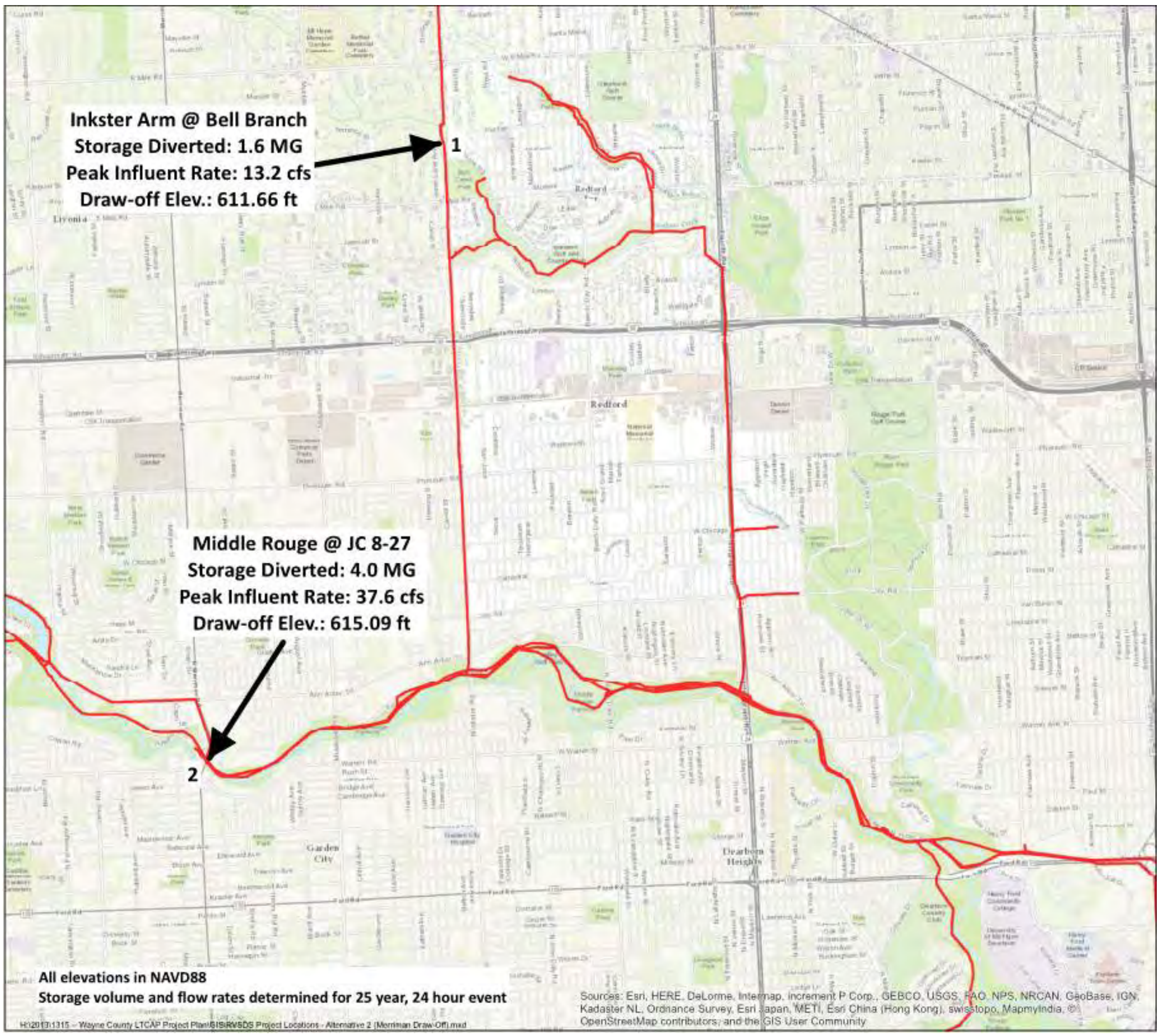

Figure 4-2: Alternative 2 Wet Weather Storage Loctions

A description of these proposed storage facilities is as follows:

Site 1 is located on the upstream end of the Inkster Road Interceptor with an interceptor draw-off location near Bell Creek, and requires a storage volume of 1.6 MG. While this is a highly developed urban area, there is a potential site within the Wayne County Bell Creek Park north of 5 Mile Road that is currently used for soccer fields (refer to Figure 4-3). This site could potentially be used to construct an underground tank, and then restored to allow continued use as a soccer field. The facility will require inlet and outlet sewers to the existing interceptor on the west side of Inkster Road, and a control building for inlet pumping, flushing and dewatering controls after a storage event.

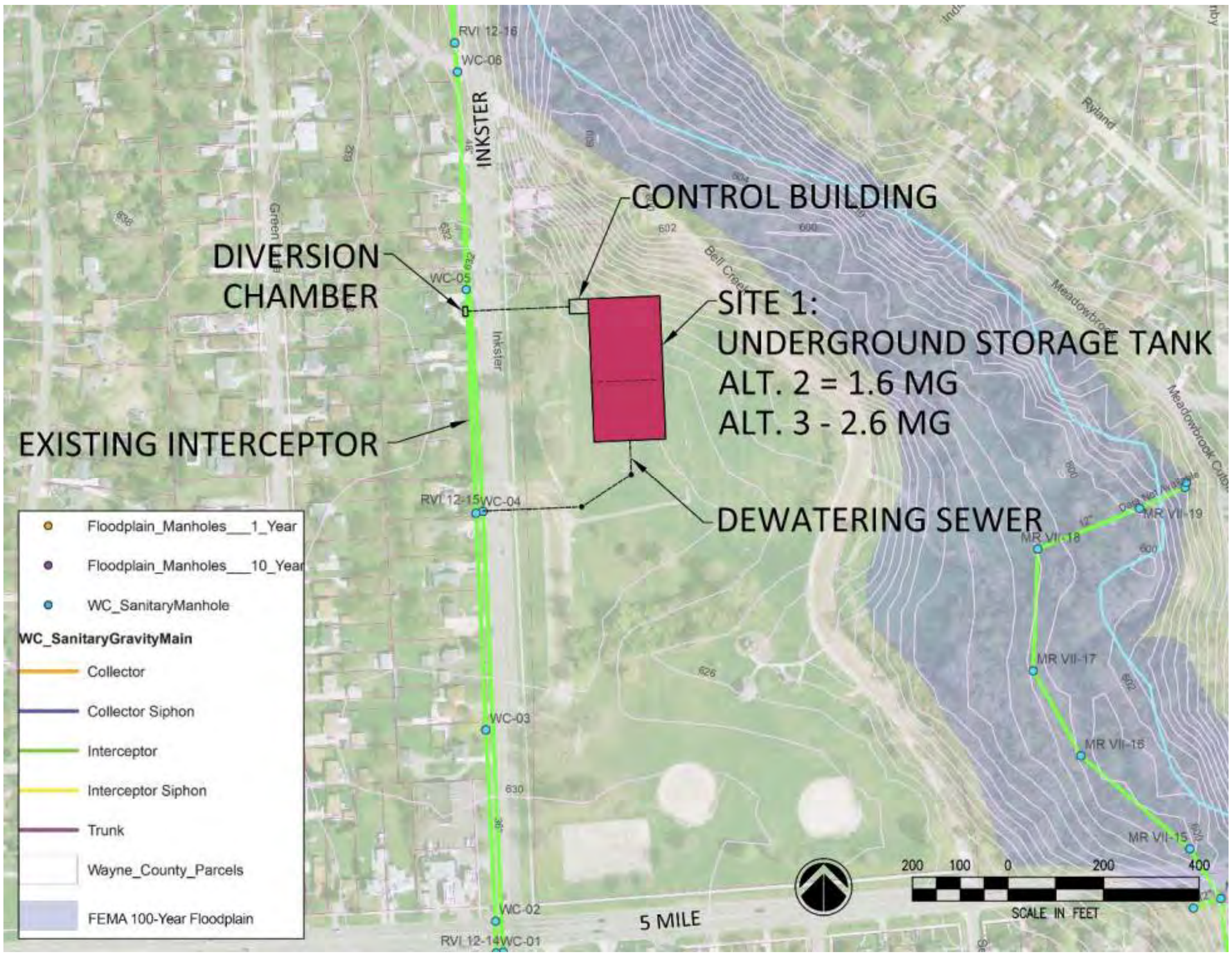

Figure 4-3: Alternative 2 / Site 1 – Inkster Arm Storage (1.6 MG Option)

Site 2 has an interceptor draw-off location near Merriman Road from the parallel interceptors within Hines Park on the north side of Hines Drive, requiring a storage capacity of 4.0 MG. The park property within this area is completely inundated during wet weather river flooding conditions, and therefore does not meet the criteria for siting a basin. A review of other potential sites identified the current open property outside the flood plain from the abandoned Hawthorn Valley Golf course as a potential basin location (see Figure 4-4). The west end of this site is currently under redevelopment as a housing project. There is, however, vacant property on the north end of the site that can accommodate the storage footprint required, but will require a pump station and inlet and outlet sewers to route flows to and from the facility, This site will also require land acquisition from a private owner, and easements to route sewers through the Apartment complex parking lot to the site.

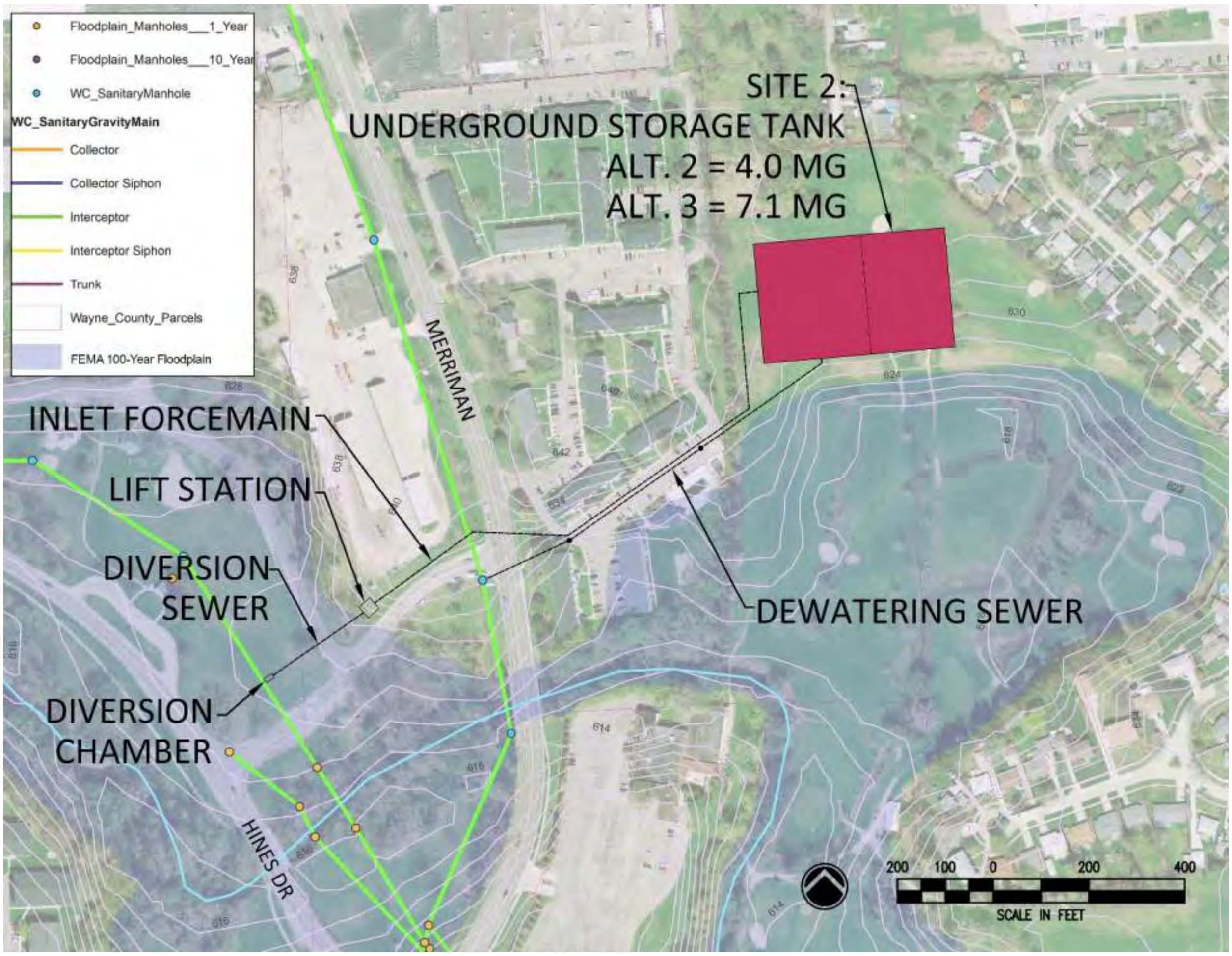

Figure 4-4: Alternative 2 / Site 2 – Middle Rouge Storage (4.0 MG)

Alternative 2 includes all components of Alternative 1 (through the entire 20-year planning horizon), plus the two wet weather storage facilities. The total estimated project cost for Alternative 2 is $127 million.

Alternative 3

This alternative focuses on decentralized wet weather storage, based on the assumption that the investments in the system will be focused on a conventional strategy of wet weather storage; in this alternative, there are no investments in the Asset Management Plan or any assumed local inflow/infiltration reduction programs. To accomplish SSO control under this scenario, the RVSDS H/H modeling effort revealed the need for four flow storage basin sites (see Figure 4-5).

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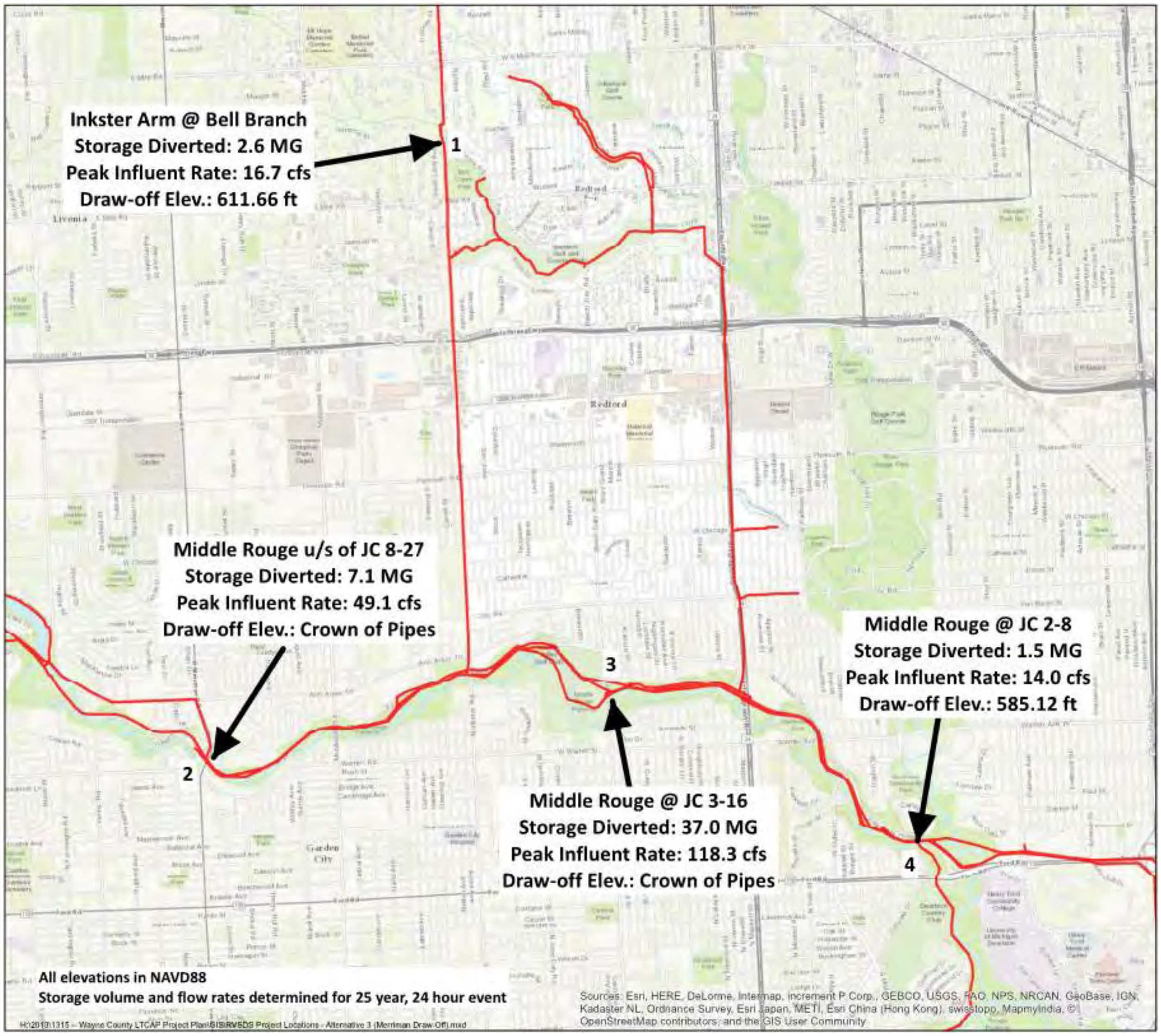

Figure 4-5: Alternative 3 Wet Weather Storage Locations

A description of these proposed storage facilities is as follows:

Sites 1 and 2 are located at the same locations and have the same draw-off points identified for Alternative 2, but require larger storage volumes and design flows. Site 1 at the Bell Creek Park located on Inkster Road north of 5 Mile would be upsized from 1.6 MG (Alternative 2) to 2.6 MG (Alternative 3). Site 2 is located on the north end of the abandoned Hawthorne Valley Golf Course property and would be upsized from 4.0 MG (Alternative 2) to 7.1 MG (Alternative 3). Both sites can accommodate the larger basin footprint and utilize the same layout configuration for the control building, pump station, and inlet and outlet sewers as depicted on Figure 4-6 and Figure 4-7.

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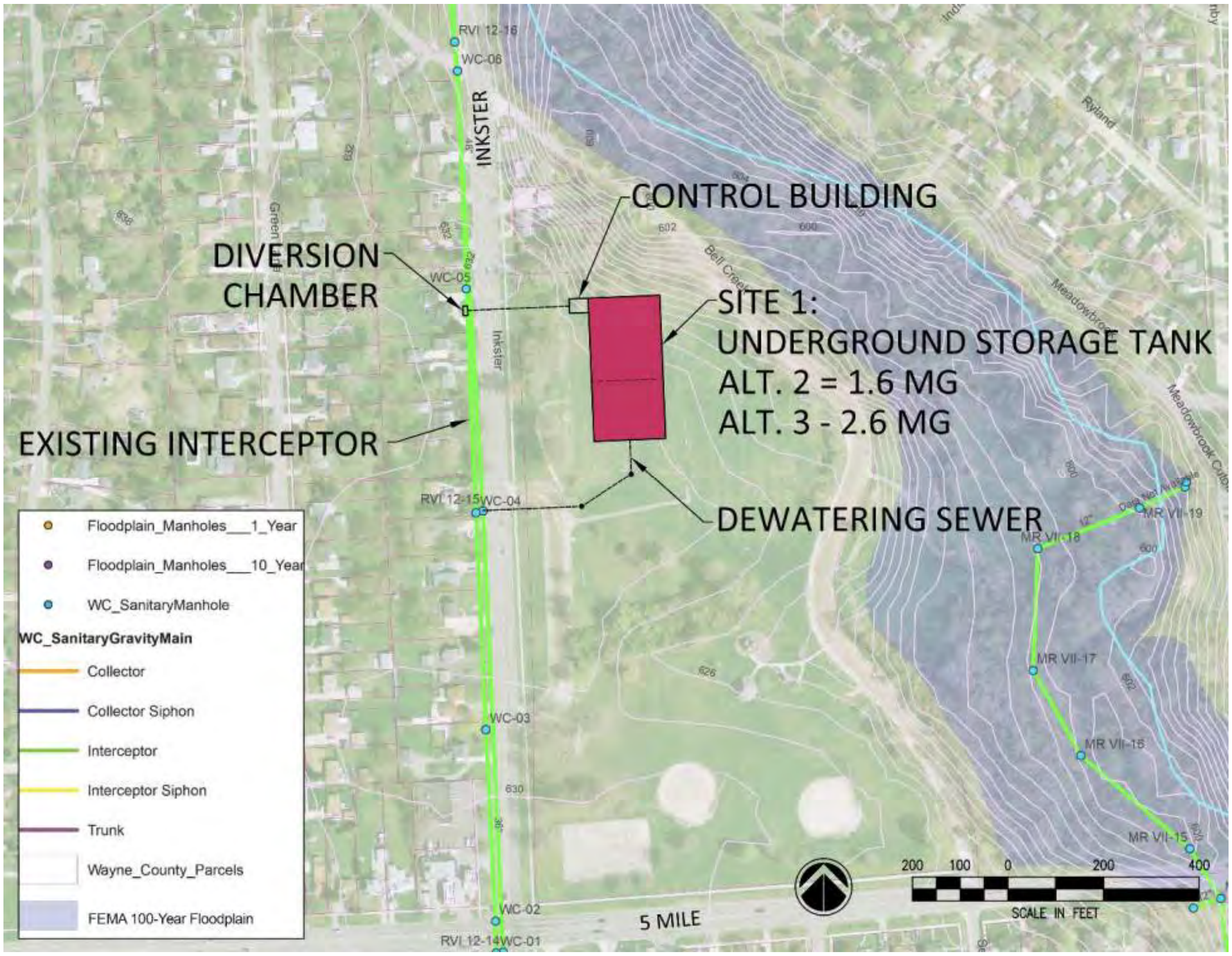

Figure 4-6: Alternative 3 / Site 1 Inkster Arm Storage (2.6 MG Option)

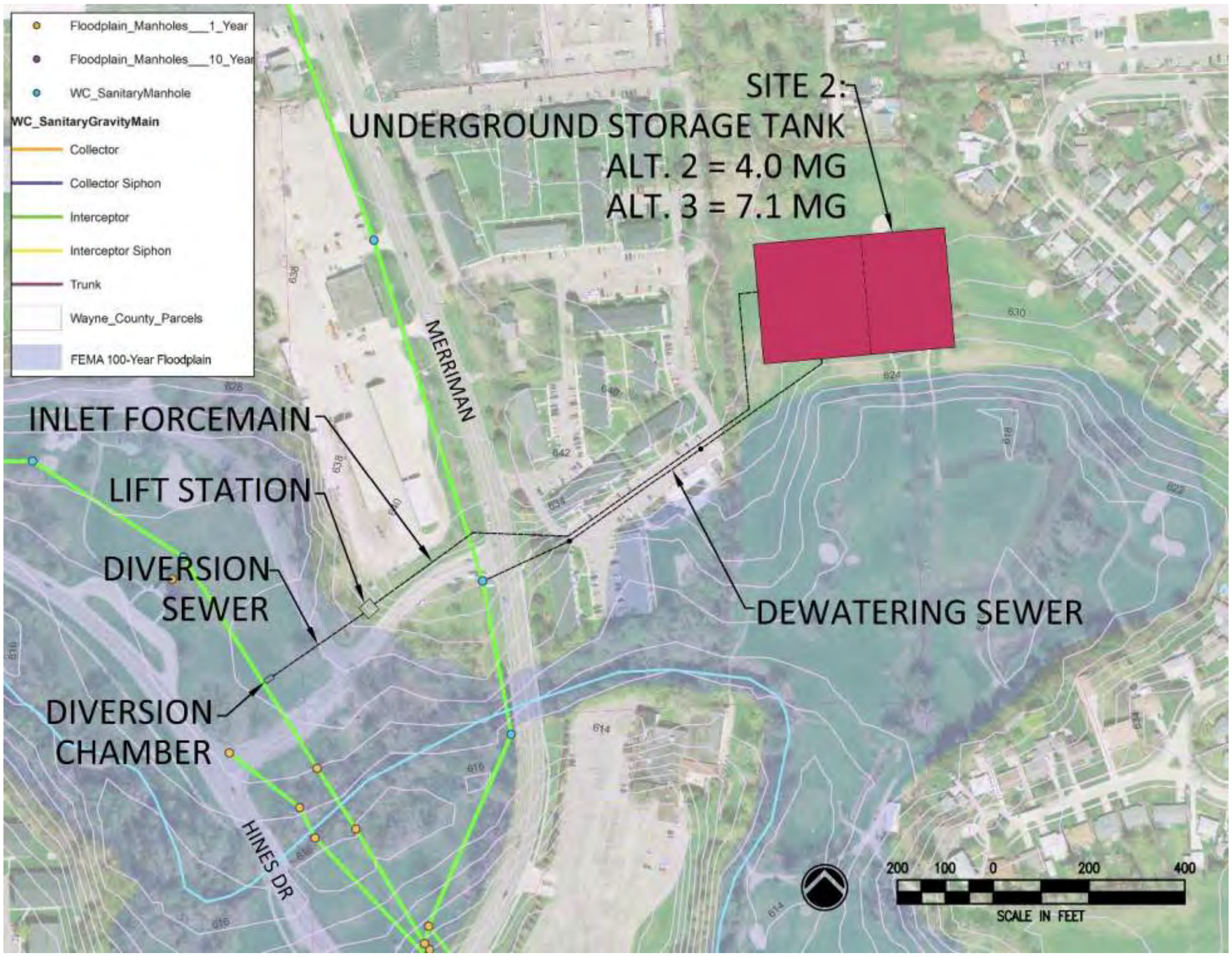

Figure 4-7: Alternative 3 / Site 2 Storage (7.1 MG Option)

Site 3 is located in the vicinity of Hines Drive and Beech Daly Roads and requires a much larger (37 MG) storage basin (see Figure 4-8). The only open property large enough to construct a basin of this size in this vicinity outside of the floodplain is the Warren Valley Golf Course and is currently owned by the City of Dearborn Heights. To make this site work and still maintain its future use as a golf course, an underground basin could be constructed that would be restored as a golf course upon completion, with potential site enhancements using excavated materials. It will, however, require temporary closing of a portion of the course with loss of revenues for an extended period (likely spanning at least two summer seasons) to allow basin construction and re-establishment of disturbed areas for the course restoration. The existing interceptors are adjacent to the site which will minimize inlet and outlet sewer lengths, but the control building and pumping facilities should be located on the perimeter of the golf course off of Beech Daly Road to provide access from Beech Daly Road to avoid disruption to the golf course.

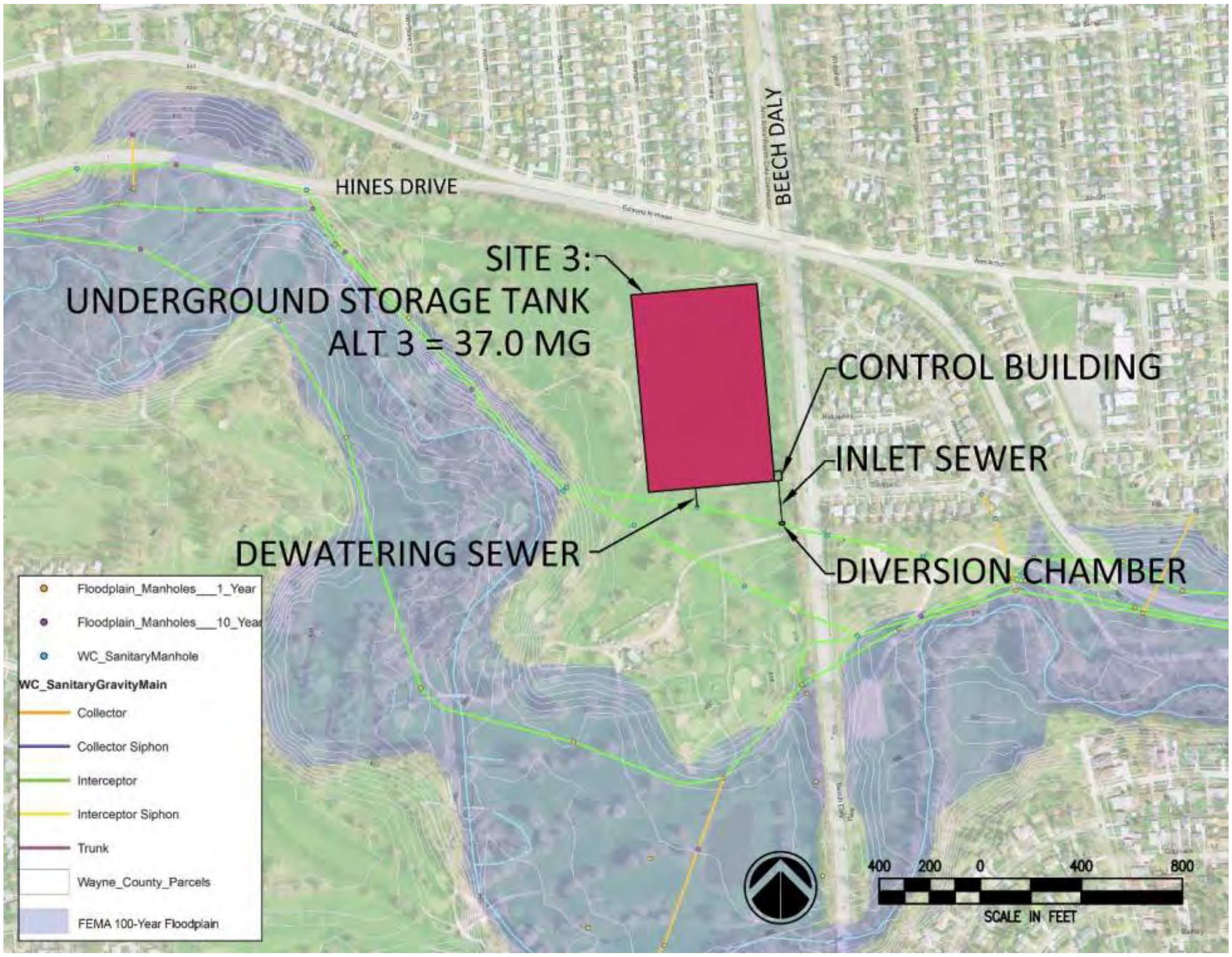

Figure 4-8: Alternative 3 / Site 3 Storage

Site 4 requires a draw-off from the existing interceptors near the end of Hines Drive north and west of Ford Road. For Alternative 3 conditions, a storage volume of 1.5 MG is required. The Hines Park property in the vicinity of this draw-off location is entirely within the flood plain and is frequently flooded, and therefore does not satisfy the criteria as a basin site. There is, however, some other open park areas within Rouge Park to the north located north of Ann Arbor Trail and east of Parkland that could fit the basin footprint requirements (refer to Figure 4-9). The layout for this site will require inlet and outlet sewers to be installed to the basin, with a pump station located in the vacant area outside the floodplain north of the draw-off location that could be accessed from Ann Arbor Trail. Similar to the other park sites, the underground tank can be restored in such a way to provide dual use of this area as a recreational field or parking area.

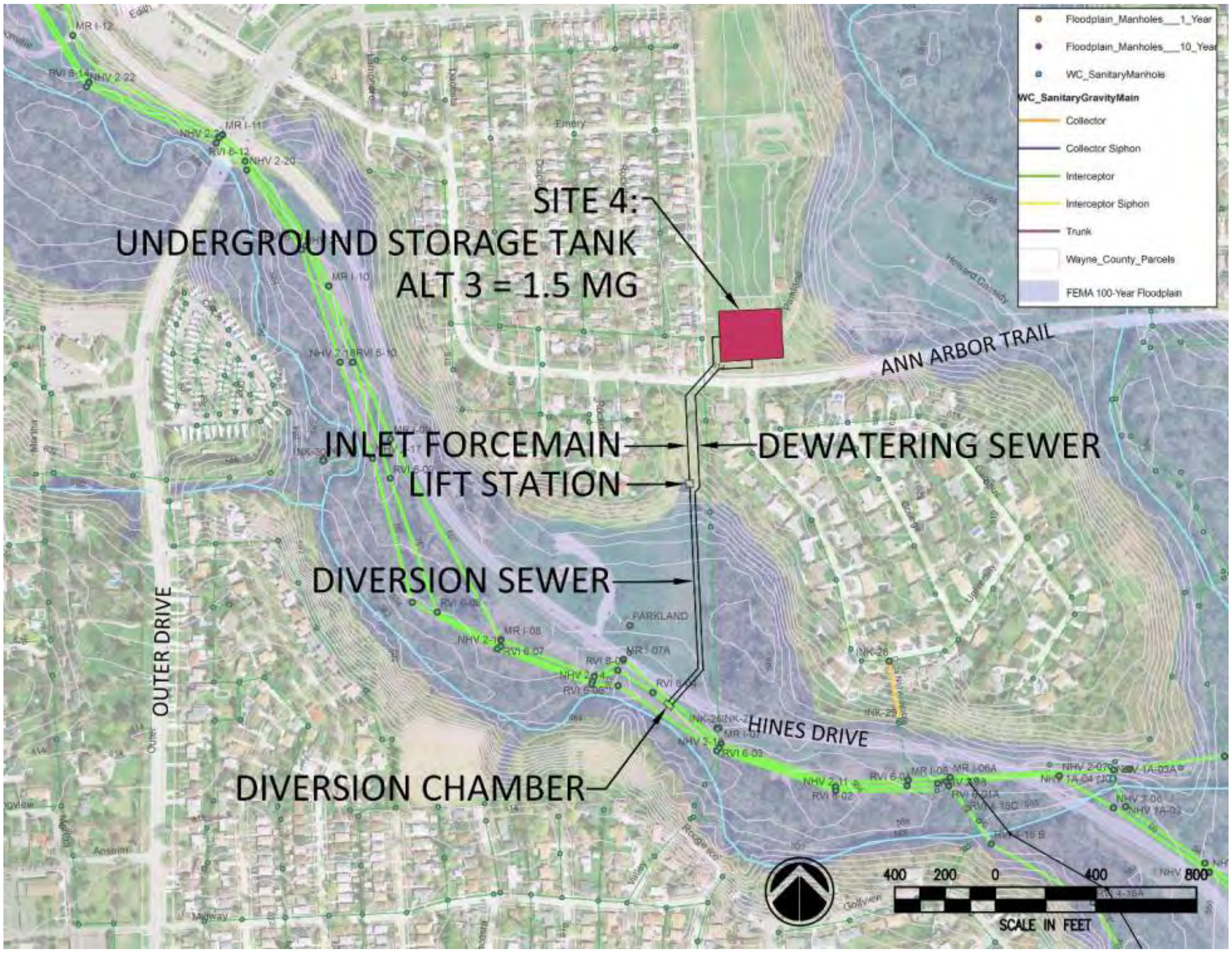

Figure 4-9: Alternative 3 / Site 4 Storage

The estimated project cost for Alternative 3 which includes all four basin sites is $247 million.

Alternative 4

This alternative focuses on enhanced conveyance and a single wet weather storage facility at the downstream end of the Middle Rouge Interceptor. The Alternative 4 plan consists of relief interceptors to transport the design event peak flows to one central storage facility without any of the asset management plan flow reductions. Components of this alternative include over 9 miles of relief sewers along the Inkster Arm and Middle Rouge to the downstream end near Ford Road, and a single 43.2 MG wet weather storage facility, as shown in Figure 4-10. The flow conveyance enhancements are illustrated on Figure 4-11.

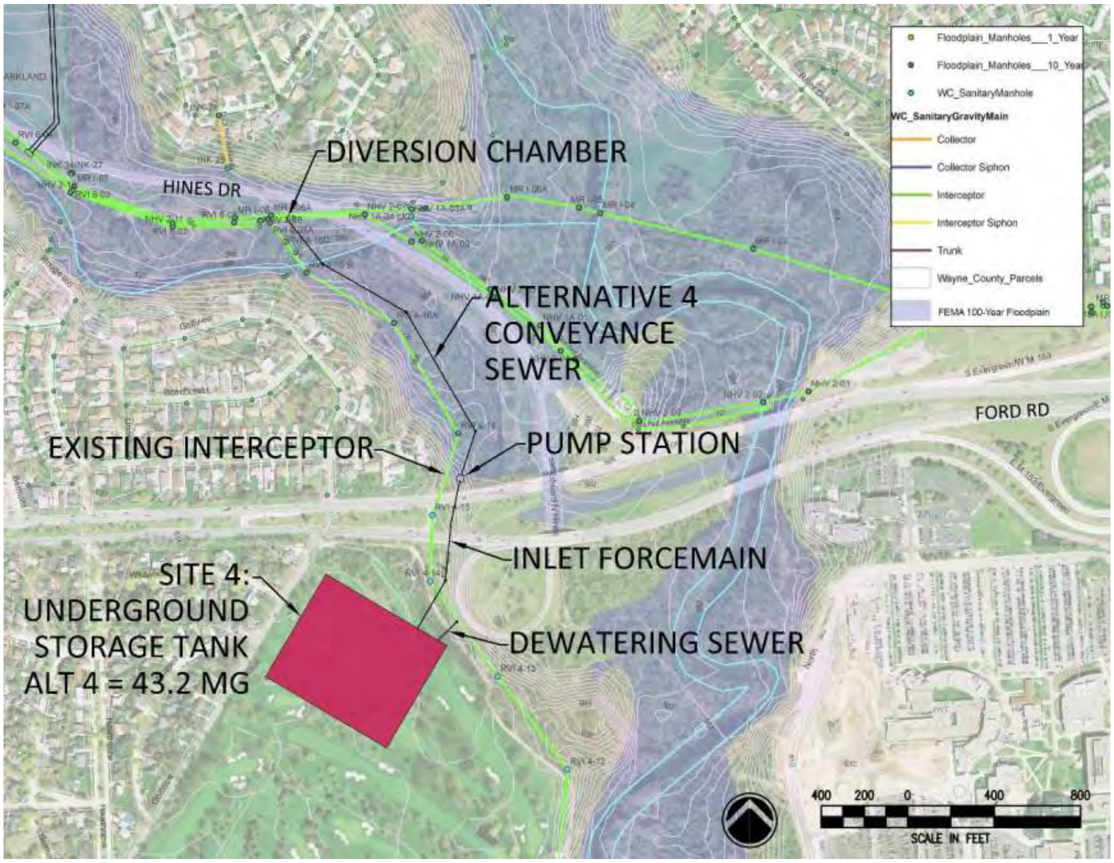

Figure 4-10: Alternative 4 – Single Storage Facility

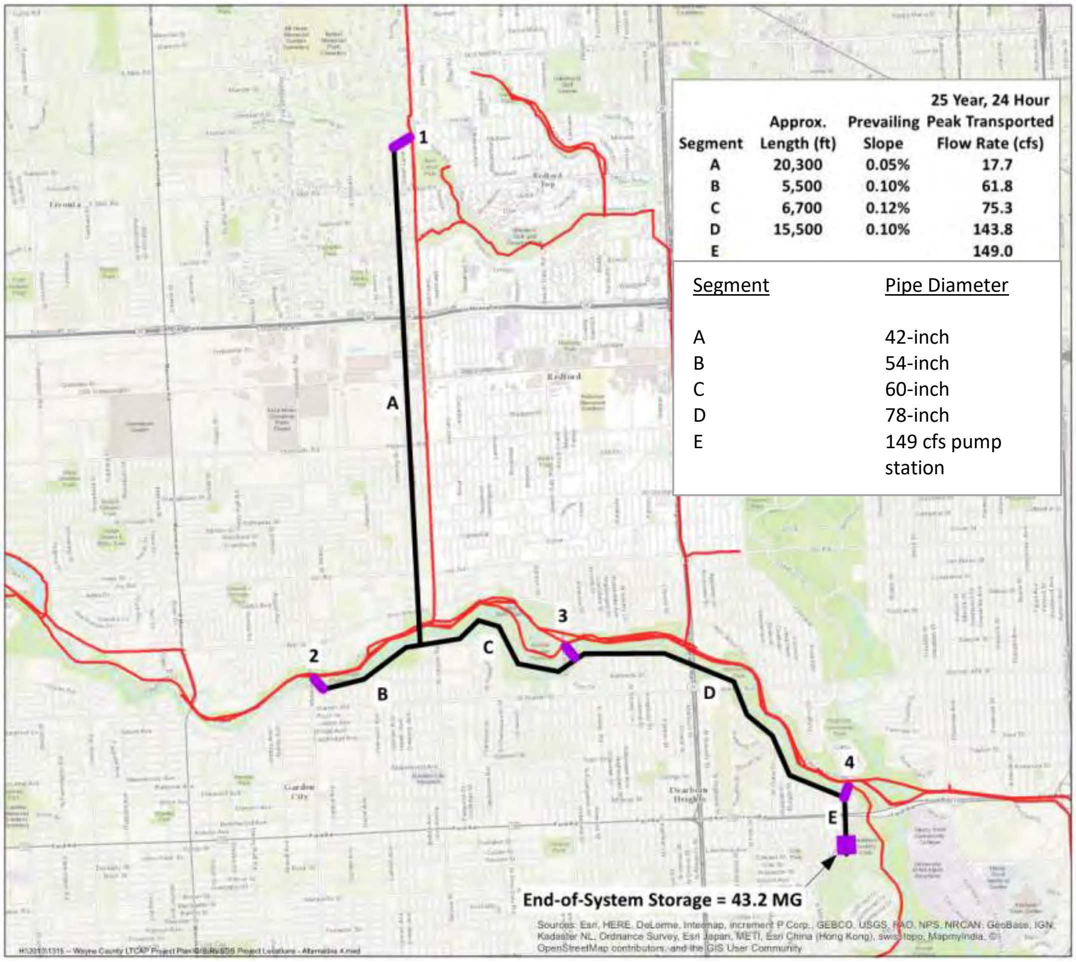

Figure 4-11: Alternative 4 – Conveyance Enhancement Reaches

A review of potential sites available in the vicinity of the draw-off location shows no open property available within Hines Park that is not in the floodplain, and the Rouge Park site utilized for Alternative 3 is much too small to accommodate the larger storage volume required for this alternative. The only open space outside of the floodplain in this vicinity large enough for a basin of this size is the Dearborn Country Club Golf Course located south of Ford Road (see Figure 4-10). Similar to the Warren Valley Golf Course *Alternative 3 / Site 3* storage basin, an underground storage tank would be constructed, and then the site restored as a golf course upon completion, with potential golf course site enhancements using excavated materials. This will, however, require temporary closing off a portion of the course with loss of revenues, likely spanning at least two summer seasons, to allow basin construction and re-establishment of disturbed turf areas for the course restoration. The site will also require an extension of the interceptor relief sewer to a pump station on the north side of Ford Road to lift flows into the basin, using a forcemain across Ford Road. Dewatering would be by gravity to the existing interceptor on the east side of the site that flows south to the Rouge Valley Oakwood Interceptor.

The estimated project cost for Alternative 4 is $260 million.

Alternative 5

This alternative is similar to Alternative 4, but instead of a wet weather storage facility, a new wastewater treatment facility would be constructed on the Dearborn Country Club location as depicted in Figure 4-10. The alternative also includes the same nine miles of interceptor relief sewers described in Alternative 4 to transport design event peak flows to the treatment facility. The components for this alternative are equivalent to the facilities illustrated in Figure 4-10 and Figure 4-11.

This option is by far the costliest of all alternatives, and has many challenges for implementation, but is being presented for cost comparisons with the other options in accordance with Project Plan alternative evaluation requirements requested by the MDEQ. This option will likely require permanent closure for portions of the existing Dearborn Country Club Golf Course which may be impractical and cost-prohibitive. Nonetheless, the alternative is being considered to evaluate the range of options in comparison with the other alternatives.

The estimated project cost for Alternative 5 is $1.07 billion.

Summary of Alternatives

A comparison summary of the components included in the various alternatives, including the estimated project cost for each, is presented in Table 4-2. The conventional approaches to SSO control (storage, transport, and treat) are not economically feasible for this system. A robust Asset Management Plan, as represented in Alternative 1, will focus on targeted system improvements necessary to restore the system to operate within its original design intent. Alternative 2 provides a realistic and implementable solution to address SSOs if the Asset Management Plan does not fully achieve the goals of SSO control for the design event.

Additional cost information for each alternative are included in Tables 4-3 to Table 4-7.

Table 4-2: SRF Project Plan Components

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Asset Management Plan Implementation (Y/N)	YES	YES	NO	NO	NO
STORAGE TANK VOLUMES					
SITE 1	--	1.6 MG	2.6 MG	--	--
SITE 2	--	4.0 MG	7.1 MG	--	--
SITE 3	--	--	37.0 MG	--	--
SITE 4A	--	--	1.5 MG	--	--
SITE 4B	--	--	--	43.2 MG	Water Resource Recovery Facility
CONVEYANCE SEWERS (Approx. 9 miles)	NO	NO	NO	YES	YES
CONCEPTUAL PROJECT COST	**$80 million**	**$127 million**	**$247 million**	**$260 million**	**$1.07 billion**

Recommended Alternative and Project Plan Schedule

For the recommended Alternative, Alternative 1, most activities are scheduled to be implemented in 2019 to 2023, with ongoing inspection and repair/rehabilitation activities continuing throughout the 20-year planning horizon. The conceptual project costs include the entire 20-year planning horizon. During 2023, flow metering will be used to evaluate the effectiveness of the system improvements. If additional wet weather storage is deemed necessary, the wet weather storage components of Alternative 2 will be re-evaluated, located, and implemented starting in 2024.

Alternatives 3-5 are not being considered for implementation due to magnitude of cost difference.

Detailed Cost Estimates

The tables on the following pages include concept-level estimates for each of the five alternatives presented in this section.

Table 4-3: Alternative 1 Conceptual Cost Estimate

ENGINEER'S OPINION OF CONSTRUCTION COST **DRAFT**

PROJECT: Rouge Valley LTCAP **DATE:** 03/22/19
LOCATION: Wayne County **PROJECT NO.**
BASIS FOR ESTIMATE: [X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL BY: GPK
WORK:
Alternative 1 - Asset Management Plan

ITEM	Description	Conceptual Cost			
		Unit Cost	Units	Quantity	Cost
1	Local and County Floodplain Manhole Replacement/Repairs	$ 10,000,000	LS	1	$ 10,000,000
2	Ongoing Floodplain Manhole Inspections (through 2023)	$ 400,000	LS	1	$ 400,000
3	RVSDS Interceptor Televising and Condition Ratings (through 2023)	$ 3,000,000	LS	1	$ 3,000,000
4	Sewer Rehibilitation and Junction Retrofits (through 2023)	$ 15,000,000	LS	1	$ 15,000,000
5	CSO Capture Optimization	$ 2,000,000	LS	1	$ 2,000,000
6	LS1A Screening Improvements / Lower Rouge Isolation	$ 5,000,000	LS	1	$ 5,000,000
7	Lower Rouge - Replace Line Connection Siphon @ L-34	$ 500,000	LS	1	$ 500,000
8	Wayne County Parks Dual Purpose Pathways	$ 1,000,000	LS	1	$ 1,000,000
9	Asset Management Activities - Years 6-20	$ 20,278,000	LS	1	$ 20,278,000
	Inspection / Construction Subtotal	$ 57,178,000			
	Contingency, 20%	$ 11,436,000			
	Engineering, Legal and Administration, 20%	$ 11,436,000			
	Land Acquisition and Easements	N/A			
	Total Project Cost	**$ 80,050,000**			

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Table 4-4: Alternative 2 Conceptual Cost Estimate

ENGINEER'S OPINION OF CONSTRUCTION COST **DRAFT**

PROJECT: Rouge Valley LTCAP **DATE:** 03/22/19

LOCATION: Wayne County **PROJECT NO.**

BASIS FOR ESTIMATE: [X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL BY: SAK

WORK:

Alternative 2-Asset Management and Wet Weather Storage

ITEM	Description	Conceptual Cost Unit Cost	Units	Quantity	Cost
1	Asset Management Program (Alternative 1 for 2018-2023)	$ 80,050,000	LS	1	$ 80,050,000
2	Site 1 - Bell Creek Park				
	A. Storage Tank, 1.6 MG	$ 6,600,000	LS	1	$ 6,600,000
	B. Submersible Pump Station 13.2 cfs	$ 2,720,000	LS	1	$ 2,720,000
	C. Inlet and Outlet Sewers / Diversion Chamber	$ 983,000	LS	1	$ 983,000
	D. Park Restoration	$ 200,000	LS	1	$ 200,000
					$ -
3	Site 2 - Hawthorne Vallley Abandoned Golf Course				$ -
	A. Storage Tank, 4.0 MG	$ 14,070,000	LS	1	$ 14,070,000
	B. Submersible Pump Station 37.6 cfs	$ 5,721,000	LS	1	$ 5,721,000
	C. Inlet Outlet Sewers / Diversion Chamber	$ 1,065,000	LS	1	$ 1,065,000
	D. Site Restoration	$ 200,000	LS	1	$ 200,000
	Construction Subtotal	$			111,609,000
	Contingency, 20% (applies to Items 2 and 3 only)	$			6,312,000
	Engineering, Legal and Administration, 30% (applies to Items 2 and 3 only)	$			9,468,000
	Land Acquisition and Easements		TBD		
	Total Project Cost	**$**			**127,389,000**

Table 4-5: Alternative 3 Conceptual Cost Estimate

ENGINEER'S OPINION OF CONSTRUCTION COST DRAFT

PROJECT Rouge Valley LTCAP **DATE:** 03/01/19

LOCATIOI Wayne County **PROJECT NO.**

BASIS FOR ESTIMATE: [X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL BY: SAK

WORK:

Alternative 3 – Decentralized Storage

ITEM	Description	Conceptual Cost			
		Unit Cost	Units	Quantity	Cost
1	Site 1 - Bell Creek Park				
	A. Storage Tank, 2.6 MG	$ 9,860,000	LS	1	$ 9,860,000
	B. Submersible Pump Station 16.7 cfs	$ 3,241,000	LS	1	$ 3,241,000
	C. Inlet and Outlet Sewers/Diversion Chamber	$ 1,050,000	LS	1	$ 1,050,000
	D. Park Restoration	$ 200,000	LS	1	$ 200,000
					$ -
2	Site 2 - Hawthorne Valley Abandoned Golf Course				$ -
	A. Storage Tank, 7.1 MG	$ 22,600,000	LS	1	$ 22,600,000
	B. Submersible Pump Station 49.1 cfs	$ 6,895,000	LS	1	$ 6,895,000
	C. Inlet Outlet Sewers/Diversion Chamber	$ 1,372,000	LS	1	$ 1,372,000
	D. Site Restoration	$ 200,000	LS	1	$ 200,000
					$ -
3	Site 3 - Warren Valley Golf Course				$ -
	A. Storage Tank, 37.0 MG	$ 88,370,000	LS	1	$ 88,370,000
	B. Submersible Pump Station 118.3 cfs	$ 12,761,000	LS	1	$ 12,761,000
	C. Inlet Outlet Sewers/Diversion Chamber	$ 800,000	LS	1	$ 800,000
	D. Golf Course Restoration	$ 2,000,000	LS	1	$ 2,000,000
					$ -
4	Site 4 - Rouge Park				$ -
	A. Storage Tank, 1.5 MG	$ 10,260,000	LS	1	$ 10,260,000
	B. Submersible Pump Station 14.0 cfs	$ 2,865,000	LS	1	$ 2,865,000
	C. Inlet Outlet Sewers/Diversion Chamber	$ 1,533,000	LS	1	$ 1,533,000
	D. Rouge Park Restoration	$ 400,000	LS	1	$ 400,000
					$ -
					$ -
					$ -
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					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
	Construction Subtotal	$			164,407,000
	Contingency, 20%	$			32,881,400
	Engineering, Legal and Administration, 30%	$			49,322,100
	Land Acquisition and Easements		TBD		
	Total Project Cost	**$**			**246,610,500**

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Table 4-6: Alternative 4 Conceptual Cost Estimate

ENGINEER'S OPINION OF CONSTRUCTION COST — **DRAFT**

PROJECT Rouge Valley LTCAP — **DATE:** 03/01/19

LOCATIO Wayne County — **PROJECT NO.**

BASIS FOR ESTIMATE: [X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL — BY: SAK

WORK:

Alternate 4 – Enhanced Conveyance and Downstream Storage

ITEM	Description	Conceptual Cost			
		Unit Cost	Units	Quantity	Cost
1	Conveyance Sewers				
	A. 42" Diameter Sewer-Segment A	$ 1,235	LF	20300	$ 25,070,500
	B. 54" Diameter Sewer-Segment B	$ 1,195	LF	5500	$ 6,572,500
	C. 60" Diameter Sewer-Segment C	$ 1,295	LF	6700	$ 8,676,500
	D. 78" Diameter Sewer-Segments D and E	$ 1,550	LF	15500	$ 24,025,000
					$ -
2	Site 4 - Storage Facility-Dearborn Country Club Golf Course				$ -
	A. Storage Tank, 42.2 MG	$ 152,905,000	LS	1	$ 152,905,000
	B. Submersible Pump Station 149.0 cfs	$ 14,998,000	LS	1	$ 14,998,000
	C. Inlet Outlet Sewers/Diversion Chamber	$ 1,283,000	LS	1	$ 1,283,000
	D. Golf Course Restoration	$ 4,000,000	LS	1	$ 4,000,000
					$ -
					$ -
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	Construction Subtotal	$			173,191,275
	Contingency, 20%	$			34,638,255
	Engineering, Legal and Administration, 30%	$			51,957,383
	Land Acquisition and Easements			TBD	
	Total Project Cost	**$**			**259,786,913**

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Table 4-7: Alternative 5 Conceptual Cost Estimate

ENGINEER'S OPINION OF CONSTRUCTION COST **DRAFT**

PROJECT: Rouge Valley LTCAP **DATE:** 02/07/19

LOCATION: Wayne County **PROJECT NO.**

BASIS FOR ESTIMATE: [X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL BY: SAK

WORK:

Alternative 5 - Transport and Treat

ITEM	Description	Conceptual Cost			
		Unit Cost	Units	Quantity	Cost
1	Conveyance Sewers				
	A. 42" Diameter Sewer-Segment A	$ 1,235	LF	20,300	$ 25,070,500
	B. 54" Diameter Sewer-Segment B	$ 1,195	LF	5,500	$ 6,572,500
	C. 60" Diameter Sewer-Segment C	$ 1,295	LF	6,700	$ 8,676,500
	D. 78" Diameter Sewer-Segments D and E	$ 1,550	LF	15,500	$ 24,025,000
2	Site 4 - Dearborn Hills Country Club				
	A. Water Resource Recovery Facility, 100 MGD	$ 710,000,000	LS	1	$ 710,000,000
	Construction Subtotal	$			710,005,000
	Contingency, 20%	$			142,001,000
	Engineering, Legal and Administration, 30%	$			213,002,000
	Land Acquisition and Easements		TBD		
	Total Project Cost	**$**			**1,065,008,000**

5 RECOMMENDATIONS

To achieve the goals of FOA 2117 and the LTCAP, implementation of Alternative 1: Asset Management Plan is recommended. This alternative is the most cost-effective and targets improvements to the components of the system that will have the best long-term benefit to the system and to the environment.

Furthermore, this strategy focuses on the removal of river-dependent inflow. A successful completion of Alternative 1 will achieve the SRF Fiscal Sustainability Plan goal of "implementing water and energy conservation efforts", as the removal of river-dependent inflow will significantly reduce the costs of pumping and treating additional flows during wet weather. Additionally, the focus on flow removal (as opposed to conveyance and storage only) will reduce the reliance on large pump stations to pump flows to storage areas during wet weather events.

The Asset Management approach will span a 20-year planning horizon.

Years 1-5: The first five years will focus on an aggressive approach to floodplain manhole repairs, sewer televising, sewer rehabilitation, junction retrofits, CSO operational modification, and capital improvements at LS1A. Sections 5.1 and 5.2 present a detailed discussion of the Alternative 1 (Asset Management Plan) components, including summaries from the RVSDS H/H model analysis that support this strategy.

Years 6-10: As described in Section 5.4, the second five years will consist of continued system inspection and repair (Alternative 1), although at a less aggressive pace than the first five years. If additional wet weather storage is deemed necessary (Alternative 2), the storage facility(ies) will be designed and constructed during this period. During this period, hydraulic improvements will be made to local line connections to the RVSDS Interceptors.

Years 11-20: As described in Section 5.5, the final ten years of the 20-year planning horizon will consist of continued system inspection and repair. During this period, adjustments will be made to the magnitude of inspection and repairs as deemed necessary to manage SSOs.

5.1 ASSET MANAGEMENT (AM) PROJECTS

5.1.1 REMOVE RIVER INFLOW

a. The flow metering and hydrologic and hydraulic computer modeling effort revealed that river inflow remains a major source of flows in the RVSDS and is a primary contributor to SSOs within the system; especially along the Middle Rouge Interceptor. The river inflow hydrograph (Figure 5-1) reveals that 193 million gallons (MG) is estimated to enter the RVSDS during the 25-year, 24-hour design storm event; most of this likely into dislodged manhole covers, open pipe joints, or other openings within the 1- and 2-year floodplain of the Middle Rouge River.

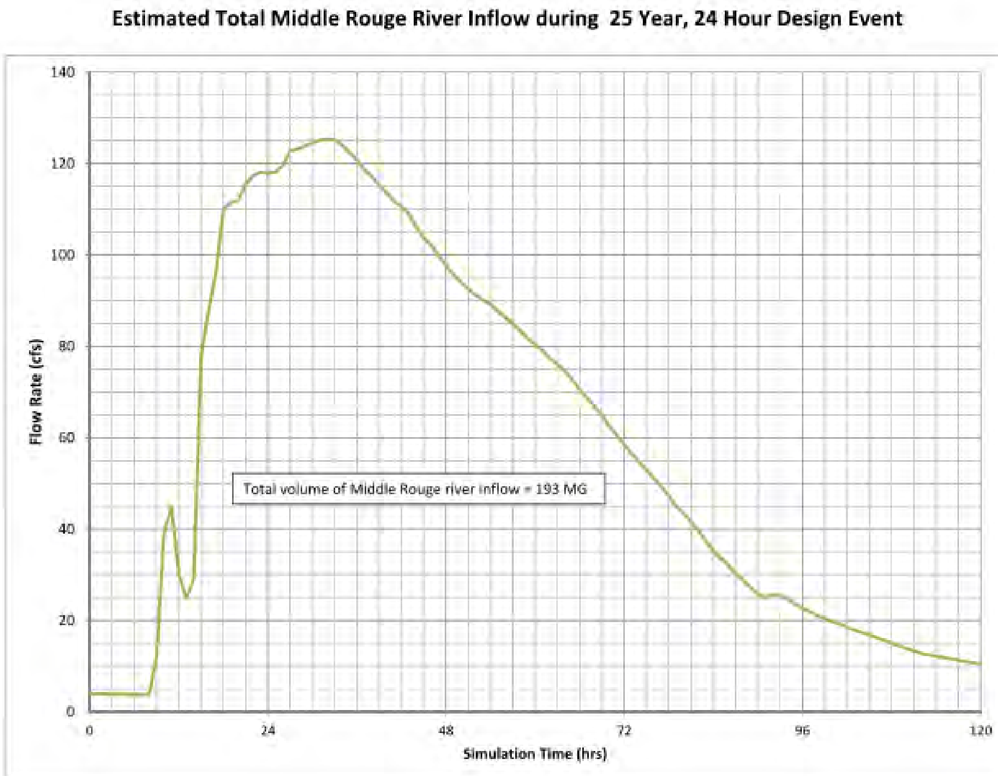

Figure 5-1: River Inflow Hydrograph near Dearborn Heights for 25-year, 24-hour Design Storm Event

b. Field reconnaissance has confirmed that river inflow into damaged or compromised manholes is a primary concern in the RVSDS. Hydraulic surcharging within the Middle Rouge Interceptor results in manhole frames being dislodged. As the sewer flows subside and the river levels increase, the floodplain has access to the interceptor via exposed manhole openings (typically 24-inch diameter) in structures. Even a small amount of head above the structure can result in significant inflow rates. See Appendix J for further details.
c. Floodplain Manhole Retrofits
    i. There are approximately 315 RVSDS manholes in the 1- and 2-year floodplains of the Middle Rouge and Lower Rouge. Based on the LTCAP field reconnaissance effort completed in 2015, it is evident that these manholes are prone to hydraulic surcharging above the rim (which tends to dislodge manhole frames, castings, and/or lids) and subsequent river inflow. Additionally, it is suspected that some manhole covers are periodically removed by local property owners to attempt to dewater flooded lands. Retrofitting these manholes can remove this source of river inflow.
        1. Manholes can be locked to prevent unauthorized opening during wet weather events.
        2. Manholes along the river banks can be outfitted with special manholes that cannot be dislodged and will remain closed when the river level rises above the interceptor hydraulic grade line (HGL). The manholes should be allowed to relieve the system due to high surcharge until the improvement program is completed and it is determined that relief is no longer needed.

Analysis of storm events larger than the design event will be needed to determine how best to address those conditions once the system has achieved compliance.

3. Some manholes will require rehabilitation or rebuilding, depending on observed structural condition.
4. There are locally owned manholes and junctions in the 1- and 2-year floodplain that will also require attention by the RVSDS communities (e.g., M-20) to reduce river inflow into the RVSDS interceptors.

d. Local Floodplain Manholes

i. It will be necessary for the RVSDS communities to address their individual collection systems within the 1- and 2-year floodplain. There are approximately 400 confirmed locally-owned manholes and an additional 100 interpolated locally-owned manholes in the 1- and 2-year floodplain (see

ii. Figure 5-2). There are locally owned junctions in the 1- and 2-year floodplain that will also require attention by the RVSDS communities (e.g., M-20) to reduce river inflow into the RVSDS interceptors.

iii. The cost estimates in this Project Plan reflect the efforts to address locally-owned manholes in the floodplain. This is a critical component to the Asset Management plan, because *river inflow will not be addressed until all manholes in the floodplain, regardless of ownership, are located, inspected, and retrofitted*.

Figure 5-2: Example of County (yellow) and local (green) Manholes in the Middle Rouge Floodplain between Inkster and Telegraph Road

e. Floodplain Manhole Inspection Program
   i. The 315 (+/-) RVSDS floodplain manholes, as well as additional locally-owned floodplain manholes, will need to be inspected, on an annual basis, into perpetuity to ensure they are operating as intended and that river inflow is isolated from the RVSDS. This inspection program will include annual inspections of the cover and a cursory inspection of the upper interior to verify whether there is a potential for river inflow. Dislodged castings/frames will be reset and re-attached. Communities will be informed if their structures are failing to meet the selected standard for inflow protection. Full structural (Manhole Assessment Certification Program (MACP)-compliant) inspections for the manholes would likely occur on a less frequent basis (say, 10-year cycle). See Appendix G for further detail about the inspection of the floodplain manholes as part of Phase 1 of the LTCAP.

f. Wayne County Parks Dual Purpose Pathways
   i. As many of the RVSDS manholes remain hidden in the woods along the Middle and Lower Rouge Rivers, it is often hard to find the manholes for inspection and therefore it is more difficult to control river inflow. Where possible, add new pathways or revise existing pathways along the Middle and Lower Rouge Rivers within Wayne County Parks that service as dual purpose paths for recreation and RVSDS maintenance. This will make it easier for future inspection and maintenance of manholes and sewer pipes.

Table 5-1: Impacts of Item 5.1.1 Remove River Inflow

Task	Benefit	Impact on Design-Event SSO Volume	Planning Level Cost Estimate	Schedule
Local and County Floodplain Manhole Replacement and Repairs	Address river inflow in a comprehensive and cost effective manner	Major	$10 Million (TOTAL)	2019 to 2023
Local and County Floodplain Manhole Inspections		Preventive Measures	$80,000 per year	2019 into perpetuity
Wayne County Parks Dual Purpose Pathways	Easy accessibility to manholes in floodplain	Preventive Measures	Cost To Be Determined	Ongoing: Work alongside Wayne County's Park and Recreation Master Plan for Hines Park

5.1.2 *ADDRESS HYDRAULIC CAPACITY AND STRUCTURAL INTEGRITY*

a. The RVSDS hydrologic and hydraulic modeling effort revealed that the Middle Rouge Interceptor, downstream of the Inkster Arm, does not have its expected hydraulic capacity, as observed system flow depths exceed that which the hydraulic model would predict for wet weather events. Based on field observations and review of previous pipe inspection data, this is likely due to a combination of:
    i. Lack of system venting,
    ii. Pipe friction coefficient, and
    iii. Abnormal junction losses.
b. Five system vents were installed in late 2016/early 2017 in the RVSDS Middle Rouge Interceptor system along Hines Drive from Merriman Road to Ford Road under the LTCAP Work Plan. The effectiveness of the venting is expected to be fully realized in combination with the reduction of river-dependent inflow. See Appendix I for further detail about the system venting locations.
c. Leading up to the STCAP effort, the RVSDS was televised in 2006. Although approximately 11,000 LF (2%) of the RVSDS was lined during the STCAP, there are many sewers that had fair to poor structural scores that will need to be revisited. Furthermore, high definition images of pipe walls during the LTCAP effort revealed significant pipe corrosion with exposed aggregate; this reveals that that significant sewer rehabilitation is necessary. Rehabilitation of select interceptor system segments will improve the structural integrity of the sewer and should also significantly reduce the friction coefficient to a level that is consistent with the original design parameters for RVSDS.
d. RVSDS H/H modeling efforts reveal that a change in Manning's n coefficients for the interceptors is expected to have a significant positive impact on system flow capacity through pipe rehabilitation and lining of select reaches.
e. Systematic Sewer Televising and Rehabilitation

i. The RVSDS will initially be inspected on a 5-year cycle; this will help to ensure that pipe wall condition is more closely tracked and that any inflow/infiltration issues can be addressed in a timely manner.

ii. High definition videos will help to better characterize pipe wall roughness and confirm where rehabilitation can have a positive impact on hydraulic performance; this will help to ensure that rehab/lining projects are directed to the most critical areas.

iii. Sewer rehabilitation will be an ongoing program and will help to ensure the long-term performance of the RVSDS. Rehabilitation will address both structural problems and hydraulic issues along the RVSDS interceptors.

f. Junction Retrofits

i. As the RVSDS pipes are rehabilitated, opportunities will exist to inspect and repair existing junction chambers. Depending on the pipe rehabilitation methods, some junctions may need to be replaced or altered to accommodate the equipment necessary for lining. When these opportunities present themselves, the junction chambers should be rebuilt or modified such that flow transitions are more efficient, thereby minimizing junction [hydraulic] losses.

g. Verification

i. Once the major improvements have been implemented, a detailed monitoring program will be conducted to determine if the goals of the LTCAP have been achieved. If not, determine the required additional actions.

Table 5-2: Impacts of Item 5.1.2 Address Hydraulic Capacity and Structural Integrity

<table>
<tr><th>Task</th><th>Benefit</th><th>Impact on Design-Event SSO Volume</th><th>Planning Level Cost Estimate</th><th>Schedule</th></tr>
<tr><td>Televising</td><td>Identify and prioritize RVSDS improvements</td><td>Preventive Measures</td><td>$600,000 per year</td><td>2019 to 2023 First round of televising will be completed and continue program on a 5-year cycle</td></tr>
<tr><td>Sewer Rehabilitation</td><td>Improve structural integrity and hydraulic capacity</td><td>Major</td><td rowspan="2">$15 Million (TOTAL)</td><td>2019 to 2023</td></tr>
<tr><td>Junction Retrofits</td><td>More efficient flow transitions and a reduction in hydraulic losses</td><td>Major</td><td>2019 to 2023</td></tr>
</table>

5.1.3 MINIMIZE SSO VIA CSO OPERATIONAL MODIFICATIONS

A proposed strategy for the LTCAP improvements is to throttle the flows (flow that exceeds interceptor capacity to discharge to the river during significant rain events) from CSO regulators during major storm events to optimize existing interceptor capacity for separate sanitary service areas. Preliminary hydrologic and hydraulic computer modeling analysis has shown that implementation of this strategy, in conjunction with other AM Program efforts outlined in this document, has the potential to further reduce the need for regional wet weather storage in the RVSDS. Additional technical analyses including discussions with MDEQ on the regulatory requirements for implementation of this strategy is needed to confirm its acceptance.

While the strategy will increase peak discharge to the river from CSO areas during significant rain events, in general, it is expected that the total captured volume of combined sewage should not be increased. This can typically be accommodated by capturing more flow during times when interceptor capacity is available to offset the reduced capture during peak flow conditions. If controlled efficiently, this can reduce the volume of combined sewer overflow on an annual basis, since there are many more small events per year during which the RVSDS interceptor can capture a larger flow volume, thereby reducing discharges to the environment. The increased discharge to the environment (via CSO) during larger events due to the proposed CSO throttling should be more than offset by the increased capture for the more numerous smaller CSO events during which CSO volumes are reduced.

A preliminary technical review of anticipated system components needed for the CSO regulator throttling option is provided below, along with a conceptual planning level cost estimate. This information is intended to be used for preliminary screening of the feasibility of the strategy to assess if it is cost effective in comparison with other regional storage alternatives and be used to initiate discussions with MDEQ on the acceptability and anticipated regulatory compliance requirements for implementation.

a. Background

   i. There are currently 34 active CSO regulators within the RVSDS Interceptor System as shown in Figure 5-3. Twenty-four (24) locations are tributary to CSO control facilities at four existing retention treatment basins. The remaining 18 sites have uncontrolled CSO discharges to the Rouge River that are to be controlled with future CSO control projects. The schedule for the Phase II CSO improvements varies by community based on their individual NPDES permit requirements for the CSO discharges. The CSO control program improvements fall under requirements of NPDES permits issued to the separate CSO systems rather than the compliance actions required for RVSDS under FOA 2117.

   ii. Table 5-3 and Table 5-4 provide a breakdown of the various groupings of CSO regulators being considered for throttling of sanitary flows.

Table 5-3: Active CSO Regulators Tributary to Existing RTB Basins

RTB Basins	Number of CSO: Facility Id
Dearborn Heights RTB	6 locations: CSO 2 (M-33), CSO 4 (M-16), CSO 5 (M-15), CSO 6 (M-17), CSO 3 (M-18), CSO 10 (M-19)
Redford RTB	3 locations: CSO 36 (U-6), CSO 38 (U-8), CSO 37 (U-7)
Inkster RTB	8 locations: CSO 19 (L-47), CSO 20 (L-48), CSO 21 (L-39), CSO 22 (L-38), CSO 63 (L-45), CSO I-3 (L-40), CSO I-8 (L-44), and CSO I-5/6/9 (001/002/003)
Inkster Middlebelt Road RTB	2 locations: CSO 18 (L-46) and CSO I-2 (009)

Table 5-4: Active CSO Regulators with Currently Uncontrolled CSO Discharges (directly to river)

Location of Active CSO Regulators		Number of CSO: Facility Id
Middle Rouge	Dearborn Heights	2 Locations: CSO 7 (M-14) CSO 8
Main Rouge	Dearborn Heights	1 Location: CSO 46 (U-1)
	Redford	1 Location: CSO 45 (U-2)
Lower Rouge	Dearborn Heights/Inkster	2 Locations: CSO 11 (L-42), CSO 13 (L-41)
	Dearborn Heights	1 Location: CSO 12 (L-43)
Upper Rouge	Redford	6 Locations: CSO 39 (U-5), CSO 40 (U-3), CSO 41 (U-4), CSO 42 (U-11), CSO 43 (U-9), CSO 44 (U-10)

iii. Throttling the CSOs will have a positive impact on the interceptor system. All regulators are recommended for the throttling strategy, although a phased approach is recommended:

1. Phase 1: High priority throttling locations based on cost-effectiveness of peak flow management (see following discussion), to be implemented during the next 3-5 years.
2. Phase 2: Remaining throttling locations to be implemented beyond 2022, based on the remaining need for peak flow control as determined from ongoing flow metering efforts.

iv. Based on analysis using the RVSDS H/H model, it is apparent that a subset of the regulators are ideal candidates for throttling and will be considered high priority (Phase 1) throttling projects. This is due to the following constraints:

1. The primary objective is to address the hydraulic profile in the Middle Rouge Interceptors; as such, all regulators along the Lower Rouge Interceptors were removed from the list of potential throttling candidates.
2. Of the remaining regulators tributary to the Middle Rouge Interceptors, (Series M and U regulators, including Redford), many are directly impacted by the hydraulic gradient in the receiving interceptor sewer. This hydraulic

characteristic causes the regulators to naturally throttle to zero or near zero flow (due to lack of head differential). These regulators should require no retrofits.

3. Several regulators discharge less than 1 cfs peak flow into the interceptor; the impact of these regulators on system performance and wet weather storage volume is lower than Phase 1 locations. Throttling at these regulators will be considered as Phase 2 projects and their need will be further evaluated beyond 2022.

v. Upon eliminating regulators due to location (Lower Rouge Interceptor), adverse hydraulic conditions, or low peak flow, there remain five (5) regulators that contribute the majority of peak flow volume into the Middle Rouge Interceptor and should be targeted for the initial throttling program. Those regulators are:

1. M-13 (direct discharge to river),
2. M-14 (direct discharge to river),
3. U-2 (direct discharge to river),
4. U-6 (tributary to Redford CSO RTB), and
5. U-11 (direct discharge to river).

Four out of the five regulators listed above have NPDES Permits. Table 5-5 below lists the NPDES Permit Numbers and their currently scheduled completion of construction deadlines.

The planning-level cost estimate for the CSO throttling program, $2.0-$2.5 million, would be economically viable, given the potential to reduce wet weather storage volume by 1.5 million gallons. The reduction in construction costs associated with a corresponding reduction in additional flow storage volume should be at least $6 million to $7 million, based on typical per-gallon costs for wet weather flow storage. This easily exceeds the estimated costs associated with the throttling effort.

Table 5-5: Regulator New Construction Deadlines

Regulator ID	NPDES Permit Number	Construction Deadline
M-13	MI0051489	To be determined when the expired permit is reissued
M-14	MI0051489	To be determined when the expired permit is reissued.
U-2	MI0051535	October 1, 2025
U-6	N/A	N/A
U-11	MI0051535	October 1, 2025

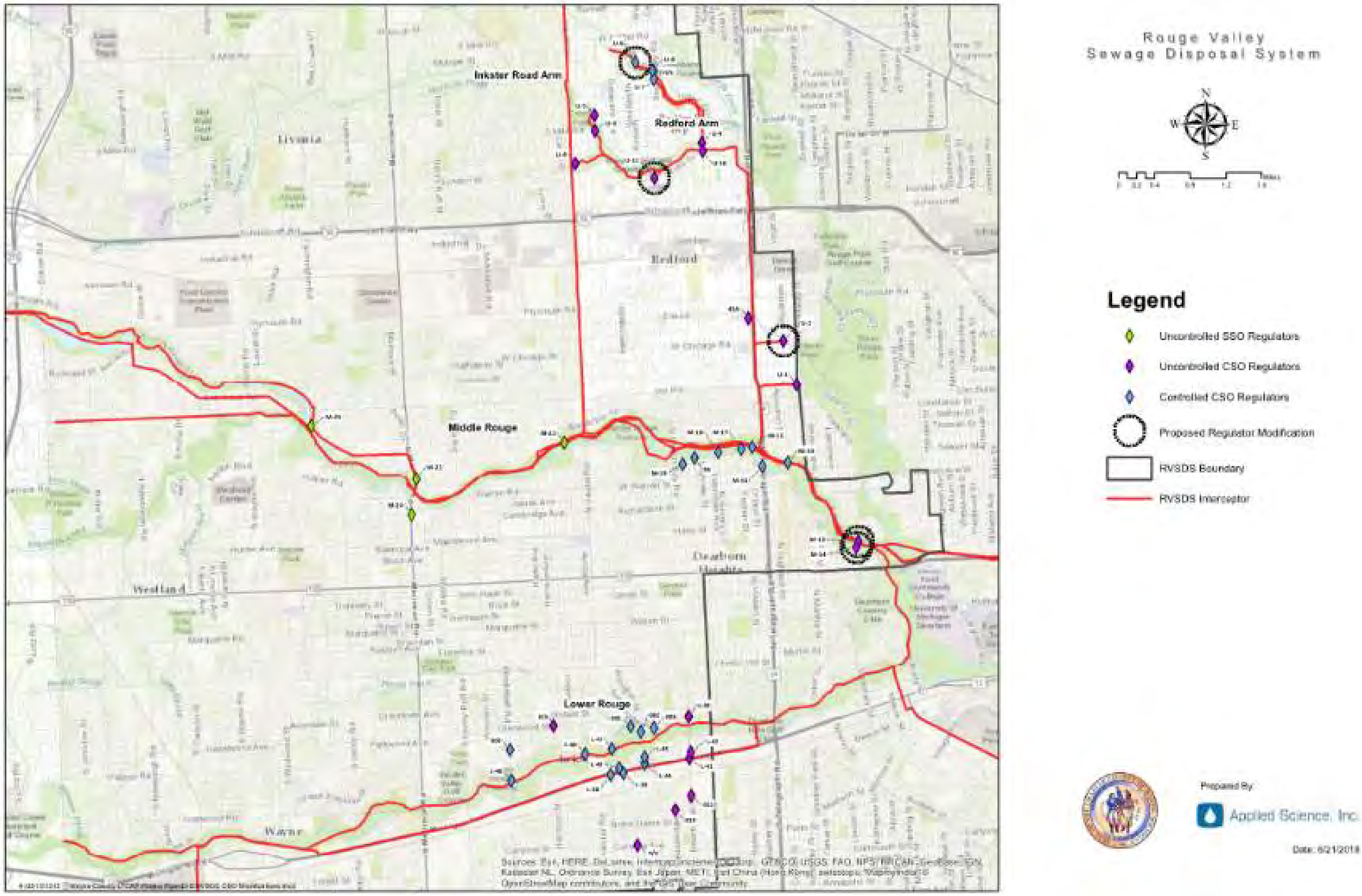

Figure 5-3: CSO Locations

b. Requirements to Throttle Flow

The existing regulators vary considerably in the type, size, tributary area, size and location of the sanitary connection. A preliminary review of the site requirements was conducted based on readily available information compiled for the LTCAP project to identify expected design components for the CSO throttling and estimate the average costs for typical site conditions. A more detailed evaluation of the individual site requirements will be necessary to confirm these planning level costs if carried forward for implementation.

i. Control Gates

1. The CSO throttling option will require installation of a remotely controlled power operated control gate or valve to be installed on each sanitary connection to shut off flow to the interceptor. The existing CSO regulators control peak flow delivered to the interceptor using tipping gate, vortex, float controlled, or high pipe overflow devices that currently do not require power or instrumentation for operation. Since CSO throttling is only anticipated for larger storm events, it is expected that rather than replacing the existing regulators with modulating control gates, the simplest way to implement the strategy and also minimize O&M requirements for normal conditions, would be to leave the existing regulators in place to function as designed, and install the control gate downstream of the existing regulating device, and function as an open/close valve to be operated only when needed.

   In order to accommodate the desire to offset the reduction in captured volume during peak flow conditions, the flow rate to the interceptor needs to be increased during small events. This could potentially be accommodated by enlarging the capacity of the regulator (e.g. enlarging the opening or replacing the vortex valve with a larger size).

   The preferred location for installing the gate at each site will vary depending on the existing regulator type and structure configuration, as well as site conditions in the vicinity of the existing regulator. At many of the sites it may be possible to install a wall mounted gate within the existing regulator structure outlet chamber where space exists on the discharge pipe wall. Other locations may require construction of a new manhole structure over the sanitary sewer outlet, provided there is sufficient distance between the existing regulator chamber and interceptor to install an additional manhole. If a new structure is constructed, the gate should be installed as close to the existing regulator chamber as possible to minimize the length of sewer that could potentially trap solids when the control gate is closed.

   For preliminary costing purposes it is assumed that each control gate site will require construction of a new manhole or gate structure near the existing regulator chamber to house the new gate. Building a new structure may also offer additional flexibility for gate type selection and installation as compared with conducting retrofit work in existing structures to chip out concrete channels and install wall mounted gates in the existing chambers. Specific needs and requirements for the individual sites will be further evaluated during detailed design to select the most cost effective and constructible options.

An additional design consideration for the control gate is the location of the gate actuator. Typically, an above grade location is preferred to provide better maintenance access. This may not be possible at some of the regulator sites due to location in flood prone areas unless the grade line can be raised or more costly submersible actuator and gate operator is used. For planning level cost estimate purposes, additional costs have been assumed to be required at 10 of the sites for added features.

ii. Control Panel with Electrical/Instrumentation/SCADA equipment

1. A control panel is required for electrical and instrumentation to service the gate and SCADA controls. These items are typically housed in a ground level utility cabinet located near the control gate structure. Major instrumentation would include a remote terminal unit (RTU), gate controller for actuators, gate position indicator (open or closed), and communications consisting of an antenna with cell phone input/output connections to the Wayne County SCADA system. Electrical equipment would include a power panel with battery backup to send alarms in the event of power or gate failure.

   To protect the equipment the control panel should be located above river flood levels. Since some of the regulator sites are located within the floodplain, additional cost may be incurred for raising the grade (and addressing any floodplain permitting impacts) or extending electrical and control conduits from the control gate to a higher ground location for the control panel outside the floodplain. Based on a preliminary review of chamber locations from available drawings, regulator M-13 is in the floodplain and will require additional design provisions to protect any controls from flooding impacts.

iii. Electrical Service for Control Plan (provided by Utility Company)

1. Cost for power service from the utility company will vary considerably for each site based on distance from the existing power network. For planning level cost estimate purposes, an average allowance amount of $30,000 per gate location has been assumed to bring power to each site. Verification of this cost will require coordination with the power company for a more detailed evaluation of the individual site requirements to confirm the specific design configuration and outside utility costs for extending power to the 34 separate locations

iv. Wayne County SCADA System Upgrades

1. LS1A, Livonia Basin, the Dearborn Heights CSO RTB, and the flow meters and rain gages within the RVSDS are currently monitored and operated from the central Wayne County SCADA system currently located at the Downriver Wastewater Facility. There are also separate control systems at the individual CSO RTB facilities, LS1A and Livonia Basin. To maintain this capability for the new control gate sites, SCADA equipment and programming upgrades will be required to connect to additional I/O points at the central Facility, with more connections for the control gates associated with a particular existing and future RTB facility. For planning level cost estimate purposes, a cost of $200,000 for these SCADA system upgrades has been assumed to include any additional hardware and software programming to incorporate the control gates into the system. Figure 5-4 below is a typical schematic for the CSO throttling.

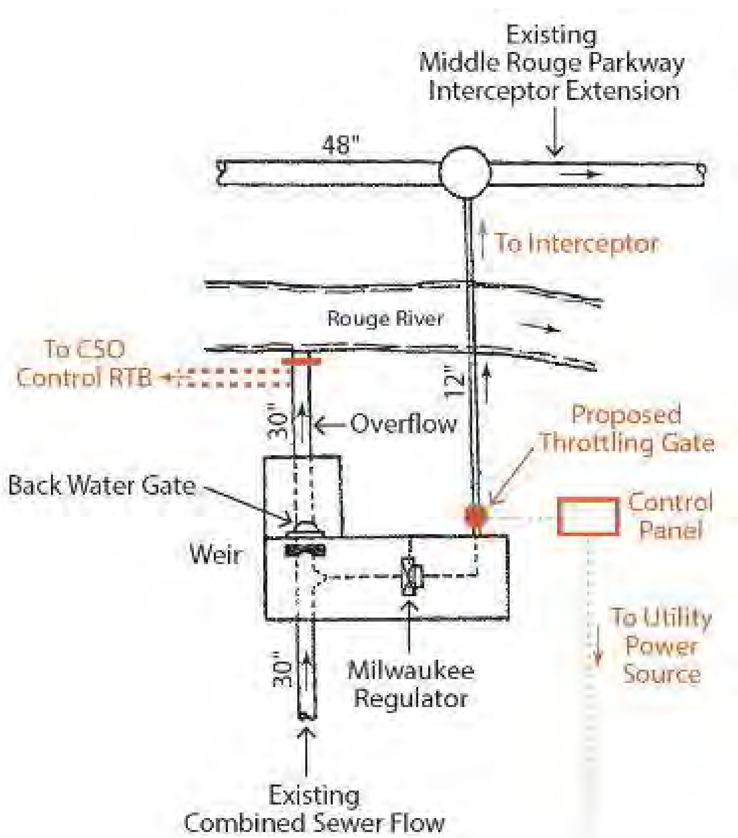

Figure 5-4: CSO Throttling Typical Schematic

Table 5-6: Impacts of Item 5.1.3 CSO Capture Optimization

Task	Benefit	Impact on Design-Event SSO Volume	Planning Level Cost Estimate	Schedule
Phase 1: High Priority throttling locations (5 regulators)	Reduce wet weather storage needs by ~1.5 million gallons on the Middle Rouge Interceptor	Major	\$2 -\$2.5 Million	2020 to 2022
Phase 2: Remaining throttling locations	Further reduce wet weather storage	Major	**TBD**	2022 into perpetuity

5.1.4 SCREENING IMPROVEMENTS/LOWER ROUGE INTERCEPTOR ISOLATION

a. The existing screens at LS1A can become blinded which makes it difficult to clean (there is no mechanical removal of debris) and results in excessive head upstream of the pumps, which propagates upstream in the Middle Rouge Interceptor. Current operations at LS1A are shown in Figure 5-5. The Task H: LS1A Operational Modifications memo from Wade Trim dated January 15, 2016 describes the proposed wet weather flow diversion away from the existing screens that are prone to blinding and towards the automated screens. The technical memorandum is included in Appendix H. This project will help to further reduce the hydraulic grade in the Middle Rouge Interceptor and ensure optimal performance at LS1A. Figure 5-6 shows the proposed operations for LS1A.

Figure 5-5: LS1A Current Operations

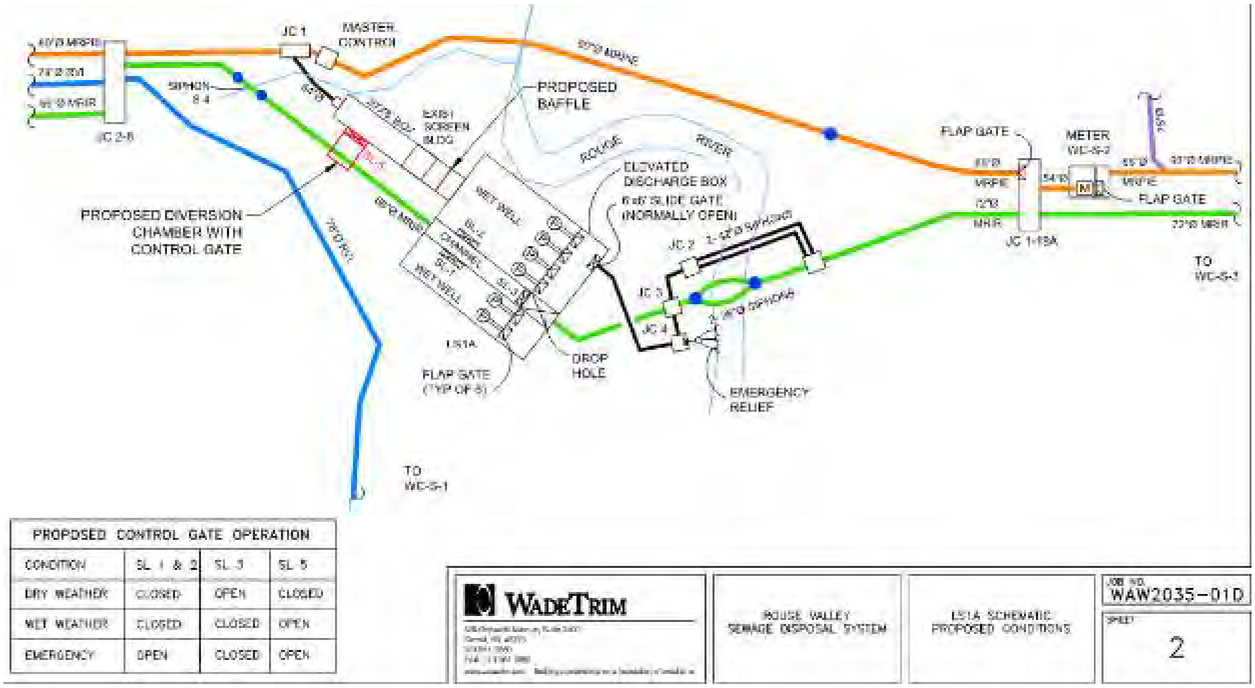

Figure 5-6: LS1A Proposed Operations

b. As part of this project, a sluice gate will be added to JC 2-8 such that the Middle Rouge flows will be prevented from flowing towards the Lower Rouge and Oakwood Interceptors. This helps to address hydraulic surcharging in the Lower Rouge Interceptor and more fully utilizes the flow capacity of LS1A during wet weather events. Since the addition of a sluice gate impacts both the Middle and Lower Rouge interceptors, it benefits the entire system and is therefore considered a part of the AM component of the Project Plan.

c. These two projects should be implemented together; the JC 2-8 sluice gate will direct more flows to LS1A, thereby requiring that the screening and pumping systems are fully-functional.

Table 5-7: Impacts of Item 5.1.4 LS1A Screening Improvements/Lower Rouge Isolation

Task	Benefit	Impact on Design-Event SSO Volume	Planning Level Cost Estimate	Schedule
LS1A Operational Improvements	Reduce the hydraulic grade in the Middle Rouge Interceptor and reduces operational needs	Minor	$5 - $6 Million	2020 to 2021
JC 2-8 Sluice Gate	Reduces the HGL to the Lower Rouge Interceptor and fully utilizes LS1A	Minor		

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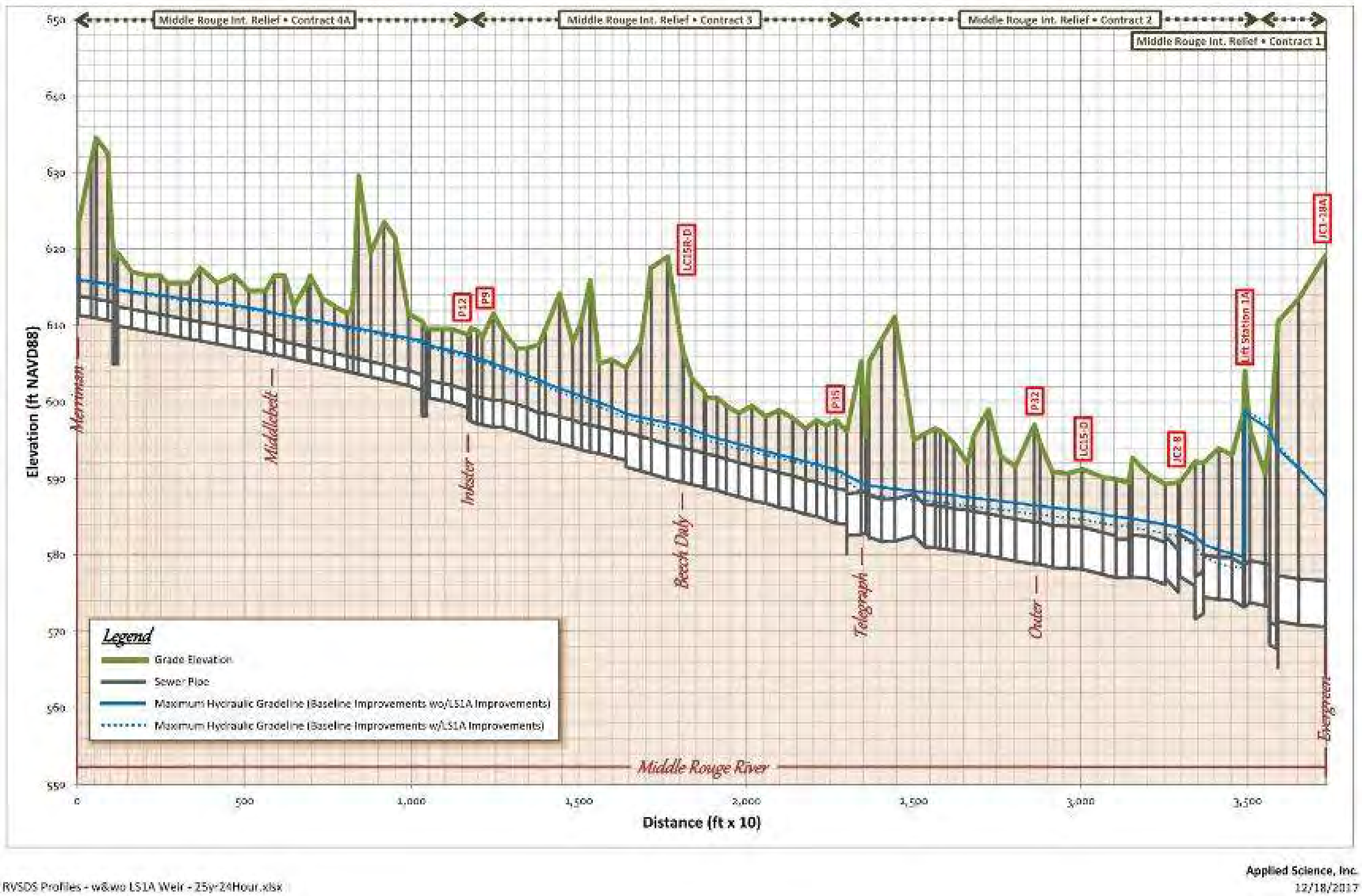

Figure 5-7: Estimated Maximum RVSDS HGL Before and After LS1A Improvements for 25 year, 24 Hour Design Storm

5.2 ANCILLARY PROJECTS

5.2.1 *LINE CONNECTION SIPHON*

a. The lone suspected SSO location in the Lower Rouge Interceptor is a line connection siphon (L-34).
    i. There have been confirmed SSOs at L-34 during the wet weather monitoring; this is likely due to solids deposition or other debris collecting in the small diameter siphons (see Figure 5-8 for meter data confirming surcharge at this siphon).
    ii. The proposed line connection siphon will be a 155-foot long 12-inch diameter pipe; this will allow for adequate flow and reduce the potential for blockages.

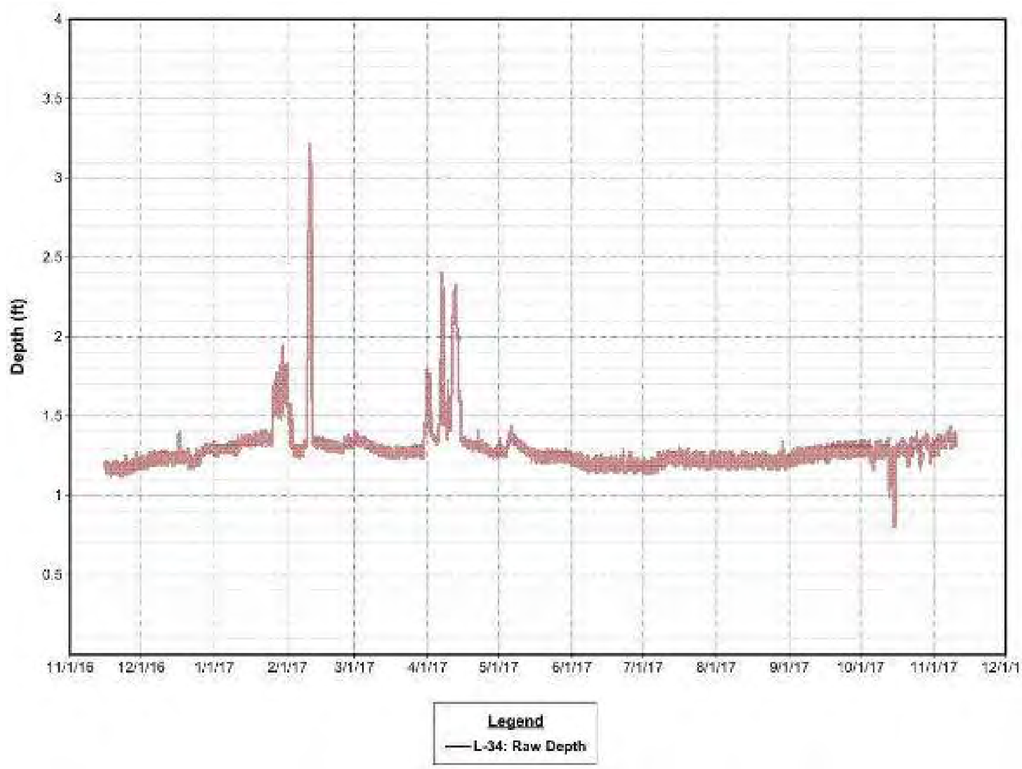

Figure 5-8: L-34 Meter Data

Table 5-8: Impacts of Item 5.2.1 Line Connection Siphon

Task	Benefit	Impact on Design-Event SSO Volume	Planning Level Cost Estimate	Schedule
Reconstruct L-34 (local line connection siphon)	Address SSO along the Lower Rouge Interceptor	0.17 MG (Minor)	$500,000	2020

5.2.2 RESOLVE GLWA BOUNDARY CONDITIONS

a. The boundary conditions in GLWA's Northwest Interceptor at the point of discharge from RVSDS are in the process of being evaluated by GLWA as part of their regional wastewater master planning efforts. The results from these efforts are not expected until after this Project Plan has been submitted. The boundary condition will impact the flow capacity of LS1A and will impact the hydraulic grade line in the lower reaches of the RVSDS. It has been assumed for the analysis presented herein that a maximum boundary condition HGL of 90 feet (Detroit Datum) at the WRRF influent wet well level will be experienced by the RVSDS for the 25-year, 24-hour design event. Historic data suggests that this maximum wet well level is achievable. This HGL has been reached and exceeded during recent wet weather events.

Table 5-9: Impacts of Item 5.2.2 Resolve GLWA Boundary Condition

Task	Benefit	Impact on Design-Event SSO Volume	Planning Level Cost Estimate	Schedule
GLWA Boundary Condition	A defined boundary condition downstream of LS1A	Major (range of boundary conditions significantly impacts amount of predicted SSO volume)	Included in GLWA costs charged to RVSDS	Dependent on GLWA completing Master Plan

5.2.3 WET WEATHER FLOW CONTROL IN THE INKSTER ARM

a. The hydraulic surcharge in the Inkster Arm can be addressed by local inflow/infiltration reduction efforts. Specifically, the City of Livonia is currently embarking on a footing drain disconnection (FDD) program; they removed 11 footing drain connections in 2014 and removed 49 footing drain connections in 2017/18. The City of Livonia plans to remove around 40 footing drain connections in 2019 and will be continuing with additional disconnections in future years. The City is planning to track the resulting flow reduction and will likely continue this program.

b. FDDs are generally the most cost-efficient method to reduce wet weather flows in a wastewater collection system. This FDD program, in combination with the river inflow and hydraulic improvements along the lower reaches of the Middle Rouge Interceptor, should address the hydraulic surcharging on the Inkster Arm.

c. The total impact of FDD programs in the RVSDS service area cannot be quantified without confirmation on the number and extent of locally implemented FDD programs within the RVSDS service area. Wayne County will continue to encourage these programs throughout the RVSDS service area and will work with individual communities to track the number of disconnections during implementation of the Asset Management Plan.

Table 5-10: Impacts of Item 5.2.3 Wet Weather Flow Control for RVSDS Inkster Arm

Task	Benefit	Impact on Design-Event SSO Volume	Planning Level Cost Estimate	Schedule
Livonia Footing Drain Disconnections	Reduce or eliminate the need for a wet weather project along the Inkster Arm	Major	Cost not borne by Wayne County; cost dependent on local commitment to FDD program	2019 into perpetuity; work completed as part of local collection system capital program

5.3 COMMUNITY-SPECIFIC PROJECTS

The projects listed below are not integral to the Project Plan and are not part of the Alternatives Analysis. However, they are necessary to help reduce the risk of SSOs within the local collection systems. As part of the H/H modeling of the RVSDS, several local connections to the RVSDS Interceptors were noted to be undersized relative to the metered flow rates.

5.3.1 HYDRAULIC IMPROVEMENTS AT LOCAL LINE CONNECTIONS

a. Multiple locally-owned sewers connecting the local collection systems to the RVSDS interceptors are predicted to have inadequate hydraulic capacity to convey the design event flow rate without surcharge and potential SSO in the immediate vicinity of the RVSDS interceptors (Figure 5-9).

b. Upon implementing the AM Plan and wet weather storage, it should be possible to increase the hydraulic capacity of these community connections so that surcharge immediately upstream of the connections is no longer likely. Although these improvements will not guarantee hydraulic performance further upstream in each local collection system, it will reduce the risk of unintended SSOs along the interceptor.

c. This work would be completed as part of local collection system capital projects and would not be completed until the wet weather storage project(s) is/are implemented. The cost would be borne by the impacted communities.

Table 5-11: Impacts of Item 5.4.1 Hydraulic Improvements to Local Connections to the RVSDS

Task	Benefit	Approximate SSO Volume Reduction	Planning Level Cost Estimate	Schedule
Address Line Connections	Prevent surcharge into system	Unknown	**TBD**	2023 to 2025

5.4 YEARS 6-10 (ALTERNATIVE 1 AND ALTERNATIVE 2 (IF NECESSARY))

Implementation of Alternative 1, continued system inspection and rehabilitation and improvements to local system line connections, will be ongoing during this period. After the first five years of implementation of Alternative 1, the RVSDS will be assessed to determine if there are estimated remaining SSO locations for the 25-year, 24-hour design storm using the RVSDS hydrologic/hydraulic models and flow metering. If it is determined that there are remaining SSO locations likely for the design storm, implementation of Alternative 2, design and construction of wet weather storage facilities, will occur during Years 6-10 to address remaining SSOs.

5.5 YEARS 11-20

This period will consist of ongoing systematic inspection and rehabilitation of the RVSDS Interceptors.

5.6 COST APPORTIONMENT AND AFFORDABILITY

Table 5-12 summarizes the conceptual costs for the 20-year planning horizon, including the Asset Management Components (Alternative 1) and, if deemed necessary, the wet weather storage facilities identified in Alternative 2.

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Table 5-12: RVSDS LTCAP / SRF Project Plan Cost Table (Comprehensive: Alternatives 1 & 2) [2019 Dollars]

SRF Project Plan Task			FISCAL YEAR BEGINNING										
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029-2038
Asset Management Projects	Remove River Inflow	Local and County Floodplain Manhole Replacement and Repairs	$2,880,000	$2,880,000	$2,880,000	$2,880,000	$2,880,000	$800,000	$800,000	$800,000	$800,000	$800,000	$500,000
		Local and County Floodplain Manhole Inspections	$115,200	$115,200	$115,200	$115,200	$115,200	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000
		Wayne County Parks Dual Purpose Pathways	$298,000	$298,000	$298,000	$298,000	$297,000						
	Address Hydraulic Capacity and Structural Integrity	Televising	$865,000	$865,000	$865,000	$865,000	$865,000	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000
		Sewer Rehabilitation Junction Retrofits	$4,050,000	$4,050,000	$4,050,000	$4,050,000	$4,050,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$500,000
	CSO Operational Enhancements			$900,000	$900,000	$900,000							
	LS1A Screening Improvements/Lower Rouge Isolation			$3,600,000	$3,600,000								
Ancillary Projects	Line Connection Siphon (Lower Rouge)			$720,000									
Wet Weather Storage	Alternative 2 Wet Weather Storage (If Necessary)		**Alternative 2 Only -->**					$2,300,000	$3,000,000	$15,000,000	$20,000,000	$7,000,000	
Community Specific Projects	Hydraulic Improvements to Local Connection to the RVSDS							Costs by others					
ANNUAL COST (ALTERNATIVE 1 ONLY)			**$8,208,200**	**$13,428,200**	**$12,708,200**	**$9,108,200**	**$8,207,200**	**$2,480,000**	**$2,480,000**	**$2,480,000**	**$2,480,000**	**$2,480,000**	**$1,680,000**
ANNUAL COST (IF ALTERNATIVE 2 IS NECESSARY)			**$8,208,200**	**$13,428,200**	**$12,708,200**	**$9,108,200**	**$8,207,200**	**$4,780,000**	**$5,480,000**	**$17,480,000**	**$22,480,000**	**$9,480,000**	**$1,680,000**

Table 5-12 includes initial and ongoing costs related to Alternative 1 (Asset Management Plan), as well as the potential costs related to wet weather storage in Years 6-10 (if deemed necessary after the first five years of Alternative 1). Costs in this table reflect contingencies, engineering, legal, and administrative costs.

Given the proposed 2019/2020 Rate Package, the current annual expenditures are $57.5 million. The additional expenditures listed above would result in rate increases ranging from 7.3% to 20.7%, depending on the level of investment required.

Table 5-13: RVSDS LTCAP / SRF Project Plan Cost Table (Years 1-5) [2019 Dollars]

		LTCAP-Related Costs: Rate Year Beginning									
RVSDS Customer	Allocation Percentage from Proposed 19/20 Rate Package Presentation[1]	2019	2020	2021	2022	2023	Increase/Decrease Relative to Existing Fixed Charges Over 5-yr Period[2,7]	Total Number of Households[3]	Population in Service Area	Number of Households in Service Area	Approximate Monthly Increase in Typical Sewer Bill (Average over 5 years)[4]
DEARBORN HTS	8.34%	$ 216,923	$ 325,384	$ 325,384	$ 442,188	$ 442,188	24%	22,506	36,004	12,001	$ 2.43
GARDEN CITY	5.29%	$ 137,438	$ 206,157	$ 206,157	$ 280,162	$ 280,162	33%	10,856	25,709	10,856	$ 1.70
INKSTER	5.66%	$ 147,087	$ 220,630	$ 220,630	$ 299,831	$ 299,831	13%	10,147	23,806	10,147	$ 1.95
LIVONIA	27.75%	$ 721,573	$ 1,082,359	$ 1,082,359	$ 1,470,898	$ 1,470,898	18%	37,957	96,589	37,957	$ 2.56
NORTHVILLE	1.51%	$ 39,283	$ 58,924	$ 58,924	$ 80,076	$ 80,076	14%	1,182	2,570	1,182	$ 4.47
PLYMOUTH	1.03%	$ 26,768	$ 40,152	$ 40,152	$ 54,565	$ 54,565	-46%	4,141	8,940	4,141	$ 0.87
REDFORD TWP	10.87%	$ 282,543	$ 423,814	$ 423,814	$ 575,952	$ 575,952	19%	19,201	42,921	14,307	$ 2.66
ROMULUS	0.75%	$ 19,495	$ 29,243	$ 29,243	$ 39,741	$ 39,741	20%	9,197	2,275	758	$ 3.46
VAN BUREN TWP	1.98%	$ 51,578	$ 77,367	$ 77,367	$ 105,140	$ 105,140	51%	12,276	6,627	2,209	$ 3.14
WAYNE	4.97%	$ 129,130	$ 193,696	$ 193,696	$ 263,227	$ 263,227	-2%	6,915	17,213	6,915	$ 2.51
WESTLAND	19.16%	$ 498,222	$ 747,333	$ 747,333	$ 1,015,606	$ 1,015,606	38%	36,003	84,058	36,003	$ 1.86
OAKLAND COUNTY (Novi)	12.48%	$ 324,592	$ 486,888	$ 486,888	$ 661,668	$ 661,668	24%	24,334	53,816	17,939	$ 2.44
W.C. AIRPORT	0.21%	$ 5,370	$ 8,054	$ 8,054	$ 10,946	$ 10,946	146%	N/A	N/A	N/A	N/A
Totals	100.00%	***$ 2,600,000***	***$ 3,900,000***	***$ 3,900,000***	***$ 5,300,000***	***$ 5,300,000***					

Existing Annual Fixed Charges	$ 57,563,091	$ 57,563,091	$ 57,563,091	$ 57,563,091	$ 57,563,091	$ 287,815,455
Additional Annual Charges (Alternative 1)[5]	$ 2,600,000	$ 3,900,000	$ 3,900,000	$ 5,300,000	$ 5,300,000	$ 21,000,000
Total Projected Annual Charges[6]	$ 60,163,091	$ 61,463,091	$ 61,463,091	$ 62,863,091	$ 62,863,091	$ 308,815,455
Percent Increase Related to LTCAP Only						7.3%

[1] *Allocation excludes Canton, Northville, and Plymouth Townships per planned termination of RVSDS sewer service to those communities. Percentages were calculated based on self reported two year flow data.*

[2] *The rate increase or decrease was calculated by the Total of Rate Year 2019/2020 divided by the Annual Billing Amount from the previous rate year; detailed calculations can be found in the proposed 2019/2020 rate package*

[3] *SEMCOG Data*

[4] *Actual increases in sewer bills will vary by year and by municipality based on the annual rate package and on the County's successful application for low interest SRF loans for the recommended projects.*

[5] *Reflects $2.6 million/yr starting in 19/20 rate year for initial LTCAP rollout, then two SRF Loans (2020 and 2022), for remainder of Alternative 1 costs at a 20-year term at 2.0% (2020) and 2.25% (2022)*

[6] *Does not include other additional costs for future years (e.g. increases in GLWA disposal fees, deficit funding replenishment, etc.)*

[7] *The term 'existing' refers to the existing rate package which was adopted in 2015*

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Table 5-13 details the Alternative 1 costs during Years 1-5 (2019-2023) and how those costs would be distributed to the RVSDS communities under the recently submitted Rate Year 2019/2020 Package percentages. The rate increase is necessary to accommodate Year 1-5 of Alternative 1. The County budgeted $2.6 million for design/construction for implementation of the first year of the LTCAP Alternative 1. However, increased expenditures and likely additional rate increases over the next four years will be necessary to fully-implement the $51.7 million AM budget for Year 1-5. The timing and magnitude of additional rate increases will be dependent on the timing and interest rates of SRF loans used to finance the AM efforts. The average rate increase to accommodate Years 1-5 of Alternative would be approximately 7.3% for each municipality. The impact of the rate increases on typical monthly sewer bills is listed in the far-right column. The impact on a typical sewer bill is approximate only and does not include adjustments for the impact of revenues from non-residential customers

Tables 5-14 and 5-15 include a summary of the projected costs and apportionment (by municipality), for the remaining portion of the 20-year planning horizon.

Table 5-14 highlights the costs under the assumption that Alternative 2 (wet weather storage) will not be necessary. Table 5-15 includes the cost impacts with wet weather (Alternative 2) storage costs.

Table 5-14: RVSDS LTCAP / SRF Project Plan Cost Table (Years 6-20) [2019 Dollars]

		Cost Allocation - SRF Project Plan ALTERNATIVE 1 (Years 6-20)	
RVSDS Customer Community	Allocation Percentage from FY19/20 Rate Package Presentation[1]	2024-2028 (Years 6-10)	2029-2039 (Years 10-20)
DEARBORN HTS	8.34%	$ 202,077	$ 136,891
GARDEN CITY	5.29%	$ 119,661	$ 81,061
INKSTER	5.66%	$ 150,596	$ 102,017
LIVONIA	27.75%	$ 704,133	$ 476,993
NORTHVILLE	1.51%	$ 39,671	$ 26,874
PLYMOUTH	1.03%	$ 56,792	$ 38,472
REDFORD TWP	10.87%	$ 274,056	$ 185,651
ROMULUS	0.75%	$ 18,731	$ 12,689
VAN BUREN TWP	1.98%	$ 39,519	$ 26,771
WAYNE	4.97%	$ 151,935	$ 102,924
WESTLAND	19.16%	$ 418,608	$ 283,573
OAKLAND COUNTY (Novi)	12.48%	$ 301,653	$ 204,346
W.C. AIRPORT	0.21%	$ 2,558	$ 1,733
Totals	*100%*	*$ 2,480,000*	*$ 1,680,000*

[1] *Allocation excludes Canton, Northville, and Plymouth Townships. Percentages re-allocated to remaining RVSDS communities*

The costs for Years 6-20 associated with Alternative 1 include ongoing Asset Management activities and will reflect lower costs than Years 1-5. Although the average additional cost to support Alternative 1 of this Project Plan will be just over $10 million per year in Years 1-5, this additional cost drops to $2.5 million in Years 6-10 and $1.7 million in Years 10-20.

Table 5-15: RVSDS LTCAP / SRF Project Plan Cost Table, Years 6-10 (Alternative 2 (If Necessary))

		Cost Allocation - SRF Project Plan ALTERNATIVE 2 (Years 6-10)				
		Rate Year Beginning				
RVSDS Customer Community	Allocation Percentage from FY19/20 Rate Package Presentation[1]	2024	2025	2026	2027	2028
DEARBORN HTS	8.34%	$ 398,804	$ 457,206	$ 1,458,388	$ 4,802,592	$ 790,933
GARDEN CITY	5.29%	$ 252,674	$ 289,677	$ 924,005	$ 3,042,826	$ 501,120
INKSTER	5.66%	$ 270,413	$ 310,013	$ 988,875	$ 3,256,448	$ 536,301
LIVONIA	27.75%	$ 1,326,584	$ 1,520,853	$ 4,851,188	$ 15,975,366	$ 2,630,965
NORTHVILLE	1.51%	$ 72,219	$ 82,795	$ 264,099	$ 869,701	$ 143,230
PLYMOUTH	1.03%	$ 49,212	$ 56,418	$ 179,962	$ 592,631	$ 97,600
REDFORD TWP	10.87%	$ 519,444	$ 595,513	$ 1,899,556	$ 6,255,396	$ 1,030,194
ROMULUS	0.75%	$ 35,842	$ 41,091	$ 131,070	$ 431,623	$ 71,084
VAN BUREN TWP	1.98%	$ 94,824	$ 108,711	$ 346,763	$ 1,141,920	$ 188,062
WAYNE	4.97%	$ 237,401	$ 272,167	$ 868,154	$ 2,858,903	$ 470,829
WESTLAND	19.16%	$ 915,961	$ 1,050,098	$ 3,349,583	$ 11,030,455	$ 1,816,593
OAKLAND COUNTY (Novi)	12.48%	$ 596,749	$ 684,140	$ 2,182,255	$ 7,186,348	$ 1,183,512
W.C. AIRPORT	0.21%	$ 9,872	$ 11,317	$ 36,100	$ 118,881	$ 19,578
Totals	*100%*	***$ 4,780,000***	***$ 5,480,000***	***$ 17,480,000***	***$ 22,480,000***	***$ 9,480,000***

	2024	2025	2026	2027	2028
Existing Annual Fixed Charges (FY19/20 Rates)	$ 57,563,091	$ 57,563,091	$ 57,563,091	$ 57,563,091	$ 57,563,091
Additional Annual Charges (Alternative 2)	$ 4,780,000	$ 5,480,000	$ 17,480,000	$ 22,480,000	$ 9,480,000
Total Projected Annual Charges	$ 62,343,091	$ 63,043,091	$ 75,043,091	$ 80,043,091	$ 67,043,091
Percent Increase	8.3%	9.5%	30.4%	39.1%	16.5%
Average Percent Increase (Total Costs, Years 6-10)	20.7%				

[1] *Allocation excludes Canton, Northville, and Plymouth Townships. Percentages re-allocated to remaining RVSDS communities*

If Alternative 2 is deemed necessary, the additional costs for wet weather storage will increase the projected annual charges to nearly $80 million a year during the construction of the wet weather facility(ies), which would represent a fee increase nearly 40% relative to existing annual fixed charges. Including the total projected wet weather storage costs and spreading the costs over the five-year period (Years 6-10), it would represent an overall rate increase of 20.7% relative to the proposed (FY2019/2020) Rate Package.

Based on the information provided in the previous tables, there are several scenarios that could play out over the 20-year planning horizon.

a. Alternative 1 Projects Only: Rate increase of 7.3% to cover Year 1-5 costs
Reduced costs in Years 6-10
Reduced costs in Years 11-20

b. Alternative 1 & 2: Rate increase of 7.3% to cover Year 1-5 costs
Second rate increase of ~13% to cover Year 6-10 costs
Reduced costs in Years 11-20

Affordability

During the cost allocation outreach effort in 2017-2018, feedback was sought on whether any of the RVSDS communities have any affordability issues as related to the EPA guidance on water/sewer rate affordability. Based on the feedback we received, there are concerns about individual communities and their current burden with respect to sewer rates as compared to median household income.

The City of Inkster has previously coordinated with the MDEQ on their financial capability and the City of Inkster demonstrated that they were a High Burden Community, based on a Residential Indicator score of 2.1% and permitted financial capability score of 1.33.

The proposed cost allocation framework and the presence of at least one community with affordability limitations may impact the scope and schedule of projects as recommended in this Project Plan.

Projected impacts on typical residential sewer fees range from just under $4 per month to over $11 per month. This may trigger affordability thresholds in some RVSDS communities.

DRAFT – June 29, 2019

Estimated Required Local Relief Projects

# Trib. Community	Ex. Conn. Size	Flow beyond Ex. Conn. Capacity	Model Line Conn. #
MIDDLE ROUGE			
1. Livonia	30"	17.4 cfs	073
2. Livonia/Westland	15"	22.2 cfs	074/191
3. Garden City/Westland	27"	16.9 cfs	026
4. Garden City/Westland	(2) 16.5"	38.2 cfs	027
5. Livonia	18"	17.3 cfs	075
6. Dearborn Heights	18"	11.3 cfs	015
7. Dearborn Heights	10"	3.8 cfs	017
8. Dearborn Heights	21" & 15"	8.3 cfs	020/021
LOWER ROUGE			
9. Wayne/Westland	4", 6", & 8"	3.5 cfs	184

Figure 5-9: Estimated Required Local Relief Projects from RVSDS H/H Model Analysis

6 EVALUATION OF ENVIRONMENTAL IMPACTS

6.1 *GENERAL*

Analysis of the anticipated environmental impacts resulting from the proposed projects must address beneficial and adverse, short- and long-term, and irreversible and irretrievable impacts.

6.1.1 *LONG-TERM IMPACTS*

The implementation of the recommended Alternative 1 under this Project Plan a comprehensive Asset Management Plan), would allow for improved operation of the existing facilities by replacing and upgrading components that no longer function as originally intended.

Removing river-dependent inflow, as well as local inflow/infiltration reduction projects, will reduce energy costs at both LS1A (lower pumping volumes) and the GLWA Water Resource Recovery Facility (less volume treated).

No acquisition of private property is anticipated to be required for the implementation of Alternative 1 of the Project Plan. The components of Alternative 1 will be constructed along/within existing facilities where easements exist. If additional wet weather storage is deemed necessary, Alternative 2 efforts will likely require land acquisition for the necessary pumping and storage facilities.

6.1.2 *SHORT-TERM IMPACTS*

The implementation of the Project Plan will create indirect and induced employment in other economic sectors of the area and at sites where construction materials are manufactured. No residents will be displaced due to construction activities.

Construction would take place at/along the existing facilities and there would be medium to heavy traffic to and from the construction sites. Environmental disruption including noise, soil erosion, fumes, etc. would occur during construction. All these impacts would produce temporary adverse aesthetic impacts.

6.1.3 *IRREVERSIBLE IMPACTS*

The investment in non-recoverable resources committed to the Project Plan would be traded for the restored and improved performance of the facilities during the life of the system. The commitment of resources includes public capital, energy, labor and unsalvageable materials. These non-recoverable resources would be foregone for the provision of the proposed improvements. Construction accidents associated with this project may cause irreversible bodily injuries or death. Accidents may also cause damage to or destruction of equipment and other resources.

7 MITIGATION

7.1 *GENERAL*

The Project Plan is required to include proposed mitigation of any potential adverse impacts on the environment. As described in the previous section, the overall environmental impact of the project will allow for water quality improvement, through continued operation of the RVSDS and the control of SSOs during the design storm event.

7.2 *LONG-TERM IMPACTS*

Any potential soil erosion impacts would be mitigated through the contractor's required compliance with a program for control of soil erosion and sedimentation, as specified in Part 91 of Michigan Act 451, P.A. of 1994. Areas of any earth-changing activities will be restored to existing conditions.

7.3 *SHORT-TERM AND CONSTRUCTION-RELATED IMPACTS*

Environmental disruption will occur during construction. Guidelines will be established for cover vegetation removal, dust reduction, traffic control and accident prevention. Once construction is completed, those short-term effects will stop and the area will be returned to the original conditions insofar as possible

8 PUBLIC PARTICIPATION

8.1 GENERAL

A meeting with RVSDS community representatives was held on April 10, 2019, and the draft RVSDS LTCAP SRF Project Plan was provided to RVSDS customer communities on April 15, 2019. A summary of the Project Plan was prepared and distributed to RVSDS customer community representatives for use in soliciting a resolution of support for the Project Plan from the governing body of each community. The Project Plan was summarized, and questions answered by local community staff, Wayne County staff, and/or the OHM team, at the city council/township board meetings where the resolution of support was considered. Many of the city council/township board meetings were broadcast on local government television channels which provided an additional opportunity for informing the public about the Project Plan.

A Public Hearing and a description of opportunities for public review and comment on the RVSDS LTCAP SRF Project Plan were advertised in the Detroit News and Detroit Free Press on April 26, 2019 (see Appendix K). Additionally, notice of the Public Hearing and a description of opportunities for public review and comment on the RVSDS LTCAP SRF Project Plan were published online on Wayne County's website at https://www.waynecounty.com/departments/environmental/home.aspx
as follows:

> **PUBLIC HEARING FOR ROUGE VALLEY SEWAGE DISPOSAL SYSTEM, SRF PROJECT PLAN FOR LONG TERM CORRECTIVE ACTION PLAN**
>
> The Wayne County Department of Public Services-Environmental Services Group will hold a public hearing for the purpose of receiving comments from interested persons regarding application to the Michigan Department of Environment, Great Lakes, and Energy for funding assistance through the Clean Water State Revolving Fund Program for proposed improvements to the Rouge Valley Sewage Disposal System (RVSDS). The hearing will be held at 6:00 P.M. on Wednesday, May 22, 2019 at the City of Livonia City Hall located at 33000 Civic Center Drive, Livonia, MI 48154.
>
> The recommended improvements are described in a 20 year SRF Project Plan for the RVSDS Long Term Corrective Action Plan. Click here to view a copy of the Project Plan. The Project Plan is also available for review at:
>
> - Wayne County Department of Public Services, 400 Monroe Street, Suite 400, Detroit, MI 48226

- OHM Advisors, 34000 Plymouth Road, Livonia, MI 48150

Copies of the RVSDS LTCAP SRF Project Plan were placed at the following locations for the public's review and were available beginning on April 26, 2019:

- OHM Advisors, 34000 Plymouth Road, Livonia, MI 48150
- Wayne County Department of Public Services, 400 Monroe Street, Suite 400, Detroit, MI 48226
- Online at https://www.waynecounty.com/departments/environmental/home.aspx

8.2 PUBLIC HEARING

A formal public hearing was held on May 22, 2019 at 6 o'clock at the City of Livonia City Hall located at 33000 Civic Center Drive, Livonia, MI 48154 to review the information presented in the Project Plan, including estimated user costs and to receive comments and views of interested persons. Appendix K includes the Public Notice, Affidavits of Publication, and Public Hearing Transcript.

8.3 RESOLUTION

Wayne's County resolutions adopting the RVSDS LTCAP SRF Project Plan is provided in Appendix L. Resolutions from RVSDS communities formally supporting the first five year Asset Management Plan in the amount of $51,660,000 of the 2019 SRF Project Plan, Long Term Corrective Action Plan for Improvements to the Wayne County Rouge Valley Disposal System are provided in Appendix L.

8.4 CORRESPONDENCES TO AGENCIES

All agency correspondences are included in Appendix M. This includes notifications to Indian Tribes as well as government agencies such as the Michigan Natural Features Inventory and the State Historic Preservation Office and

8.5 FINALIZATION OF PROJECT PLAN

Comments on the RVSDS LTCAP SRF Project plan received from RVSDS community representatives and from attendees at the public hearing were incorporated into the Project Plan as appropriate. There were no additional public comments received from the RVSDS SRF Project Plan.

9 GLOSSARY

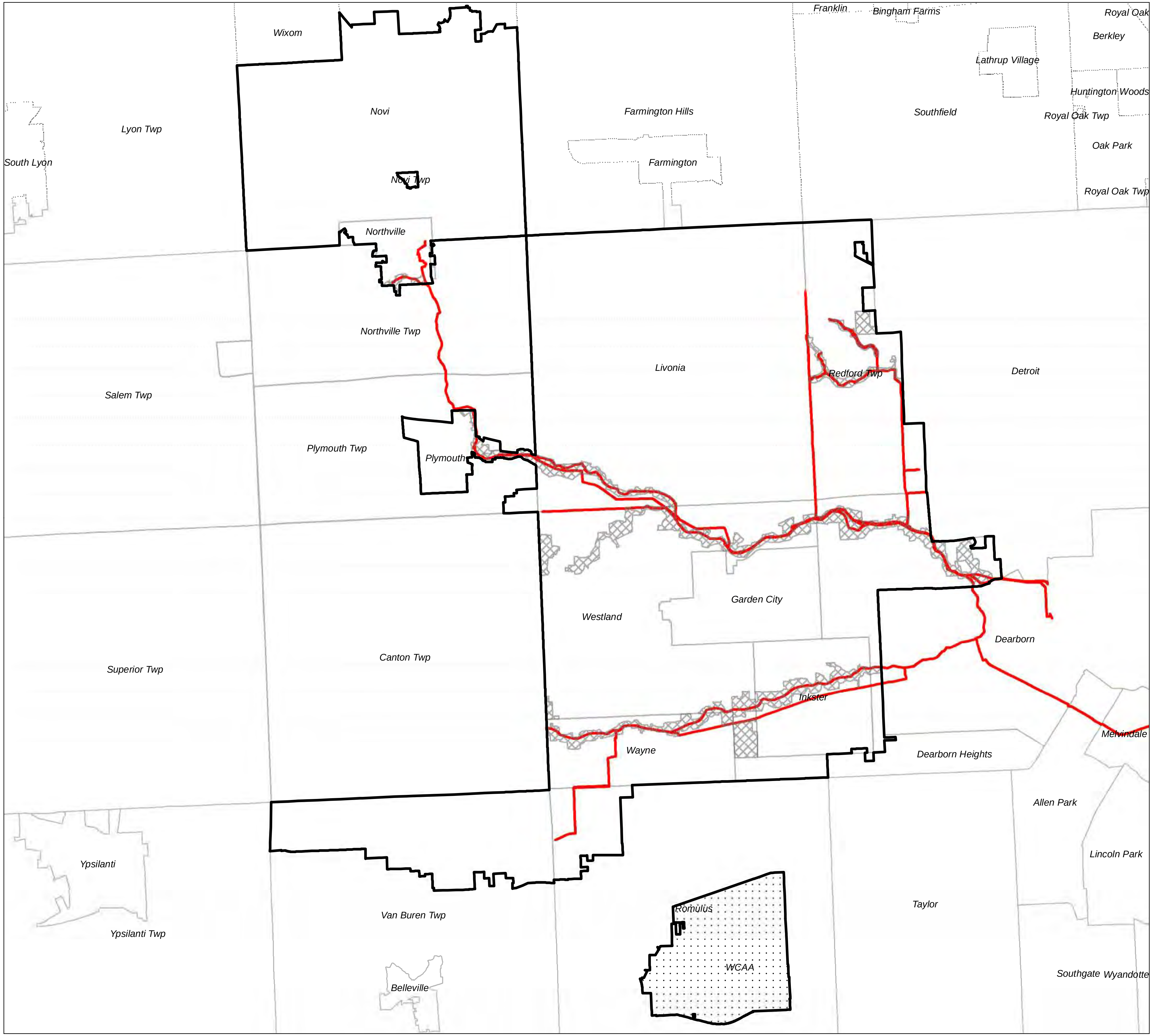
Term	**Description**
10-year Storm	A storm of a designated duration (ranging from 30 minutes to 24 hours) that has a 10% chance of occurring in a given year.
100-year Storm	A storm of a designated duration (ranging from 30 minutes to 24 hours) that has a 1% chance of occurring in a given year.
Average Flow	The average quantity of flow that passes a point over a given period of time.
Bypass	The measurable diversion of raw sewage out of the sewer system.
Cost-Effectiveness Analysis	An analysis performed to determine which alternate collection or treatment system would result in the minimum total resource cost to meet the requirements. A cost-effectiveness analysis for a sewer system determines this by comparing with total costs for transportation and treatment of the infiltration/inflow.
Cost-Effectiveness Guidelines	Developed by EPA to aid grantees in the selection of a system component which will result in the minimum total resources cost over a fixed period of time to meet federal, state, and local requirements.
Design Flow	The average quantity of wastewater which a treatment facility or collection system component is designed to handle. Usually expressed in millions of gallons per day (MGD) or cubic feet per second (cfs).
Design Period	Time span over which proposed collector or treatment facilities are expected to be operating; period over which facility costs are amortized.
Drainage District or Watershed	The tributary area of a particular point on a channel system that contributes storm water runoff upstream of that point.
Flood	An overflow of lands not normally covered by water that is used or are usable to man. Normally a "flood" is considered as any temporary rise in stream flow and stage that results in significant adverse effects in the vicinity. (See surface runoff for comparison.)
Floodplain	The relatively flat area or low land adjoining the channel of a river or stream, which has been or may be covered by flood water. Formally defined as the area that would be flooded during a 100-year storm; in this document, it also refers to the 1-year and 2-year floodplains along the Middle and Lower Rouge Rivers, as they typically overtop their banks at least 2 times per year.
Head	A measure of pressure exerted by a fluid expressed as the height of an enclosed column of the fluid that could be balanced by the pressure in the system.
Head loss	The difference in water level between the upstream and downstream sides of a treatment process attributed to friction losses.

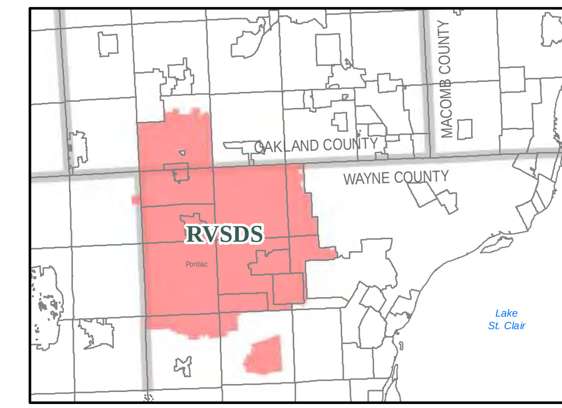
Term	Description
Hydraulic Gradient	The slope of the hydraulic grade line. This is the slope of the wastewater surface in an open channel or the slope of the water pressure for pipes under pressure.
Hydrograph	A curve denoting the discharge of flow over a period of time.
Infiltration/Inflow (I/I)	The total quantity of water from both infiltration and inflow without distinguishing the source.
Infiltration	The water entering a sewer system from the soil through defective pipes, foundation drains, pipe joints, connections and manhole walls.
Inflow	The water discharged into a sewer system from roof drains, cooling water discharges, drains from springs and swampy areas, manhole covers, cross-connections from storm sewers and combined sewers, catch basins, storm waters, surface runoff, street wash waters or drainage.
Influent	The flow entering a treatment process.
Interceptor	Any pipe, regardless of size that carries wastewater directly to a treatment plant or pumping station. Generally, they are the largest pipes in the collection system.
Lateral	The pipe to which individual houses and business establishments connect to public sewers.
Lift Station (Pump Station)	A facility within a sanitary sewer system which pumps flows from a lower elevation to a higher elevation.
Main/Submain	The word "main" is frequently used loosely to indicate a large pipe, which is not a lateral and not an interceptor. If frequently forms one of the larger branches of a complex collection system.
MDEQ	Michigan Department of Environmental Quality, now known as Environment, Great Lake and Energy (EGLE).
National Pollutant Discharge Elimination System (NPDES)	The effluent discharge permit system established under the 1972 Federal Water Pollution Control Administration as part of the Clean Water Act, which places conditions on the type and concentration of pollutants that discharge to a waterway of the United States.
Peak Flow	The maximum quantity of flow that passes a point over a given period of time.
Sanitary Sewer	A sewer intended to carry only sanitary and industrial wastewater from residences, commercial buildings, industrial plants, and institutions, including service connections.
Sanitary Sewer System (Sewage Collection System)	The entire network of sanitary sewers and pumping stations which collect a municipality's wastewater.

Term	Description
SCADA	Supervisory Control and Data Acquisition
Secondary Impacts	Those resulting from indirect or induced changes in community land use patterns, population and economic growth, and environmental quality resulting from induced growth.
SEMCOG	South East Michigan Council of Governments
Service Area	The area which is serviced by a wastewater treatment system.
Sewage	Sewage refers to the wastewater from residential, commercial, and industrial establishments, which flows through the pipes to a treatment plant.
Sewer	Sewer refers to the pipe used to transport wastewater.
Sewer or Sanitary District	A sewer district is usually either a semi-autonomous governmental unit whose purpose is the provision of sewerage or a special assessment district within which sewerage facilities are provided to residents.
State Revolving Fund (SRF)	This program was established to provide low cost financing for the construction of publicly owned water pollution control facilities. The program is jointly administered by the Michigan Municipal Bond Authority and the Michigan Department of Environmental Quality.
Storm Sewer	A sewer intended to carry only storm waters, surface runoff, street wash waters, and drainage.
Surface Runoff	Water that is derived directly from precipitation and passes over the ground into storm sewers and water-courses (see "Flood" for comparison).
Trunk Sewer	Generally, a large diameter municipal sewer that collects flow from smaller diameter municipal sewers and discharges to an interceptor sewer.
Total Suspended Solids (TSS)	The measure of particulate matter suspended in a sample of water or wastewater. After filtering a sample of a known volume, the filter is dried and weighed to determine the residue retained.
US EPA	The United States Environmental Protection Agency.
User Charge	Fees levied upon users of a water or wastewater system, based on the volume and/or characteristics of the water.
Water Quality Criteria	The levels of pollutants that affect the suitability of water for a given use. Generally, water use classification includes: public water supply, recreation, propagation of fish and other aquatic life, agricultural use and industrial use.
WRRF	Water Resource Recovery Facility (previously referred to as a Wastewater Treatment Plant, or WWTP)

Appendix A: RVSDS Interceptor System

Rouge Valley
Sewage Disposal System





Location Map

Figure 2-1
District and Community
Boundaries

Prepared By:
Applied Science, Inc.

Date: 3/1/2019

H:\2013\1315 -- Wayne County LTCAP Project Plan\Memos\H&H Report\Fig 2-1 - RVSDS District and Community Boundaries.mxd

DRAFT – June 29, 2019

Appendix B: Wayne County RVSDS Work Plan for LTCAP

Wayne County Rouge Valley Sewage Disposal System

Work Plan for
Long Term Corrective Action Plan

Original Report Date: July 16, 2015
Phase 1 Schedule Modifications: November 13, 2015

Prepared by:
OHM Advisors
34000 Plymouth Road
Livonia, MI 48150

and

Wayne County Department of Public Services
Environmental Services Group

Rouge Valley Sewage Disposal System
Work Plan for Long Term Corrective Action Plan

July 16, 2015 (Effective Date of Work Plan)
November 13, 2015 (Updated Schedule for Phase 1)

Introduction

This document presents a Work Plan for development of a Long Term Corrective Action Plan (LTCAP) for Wayne County's Rouge Valley Sewage Disposal System (RVSDS). Upon completion of the Short Term Corrective Action Plan (STCAP) in 2012, Third Amended Final Order of Abatement Number 2117 ("FOA") requires that Wayne County identify in an LTCAP any additional system improvements needed to bring the system into compliance with the FOA including compliance with the Michigan Department of Environmental Quality (MDEQ) Sanitary Sewer Overflow (SSO) Policy and SSO Clarification Statement.

Wayne County has been diligently working since 2012 to develop the LTCAP. Work completed to date includes:

- Continuation of and improvements to the ongoing flow monitoring program;
- Development and enhancements to the RVSDS hydraulic model, including additional structures, enhanced operational characteristics of pump stations and storage units, and more accurate georeferencing for better integration with the County's Geographic Information System (GIS); and
- Enhancements to the County's GIS database for the RVSDS, including more detail on system rim/invert elevations, maintenance/rehabilitation history, and condition ratings for pipes and manholes.

In 2014, Wayne County and MDEQ agreed in principle to a revision of the due date for completing the LTCAP to June 29, 2016. Fourth Amendment No. AACO-000031 to FOA 2117 containing the revised schedule has been signed by Wayne County and is in the MDEQ approval process.

During the effort to calibrate the hydraulic model of the RVSDS to data from recent storm events, a good match to observed conditions in the majority of the RVSDS was obtained except for the lower reaches of the Middle Rouge interceptor between Inkster Road and Lift Station 1A (LS1A). Considerable effort was expended to adjust parameters in the model such as hydraulic characteristics (e.g., junction losses and pipe friction coefficients), across the range of typical values in order to better match observed conditions; however, this effort did not reconcile the differences between observed and modeled flow depth.

Although a reasonable model/tool has been developed to characterize the RVSDS, it would be premature to base large-scale capital improvements on this model given the hydraulic discrepancies observed in the Inskster-to-LS1A reach (depicted in Figure 1). Since the majority of model-predicted SSOs in the RVSDS hinge on this critical interceptor reach, additional detailed work to characterize this reach is necessary in order to determine the source(s) of the hydraulic discrepancies (see Figure 2 for a schematic of the lower reaches of the Middle Rouge Interceptor).

A two-phase strategy is now proposed for a LTCAP to meet the requirements of the FOA 2117 for the RVSDS. The phased approach is summarized as follows:

- **<u>Phase 1</u>**:
  - Complete the RVSDS LTCAP (expected to be completed in late 2015). This document will identify specific activities (Phase 1 projects) focused on the primary causes of suspected SSOs along the RVSDS Middle Rouge interceptor.
  - Establish additional temporary flow meters along the Middle Rouge interceptor, primarily downstream of Inkster Road, to better characterize the location(s) and severity of hydraulic losses and to confirm flow rates in this reach of the RVSDS.
  - Implement select modifications to the Middle Rouge interceptor system to further reduce river inflow and eliminate hydraulic constraints likely caused by venting limitations and/or extraordinary junction losses.
  - Address known hydraulic restrictions within the Lower Rouge interceptor.
  - Complete additional system analysis as the foundation for determining targeted and cost-efficient capital improvement projects for the RVSDS under Phase 2 projects.
  - Enhance the GIS data for the interceptor system, including structural condition, maintenance history, and other information useful for ongoing analysis, modeling, and O&M.

> ***Phase 1 Goals:***
>
> *Address existing SSO on Inkster Arm by lowering the HGL on the Middle Rouge interceptor at Inkster Road*
>
> *Enhance confidence in design flow conditions for other potential SSOs along the Middle Rouge interceptor*

- **<u>Phase 2:</u>**
  - Finalize RVSDS hydraulic model calibration.
  - Submit a LTCAP SRF Project Plan for Phase 2 projects that identifies recommended capital improvements. Plan, design, finance, and construct the remaining capital improvements necessary to bring the RVSDS system into compliance with the FOA including compliance with the MDEQ SSO Policy and SSO Clarification Statement.

- **<u>Ongoing Activities</u>**
  - Continued flow metering and rainfall monitoring in the RVSDS service area.
  - Continued floodplain manhole inspection program (reduce potential for river inflow).

Proposed Work Plan

The following pages describe the specific activities that will be undertaken as part of this phased approach to implement a LTCAP for RVSDS as required under FOA 2117. As demonstrated in this work plan, the Wayne County team's knowledge of the system, based on modeling completed to date, allows for a targeted and systematic approach that is intended to increase the confidence of the MDEQ, the County, and the RVSDS communities in the efficacy of future improvements. A graphical schedule for work plan implementation is included as Exhibit 1.

PHASE 1 ACTIVITIES (Began Early 2014; through May 30, 2017)

Phase 1 activities are targeted to the lower reaches of the Middle Rouge interceptor where the model discrepancies have been noted. Each task below is an integral component of characterizing this portion of the RVSDS. The LTCAP document developed under Task A is proposed to be completed ahead of the scheduled June 2016 completion date so as to identify and expedite the Phase 1 activities. The LTCAP document will outline the Phase 1 / Phase 2 approach and will include additional detail on the components within this Work Plan. The LTCAP is not intended to be a conclusion or summary of the Phase 1 effort, but will serve as a formal declaration of the Phase 1 / Phase 2 strategy and to meet the documentation requirements in the FOA.

The LTCAP will include information developed as part of Tasks B-N (as available by December 2015). Under Phase 2, key reports and findings developed after December 2015 will be documented in a State Revolving Fund (SRF) Project Plan for Phase 2 LTCAP projects.

A. LTCAP Development and RVSDS Community Coordination

Work tasks to include:

1. Prepare LTCAP report document, including the following sections
   i. Technical Memoranda on meter analysis and modeling
   ii. Model-predicted SSOs
   iii. Discussion of hydraulic discrepancies in the Middle Rouge interceptor (lower reach)
   iv. Phase 1 / Phase 2 approach
   v. Recommended Phase 1 projects and cost estimates, including projects along the Middle Rouge and Lower Rouge interceptors
   vi. Preliminary, planning level information about likely Phase 2 projects
2. Prepare for and attend up to three (3) RVSDS Community update meetings

Deliverables: RVSDS Stakeholder Meetings (communities, MDEQ, etc.)
Draft LTCAP Document
Final LTCAP Document

Schedule: Began: March 6, 2014
Draft LTCAP: April 30, 2016

B. Field Survey

This task includes survey and field work necessary to update the RVSDS hydraulic model and to better understand the hydraulic conditions in the lower reaches of the Middle Rouge interceptor between Inkster Road and LS1A.

Work tasks to include:

1. Perform survey for identified components of the RVSDS necessary to update the hydraulic model. These components include:
    i. There are 5 tipping gate regulators in Redford for which assumptions have been made; these regulators greatly affect the downstream interceptor flow rates. These are Regulators U2, U6, U7, U8, and U11. The tipping gates will be inspected to determine size, model number and current pin setting. Also, for Regulator U6, a new regulator chamber structure was built downstream of the older regulator. Verify the current conditions in the older regulator and whether there is still a gate or wall opening.
    ii. There are 3 former CSO outfalls that are now SSO outfalls, M-21, M-22 and M-25. The Wayne County team has assumed that the regulators are fully open shear gates on wall pipes at these regulators and this needs confirmation. These regulators were surveyed by Wade-Trim (WTA) in 2008 as part of the Sanitary Sewer Evaluation Survey (SSES). However, accurate information is not available on the regulator itself, and the pipe connection from the regulator and the Wayne County interceptor in the vicinity of the regulators. This information is critical in how SSOs are estimated for these locations in the model. Survey data will include: the incoming pipe, the regulator itself, the connection to the interceptor, the interceptor, the overflow weir, the BWG and the SSO outfall.
    iii. There are two locations in the Lower Rouge system with interconnections between the Lower Rouge Interceptor and the Wayne Interceptor. Stop logs may or may not exist at these interconnections. These interconnections are included in the RVSDS hydraulic model as fully open. One interconnection is at RVI 15 JC-18 in Wayne; the other is near RVI 15 MH-1 at Merriman Road in Westland. Survey will include elevations of connecting pipes and verification of the presence/absence of stop logs.
    iv. There are two complex junction chambers along the Middle Rouge interceptor system. One chamber is where the Redford Arm connects to the Middle Rouge interceptor system; the other is where the Inkster Arm connects. The following information will be collected for JC 2-38 (Telegraph Road) and JC 3-37 (Inkster Road): dimensions, layout, presence of sludge deposits, and key elevations (rim, invert, overflow) of interconnection chambers.
    v. JC 2-8 was rebuilt and raised as part of the STCAP. But the top elevation of the structure is not on the as-built drawings. The structure was raised to accommodate the gate operators and the top elevation was determined during construction in the field. The top elevation will be surveyed., as well as the dimensions, layout, and all invert elevations of the interior of the junction chamber.
    vi. There is an old 30-inch sewer along Inkster Road that runs from the Bell Branch to near the LV Basin (Livonia EQ Basin) flow meter. It runs from RVI 12 MH-19 to MH-16 and is shown to be interconnected with the RVI

interceptor at these locations. This sewer will be surveyed with invert elevations, rim elevations, interconnections and diameters of incoming pipes.

vii. There is a regulator/CSO outfall in Livonia, M26, whose status is unknown. The regulator and CSO outfall are included in the hydraulic model but it is suspected the outfall was bulkheaded by Livonia during a sewer separation project in the 1990s. The regulator and CSO outfall will be surveyed to confirm the operational status.

viii. There is an overflow weir chamber that discharges to the connecting pipe to LS1A. The weir plate is adjustable and the setting is not known. In the hydraulic model, it was assumed that the weir plate top elevation is at the MRPIE interceptor crown elevation in the model. The top elevation of the weir plate will be surveyed.

ix. There is an old regulator chamber at Warren Avenue along Middlebelt Road in Garden City. The regulator chamber is on a 72 inch sewer (which was previously combined) that diverted low flows into a pumping station that discharged westerly towards Merriman Road. The regulator chamber also had a diversion dam and backwater gate. The survey will be conducted to confirm that no flow occurs through the old regulator towards Merriman Road. The survey will also include a confirmation of the presence and elevation of the diversion dam and backwater gate.

x. There is an existing regulator chamber at the Middle Rouge River and Middlebelt Road that serves Garden City and Westland (M-20). This regulator chamber is at the downstream end of the 72 inch sewer on Middlebelt Road. A 22 inch diameter opening trough the regulator chamber that controls the flow rate into the MRPIE interceptor has been assumed in the hydraulic model. Previously, a 22 inch vortex valve existed at this location. The outfall to the river is reportedly bulkheaded. Also, there are two parallel 16 inch ductile iron siphons downstream of the regulator chamber that connect to the MRPIE interceptor. Significant SSO volumes are predicted to occur in this vicinity through manhole/regulator chamber openings. The regulator chamber will be surveyed including the regulator opening dimensions and elevations, the presence/absence (and model number) of a vortex valve, and top elevations of all manholes and chamber openings, including the downstream siphon manholes.

2. Verify information for select local sewers and their connections to the RVSDS. This will require coordination with Wayne County and local community staff. At this time, additional information is needed about the following sewers connected to RVSDS:
    i. Lefler-Ready sewer,
    ii. Lefler-Ready Relief sewer,
    iii. Red Run sanitary sewer, and
    iv. Two parallel sewers servicing Dearborn Heights (Area 13).

Deliverables: Documentation of sewers and connections, including survey data and survey schematics where necessary

Schedule: Survey Completed September 2015, except for two local reaches (Lefler-Ready and Area 13). These two reaches will be surveyed by December 15, 2015.

C. Temporary Flow Meter and Level Sensor Installation

This task includes installation of temporary flow meters and level sensors in select sections of RVSDS to better understand: the hydraulic conditions in the lower reaches of the Middle Rouge interceptor, relationship of Rouge River stage to RVSDS flow delivery in the lower reaches of the Middle Rouge interceptor, and how conditions in the downstream Detroit Water and Sewerage Department (DWSD) sewers affect RVSDS flow delivery.

Wayne County has recently installed additional meters within the RVSDS, including two along the Inkster Arm (near the Livonia EQ Basin) and a meter and level sensor at the Oakwood / DWSD interceptor crossover. In addition to this, Wayne County has also upgraded 17 meters, installed 11 new meter cabinets, and upgraded 13 meter power supplies as part of the ongoing Priority 1B improvements.

If specific meters and/or sensors, as included in the list below, are found to be useful for the County's ongoing System Monitoring Plan, they may, at the County's discretion, be maintained as permanent meters following this task.

Work tasks to include:

1. Three parallel interceptor meters at Outer Drive (one flow meter on each interceptor; 24-month monitoring duration expected due to need to have flow meter data after the implementation of venting and floodplain manhole retrofits):
    i. MRPIE I-11
    ii. RVI 6-13
    iii. MRIR 2-21
2. Three parallel interceptor meters west of Telegraph Road (one flow meter on each interceptor; 24-month monitoring duration expected due to need to have flow meter data after the implementation of venting and floodplain manhole retrofits):
    i. MRPIE II-1
    ii. RVI 6-28
    iii. MRIR 2-21
3. Install flow meters at five locations in Dearborn Heights (two flow meters at each location placed upstream and downstream of suspected river inflow and/or SSO point; 4-month monitoring duration expected):
    i. Lefler-Ready (Bill's Drain)
    ii. Lefler-Ready Relief along Beech-Daly Road
    iii. Red Run Sanitary Sewer through Warren Valley Golf Course
    iv. Area 13 sanitary sewer
    v. Area 13 sanitary relief sewer
4. Extend level sensor range at JC 2-8 (if possible): Determined unnecessary, October 2015

5. Use data from USGS depth gage at Middle Rouge River at Hines Drive (USGS 04167150)
    i. This gage (river stage only) was reinstated with funding from the US EPA Great Lakes Restoration Initiative (GLRI) and has been collecting data since late April 2015. There are plans to establish the stage-discharge relationship, so discharge may be available (although stage alone will be useful for the purposes of this project).
    ii. The USGS intends to fund the operation of this gage for three years (through April 2018), although funds are appropriated annually. For the purposes of this scope, it is assumed that the gage will remain in operation (at the expense of USGS) through the duration of this project.

Deliverables: Temporary meter and level sensor installation and ongoing data collection (assumed to be performed as part of a separate contract)
Technical Memoranda – Meter Data Evaluation

Schedule: Items 1 and 2 (interceptor meters) installed on September 11, 2015
Item 3 (Temporary local sewer meters) to be installed by April 30, 2016 to capture spring storms
Item 4 (level sensor) will not be modified (deemed unnecessary, October 2015)
Item 5 (USGS data): collection of data is ongoing by USGS (started April 2015)

D. Junction Chamber Inspection

This task will include the collection of specific data to better understand and hydraulically model **u**nique hydraulic characteristics in select segments of the RVSDS.

Work tasks to include:

1. Conduct detailed field survey with confined space entry to confirm junction chamber dimensions, configuration, inverts, connecting pipe diameter and inverts for the following junctions:
    i. JC 2-8 (just upstream of LS1A)
    ii. JC 2-38 (near Telegraph Road)
    iii. JC 3-37 (near Inkster Road)
    iv. Junction chambers between Meters 9P, 10P, and 11P
2. Field work will be performed during low flow periods. If flow conditions do not permit an adequate inspection of a particular junction, a bypassing plan will be developed and recommended to isolate chambers for physical entry.
3. Document physical condition and any unusual conditions affecting hydraulics conditions with photos and sketches. Perform a video inspection using High Definition video technology, such as GoPro or similar.
4. Adjust the RVSDS hydraulic model to reflect observed conditions.

5. If the observed conditions (through metering and internal inspection) confirm the existence of extraordinary head losses or other adverse conditions at any specific junction, develop a physical model of the structure. The physical model(s) will be constructed in a hydraulic laboratory and will consist of a scaled-down model(s) under various flow conditions. The physical model(s) will reveal the following:
    i. Actual head losses under normal and wet weather conditions
    ii. Constructible junction retrofits that will minimize losses and maximize flow capacity
6. Based on the findings from this task, develop schematics for modification of select junctions to minimize hydraulic losses. Junction modifications will be prioritized based on the potential magnitude of head loss reduction.

Deliverables: Junction Survey Data, Schematics, Photos and Videos
Physical Hydraulic Model(s) with Technical Memoranda
Junction Modification Schematics

Schedule: Hydraulic model summary and retrofit schematics: July 31, 2016
Construction of junction modifications (if deemed necessary): May 30, 2017

In October 2015, it was determined that it would be more effective to complete this task after reviewing additional flow meter data available upon the execution of additional temporary flow metering provided under Task C.

E. Inspection/Cleaning of Siphons and Restrictions

This task will include field inspection and cleaning of select restrictions within RVSDS, along with data to better describe the restrictions in the RVSDS hydraulic model.

Work tasks to include:

1. Identify locations for inspection and (if necessary) cleaning of select siphons and restrictions. The preliminary (high priority) list of structures includes:
    i. R-3
    ii. R-4
    iii. R-5A
    iv. R-45 through R-50: Restrictions 45, 46, 47 & 49 are removed from this list in November 2015 because of their small size and very low probably of causing pipe clog.
    v. R-60
2. Other structures within the overall RVSDS may also require inspection and cleaning. These structures should be considered Priority 2 and are listed in Exhibit 2 *Special Structures and Siphons*. Exhibit 2 also includes a map illustrating the locations of the special structures and siphons.

Deliverable: Structure Inspection (County Operations Staff / Contracted Services)
Structure Cleaning (Contracted Services)

Schedule: Planning: October 15, 2015
High Priority Structure Inspection: June 30, 2016
High Priority Structure Cleaning: September 30, 2016
Other Structures: Future activity, if needed.

F. SCADA System Improvements

This task includes the implementation of select improvements to the Supervisory Control and Data Acquisition (SCADA) system for the RVSDS to provide better data for the RVSDS hydraulic model and better control of RVSDS operations. Wayne County is currently implementing Priority 1B SCADA improvements. These ongoing improvements will be complemented with the improvements outlined below.

Work tasks to include:

1. Identify RVSDS components that would benefit from enhancements to controls and system data availability. Preliminary identified upgrades include:
    - i. Re-program SL-3 at LS1A to remain closed when pumps are running
    - ii. Historize RTB dewatering flow meters
    - iii. Historize SL-3 position at LS1A
    - iv. Add an alarm level at JC 2-8
    - v. Include information from the Inkster CSO RTB at Middlebelt Road

Deliverables: Technical Memorandum on recommended SCADA upgrades
Implementation of SCADA upgrades (to be performed by Wayne County and/or their SCADA contractor(s)).

Schedule: Technical Memorandum: November 30, 2015
Implementation: Began May 2015. Completion August 31, 2016

G. Inspect Floodplain Manholes for Inflow/Outflow Potential

Under the STCAP, Wayne County rehabilitated 968 RVSDS manholes, including modifications intended to prevent river inflow along the Middle and Lower Rouge floodplains. This task will include the inspection of additional manholes where potential remains for river inflow to the RVSDS.

Work tasks to include:

1. Create a set of manhole maps to be used by field staff to identify and prioritize manholes for inspection. The manhole maps will be limited to the Middle Rouge RVSDS reaches downstream of Merriman Road. Manholes will be color-coded for prioritization:
    - i. Blue: manholes above the 10-year floodplain (low priority for inspection)

ii. Green: manholes below the 10-year floodplain and above the 2-year floodplain (medium priority)
iii. Yellow: manholes below the 2-year floodplain and above the 1-year floodplain (high priority)
iv. Red: manholes below the 1-year floodplain (FIRST priority)

2. Locate the "unfound" manholes from the previous SSES and confirm coordinates and rim elevations (using GPS-based survey). It is likely that a significant percentage of the "unfound" manholes are buried or otherwise inaccessible. This effort will focus on finding as many as is practical. Mark those manholes found with permanent posts
3. Initiate the inspection by focusing on the FIRST priority manholes. Based on USGS flood frequency data and known RVSDS manhole rim elevations, there are about 260-270 manholes below the 1-year recurrence interval flood elevation. This inspection will include a physical evaluation of the manhole rim, including:
    i. Evidence of a dislodged cover or frame (take photo)
    ii. Presence of gasketed manhole cover (Y/N)
    iii. Is manhole bolted down (Y/N)
    iv. Other opportunities for river inflow, such as damaged chimney or manhole wall
    v. This inspection will be conducted as follows:
        1. County-owned manholes between Inkster and LS1A
        2. County-owned manholes between Merriman and Inkster
        3. County-owned manholes along Brady and Lower Rouge
        4. City-owned manholes on community sewer connections on the Middle Rouge interceptor downstream of Merriman (only those suspected to be below the 1-year floodplain). The initial assumption is that there will be 50-60 locally-owned manholes as part of this inspection effort.
4. Inspect manholes for illicit storm water connections, possibly including smoke testing.
5. Design and construction of manhole modifications are included in Task J.

Deliverables: Survey Needs Map – Floodplain Manholes
"Unfound" Manhole Survey
Summary Tables for First and High Priority Manholes

Schedule: Inspection & Summary Results (First Priority Manholes) November 30, 2015
Inspection & Summary Results (High Priority Manholes): April 30, 2016

H. LS1A Operational Modifications

Under this task, operational protocols for LS1A will be reviewed, with particular emphasis on hydraulic conditions for flows through the lift station that may be increasing upstream hydraulic gradients beyond those intended in the design of LS1A.

Work tasks to include:

1. Meet with Wayne County operations staff to review current operation and maintenance practices, pump settings, and station performance
2. Conduct field survey and confined space entry inspection to confirm configuration, dimensions, weir and control gate sizes and inverts for wet well inlets, bar racks, and master control diversion structure.
3. Compile findings and evaluate potential hydraulic issues that may be contributing additional head losses beyond those intended in the design of LS1A.
4. Based on findings, evaluate potential alternatives to improve station performance, including the following items:
    i. Operational modifications,
    ii. Lowering the overflow weir plate at Master Control,
    iii. Adding strainers to pumps (existing pumps have 5 inch and 4-1/2 inch maximum sphere sizes),
    iv. More capital intensive projects will likely be reviewed during Phase 2 (see scope under Phase 2 Activities).

Deliverables: Summary report with recommendations and construction cost estimates
Implementation of recommended operational modifications
Design and construction of select improvements

Schedule: Summary Report: January 15, 2016
LS1A Phase 1 Modifications: December 31, 2016 (could need implementation by a construction contractor. It is unknown at this time what improvements are needed. The size of the project may affect the completion date for project).

I. System Venting

This task will include planning and implementation for the installation of vents in the RVSDS at select locations. A gravity sewer system requires adequate venting to operate efficiently, especially in cases where there are multiple junctions and community flow inputs, as these transitions typically require adequate venting to avoid scenarios with compressed air and/or vacuums, both of which can significantly reduce the hydraulic capacity of the interceptor system.

Work tasks include:

1. Identify vent locations, focusing on the following types of junctions:
    i. Significant sources of community inflow
    ii. Upstream of siphons or sewer size transitions (such as river crossings)
    iii. Other junctions deemed critical by the RVSDS project team
2. Conduct field reconnaissance for each identified structure, noting the type of structure, dimensions, and other characteristics that may hinder vent installation.

3. Determine the floodplain elevations at each structure and identify the appropriate freeboard and resulting vent height to avoid inundation during the selected river event (i.e. 10-year, 100-year).
4. Determine the appropriate modifications required at each structure to accommodate a vent and provide schematics for installation. It is assumed that these schematics will be used by Wayne County staff for installation.
5. Install vents at recommended structures.

Deliverables: Proposed Vent Location Map
Vent Schematics (type, height, dimensions, and related improvements)
Installation of RVSDS vents

Schedule: Proposed Vent Location Map and Schematics: November 30, 2015
Install vents: September 30, 2016

J. Floodplain Manhole Improvements

Work tasks include:

1. Using the data collected in the field (Task G), develop a plan and specifications for improvements to select manholes to prevent river inflow. Improvements may include, but will not necessarily be limited to:
   i. Upper manhole / chimney modifications to prevent soil/water intrusion and to provide an adequate base for a waterproof casting and cover.
   ii. Replace manhole frame and cover with a waterproof (bolted/gasketed) cover. Consider alternate cover types, including hinged covers with locks.
   iii. Where deemed necessary, include a waterproofing wrap (such as WrapidSeal or similar) around the chimney and frame. This will help to reduce inflow and infiltration caused by floodplain waters around the top portion of the manhole.
   iv. In locations where venting is recommended (Task I), manhole retrofit details will be provided as part of the Task I deliverables.
2. Prepare a summary memorandum (with related figures/schematics) for manholes not owned by the County (City-owned structures). This document will be shared with the appropriate communities for their use in addressing river inflow on their local systems.
3. Implement recommended manhole improvements.

Deliverables: Proposed Manhole Improvement Map
Specifications, schematics and other information necessary to construct manhole improvements, specific to each identified manhole
Construction of select manhole improvements

Schedule: Proposed Manhole Retrofit Map: November 30, 2015
Specifications, schematics and other information necessary to construct FIRST priority manhole improvements: April 30, 2016
Construction of FIRST priority manhole improvements: December 30, 2016 (It is unknown at this time how many manholes will be improved. The size of the project may affect the completion date for project).

K. Regulator Modifications

Under this task, configurations for RVSDS regulator configurations will be assessed and recommendations for revisions (if any) prepared.

Work tasks include:

1. As part of the RVSDS hydraulic model updates, regulator survey data (from Task B) will be added to the hydraulic model, including updates to regulator configurations, inverts, and regulator opening dimensions.
2. Evaluate potential for enlarging regulator openings at M-20, M-21, M-22 and M-25 to reduce SSO frequency.
3. Use model to verify appropriate regulator opening sizes at selected regulators.
4. Run model for different scenarios to quantify benefits of SSO reduction and impact on design event flow rates in RVSDS Interceptor.
5. Summarize results in Technical Memorandum with recommendations on feasibility for implementation.
6. Implement recommended regulator modifications.

Deliverables: Technical Memorandum – Proposed Regulator Modifications
Implement recommended regulator modifications

Schedule: Technical Memorandum: February 29, 2016
Implement regulator modifications: May 30, 2017. (It is unknown at this time what improvements are needed. The size of the project may affect the completion date for project).

L. Determine the Range of DWSD Boundary Conditions with RVSDS

Analysis of RVSDS observed flows and hydraulic model results to date have revealed that current DWSD operations are having a significant impact on the ability of RVSDS to deliver contracted flows. This task will continue that analysis and discussions with DWSD, for the purpose of setting boundary conditions with DWSD in the RVSDS hydraulic model for a variety of hydrologic/hydraulic conditions.

Work tasks include:

1. Coordinate with DWSD staff to verify intended operations during wet weather events for those facilities that may impact the RVSDS and LS1A.
2. Develop and submit a list of recommended operational enhancements (as discussed at previous meetings between Wayne County and the RVSDS Project Team) that DWSD may consider. Seek feedback on those enhancements and determine whether they may impact assumed boundary conditions.
3. Establish up to four (4) sets of DWSD boundary conditions (based on a range of potential operational conditions) that can be used in the RVSDS EPA SWMM model. Each boundary condition will be based on a combination of DWSD system conditions that are based on known operational history and potential future operational modifications.
4. Summarize the information in a Technical Memorandum. This document will include specific instructions on how to model each boundary condition in EPA SWMM, including some or all of the following information at downstream nodes that require a boundary condition:
    i. Constant hydraulic grade line (HGL) (if applicable)
    ii. Time series (variable) HGL (if applicable)
    iii. Defined flow hydrograph
    iv. Changes to key hydraulic components (such as stop-log weirs)

Deliverable: Technical Memorandum – DWSD Boundary Condition Scenarios

Schedule: Work is currently ongoing. Technical Memorandum: September 30, 2016. (Depends on availability and willingness of DWSD to resolve this issue).

M. Wet Weather Response Team

Work tasks include:

1. Establish a formalized Floodplain Manhole Inspection plan with Wayne County Operations staff. This would be based on the GIS-based Initial Asset Inventory and handheld tablets to systematically inspect high-priority manholes and correct deficiencies as they are noted. This will be established as an ongoing program, and will focus first on those manholes that are at the highest risk of river inflow (those within the 1-year floodplain).
2. Develop and update a list of high priority manholes. These manholes would be those that have been found to be more susceptible to inflow or SSO activity.
3. Develop a plan to engage Wayne County staff during wet weather events. This plan will include the following:
    i. Rainfall depth triggers to activate team (i.e. >1.0 inch of rainfall)
    ii. Online data sources to monitor conditions (i.e. USGS gage data, SCADA data feeds, NOAA radar-based rainfall estimates, etc.)
    iii. Specific facilities to inspect, including key attributes to note at each facility. For example:

1. Water levels (relative to rim elevation or top of pipe elevation)
2. Unusual hydraulic characteristics
3. Debris/blockage
4. Overflows to (or inflows from) Middle/Lower Rouge
5. Other (TBD)

4. During the first 24 months of this project, the OHM-led RVSDS Project Team will assist in the implementation of the Wet Weather Response Plan, including the deployment of field staff to critical structures. It is assumed that Wayne County staff will be available during this period to assist in accessing structures and SCADA data feeds.

Deliverable: Wet Weather Response Plan

Schedule: Began and will continue throughout Phase I. May continue into Phase 2 (if needed)

N. Continue Development of RVSDS Asset Management Plan

Work tasks include:

1. Update GIS-based mapping of the RVSDS system to include all relevant survey and other data for the RVSDS collected under the Phase 1 activities
2. Continue to enhance the GIS-based mapping of the RVSDS system components, focusing on additional attributes that define critical O&M strategies for specific system components, such as:
   i. Need for frequent monitoring/inspection (i.e. siphons)
   ii. Need for frequent maintenance (i.e. siphons, critical junctions)
   iii. Manhole inundation frequency (recurrence interval) for those manholes in the floodplain that need to be part of the ongoing river inflow identification program.
3. Add regulators to the GIS geodatabase and include operational status (including vortex type/size and other key dimensions/elevations)
4. Schedule and cost estimates for ongoing system cleaning and televising
5. Schedule and cost estimates for ongoing inspection of key system controls (regulators, gates, diversions, stop logs, etc.)
6. Long-term deterioration forecasting and estimates of annual system rehabilitation/replacement costs to sustain adequate structural and I/I characteristics

Deliverables: Updated GIS Geodatabase (electronic submittal)
Summary Report: Long-Term RVSDS O&M and Rehabilitation Strategy

Schedule: Updated GIS Geodatabase submitted on September 25, 2015
Summary Report: RVSDS O&M and Rehab Strategy: May 30, 2017 (end of Phase I)
Ongoing Asset Management Enhancements – Phase 2 and Ongoing

PHASE 2 ACTIVITIES (Begins June 1, 2017; through June 29, 2019)

A. Flow Metering

Work tasks include:

1. Continue the Middle Rouge interceptor flow meter program. This program is proposed to be extended to allow for the evaluation of wet weather response after the implementation of Phase 1 projects. System venting, floodplain manhole retrofits, and junction retrofits are intended to partially or fully restore the interceptor to its intended design capacity, so this extended metering period will be critical in order to determine the level of success of the targeted Phase 1 projects.

Deliverables: Ongoing data collection (assumed to be performed as part of a separate contract)
Technical Memoranda – Meter Data Evaluation
Flow Meter / Depth Sensor removal (anticipated in July 2017)

Schedule: Remove additional flow meters on or around July 1, 2017

B. Update RVSDS Hydrologic/Hydraulic Model

The RVSDS model updates will begin in Phase 1 with the additional survey (Task B) and work related to the junction chamber evaluation (Task D). However, the re-calibrated model that will be used to identify Phase 2 capital projects will not be completed until the end of the flow metering period (mid-2017).

Phase 2 Goals:

Design and implement capital projects to address SSOs that remain after Phase 1 projects

Continue floodplain manhole inspection and improvement program

Work tasks include:

1. Update the RVSDS hydraulic model with all survey and other data collected under Phase 1 (to be completed as data are collected in Phase 1).
2. Using flow meter data collected during and immediately following Phase 1 activities, complete the hydrologic and hydraulic calibration of the RVSDS model. This calibration will focus on enhancements to the Middle Rouge interceptor that could not be resolved prior to Phase 1.
3. Using the updated model, determine the location and severity of remaining SSO locations in the RVSDS service area. This model will be used for the Phase 2 Alternatives Analysis.

Deliverables: Updated EPA SWMM Model
Model-Predicted SSOs (Table)

Schedule: June 1, 2017 – August 31, 2017

C. Phase 2 Project Evaluation and Alternatives Analysis

Work tasks include:

1. Using the updated RVSDS EPA SWMM model, evaluate and prepare planning-level cost estimates for system improvements intended to address SSOs. These alternatives will likely be more capital-intensive than those projects defined in Phase 1, given that there will be increased confidence in the hydrologic and hydraulic models.
2. Potential projects may include:
   i. Enhanced flow conveyance
   ii. Wet weather storage and pumping
   iii. Regulator modifications (based on preliminary recommendations in Phase 1, adjusted based on specific capital improvement needs along the interceptors)
   iv. Larger-scale upgrades to LS1A that were not implemented in Phase 1, including the potential for the following improvements:
      1. Upgrading pumps/impellers for enhanced solids handling
      2. Adding mechanically screened bar racks to SL-1 and SL-2 or in the wet well (existing bar racks have 2-5/8 inch openings)
3. Prepare for and attend RVSDS Community meetings to discuss alternative projects and seek local consensus and buy-in for these improvements.
4. Coordinate with MDEQ staff on recommended alternatives (2 meetings anticipated)

Deliverables: Alternatives Summaries, Schematics, and Planning-Level Cost Estimates
RVSDS Community Meeting Summaries

Schedule: September 1, 2017 – July 31, 2018 (Alternatives Analysis)
September 30, 2017 – March 31, 2018 (RVSDS Community Meetings and Approvals)

D. SRF Project Plan for Phase 2 Projects

Work tasks include:

1. Prepare and submit an SRF Project Plan for the recommended Phase 2 improvements.

Deliverables: Draft SRF Project Plan
Final SRF Project Plan

Schedule: June 29, 2019 (delivery of final SRF Project Plan)

E. Ongoing Floodplain Manhole Improvements

Work tasks include:

1. Continue floodplain manhole inspections that were commenced during Phase 1. Focus on the Medium Priority manholes for this inspection period. Track the locations of inspections and inspection results.
2. Repair manholes that are not adequately sealed. These repairs may include the installation of waterproof frame and covers, venting, raising the elevation of the manhole, and other modifications to the upper portion of manholes as deemed necessary.

Deliverables: Updated manhole inspection and repair tables.

Schedule: Manhole repairs: ongoing (HIGH Priority in summer 2017, Remaining Manholes in 2018)

F. Design, Finance, and Construct Phase 2 Projects

The County will proceed with the design and construction of Phase 2 Projects based on the schedule in the approved SRF Project Plan. The timing of project design and construction will depend on the established financing and plan submittal schedule as approved by the MDEQ.

ONGOING ACTIVITIES

Wet Weather Flow Metering / Monitoring

Work tasks include:

1. Continue metering flows in the RVSDS according to the most recent version of the RVSDS System Monitoring Plan. It is anticipated that there will be a defined monitoring period after completion of Phase 2 to demonstrate regulatory compliance. Temporary meters installed as part of Phases 1 and 2 will likely be removed. Wayne County may periodically update the System Monitoring Plan for the RVSDS, including but not limited to changing the locations of meters throughout the RVSDS.

Deliverables: Continued quarterly and annual reports summarizing data and system analysis conducted under the System Monitoring Plan for the RVSDS

Schedule: Ongoing

Floodplain Manhole Improvements (Ongoing Annual Program)

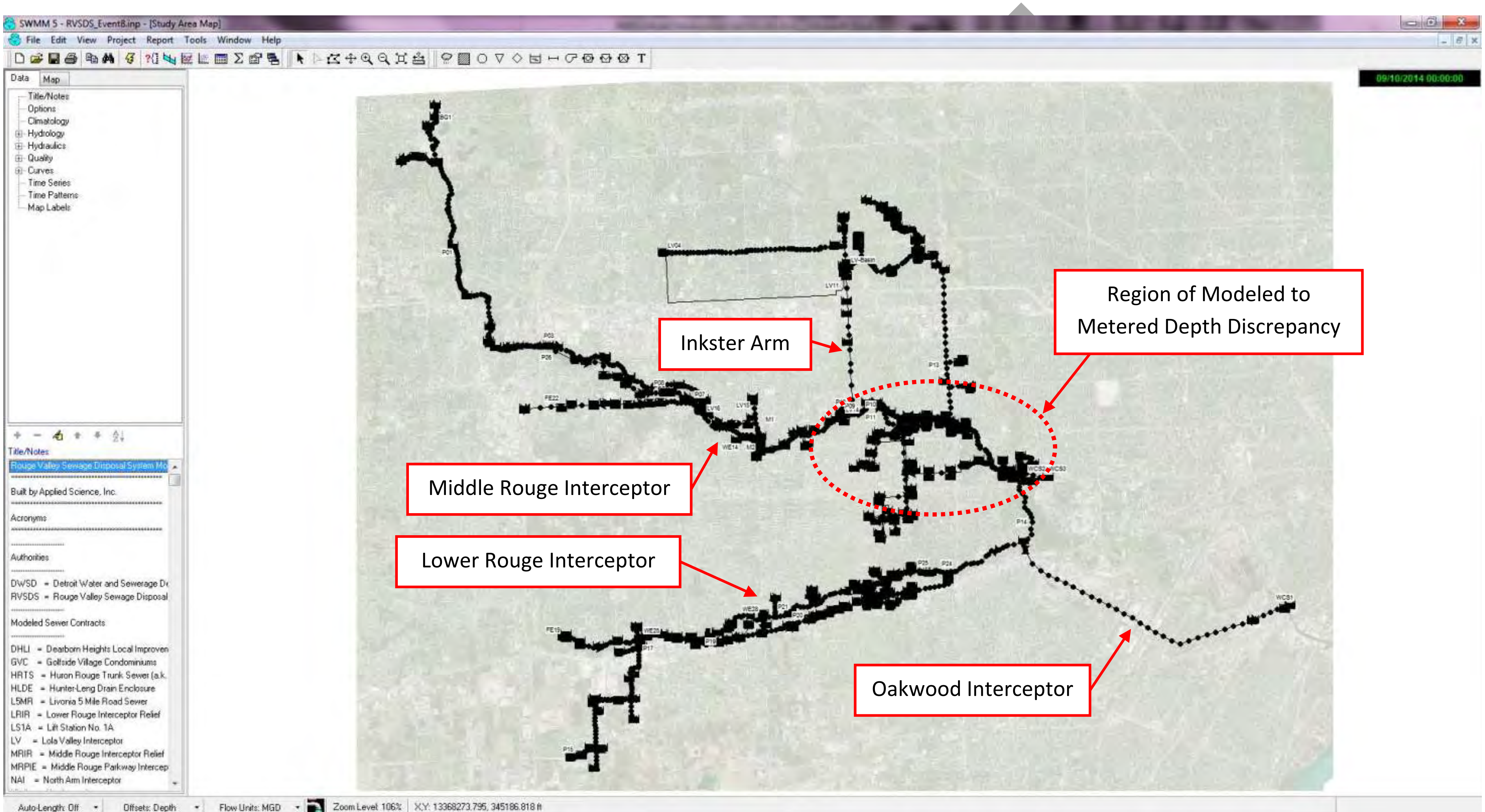
Work tasks include:

2. Manholes within the floodplain will be subject to deterioration and will require regular inspection and maintenance so as to reduce the potential of river inflow. Continue floodplain manhole inspections on an annual basis and track the locations of inspections.
3. Retrofit and/or repair manholes that are not adequately sealed. These retrofits may include the installation of waterproof frame and covers, venting, raising the elevation of the manhole, and other modifications to the upper portion of manholes as deemed necessary.

Deliverables: Annually-updated manhole inspection and retrofit table.

Schedule: Ongoing (annual) inspection program.

Figure 1. Screenshot of RVSDS SWMM5 Model



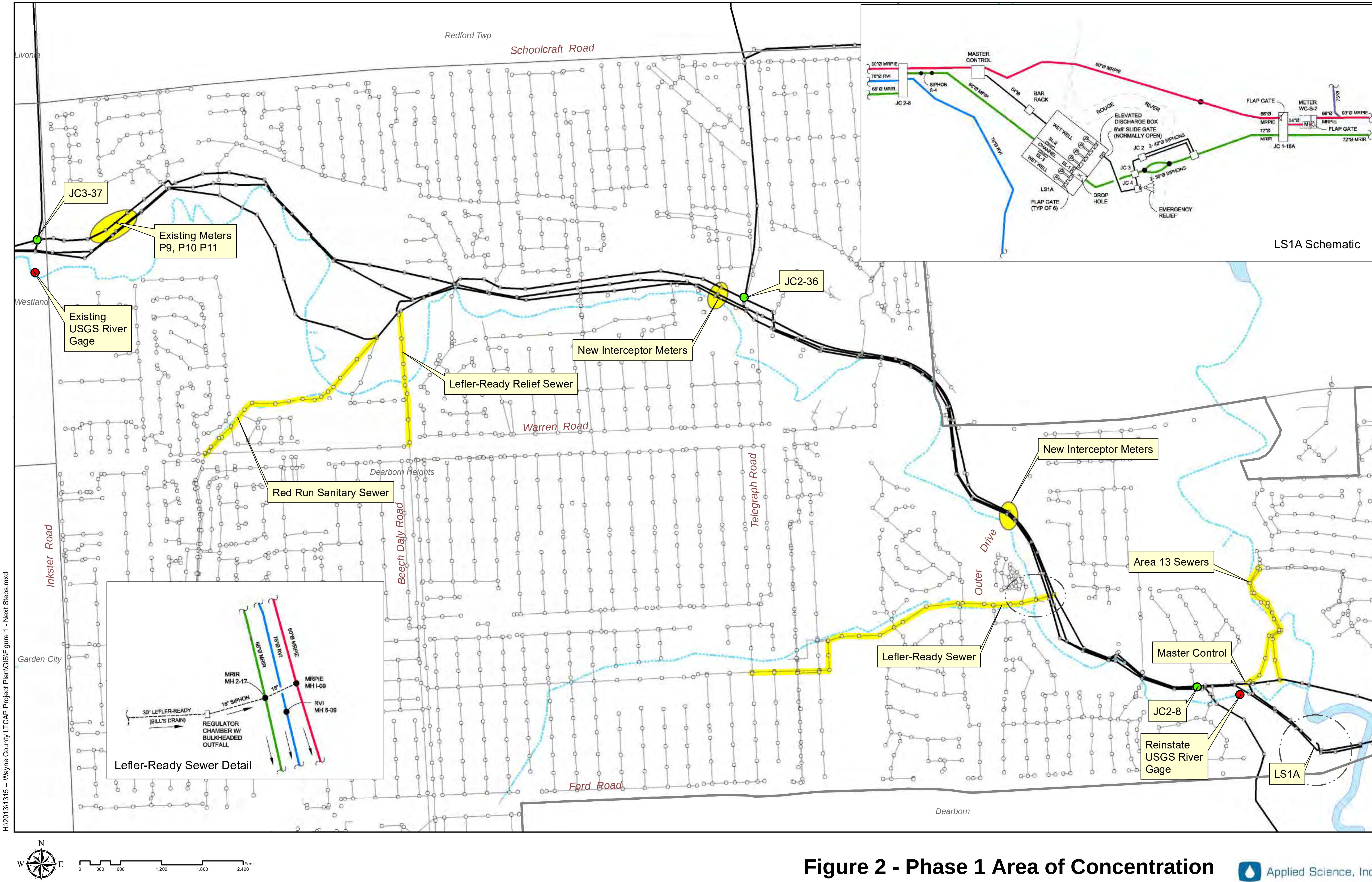


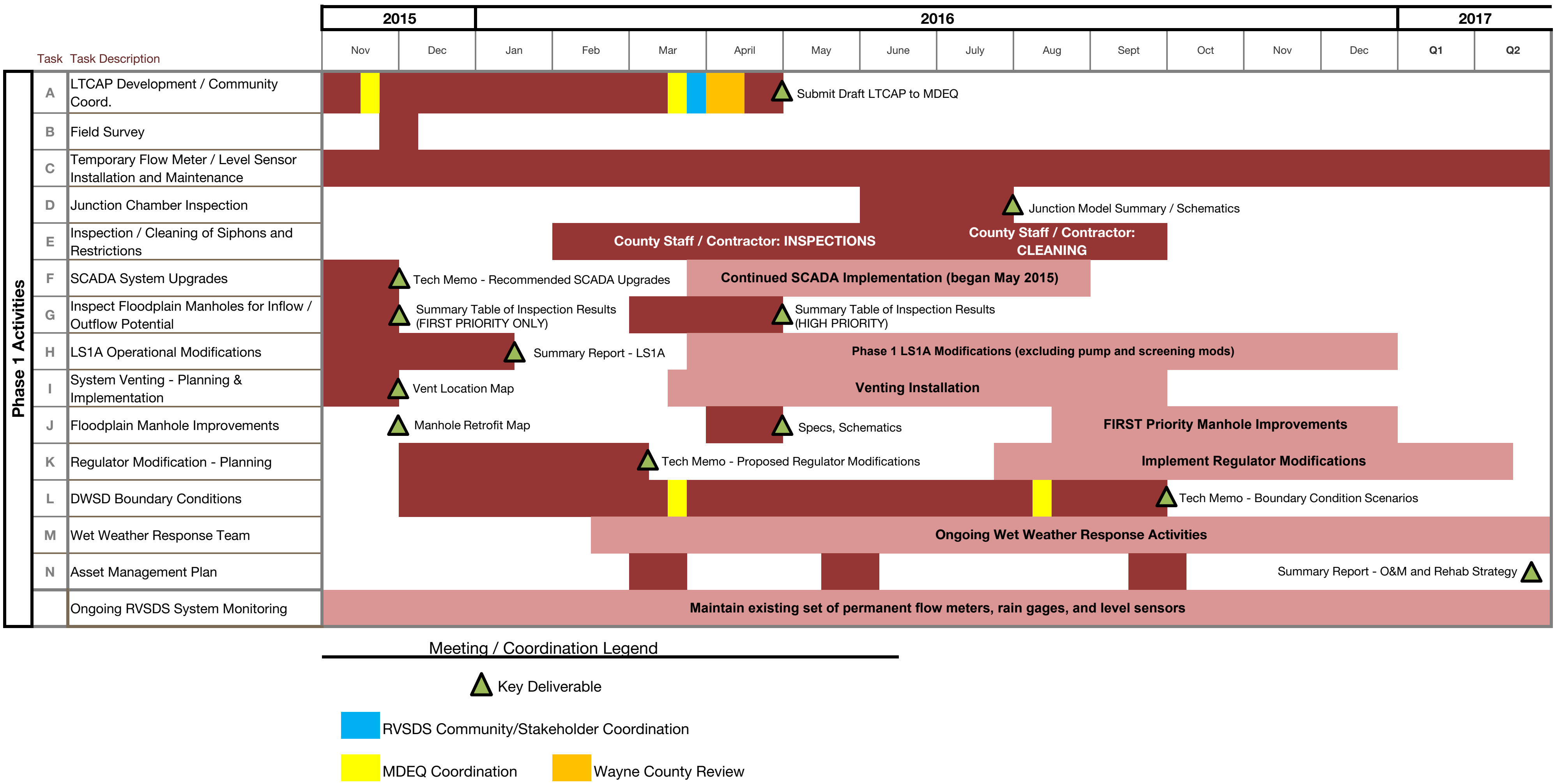
Figure 2 - Phase 1 Area of Concentration

Applied Science, Inc.

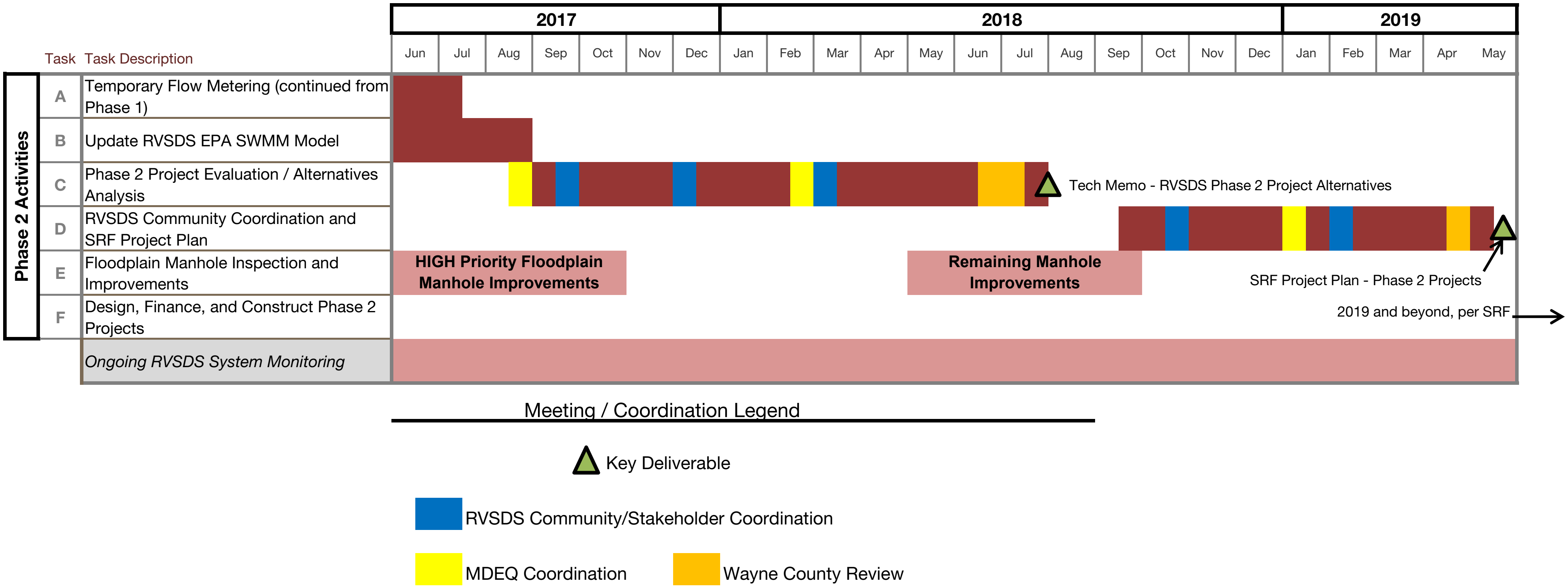
Date: 6/24/2015

Exhibit 1
Schedule

RVSDS LTCAP Work Plan - Phase 1 Project Schedule



RVSDS LTCAP Work Plan - Phase 2 Project Schedule



11/17/2015

Exhibit 2

Special Structures and Siphons

(including location map)

Rouge Valley Sewage Disposal System					
Special Restrictions					
County Restriction ID	**U/S GIS Manhole ID**	**D/S GIS Manhole ID**	**Description**	**Percent of Incoming Sewer Height Blocked**	**Distance of Crossing to Closest Access Point**
R 1	RVI 3-15	RVI 3-15A	60" sanitary sewer crossing via special structure	29.5%	Just U/S of RVI 3-15A
R 2	RVI 4-23	Missing from GIS	102" sewer and 24" sewer crossing via special structure	58.3%	30' D/S of RVI 4-23
R 60	RVI 6-09	RVI 6-08	Change in sewer diameter from 78" to 66" for ditch crossing	15.4%	107' U/S of RVI 6-08
R 50	RVI 6-10	RVI 6-09	18" sanitary sewer crossing via C.I. pipe directly through sewer	23.1%	93' U/S of RVI 6-09
R 49	RVI 6-18	RVI 6-17	12" storm sewer crossing via depression in sewer crown	14.0%	84' U/S of RVI 6-17
R 48	RVI 6-26	RVI 6-25	12" sanitary sewer crossing via C.I. pipe directly through sewer	15.4%	Just D/S of RVI 6-26
R 5A	RVI 6-30	RVI 6-29	48" MRPIE sewer crossing via special structure	55.0%	Just U/S of RVI 6-29
R 47	RVI 6-36	RVI 6-35	12" sanitary sewer crossing via depression in sewer crown	15.2%	45' D/S of RVI 6-36
R 46	RVI 6-50	RVI 6-49	42" storm sewer crossing via depression in sewer crown	15.2%	32' U/S of RVI 6-49
R 45	RVI 6-54	RVI 6-53	18" storm sewer crossing via depression in sewer crown	16.7%	57' D/S of RVI 6-54
R 13	Absent from GIS	NHV 6-58	Change from 60" diameter to 24" high box for Livonia drain crossing	40.0%	Entirely between manholes
R 13	Absent from GIS	MR III-2A	Change from 48" diameter to 34" high box for Livonia drain crossing	29.2%	Entirely between manholes
R 39	RVI 7-14A	RVI 7-14	54" storm sewer crossing via special structure	66.7%	Entirely between manholes
R 38	RVI 7-17C	RVI 7-17B	Change in sewer shape from 30" circular to 38" x 24" LO-HED for 12" sanitary sewer, 5" gas, and 8" water main	20.0%	Entirely between manholes
R 51	RVI 8-19	--	15" sanitary sewer crossing via C.I. pipe directly through manhole	25.0%	At RVI 8-19
R 30	RVI 8-24	RVI 8-23A	Change in sewer diameter from 60" to 42" for river crossing	30.0%	Just U/S of RVI 8-23A
R 29	RVI 8-28	RVI 8-27	Change in sewer diameter from 54" to 42" for river crossing	22.2%	Entirely between manholes
R 28	RVI 9-11	RVI 9-10A	20" water main crossing via special structure	48.1%	Just U/S of RVI 9-10A
R 27	RVI 9-13	RVI 9-12	Change in sewer diameter from 54" to 42" for river crossing	22.2%	59' D/S of RVI 9-13
R 61	RVI 12-12	--	42" sanitary sewer crossing via a junction chamber	11.1%	At RVI 12-12
R 12	RVI 12-17	RVI 12-16	Change in sewer shape from 48" circular to 45" x 29" elliptical for two 6" and one 8" gas line	39.5%	114' D/S of RVI 12-17
R 11	RVI 13-04	RVI 13-03	54" storm sewer crossing via depression in sewer crown	16.7%	72' U/S of RVI 13-03
R 10	RVI 13-05	RVI 13-04A	Change in sewer diameter from 60" to 48" for river crossing	20.0%	Entirely between manholes
R 9	RVI 13-09	RVI 13-08	78" x 96" corrugated metal pipe crossing via special structure	33.3%	98' U/S of RVI 13-08
R 6	RVI 13-26	RVI 13-25	Change in sewer diameter from 60" to 48" for river crossing	20.0%	Just U/S of RVI 13-25
R 7	RVI 14-01	RVI 13-27	Change in sewer diameter from 60" to 48" for river crossing	20.0%	Just U/S of RVI 13-27
R 8	WI E-17	WI E-16	60" sanitary sewer crossing via special structure	44.7%	At WI E-17
R 44	RVI 14-21	--	18" sanitary sewer crossing via C.I. pipe directly through manhole	0.0%	At RVI 14-21
R 43	RVI 14-24	RVI 14-23	36" storm sewer crossing via depression in sewer crown	18.5%	98' D/S of RVI 14-24
R 26	RVI 15-05	RVI 15-04	60" storm sewer crossing via special structure	64.8%	41' D/S of RVI 15-05
R 21	RVI 15-19	RVI 15-18A	36" and 18" sewer crossing via depression in sewer crown	33.3%	Just U/S of RVI 15-18A
R 42	RVI 15-20A	--	30" sewer crossing via special structure	11.1%	At RVI 15-20A
R 22	RVI 16-05	RVI 16-04A	Change in sewer diameter from 54" to 36" for river crossing	33.3%	Entirely between manholes
R 23	RVI 16-07	RVI 16-06	Change in sewer diameter from 54" to 42" for river crossing	22.2%	Just U/S of RVI 16-06
R 52	RVI 16-10A	--	30" sanitary sewer crossing via C.I. pipe directly through manhole	0.0%	At RVI 16-10A
R 53	RVI 16-10B (JC17)	--	27" sewer crossing via junction chamber	20.8%	At RVI 16-10B (JC17)
R 24	RVI 16-16	RVI 16-15A	Change in sewer diameter from 48" to 36" for river crossing	25.0%	Just U/S of RVI 16-15A
R 25	RVI 16-20	RVI 16-19	Change in sewer diameter from 48" to (3) 20" for storm sewer crossing	58.3%	Manhole at structure
R 5	MR I-05	MR I-04	Change in sewer diameter from 60" to three 36" for river crossing	40.0%	Entirely between manholes
R 3	MR II-12	MR II-11	Change in sewer diameter from 48" to 36" for river crossing	25.0%	136' D/S of MR II-11
R 4	MR II-15A	MR II-15	Change in sewer diameter from 48" to 36" for river crossing	25.0%	Just D/S of MR II-15A
R 31	MR III-22	MR III-20	Change in sewer diameter from 42" to 30" for river crossing	28.6%	Just U/S of MR III-20
R 32	PWI 1A-01	MR III-24	Change in sewer diameter from 42" to 30" for river crossing	28.6%	128' U/S of MR III-24
R 54	MR VI-02	MR VI-01	Change in sewer diameter from 48" to 36" for river crossing	25.0%	70' D/S of MR VI-02
R 55	MR VII-02	MR VII-01	Change in sewer diameter from 42" to 30" for Shaw drain crossing	28.6%	151' U/S of MR VII-01
R 56	MR VII-05	MR VII-04	Change in sewer diameter from 42" to 30" for Blue drain crossing	28.6%	110' U/S of MR VII-04
R 57	Missing from GIS	MR VII-23	Change in sewer diameter from 36" to 30" for Bell drain crossing	16.7%	Just U/S of MR VII-23
R 41	NHV 6-15	NHV 6-14	Change in sewer shape from 48" circular to 38" x 60" rectangular for road crossing	20.8%	Entirely between manholes
R 59	NHV 1A-04 (JC)	NHV 1A-03	Change in sewer shape from 54" circular to 43" x 68" horizontal ellipse for river crossing	20.4%	Entirely between manholes
R 40	NAI 1-02	NAI 1-01A	Change in sewer shape from 42" circular to 34" x 53" horizontal ellipse for 33" x 49" CMP storm sewer crossing	19.1%	Entirely between manholes

Rouge Valley Sewage Disposal System						
Interceptor System Siphons						
County Siphon ID	**U/S GIS Manhole ID**	**D/S GIS Manhole ID**	**Upstream Pipe Size**	**Siphon Pipe Sizes**	**Downstream Pipe Size**	**Notes**
S 5	RVI 1-SMC (WC1)	RVI RISER	102"	(1) 78"	153"	WCS1
S 6	RVI 2-S1C	RVI 2-S1D	102"	(2) 78"	102"	
S 1	RVI 5-15S	RVI 5-15N	30"	(2) 20"	36"	
S 3	RVI 5-12B	RVI 5-12A	60"	(1) 30", (1) 36"	60"	
S 2	RVI 5-13B	RVI 5-13A	60"	(1) 30", (1) 36"	60"	
S 7	RVI 13-9B	RVI 13-9A	60"	(1) 30", (1) 36"	60"	
S 8	RVI 13-17B	RVI 13-17A	60"	(2) 36"	60"	
S 25	RVI 15-WC	RVI 15-EC	48"	(1) 30", (1) 36"	48"	
S 61	WI X-17	WI X-16	30"	(1) 8", (1) 12", (1) 16"	30"	
S 62	WI X-19	WI X-18	30"	(1) 8", (1) 12", (1) 16"	30"	
S 63	WI X-23	WI X-22	30"	(1) 8", (1) 12", (1) 16"	30"	
S 26	RVI 16-09B	RVI 16-09A	54"	(2) 30"	54"	
S 27	NHV 9-16	NHV 9-15	30"	(1) 14", (1) 16"	30"	
--	NHV 1-01C	NHV 1-01A	72"	(1) 48"	(3) 48"	WCS3
--	NHV 1-18A (JC)	MR IA-C2	66", 72"	(1) 54"	66"	WCS2
S 41	NHV 2-02	NHV 2-01	54"	(2) 36"	60"	LS1A
S 40	Missing from GIS	Missing from GIS	72"	(2) 42"	60"	LS1A (STCAP)
S 22	MR VII-20	MR VII-19	12"	(1) 12", (1) 8"	12"	
S 4	NHV 2-07	NHV 2-06	66"	(1) 66"	66"	
S 42	RVI 4-16C	RVI 4-16 B	78"	(2) 78"	78"	
S 43	NHV 4A-04	NHV 4A-03	24"	(1) 12", (1) 16"	24"	
S 44	NHV 4A-29	NHV 4A-28	30"	(1) 16", (1) 18"	30"	
S 45	NHV 5A-05	NHV 5A-04	48"	(1) 24", (1) 30"	48"	
S 23	PWI 1A-14	PWI 1A-13	48"H x 32"W egg	(1) 16", (1) 24"	42"	
S 24	RVI 9-18B	RVI 9-18A	48"	(2) 30"	54"	
S 46	NHV 5A-16	NHV 5A-15	48"	(1) 24", (1) 30"	48"	
S 47	NHV 5A-33	NHV 5A-32	48"	(1) 24", (1) 30"	48"	
S 48	NHV 5A-48	NHV 5A-47	48"	(1) 24", (1) 30"	48"	
S 49	NHV 5C-03	NHV 5C-02	36"	(1) 20", (1) 30"	36"	
S 50	NHV 6-03	NHV 6-02	48"	(2) 30"	48"	
S 51	NHV 6-05B	NHV 6-05A	48"	(2) 30"	48"	
S 52	NHV 6-10	NHV 6-09	48"	(2) 30"	48"	
S 9	RVI 12-18B	RVI 12-18A	48"	(2) 30"	48"	
S 10	RVI 12-12B	RVI 12-12A	54"	(1) 24", (1) 36"	54"	
S 19	MR VI-19	MR VI-06	30"	(1) 16", (1) 24"	48"	
S 20	RVI 7-00A	RVI 7-00	30"	(1) 24"	48"	
S 21	LVI 1-15	LVI 1-12	24"	(1) 8", (1) 16"	24"	
S 18	RVI 7-18A	RVI 7-18	30"	(2) 18"	30"	

Rouge Valley Sewage Disposal System - Restrictions and Siphons along Middle Rouge between Inkster Road and JC2-8

Google earth

miles 4

km 6

DRAFT – June 29, 2019

Appendix C: Wayne County RVSDS LTCAP Draft Report

Note: The appendices from the RVSDS LTCAP draft report is not included in Appendix C. The appendices in the RVSDS LTCAP draft report is redundant to the SRF Project Plan appendices.

RICK SNYDER
GOVERNOR

C. HEIDI GRETHER
DIRECTOR

February 15, 2017

Ms. Kelly Cave, P.E., Director
Wayne County Department of Public Services
Water Quality Management Division
400 Monroe, Suite 400
Detroit, MI 48226

Dear Ms. Cave:

SUBJECT: Long Term Corrective Action Plan (LTCAP)
Fourth Amended Final Order of Abatement No. 2117 (AACO-000031)
Rouge Valley Sewage Disposal System (RVSDS)

Pursuant to paragraph 3.4 of AACO-000031, Wayne County (County) submitted the LTCAP dated June 28, 2016, revised October 12, 2016 and November 28, 2016, prepared by the County and OHM Advisors in response to the Michigan Department of Environmental Quality's letter and e-mail dated September 12, 2016 and November 10, 2016, respectively.

The LTCAP is hereby approved.

In conjunction with AACO-000031, the County will continue completing the remaining tasks associated with the approved LTCAP Work Plan dated November 13, 2015 and the Compliance Program in AACO-000031, as amended.

Should you require further information, please contact me at the number below, or by e-mail at earlyd@michigan.gov.

Sincerely,

Douglas R Early

Doug Early
Water Resources Division
586-753-3762

cc: Ms. Elmeka Steele - Director, WCDPS-FMD
Mr. Kenneth Kucel – Deputy Director, WCDPS
Mr. Vyto Kaunelis – OHM
Mr. Greg Kacvinski – OHM
Ms. Nancy Russell - OHM
Ms. Karen Ridgway – ASI
Ms. Sonya Butler – MDEQ, ODWMA, RLS
Ms. Katelyn Wysocki – MDEQ, WRD, Enforcement
Ms. Laura Verona - MDEQ

Wayne County Rouge Valley Sewage Disposal System

Long Term Corrective Action Plan

REVISED: November 28, 2016

Pages Revised: 14, 33-34, and 38

Prepared by:

Wayne County Department of Public Services
Environmental Services Group
400 Monroe Street
Detroit, MI 48226

and

OHM Advisors
34000 Plymouth Road
Livonia, MI 48150

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The appendices from this document is not included in Appendix C. The appendices in the RVSDS LTCAP draft is redundant to the SRF Project Plan appendices.

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- A2: Fourth Amended Final Order of Abatement, July 2015
- A3: Wayne County Rouge Valley Sewage Disposal System: Work Plan for Long Term Corrective Action Plan, November 2015

Appendix B

- B1: Wayne County RVSDS Service Agreement Renewals / District Characteristics, ASI, April 2012
- B2: Southeast Michigan 2040 Forecast Summary, SEMCOG, April 2012

Appendix C

- C1: Wayne County RVSDS LTCAP: Hydraulic and Hydrologic Model Development, ASI, August 2015
- C2: RVSDS: Updated Geodatabase for Initial Asset Inventory, OHM, September 2015

Appendix D

- D1: Rouge Valley Antecedent Moisture Model Report, OHM, March 2015
- D2: Floodplain Manhole Inspection Results, LTCAP Phase 1, OHM, April 2016
- D3: Recommendations for System Venting, LTCAP Phase 1, OHM, March 2016
- D4: RVSDS Task H – Lift Station 1A Operational Modifications, Wade Trim, April 2016
- D5: Wayne County and DWSD/GLWA Coordination: Downstream Boundary Conditions

1. Executive Summary

1.1 Introduction

This Long Term Corrective Action Plan (LTCAP) for the Rouge Valley Sewage Disposal System (RVSDS) is provided to meet the requirements of the Fourth Amended Final Order of Abatement #2117 (FOA 2117), originally entered September 20, 1998 and most recently amended on July 29, 2015 (AACO-000031). This LTCAP is intended to demonstrate what has recently been done to address wet weather issues in the RVSDS, what is currently being done to characterize the system, and what is proposed to address FOA 2117.

The RVSDS is a regional wastewater system that transports wastewater collected by all or parts of 14 communities in Wayne County, one community in Oakland County and part of one community in Washtenaw County. The RVSDS discharges wastewater to the regional wastewater system owned by the Detroit Water and Sewerage Department (DWSD) and operated by the Great Lakes Water Authority (GLWA) for transport, treatment, and disposal. The RVSDS is managed by the Wayne County Department of Public Services Environmental Services Group ("WCDPS" or "Wayne County"). A map of the RVSDS interceptor system is shown in Appendix A, Figure A-1.

The first segments of the RVSDS interceptor system were built in the 1930s, with expansions in the 1960s and 1980s. Improvements to the RVSDS have also been made over time as necessary to meet revised regulatory requirements. Major upgrades, such as relief sewers and sewer rehabilitation projects, were implemented from 1989-1999, as a result of a Final Order of Abatement. In the 1990s, projects were implemented by some communities in the RVSDS service area to address uncontrolled combined sewer overflows (CSO), including sewer separation in five communities and the design and construction of CSO Retention Treatment Basins (RTBs) in three communities. These projects have reduced uncontrolled CSO discharges to and improve water quality in the Rouge River system. The CSO RTB facilities dewater stored wastewater to the RVSDS interceptor system. There are additional storage facilities operated by communities in the RVSDS which serve to equalize and manage their wastewater flows into RVSDS.

During the late 1990s and early 2000s, several large rain events caused significant basement back-ups and sanitary sewer overflows (SSOs) within the RVSDS. In 2001, a study was completed, which included recommendations to further study and improve the system. In 2007, Amendment 2 to FOA 2117 was entered, requiring specific actions, generally consistent with the earlier recommendations. The actions included a Short Term Corrective Action Plan (STCAP) to address known significant issues. Work completed by Wayne County to carry out the STCAP, including activities beyond the STCAP, are summarized in Section 1.3.

1.2 Regulatory Requirements

The LTCAP for RVSDS is being implemented as required by Fourth Amended Final Order of Abatement #2117 (FOA 2117), as amended. WCDPS has worked very closely with the Michigan Department of Environmental Quality (MDEQ) to keep them informed of significant findings during the investigations and improvement implementation. Wayne County also submits Annual Progress Reports for FOA 2117 to MDEQ and RVSDS communities. The MDEQ has carefully reviewed the findings and worked with WCDPS to implement reasonable adjustments to the schedule for completing the requirements of FOA 2117, where they determined it was warranted.

As the work toward developing a LTCAP progressed since 2012, MDEQ and Wayne County discussed that despite the considerable effort to calibrate the hydraulic model of the RVSDS to data from recent storm events, a good match to observed conditions in the majority of the RVSDS was obtained except for the lower reaches of the Middle Rouge interceptor between Inkster Road and Lift Station 1A (LS1A). Additionally, there have been no medium or large hydrologic events in the Middle or Lower Rouge watersheds since the STCAP implementation was completed in June 2012, and thus the RVSDS has not been tested against high river conditions during large storm events

In 2015, the fourth Amendment to FOA 2117 was entered to reflect these issues. Additionally, Wayne County proposed a two-phased work plan for developing and implementing the Long Term Corrective Action Plan for RVSDS, which was subsequently approved by MDEQ.

Key remaining dates in FOA 2117 are shown in Table 1-1. As of the submittal date of this report, this is the anticipated schedule for the LTCAP implementation, which is consistent with the requirements in the most recent Amendment of the FOA 2117 and the approved LTCAP Work Plan. The tasks for Phase 1 of the LTCAP Work Plan are shown in Table 1-2. Copies of FOA 2117 documents and key related correspondence, including the MDEQ-approved LTCAP Work Plan and Schedule, are included in Appendix A.

Table 1-1: FOA 2117 – Key Remaining Milestones (As Defined in the Fourth Amendment to FOA 2117 and the November 2015 LTCAP Work Plan)

Milestone	**Completion Date**
Submittal of LTCAP Document	06/29/2016
Extended Flow Metering Period	07/1/2017
Submittal of LTCAP/SRF Project Plan	06/29/2019
Completion of Capital Projects – Full Compliance	12/30/2022

Table 1-2: Tasks for LTCAP, Phase 1

Work Plan Tasks (as defined in the MDEQ-approved LTCAP Work Plan)
Task A: LTCAP Development and RVSDS Community Coordination
Task B: Field Survey
Task C: Temporary Flow Meter and Level Sensor Installation
Tack D: Junction Chamber Inspection
Task E: Inspection/Cleaning of Siphons and Restrictions
Task F: SCADA System Improvements
Task G: Inspect Floodplain Manholes for Inflow/Outflow Potential
Task H: LS1A Operational Modifications
Task I: System Venting
Task J: Floodplain Manhole Improvements
Task K: Regulator Modifications
Task L: Determine the Range of GLWA Boundary Conditions with RVSDS
Task M: Wet Weather Response Team
Task N: Continue Development of RVSDS Asset Management Plan

Although many studies have been completed for the RVSDS in the last 30 years (and many capital improvements have been implemented as a result of these studies), a new MDEQ SSO Policy adopted in 2002 placed additional restrictions on the frequency of SSOs. Additional system improvements may be needed to address remaining system components that do not currently meet the SSO Policy. This LTCAP provides the basis for improvements and a plan for completing them.

1.3 Investigations and System Improvements

In performing the STCAP monitoring and evaluations, several issues have been identified and addressed. Although this has resulted in extensions to schedules and additional short-term costs, it has also resulted in a better understanding of system performance during large wet weather events. This has led to a more comprehensive, yet more focused understanding of the critical needs for system improvements. A synopsis of the investigations and work performed are described on the following pages.

a. **Sanitary Sewer Evaluation Study (2006-2007)**

The Sanitary Sewer Evaluation Study (SSES) consisted of system-wide system condition assessment and resulted in specific recommendations for rehabilitation and repair within the RVSDS in order to extend the useful life of the system and to reduce wet weather flows. The SSES effort led to the development of the STCAP, which was implemented in 2010 and 2011.

b. **STCAP (2011-2012)**

During the STCAP, WCDPS implemented a systematic rehabilitation program for the interceptor sewers to reduce inflow and infiltration during wet weather events. This included improvements to Lift Station 1A (LS1A) to overcome surcharging in the downstream DWSD wastewater system and to reduce potential for SSOs when operating at full capacity by adding a discharge conduit and a new set of siphons constructed downstream of LS1A. This work also included the rehabilitation of nearly 11,000 feet of interceptor sewers and nearly 1,000 manholes along the RVSDS interceptor sewers to address infiltration and inflow (I/I) removal (source removal). The impacts of the STCAP on wet weather flows is described in Section 5.

c. **Post-STCAP and LTCAP Phase 1 (2012-present)**

Construction of the STCAP was completed in 2011. Since the completion of the STCAP projects, the County has completed additional activities to ensure that the RVSDS continues to be operated efficiently and effectively, with a goal of reducing SSOs in compliance with FOA 2117:

- Continued operation of the flow monitoring program for the RVSDS, including additional flow meters and upgrades to existing flow meters. In addition, in 2011, Wayne County began producing and publishing quarterly and annual reports summarizing data and other information about RVSDS performance; all are available online.

- Improvements to the Supervisory Control and Data Acquisition (SCADA) system at RVSDS facilities and flow meters.

- Procurement of a consultant team to prepare the Long Term Corrective Action Plan (LTCAP) in 2014.

- Collection of field and record data for the RVSDS (including data from communities' contributing systems) to more accurately describe the system, including inspection of manholes within the 1-year and 2-year floodplains of the Lower and Middle Rouge Rivers to determine rim/casting condition, potential inflow points, and developed recommendations to inspect and maintain these manholes at an increased frequency.

- Conversion of the RVSDS hydraulic and hydrologic model to SWMM5 and upgrades to the service area and interceptor system representations to reflect more recent flow meter and rainfall data, enhance the accuracy of community flow input locations, and more accurately represent operational characteristics of the system.

- Enhancements to the County's Geographic Information System (GIS) and asset management system for the RVSDS, to include more accurate data acquired for manhole/sewer locations, structural condition, and maintenance history.

- Procurement of a contractor to clean and televise key siphons and restrictions along the RVSDS interceptors.

- Identification of locations for additional system venting to address possible hydraulic constraints in the lower reaches of the Middle Rouge Interceptors.

- Identification of operational enhancements at LS1A to maximize pumping capacity while reducing the impact on system hydraulics upstream of the lift station.

- Coordination with Detroit Water and Sewerage Department (DWSD)/GLWA representatives to identify opportunities to reduce the magnitude of hydraulic surcharge in the downstream GLWA regional system that are adversely impacting the ability of the RVSDS to deliver wastewater to GLWA up to the limit specified in the service agreement.

- Progress meetings were held with the RVSDS customer communities and with the MDEQ.

In addition to the Wayne County efforts to remove I/I from the RVSDS, several communities in the RVSDS service area have also implemented local sewer rehabilitation programs.

1.4 Status of System Hydrologic/Hydraulic Model

This LTCAP was prepared to present a viable plan for compliance with FOA 2117. The hydrologic/hydraulic (H/H) model of the service area to and sewer interceptor system comprising the RVSDS developed to date provides a reasonable representation of the majority of the system. However, especially in the interceptor reaches where significant improvements are anticipated to be needed (lower reaches of the Middle Rouge Interceptors), the H/H model is not sufficiently representative of observed flow conditions. As such, the H/H model described in this report is considered to be preliminary and is not yet being used to identify any capital improvements related to conveyance or storage of wet weather flows necessary to comply with FOA 2117.

The H/H model development is described in more detail in Section 5 (and Appendix C). The hydrologic/hydraulic model has been used so far to identify which components of the RVSDS require additional enhancements and/or study. This has served as the basis of developing a two-phase approach to implementing the LTCAP as described in Section 1.5 of this Executive Summary.

The hydrologic/hydraulic model will be continuously updated through Phase 1 and into Phase 2 of this LTCAP. The proposed locations, types, and sizes of RVSDS improvements to be implanted under Phase 2 of the LTCAP will be identified in the LTCAP/SRF Project Plan, due in June 2019, and will be confirmed by the updated H/H model.

The development of the preliminary hydrologic/hydraulic model of the RVSDS is outlined below:

a. **Design Flows**

The preliminary design flows in RVSDS were developed for the 25-year, 24-hour storm event. See Section 5 for additional information on modeling for the design storm.

b. **Model Calibration**

The April 2013 storm and September 2014 storms were used to calibrate the hydrologic parameters in the hydrologic model of the RVSDS service area for the design storm event. Both events had other rainfall events days prior which led to elevated groundwater infiltration which is preferred in the development of design event parameters.

c. **Population Projections**

The preliminary hydrologic model of the RVSDS service area was developed based on population distribution available from 2010 Census data. Population updates from SEMCOG were incorporated in the model. As the updated hydrologic model is developed between Phase 1 and Phase 2, population projections will be added as necessary to reflect future conditions.

d. **Flow Metering Period**

The WCDPS has a long established a flow metering system for the RVSDS, which provides data for evaluating system performance. This is important, since each large storm event has the potential to verify existing system understanding or to identify previously unknown issues. The flow metering data collected between 2010 and 2014 were used to develop the preliminary H/H model. Ongoing flow meter data, including the new meters installed on and adjacent to the Middle Rouge Interceptors, are being collected and will be used for continued RVSDS H/H model updates.

1.5 Identification of Improvements

The primary goal of this LTCAP is to achieve compliance with the MDEQ's 2002 SSO Policy and meet the requirements of FOA 2117, and to provide improved integrity of the RVSDS into the future. There are several locations where SSOs have been either been suspected (model-predicted) or observed for events less than the 25-year/24-hour magnitude.

Since the majority of SSOs that are model-predicted or observed are within the direct hydraulic influence of the lower reaches of the Middle Rouge Interceptors, and since this reach of the RVSDS currently experiences a higher hydraulic surcharge than predicted by the H/H model, it is necessary to develop a phased approach to system improvements:

a. **Phase 1 LTCAP**

Phase 1 projects were identified as those projects that will help to establish a hydraulic scenario in the lower reaches of the Middle Rouge Interceptors to provide a better match between observed flows and hydraulic model predictions. These projects could also significantly enhance the hydraulic capacity of the Middle Rouge Interceptors without new or additional conduits. Phase 1 projects include:

- System retrofits intended to increase hydraulic capacity, including venting and siphon/restriction cleanout.
- Operational upgrades to LS1A and the SCADA system.
- Additional flow metering along the Middle Rouge Interceptors (through the reach where hydraulic discrepancies exist).
- Inspection of floodplain manholes and manhole repairs to eliminate known sources of river inflow.
- Additional flow metering along key local sewers in Dearborn Heights, where significant inflows have been predicted based on incremental metering.
- The completion dates of these activities range from December 2015 to May 2017.

b. **Phase 2 LTCAP**

Phase 2 projects will include those necessary for SSO control in compliance with FOA 2117 and to ensure long term system integrity. The locations, types and sizes of the projects to be implemented under Phase 2 will be based on the system hydraulic conditions observed after the Phase 1 project implementation and corresponding model updates. These projects fall into one of the following two categories:

- Projects to address known or model-predicted SSOs, but the need for and/or sizing of the projects will be affected by the Phase 1 projects and model updates; or
- Projects to address model predictions of SSOs or possible unacceptable depths at locations with no history of observed SSOs.
- Phase 2 projects will be identified in the LTCAP/SRF Project Plan due in June 2019, with full implementation by December 2022.

1.6 Approaches to Phase 1 System Improvements

System improvement approaches were evaluated for each component of the system to provide an initial indication of the most feasible improvements. Approaches that were infeasible or significantly more expensive were eliminated from further evaluation. Feasible options for each component were further developed into proposed projects for this LTCAP (see Section 6 for a more detailed description of the improvements). The findings from the evaluation of system improvement approaches are:

a. **I/I Source Removal**

Although I/I source removal may not be the primary solution to address known system deficiencies resulting in SSOs, it can be justified to make incremental improvements by preventing degradation of the system that may result in future increases to I/I peak flows and volumes. A significant amount of I/I source removal has already been implemented as part of the STCAP. I/I source removal improvements included manhole rehabilitation, sewer lining, rehabilitation through joint/crack repair, and improvements to LS1A.

Beyond the STCAP, Wayne County has continued in identify I/I source removal. The pre-STCAP Antecedent Moisture Model (AMM), created in 2006, was updated with post-STCAP flow data. The post-STCAP meter data demonstrated that the RVSDS has a lower wet weather flow response compared to the pre-STCAP conditions, ranging from 3-4% for more frequent hydrologic events to over 10% for a design event. This indicates that the improvements made during the STCAP have reduced the wet weather response in the RVSDS. As part of the LTCAP, manholes in the 1-year, 2-year, 10-year and 100-year floodplain have been identified. A first priority was placed on manholes below the 1-year and 2-year floodplains. Manholes with missing gasket/bolts, poor rim condition, or clear evidence of SSOs were noted and will be rehabilitated to reduce I/I during a wet weather event. Wayne County staff have already repaired several manholes where missing manhole covers were noted.

b. **Maximize Hydraulic Capacity**

The H/H model for RVSDS updated by Wayne County and its consulting team identified that the RVSDS may not be achieving its intended flow capacity required under FOA 2117, largely due to:

- Partially-open regulators;
- Potential for insufficient air flow due to lack of venting;
- Lack of pumping capacity at LS1A, including screen blockage that may create an adverse hydraulic condition;
- Potential for partial blockages at siphons and sewer size transitions (currently being evaluated); and

- Adverse hydraulic conditions in the downstream GLWA/DWSD regional wastewater system.

There was insufficient accurate information about some regulator structures tributary to the RVSDS interceptor for them to be adequately represented in the H/H model. To address this deficiency, a detailed site survey of the pertinent regulators was performed. The H/H model has been updated to better represent the regulator opening areas and pin settings. Additionally, it was recommended that Wayne County fully open the shear gate at regulator M-21; Wayne County implemented this recommendation.

One of the additional tasks to enhance hydraulic capacity at key locations is to add venting to the RVSDS interceptor system along the lower reaches of the Middle Rouge Interceptors. The venting will help reduce the occurrence of compressed air and/or vacuums, both of which can significantly reduce the hydraulic capacity of the interceptor system. A total of seven locations were identified to provide venting (see Section 6).

Siphons in LS1A were upgraded during the STCAP. To continue to improve the hydraulic capacity of LS1A, the optimal gate operations and settings have been confirmed. Additionally, the bar racks will be cleaned more frequently during Phase 1 as a pilot study. Additional improvements to the screening at LS1A will be evaluated for Phase 2 of this LTCAP.

To help maximize the hydraulic capacity of the system, Wayne County has selected a contractor to begin inspecting and cleaning siphons and restrictions in May 2016. This task will be completed by fall of 2016. Additionally, Wayne County and GLWA have been in ongoing discussions on the best approaches to address the boundary conditions of the GLWA/DWSD system that impact the RVSDS outlet capacity.

c. **Enhanced Data Management**

To better manage and understand the RVSDS, Wayne County has upgraded 18 flow meters, its SCADA system, and the GIS database for the RVSDS. Wayne County has also installed 11 new meter cabinets and upgraded 13 meter power supplies to ensure more reliable and continuous flow meter data. Additionally, temporary flow meters and level sensors have been installed. A total of six meters have been installed for a 24-month monitoring period at Outer Drive and Telegraph Road. An additional ten meters have been installed in Dearborn Heights for a 4-month monitoring period in spring/summer 2016.

Enhancing the GIS database for Wayne County is a continuous process during the LTCAP; however, a significant amount of work has been done to update the system already. Some of that work includes manhole identification, structural conditions, maintenance history and other information useful for ongoing analysis, modeling, and O&M.

d. **Hydraulic Capacity and Storage**

Due to the need to extend the flow metering period and reevaluate critical reaches of the RVSDS in Phase 2, no conveyance or storage projects are recommended at this time.

1.7 Key Recommendations

Recommendations for this LTCAP are summarized below.

a. **Plan and Implement Phase 1 Projects**

Implementation of the Phase 1 Projects will establish a more thorough understanding of the RVSDS characteristics during wet weather and should help to improve hydraulic performance in the downstream reaches of the Middle Rouge Interceptors. The total estimated cost for Phase 1 projects is approximately $900,000, which includes consultant costs incurred as part of the LTCAP planning process and estimated contractor costs to implement the cleaning, inspections, retrofits, and related work identified in this document.

b. **Define Phase 2 Projects**

Additional monitoring and modeling will be performed during and after the Phase 1 projects are complete to verify the need, size(s), and location(s) for larger-scale capital improvements to the RVSDS to address remaining SSOs. No specific recommendations or cost estimates are provided at this time. The 2019 LTCAP/SRF Project Plan will include the alternatives analysis and cost estimates for Phase 2 Projects.

c. **Design and Implement Phase 2 Projects**

Upon the completion of the LTCAP/SRF Project Plan, commence with the design and, bidding, and construction of the defined Phase 2 projects. The Phase 2 projects will be completed before December 30, 2022, per the FOA 2117 schedule.

d. **Evaluate LTCAP Effectiveness and Revise Community Capacities**

Upon the implementation of the Phase 2 Projects, a Project Performance Certification (PPC) will be prepared to modify the current framework of community outlet capacities as necessary to reflect the improved hydraulic capacity of the RVSDS.

2. Project Background

2.1 Study Area

The purpose of this section of the report is to provide a general background of the Rouge Valley Sewage Disposal System (RVSDS), define the extents of its service area, include information on the system's operational characteristics, and summarize system improvements made to address revised regulatory requirements.

The RVSDS provides sanitary sewer service to roughly 215 square miles in Wayne County, including all or part of 15 communities. They are the communities and/or agencies of Dearborn Heights, Garden City, Inkster, Livonia, Northville (City), Oakland County (on behalf of Novi), Plymouth, Redford Township, Romulus, Van Buren Township, Wayne, Western Townships Utilities Authority (WTUA) (on behalf of Canton Township, Northville Township, and Plymouth Township), and Westland. See Appendix A, Figure A-1 for an overall map of the RVSDS service area.

2.2 Existing Facilities

The first segments of the RVSDS interceptor system were built in the 1930s, with additions in the 1960s and 1980s. Today the RVSDS interceptor system includes nearly 93 miles of sewers and ranging in size from 30 inches to 102 inches. The average dry weather flow for the RVSDS is approximately 60 cfs, which is measured at the RVSDS outlet meters to the GLWA (formerly DWSD) system at three different connection points, each with their own capacity limitations. The 2015 average annual flow rate was 85 cfs, with an estimated maximum monthly average flow rate of 145 cfs.

The peak wet weather flow for the design event has not yet been determined, due to the need to further evaluate flow meter data; however, the County's contract capacity with GLWA is 378.8 cfs with a verbal agreement with DWSD to increase to 444.5 cfs. The ability of GLWA to accept a peak flow of 444.5 cfs from the RVSDS is in question, as known hydraulic constraints in the downstream GLWA interceptors and wastewater treatment plant may prevent the collective of RVSDS discharge points from flowing at the combined contract capacity. Wastes discharged to the RVSDS are typical of municipal sewage.

Interceptors

The existing RVSDS consists of two major interceptors, the Middle Rouge Interceptors (located along Edwards N Hines Road and the Middle Branch of the Rouge River) and the Lower Rouge Interceptors (located along Michigan Avenue and the Lower Branch of the Rouge River). These interceptors serve a network of smaller interceptors and trunk sewers. Local sanitary collector sewers are owned and operated by the local communities within the RVSDS. Figure A-

1 in Appendix A shows the RVSDS service area, interceptor network, and major facilities.

The Middle Rouge Interceptor system runs along the Middle Branch of the Rouge River from Northville to Dearborn Heights. The Middle Rouge Interceptor system consists of three branches, the Middle Rouge Interceptor Relief (MRIR), Middle Rouge Parkway Interceptor Extension (MRPIE), and Rouge Valley Interceptor (RVI). Flow from the MRIR is transported to LS1A in Dearborn Heights, where it flows by gravity (and is pumped during wet weather) to the GLWA Northwest interceptor; whereas the MRPIE flows into the Northwest Inceptor by gravity. The Northwest interceptor transports the sewerage to the GLWA's Wastewater Treatment Plant (WWTP). Sewerage from the RVI flows through the Oakwood Interceptor Arm to the WWTP.

The Lower Rouge Interceptor system runs along Michigan Avenue and the Lower Branch of the Rouge River from Canton Township to Dearborn Heights, ultimately flowing into the Oakwood Interceptor to the GLWA WWTP.

Combined Sewer Overflow Control and Flow Management Control Facilities

In the 1990s, projects were implemented by some communities in the RVSDS service area to address uncontrolled combined sewer overflows (CSO), including sewer separation in Garden City, Livonia, Plymouth Township, Wayne, and Westland, and the design and construction of CSO Retention Treatment Basins (RTBs) in Dearborn Heights, Inkster, and Redford Township. The CSO RTB facilities dewater stored wastewater to the RVSDS interceptor system. There are additional storage facilities operated by communities in the RVSDS which serve to equalize and manage their wastewater flows into RVSDS. Wastewater storage and/or treatment facilities which are authorized to discharge to RVSDS are:

Wayne County Owned or Operated Facilities:

- Dearborn Heights CSO RTB (2.7 MG)
- Inkster CSO RTB #1 (3.1 MG)
- Livonia Equalization Basin (2.2 MG)
- Redford CSO RTB (1.9 MG)

Local Owned and Operated Facilities:

- Inkster CSO RTB #2 (1.9 MG), City of Inkster

- Van Buren Township Equalization Basin (1.4 MG), Van Buren Township
- Wayne County Airport Authority, Pond 3W
- Wayne Equalization Basin (2.54 MG), City of Wayne

Regional Owned and Operated Facilities

- Western Townships Utilities Authority (WTUA)
  - Middle Rouge Equalization Basin (8 MG)
  - Lower Rouge Equalization Basin (11 MG)

Four combined sewer overflow Retention Treatment Basins (RTBs) provide wet weather storage and dewater into the RVSDS following wet weather events: Redford CSO RTB, Inkster CSO RTBs 1 and 2, and Dearborn Heights CSO RTB. The CSO RTBs (with the exception of the Inkster #2 CSO RTB, which wasn't in service until after 2010) were constructed in the mid-1990s and put into service in the late 1990s. The Redford and Dearborn Heights CSO RTBs are located on the Middle Rouge Interceptor (see Figure 1 in Appendix A for RTB locations). The Inkster CSO RTBs are located on the Lower Rouge Interceptor. Together, the CSO RTBs, exclusive of the Inkster #2 CSO RTB, which was not put into operation until after 2010, eliminated over 18 CSO outfalls and service a combined area of 1,724 acres.

The RTBs have a collective capacity of over nine million gallons. All discharges from the RTBs (except for Inkster RTB 2) are treated discharges that meet water quality standards. Each of the three RTBs has a permitted outfall along the Middle/Lower Branches of the Rouge River. These only discharge treated effluent, as necessary, during wet weather.

Following wet weather events which partially or fully fill the RTBs, they are dewatered and discharged to the RVSDS after the event peak flow has receded.

Lift Station 1A

LS1A provides pumping capacity for the downstream end of the RVSDS during wet weather, which is necessary to counteract the downstream hydraulics in GLWA's system and to ensure that the RVSDS can discharge at the contract peak flow rate of 444.5 cfs (although LS1A's firm capacity is only a portion of the 444.5 cfs contract limit). LS1A was built in the 1990s to address the reduced capacity of the interceptor system outlets due to the hydraulic surcharging of GLWA's Northwest Interceptor. The lift station is located on the Middle Rouge Interceptor between Edward N Hines Drive and Ford Road in Dearborn Heights.

Regulators

There are over forty regulators within the communities of Westland, Wayne, Garden City, Dearborn Heights, Inkster, Redford and Livonia in the RVSDS service area. These regulators were built to control flows into the interceptors and divert wet weather flows into alternate wastewater facilities (typically combined sewers, CSO outfalls, and, more recently, CSO RTBs).

2.3 Known System Characteristics

Several segments of the interceptors throughout the RVSDS have insufficient capacity to handle design event flows, which can result in sanitary sewer overflows (SSOs) and/or basement flooding. Areas that have historically been suspected of having insufficient hydraulic capacity to convey the 25-year / 24-hour design storm include:

- Middle Rouge Interceptors from Merriman Road downstream to LS1A.
- Inkster Arm, with observed SSOs at the Bell Branch, north of Five Mile. The performance of this sewer hinges on the HGL in the Middle Rouge Interceptors at Inkster Road.
- Additional structures may be defined as part of the Phase 1 wet weather investigations.

Preliminary H/H modeling of RVSDS identifies the areas where hydraulic surcharge is predicted to be more likely. In addition to hydraulic restrictions, some areas of the system have hydraulic discrepancies, or anomalies, where there is a significant divergence between observed flow depths and modeled flow depths. This is most evident on the Middle Rouge Interceptors downstream of Inkster Road. The Phase 1 projects identified in this LTCAP report are intended to physically verify and address the hydraulic discrepancies so the modeling effort can be completed with a higher degree of confidence.

2.4 GLWA Boundary Conditions

The outlet capacity of the RVSDS hinges on the hydraulic conditions in the downstream GLWA wastewater system. Recent flow metering reveals that the GLWA wastewater system creates a significant hydraulic restriction for LS1A and reduces the peak flow capacity well below Wayne County's allotted peak flow of 444.5 cfs.

Wayne County staff have been communicating with GLWA/DWSD staff on system optimizations that may help to reduce downstream hydraulic impacts. Information about meetings between GLWA/DWSD and Wayne County to discuss this issue is included in Appendix D.

2.5 Work Performed to Date

a. **I/I Removal Projects**

Wayne County has been actively working on I/I removal for the last six to eight years. During the STCAP, the County completed rehabilitations to manholes, lining of pipes and modifications to junctions to reduce I/I. Below is a detailed list of the work performed and completed by June 2012 during the STCAP to improve the system.

- Manhole Rehabilitation (958 manholes)
- Modifications to regulators (10) and comfort stations (4) to reduce wet weather flow into the RVSDS.
- Modifications to stop plate access covers at junction chambers (7)
- Seven interceptor sewer segments lined with cured-in-place pipe, CIPP (6,880 feet)
- Three Interceptor segments slip-lined with HOBAS™ flush joint pipe (2,180 feet)
- Spot Interceptor repairs (9)
- Interceptor joint repairs (164)

Manholes in the 1-year, 10-year and 100-year floodplain were identified along the Middle and Lower Rouge reaches of the system. All manholes in the 1-year floodplain were inspected in the fall of 2015. Additional manholes in the 2-year floodplain were inspected in April 2016. Manholes with missing gaskets/bolts, poor rim conditions, missing/loose frame and seal, and/or evidence of SSO have been documented. Wayne County has already repaired manholes with missing covers.

b. **Maximize Hydraulic Capacity**

Due to the hydraulic discrepancies between the hydraulic model and observed flows in the RVSDS, Wayne County has been working to identify manholes, regulators, siphons/restrictions, and junctions which could significantly reduce the hydraulic capacity of the interceptor system beyond that which is predicted by the preliminary hydraulic model. Three junction chambers and five manholes have been identified for system venting, which will reduce the impact of trapped air (or vacuums) in the system. Additionally, Wayne County has recently approved a contract to have siphons and geometric transitions (i.e. conflict sewers, a/k/a "restrictions") cleaned and televised to determine whether existing solids and/or debris are reducing the hydraulic capacity of the RVSDS.

c. **Enhance Data Collection, Management, and Analysis**

During the last year, Wayne County has updated flow meters, installed new meter cabinets, and upgraded meter power supplies throughout the RVSDS. Additional meters have been installed along the lower reaches of the Middle Rouge Interceptors to provide better data on the hydraulic profile through this critical reach. Also, temporary flow meters have been added to local (Dearborn Heights) sewers upstream of their connections to the Middle Rouge Interceptors, as these areas are suspected to contribute a high magnitude of wet weather flows. The temporary flow meters will be monitored for approximately 4 months.

In 2011, Wayne County began producing and publishing quarterly and annual reports summarizing data and other information about RVSDS performance; all are available online at http://www.waynecounty.com/doe/1108.htm.

The GIS database (Initial Asset Inventory) for the RVSDS has been enhanced to include:

- Structural condition of manholes and sewer pipes (from the 2007 SSES)
- Accurate coordinates for manholes and other structures
- Tabular data on the type(s) and date(s) of system repair and rehabilitation

As the RVSDS hydrologic/hydraulic model is refined, key data from the model will be exported to the GIS Initial Asset Inventory to provide a more accurate database of the RVSDS that can be used to facilitate future maintenance, inspection prioritization, and modeling efforts.

3. Need for RVSDS Long Term Corrective Action Plan

3.1 Compliance Status

The RVSDS does not currently meet Michigan's 2002 SSO Policy. Periodic SSOs have been observed within the system. Multiple studies have been conducted and improvements have been implemented since 1982. Additional system improvements have been required per FOA 2117 for the RVSDS, last updated in July 2015 (ACO-000031).

The list below includes a summary of the key milestones, including prior studies and improvements implemented since 1982. This list provides a history that establishes the need for the projects listed in this LTCAP.

1982	Comprehensive Facilities Plan (approved by MDEQ in September 1988)
1988	MDEQ issues Final Order of Abatement 2117 to Wayne County and the 15 RVSDS communities
1989	MDEQ issued 1st Amended Final Order of Abatement 2117
1999	Construction of Segment I facilities completed
1999-present	Ongoing system-wide flow and rainfall monitoring program
2002	MDEQ issued SSO Policy Document
2003	MDEQ issued SSO Clarification Statement
2005	Project Plan created to address RVSDS wet weather flows
2006	RVSDS Hydrologic and Hydraulic Modeling Analysis submitted to MDEQ
2007	MDEQ issued 2nd Amended Final Order of Abatement 2117
2007	STCAP proposed during FOA negotiations
2007-2013	RVSDS communities implemented various local rehabilitation projects
2007-present	Annual Status Reports for FOA 2117 Compliance submitted to MDEQ

2007-present	Annual Work Plans for Sanitary Sewer Operation and Maintenance to MDEQ
2008	STCAP Completed, State Revolving Fund Project Plan for STCAP Submitted
2012	Construction of STCAP completed
2012	MDEQ issued 3rd Amended Final Order of Abatement 2117
2012-2013	Evaluation of post-STCAP flow monitoring data
2012-present	Publication of quarterly and annual reports summarizing RVSDS flows
2013-present	Ongoing efforts to assess RVSDS and remove sources of I/I, including the initiation of the Phase 1 LTCAP
2015	MDEQ issued 4th Amended Final Order of Abatement 2117
2015	Submittal of LTCAP Work Plan to MDEQ
2016	Approval of LTCAP Work Plan and revised schedule by MDEQ

3.2 Water Quality Impacts

SSOs from the RVSDS typically occur during significant wet weather events, although the volume and frequency of SSOs is suspected to be lower than prior to the STCAP implementation, based on pre- and post-STCAP hydrologic modeling. Additionally, the WCDPS and RVSDS communities have continued to implement sewer system rehabilitation projects. However, early evaluation of the design event hydrology reveals that additional system improvements likely will be needed to meet the FOA 2117 requirements.

Water quality problems, such as elevated bacteria levels or sanitary trash, could be present in the Rouge River and its tributaries downstream of the SSO discharge locations. No water quality studies specific to the impacts of SSOs from RVSDS have been conducted, since MDEQ considers that SSO discharges contain raw sewage, which is prima facie evidence of a water quality violation.

3.3 System Capacity Limitations

The existing capacity limitations will likely result in SSOs during a 25-year / 24-hour design storm event. Preliminary modeling efforts validated several of the suspected capacity limitations for the design storm, although the model-predicted flow depths were, in several key locations of the RVSDS, lower than observed flow depths for the calibration events. See Section 5 for a discussion of design event wet weather flows and modeled system capacity limitations

4. Population Projections

4.1 Introduction

In order to effectively plan and design RVSDS projects that will maintain the desired level of service in the future, a population projection was analyzed for year 2040. Existing populations and future population projections were previously developed as part of the master planning process for the RVSDS. These were summarized in the following documents:

a. **Existing populations**

The 2010 Census population of the RVSDS is roughly 623,900 residents and the estimated 2015 SEMCOG population is 624,600. See the technical memorandum entitled *Hydraulic and Hydrologic Model Development* in Appendix C for tables and figures.

b. **Future population projections**

The future population projections were updated in 2012 in a report created by ASI. For many of the communities, population is expected to decline from year 2010 to year 2040. See *Wayne County Rouge Valley Sewage Disposal System Service Agreement Renewals District Characteristics* in Appendix B.

4.2 Summary of Modeled Population

For the initial modeling effort, the future population growth was not considered; this is primarily due to the impacts of projected *declining* population in the service area. The hydrologic/hydraulic model was created using the 2010 Census data. Based on the projections for an overall reduction in RVSDS population during the next 25 years, the existing populations were used as a more conservative (higher) estimate of baseflows. As the model is updated between Phases 1 and 2 of this LTCAP, the SEMCOG data will be reevaluated and the population projections will be updated as necessary.

Table 4-1 lists the estimated and projected populations within the RVSDS service area. The majority of communities are projected to experience a decline in population from 2015 to 2040, except for Canton Township, Novi, Plymouth Township and Van Buren Township (according to SEMCOG projections).

Table 4-1: Existing and Projected Residential Populations within the RVSDS Service Area

Community	**2010 Census**	**Year 2015 SEMCOG Estimated Population**	**Year 2040 SEMCOG Projected Population**
Canton Township	90,173	94,784	91,820
Dearborn Heights*	37,287	36,004	35,278
Garden City	27,692	25,709	25,010
Inkster	25,369	23,806	20,612
Livonia	96,942	96,589	92,353
Northville	2,739	2,570	2,360
Northville Township	28,497	28,874	28,204
Novi*	51,096	53,816	53,569
Plymouth	9,132	8,940	8,369
Plymouth Township	27,524	27,684	28,170
Redford Township*	44,354	42,921	39,054
Romulus*	2,429	2,275	2,297
Van Buren Township*	6,122	6,627	6,428
Wayne	17,593	17,213	16,250
Westland	84,094	84,058	78,602
Total	**551,043**	**551,870**	**528,376**

*Information is given for the part of the community in the RVSDS Service Area.

5. Hydrologic/Hydraulic Modeling of RVSDS

5.1 Introduction

EPA SWMM5 was used to update the hydrologic/hydraulic model of the RVSDS. The previously-available H/H model for the RVSDS was part of the Greater Detroit Regional Sewer System (GDRSS) H/H model. The GDRSS H/H model, while providing a reasonable representation of the RVSDS, was missing some key data that was deemed necessary for this LTCAP, most notably:

- The GDRSS H/H model included simplified representation of key pumps, control gates, and CSO RTBs. Adding more detailed information on operational characteristics allowed for the evaluation of the system H/H model under various operational scenarios.
- The GDRSS H/H model lumped several community discharge points into single model nodes. It was determined that the H/H model should include a higher resolution of community flow input locations, so as to provide a more representative set of flow conditions along the interceptors.
- The H/H model needed to be expanded to include the lower reaches of local sewers (just upstream of their discharge points) in order to determine the potential for SSOs at all low-lying structures along (or in close proximity to) the interceptors.
- The survey data from the 2007 SSES was added to the H/H model. This provided a greater resolution of manholes and other structures. Additionally, the coordinates of these structures were geo-referenced in EPA SWMM to provide a geographically-accurate schematic of the RVSDS.
- All structure elevations (rims, inverts, weirs, controls, etc.) were updated to the NAVD88 vertical datum so as to provide more consistency between record drawings and recently-surveyed manholes. Wayne County-supplied vertical datum conversion tables were used to convert record drawing elevations to the

The hydrologic model was based on observed flow rates throughout the RVSDS in post-STCAP conditions. Rainfall events from late 2012 through 2015 were evaluated to determine appropriate events for dormant season and growing season model calibrations.

The hydraulic model was used to evaluate the hydraulic performance of the interceptors and to verify the location of and potential for SSOs. Flow meter data were compared to model-predicted flow depths for calibrated wet weather events. Although the majority of the RVSDS matched well between observed and predicted flow depths, the lower reaches of the Middle Rouge Interceptors were observed to have significantly higher flow depths than those predicted by the H/H model.

Given the discrepancy between observed and predicted flows in the Middle Rouge Interceptors, the H/H model calibration effort was paused in an attempt to resolve hydraulic issues in the lower reaches of the Middle Rouge Interceptors (Phase 1 projects in this LTCAP).

Modeling details, summary of methodologies, calibration data, and key findings are included in Appendix C in the *Hydraulic and Hydrologic Model Development* Report.

5.2 Task C: New Flow Metering

Due to the hydraulic discrepancy described in the previous paragraphs, the modeling team deemed it necessary to add flow meters at key locations along the Middle Rouge Interceptors. These additional flow meters (illustrated in Figure 6-3, Section 6) should provide more useful data on the hydraulic gradient along this critical reach of the RVSDS, as well as key flow data from Dearborn Heights community discharge points.

5.3 Task B: Field Survey

During the H/H model development, numerous structures needed to be surveyed to verify key characteristics that would further define critical components of the hydraulic model. In September-November 2015, additional field survey was conducted at key junctions and in order to resolve any remaining questions by the modeling team. This survey included four local sewer reaches in Dearborn Heights that each connect to the Middle Rouge Interceptors within the area of the known hydraulic discrepancy.

The survey data were added to the Initial Asset Inventory (GIS) database. The summary of the survey data collected during this task is included in Appendix D.

6. System Improvement Strategy

6.1 Summary of Approaches

Wayne County will achieve compliance with the MDEQ's 2002 SSO Policy and meet the requirements of FOA 2117, and will provide improved integrity of the RVSDS into the future, through a phased approach. Of the proposed Phase 1 improvements, many have already been partially or fully-implemented.

The proposed improvements are separated into two phases. Phase 1 activities will address I/I source removal, optimize the hydraulic capacity of the existing system, and enhance data management. These activities are intended to reduce the scope and magnitude of larger capital improvements, which will be identified in Phase 2.

Phase 2 projects will address the remaining physical limitations that prevent the RVSDS from meeting the requirements of FOA 2117. These projects will likely include conveyance (transport-and-treat) and/or storage projects to target any remaining portions of the system that do not meet the MDEQ SSO Policy.

This LTCAP focuses on Phase 1. Phase 2 projects will not be identified until Phase 1 activities are complete and adequate flow meter data are available to complete the H/H model calibration.

The sections below describe the proposed Phase 1 and Phase 2 activities.

Phase 1

i. I/I Source Removal

The first alternative is I/I removal, as targeted improvements can reduce system flows and potentially reduce the magnitude of regional improvements needed. I/I source removal is accomplished by reducing I/I that enters a sanitary system through pipe, lateral, and manhole rehabilitation and eliminating known surface inflow sources. The ultimate goal of source reduction is to reduce peak flows and flow volumes and the associated expenses to transport-and-treat these additional flows entering the system.

1. **STCAP:** Wayne County has implemented manhole rehabilitation and lining programs as part of the STCAP (2011-2012) to enhance the service lives of aging sewers and to attempt to reduce inflow and infiltration. Analysis of pre-STCAP and post-STCAP flow meter data revealed the rehabilitation has reduced I/I by a measurable amount (see Appendix D for supporting technical memoranda on the pre- and post- analysis).

2. **<u>Task G: Inspect Floodplain Manholes for Inflow/Outflow Potential and Task J: Floodplain Manhole Improvements:</u>** Manholes within the 1-year and 2-year floodplains have been inspected and significant inflow sources have already been repaired. RVSDS manholes within the 1-year floodplain of the Middle and Lower Branches of the Rouge River were inspected in October/November 2015 and manholes within the 2-year floodplain of the same branches were inspected in April 2016. Manholes with missing gasket/bolts, poor condition rims and/or loose frame and seal were given high priority because of the significant impact they have on river inflow, a key component of I/I. The floodplain inspection memorandum, initially submitted to Wayne County in November 2015, was used by County staff to identify significant potential sources of inflow. These manholes have already been repaired with new frames/rims and additional improvements to isolate the structures from the floodplain. Additional recommendations include:

    a. Use tamper-proof bolts to secure rims in locations where missing rims have been a recurring problem.

    b. Perform bi-annual inspections on the 1-year and 2-year floodplain manholes and repair/replace components as necessary.

    c. Use the RVSDS GIS inventory to track the floodplain manhole locations and to facilitate more cost-efficient inspection and condition tracking.

See Appendix D for supporting technical memoranda on the floodplain manhole inspections.

ii. Optimize RVSDS Hydraulic Capacity

The second alternative focuses on confirming hydraulic characteristics in key reaches of the RVSDS Interceptors and establishing the originally-intended flow capacity of the RVSDS. The hydraulic discrepancies (described in Section 5) revealed the need to perform targeted improvements along specific reaches of the RVSDS Interceptors. These improvements should help to address more frequent SSOs by lowering the hydraulic grade line on the Middle Rouge Interceptor between Inkster Road and LS1A and should enhance the confidence in the design flow conditions, which is a critical step before establishing larger capital improvements intended for Phase 2 of this LTCAP.

1. **<u>Task E: Inspection/Cleaning of Siphons and Restrictions:</u>** Siphon and restriction cleaning and inspection has begun on the Middle Rouge

Interceptors between Inkster Road and LS1A to verify whether these components contribute to adverse hydraulic conditions. Six restrictions and two siphons have been identified by Wayne County to be cleaned and inspected in spring/summer 2016. See Figures 6-1 and 6-2 for locations.

2. **Task H: LS1A Operational Modifications:** Operational enhancements at LS1A were identified to maximize flow capacity at the station while reducing the impact on the system hydraulics upstream of the lift station. The gate operations and settings at LS1A have been confirmed and have been optimized to improve performance during wet weather. Additionally, Wayne County has selected a contractor to perform regularly-scheduled cleaning of the bar racks that currently clog and back up into the MRIR Interceptor. This should help to prevent adverse hydraulic conditions in the lower reaches of the Middle Rouge Interceptors. (See Appendix D for supporting technical memoranda on LS1A and related SCADA modifications, including specific recommendations for LS1A upgrades).

3. **Task I: System Venting**: System Venting is a viable technique to maximize the hydraulic capacity in the RVSDS by limiting adverse scenarios within the system where compressed air and/or vacuums, both of which can significantly reduce the hydraulic capacity of the system, are present. Characteristics for ideal locations for venting include:

    a. Key community inflow points

    b. Upstream/downstream of siphons and hydraulic transitions (i.e. stream crossings and utility conflict crossings)

    c. In the vicinity of major interceptor structures/junctions

    An analysis was conducted from Merriman to LS1A to find manholes and/or junctions in safe and secure locations where venting would be ideal, based on the criteria above. Four manholes and three junction chambers were selected along the Middle Rouge Interceptors. (See Appendix D for supporting technical memoranda on the system venting analysis). Wayne County will select a contractor to perform the vent installations in the second half of 2016.

Figure 6-1: Locations of Siphons to be Inspected/Televised

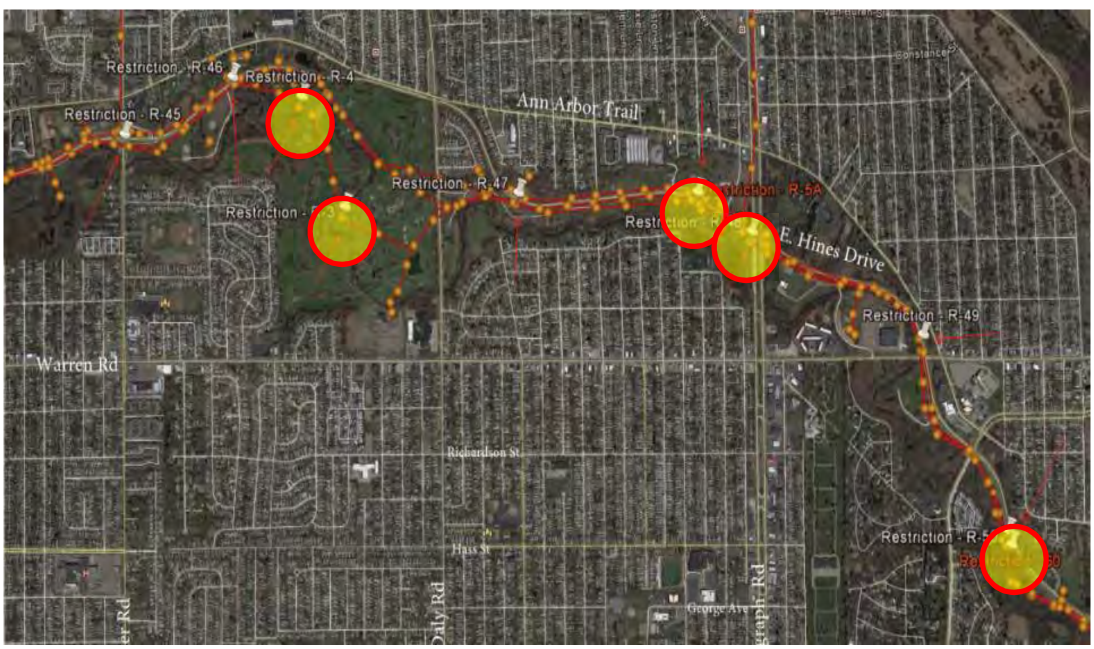

Figure 6-2: Locations of Restrictions to be Inspected/Televised

4. **<u>Task L: Determine the Range of GLWA Boundary Conditions with RVSDS:</u>** As part of the ongoing analysis of flow data and H/H modeling to develop this LTCAP, it has been revealed that the hydraulic grade line in the downstream GLWA wastewater system is considerably higher than expected, and higher than the design conditions assumed for LS1A, for storm events much smaller than the 25-year, 24-hour design storm event. Surcharging in the GLWA Interceptors downstream of and into the RVSDS during wet weather events is limiting the RVSDS flow rate that can be discharged to GLWA and limits the flow capacity of LS1A. Further, GLWA must commit to an expected hydraulic grade line in its Northwest Interceptor during the 25-year/24-hour storm for Wayne County to complete its analysis, alternatives evaluation, and design of the RVSDS LTCAP.

   Coordination between GLWA and Wayne County representatives has been ongoing for two years to identify opportunities to reduce the frequency and magnitude of hydraulic surcharge in the GLWA system that would adversely impact the RVSDS, and to develop an expected hydraulic grade line in the GLWA wastewater system during the 25-year/24-hour storm. GLWA recently initiated an accelerated study of the operations of the western part of its wastewater system, which should assist with determining the expected hydraulic grade line in the GLWA Northwest Interceptor during a 25-year/24-hour storm event. See Appendix D for a summary of coordination meetings between Wayne County and GLWA representatives.

iii. Enhance Data Management

The third alternative considered for improving management and knowledge of the RVSDS includes:

1. **<u>Task C: Temporary Flow Meter and Level Sensor Installations:</u>** Upgrading flow meters in the RVSDS will enhance the accuracy of the flow data collected and used for modeling purposes. Temporary meters and level sensors have also been installed along Outer Drive, Telegraph Road and Dearborn Heights. Dearborn Heights is within a reach of the RVSDS that is at a higher risk for SSOs, so it is important for Wayne County to understand how Dearborn Heights is impacting the RVSDS and if any improvements within the local sewers are justified. All of the meter data collected will be used to calibrate the hydrologic/hydraulic model, which should enhance confidence on design event flow depths along the lower reaches of the Middle Rouge Interceptors. See Figure 6-3 for an illustration

of additional meter locations. All of these meters have been installed in late 2015 and early 2016.

Figure 6-3: Location of New Flow Meters Installed in 2015-2016

2. **<u>Task F: SCADA System Improvements:</u>** The timing and discharge rates of the CSO RTBs tributary to the RVSDS is an important factor and needs to be monitored and controlled so as to avoid unnecessary discharges to the RVSDS Interceptors before the flow hydrograph has sufficiently receded. The dewatering data from the Wayne, Inkster, and Dearborn RTBs will be historized such that Wayne County can evaluate the impacts of the dewatering on RVSDS flow rates. The feedback from the data collection will allow Wayne County to work with the RTB owners/operators to make appropriate operational modifications to optimize the flow rates in the RVSDS following significant wet weather events. During this effort, Wayne County will also evaluate whether there are opportunities to reduce peak flows in the RVSDS by managing the timing of flows into the RTBs in such a way that further reduces flow rates in the RVSDS.

3. **<u>Task M: Wet Weather Response Team:</u>** Visual inspection of the RVSDS during wet weather events will help to confirm what is happening at key locations where system-critical hydrologic and hydraulic dynamics are

anticipated. This will help increase confidence in the hydrologic/hydraulic model. The Wet Weather Monitoring Team will be active effective May 1, 2016 and will consist of six people: two from each of the three consultants under contract for this program (OHM, ASI, and Wade Trim). OHM will maintain the team list and will have email and text distribution lists for mobilization orders. The team will use the following protocols for determine when and where to mobilize the team to inspect the RVSDS:

- In general, mobilizations are only anticipated during an event that would exceed the threshold of an annual (i.e. 1-year) event, and the team will likely favor hydrologic events that are closer to a 2-year recurrence interval. Mobilizations will only occur when the rainfall appears to be falling in a relatively uniform and widespread pattern over the RVSDS service area. The response from convective thunderstorms over small portions of the service area will not be observed.

- Rainfall forecasts:

    - OHM Advisors will monitor rainfall precipitation forecasts from the National Weather Service's Weather Prediction Center. Forecasts will be monitored on a daily basis for precipitation predicted for the next 2 to 3 days. If more than one inch of rainfall is predicted for any single 24-hour period, a WET WEATHER WATCH will be issued to the team. This alerts the primary and backup team members that a wet weather mobilization ***may*** be necessary within the next day or two and to be ready for additional instructions.

- Rainfall monitoring:

    - When wet weather is imminent, OHM Advisors will monitor radar-based rainfall depth estimates produced by the approaching storm. The total storm rainfall depth estimates from the National Weather Service Enhanced Radar Image will be used for this task. If radar estimates indicate at least one inch of rainfall is imminent and is tracking towards the RVSDS service area, a WET WEATHER ALERT will be issued to the team. This alert will include specific information on the potential timing of the storm. At this point, the team members will be on standby and will be available to mobilize if given a follow-up order.

- Hydrologic Response

    - As rainfall occurs over the RVSDS service area, the RVSDS Interceptors take at least several hours for the precipitation to have a full impact on flows and flow depths. As such, there will be adequate time to review the hydrologic response in the Middle and Lower Branches of the Rouge River and use that information to determine if a mobilization is necessary. OHM Advisors will review USGS Streamflow data for the following gages:

        - USGS 04167000 (Middle Rouge at Garden City)
        - USGS 04168000 (Lower Rouge at Inkster)
        - USGS 04167150 (Middle Rouge at Dearborn Heights)

      The gage height and flow data will be closely tracked during a WET WEATHER ALERT. If the gage heights are trending towards depths exceeding 9 to 10 feet for the three referenced USGS gages (respective flood stages of each gage), OHM Advisors will issue a MOBILIZATION ORDER.

- Mobilization Specifics

    - Upon issuing a MOBILIZATION ORDER, the project team will attempt to begin their facility inspections within 60 minutes, traffic permitting. OHM will contact all primary and secondary team members by email and text message.

    - Photographs and/or videos will be collected at each facility inspection, including, if appropriate, hand sketches to illustrate the operation of the inspected component.

    - Mobilization assignments for the project team currently under contract with Wayne County is as follows:

        - Wade Trim: LS1A (including the Master Control, JC 2-8, and JC 1-18A) and key locations along the Lower Rouge Interceptor, including:

            - RVSDS_CSO_53_(L34)_Div
            - RVSDS_INT_RVI_XIII_MH13-23

        - ASI: GLWA hydraulic conditions at key locations/facilities, such as the Hubbell-Southfield CSO regulator and RTB and other accessible junctions (i.e. junction with stop logs at NWI/RVI crossing) that would impact the RVSDS, including the Area 13 local sewer reaches in Dearborn Heights.

- OHM: Middle Rouge Interceptor, including Inkster Arm (Bell Branch SSO) and key structures primarily downstream of Middlebelt Road, including the Lefler-Ready Relief, Lefler-Ready, and Red Run, downstream to, but not including, JC 2-8. Specific structures include:
  - Local_LC015_MH1826.3 (Dearborn Heights, Lefler-Ready Sewer)
  - Local_LC027_Reg_MH01 (Dearborn Heights sewer)
  - M22, M21, M20, JC 3-16, MH 3-24 (MRPIE)

4. **<u>Task N: Continue Development of RVSDS Asset Management Plan:</u>** Enhancing the GIS database will allow Wayne County to have accurate geographic information recordkeeping and managing capability. A significant amount of work has already been completely and updated in GIS such as manhole identification, structural conditions and maintenance history. However, this work is an ongoing task and as projects are completed such as the floodplain manhole rehabilitation the GIS database will be to be updated.

<u>Phase 2</u>

i. Parallel Relief Capacity (Transport-and-Treat)

In order to investigate the potential for a transport-and-treat option, the hydraulic model discrepancies need to be identified and resolved. After the completion of the Phase 1 projects, the hydrologic/hydraulic model will better represent the system, which will allow for the H/H model to be used to locate and size relief sewers in the RVSDS.

Transport-and-treat is best used to target reaches of the interceptor sewer that can be cost-effectively constructed in order to address hydraulic surcharging above an acceptable elevation, as determined by the acceptable surcharge analysis. This option is generally viable when the total length of sewer is relatively short and where storage is prohibitively expensive, and there is no concern of passing the problem downstream or exceeding Wayne County's contract capacity with GLWA.

ii. Storage

In order to investigate the potential for distributed wet weather storage, the hydraulic model discrepancies need to be identified and resolved. After the completion of the Phase 1 projects, the hydrologic/hydraulic model will better represent the system, which will allow for the model to be used to locate and size potential storage in the RVSDS.

Distributed storage is best used to target areas where constructing a relief sewer would be prohibitively expensive and disruptive to traffic and adjacent landowners (due to total length, depth, density of land development, or a combination of the three).

iii. Decentralized Treatment

Decentralized treatment is an alternative to conveying some or all the RVSDS wastewater to the GLWA treatment plant. A basic analysis will be performed to provide a broad overview of the economic feasibility of decentralized treatment. This analysis will start with an introductory evaluation of marginal treatment costs for a new WWTP facility. Unless this analysis reveals a close economic match to other transport/storage alternatives, the evaluation of location/siting will not be performed, as that level of analysis would not be warranted if the treatment option does not pass the initial test of financial viability. If additional treatment capacity is deemed necessary through our analysis of design event flow rates, the marginal treatment costs at existing WWTP facilities will be evaluated, including, if necessary, increasing Wayne County's contract peak flow capacity with DWSD/GLWA.

7. Conclusions and Recommendations

7.1 Introduction

This section summarizes the Phase 1 LTCAP projects recommended to have an immediate impact on existing SSOs in the RVSDS Interceptors. Additional projects under Phase 2 will likely be required for implementation to meet the requirements in FOA 2117. Activities beyond Phase 1 will be adjusted based on the evaluation of Phase 1 projects on the hydraulic performance of the RVSDS Interceptors.

The recommended Phase 1 projects are an extension of what the County has been doing and continues to do to aggressively address wet weather flows in the RVSDS. In recent years, the County has established a wider network of permanent flow meters, rehabilitated interceptor sewers and manholes, and upgraded LS1A to reduce the potential for hydraulic surcharging in key reaches of the RVSDS.

7.2 Recommended Phase 1 LTCAP Projects

The Phase 1 projects in the RVSDS LTCAP that are recommended for implementation are as follows (costs are provided only for those tasks that have not yet been completed):

- Task A: LTCAP Development (already completed, this document reflects the completion of this task)
- Task B: Field Survey (already completed, described in Section 5 and Appendix D)
- Task C: Wet Weather Monitoring
- Task D: Junction Chamber Inspection (not yet determined if necessary)
- Task E: Clean and Inspect Siphons and Restrictions
- Task F: SCADA Improvements
- Task G: Floodplain Manhole Inspection (already completed, described in Section 6)
- Task H: LS1A Operational Modifications (already completed, described in Section 6)
- Task I: System Venting
- Task J: Floodplain Manhole Rehabilitation
- Task K: Regulator Modifications
- Task L: DWSD Boundary Conditions (ongoing, no costs defined in this document)
- Task M: Wet Weather Response Team
- Task N: Initial Asset Inventory (GIS Enhancements)

These projects have been identified and evaluated using the preliminary RVSDS hydrologic/hydraulic model. The intent is for the above projects to increase the level of confidence in the model and more accurately calculate conveyance and/or storage options that will be identified in Phase 2 of this LTCAP.

Table 7-1 lists the Phase 1 projects that are in various stages of completion, as well as their estimated costs, and a brief description of the project locations, types, and sizes.

Table 7-1: Phase 1 LTCAP Projects

Project Name	Cost Estimate	Project Description
LTCAP Development Costs	$343,000	Actual costs for consultant team, as of June 2016, to collect data, develop the preliminary model, and complete early LTCAP Phase 1 tasks (including the draft LTCAP report).
Task C: Wet Weather Monitoring	$72,000	Installation and maintenance of six permanent flow meters along the Middle Rouge Interceptors and ten temporary flow meters along the local collection system in Dearborn Heights.
Task E: Clean and Inspect Siphons	$233,000	Siphons and Restrictions will be cleaned and televised to maintain hydraulic capacity and determine where solids are more likely to accumulate (cost based on bid received and approved by Wayne County).
Task F: SCADA Improvements	$25,000	Through SCADA improvements, the CSO RTBs tributary to the RVSDS will be monitored and controlled to avoid unnecessary discharges to the interceptors.
Task I: System Venting	$100,000	Key manholes and junctions will be vented to reduce hydraulic discrepancies caused by compressed air and/or vacuums in the system.
Task J: Floodplain Manhole Rehabilitation	$77,000	Rehabilitate manholes with missing gaskets/bolts, poor rim conditions, and/or loose frames and seals. Assumed an average cost of $500 per rehabilitated manhole.
Task M: Wet Weather Response Team	$25,000	Wet weather mobilization for reaches with known SSOs.
Initial Asset Inventory (GIS Enhancements)	$25,000	Continue to develop the County's Asset Management Plan for the RVSDS through enhancements to the GIS database.
Phase 1 Total	**$900,000**	

7.3 Phase 2 LTCAP Projects

The Phase 2 projects in the RVSDS LTCAP have not yet been defined, but will follow the framework described in Section 6 for Transport-and-Treat, Storage and/or Decentralized Treatment. If the Phase 1 projects have a significant impact on reducing the frequency and/or magnitude of SSOs for the 25-year / 24-hour design storm event, the scope of Phase 2 projects will be limited. Phase 2 projects will target those portions of the RVSDS that are identified as not meeting the MDEQ SSO Policy after the completion of Phase 1 projects. No cost estimates are provided for Phase 2 projects at this time.

7.4 Schedule

The LTCAP implementation and post-Phase 1 monitoring/modeling will occur based on the schedule outlined in FOA 2117 and the approved LTCAP Work Plan (see Section 2 for additional details on the FOA 2117 schedule and the MDEQ-approved LTCAP Work Plan). This LTCAP will conclude with a Project Performance Certification (PPC) upon the construction of the recommended projects.

DRAFT – June 29, 2019

Appendix D: Hydraulic/Hydrologic Modeling Memo

Wayne County Rouge Valley Sewage Disposal System
Long Term Corrective Action Plan

Hydraulic and Hydrologic Model Development

Original Issue Date: August 24, 2015
Revised Date: March 1, 2017

Prepared By:

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Wayne County Department of Public Services
Water Quality Management Division

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1. Background

Wayne County is currently in the process of executing a Corrective Action Plan for the control of sanitary sewer overflow (SSO) in the Rouge Valley Sewage Disposal System (RVSDS) as required by the Final Order of Abatement (FOA) 2117 issued by the Michigan Department of Environmental Quality (MDEQ). The system improvement projects of the Corrective Action Plan are divided into two categories.

The first category consists of projects that were developed from a detailed Sanitary Sewer Evaluation Study (SSES) completed in 2008. These projects are considered short-term solutions and mainly focused on structural defects and localized capacity issues. These Short-Term Corrective Action Plan (STCAP) projects were implemented in 2012. The second category of projects will consist of broader system capacity issues that will most likely require large scale construction projects and will serve as a long-term solution. As such, these Long-Term Corrective Action Plan (LTCAP) projects will require a more detailed analysis.

This report presents the efforts undertaken to develop and calibrate a computational model of the RVSDS. This model is to be used as part of the development of the LTCAP projects.

2. System Characteristics

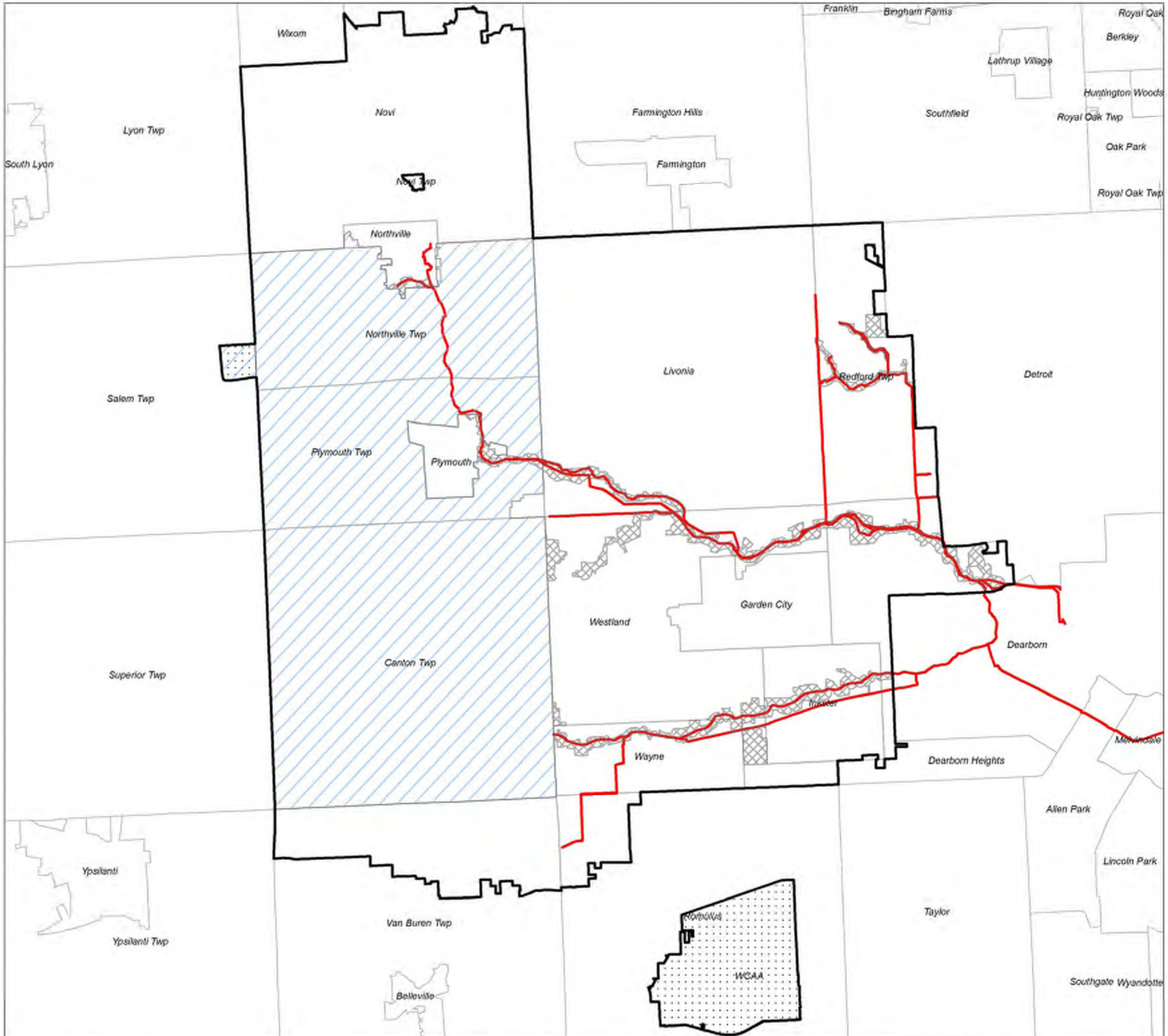
The RVSDS is a network of Wayne County owned and maintained interceptor sewers that transport wastewater from local client communities to the Great Lakes Water Authority (GLWA) Water Resource Recovery Facility (WRRF) for treatment and disposal. The RVSDS boundary and interceptor network is shown on Figure 2-1 and Table 2-1 presents a listing of the communities served by the RVSDS along with their tributary services areas and residential population. More detailed reports of the RVSDS district characteristics are available from Wayne County and have been utilized in the development of the model.

Figure 2-1 also depicts the boundary of the Western Townships Utility Authority (WTUA) service area within the RVSDS. The WTUA communities, consisting of Northville Township, Plymouth Township, and Canton Township, operationally split their wastewater discharges between the RVSDS and the Ypsilanti Community Sewer Authority (YCUA) system. Between 2010 and 2014, 29.0% to 47.8% of the wastewater generated by the WTUA communities was discharged to the RVSDS. In February 2017, WTUA indicated their intent to discontinue use of their connection to the RVSDS. The details of the WTUA disconnection from the RVSDS have not been fully defined. For the purposes of modeling, it has been assumed that WTUA will discharge no flow to the RVSDS, but the City of Plymouth flow that uses the WTUA system to discharge into the RVSDS will continue to discharge at this point.

Table 2-1
Tributary Service Area and Population by RVSDS Community

Community	Sanitary Area (acres)	Combined Area (acres)	Other Area (acres)	Total Contributing Area (acres)	2010 U.S. Census Residential Population
Canton Township	23,121.4	--	--	23,121.4	90,170
Dearborn Heights *(part)*	3,268.4	1,143.7	--	4,412.1	38,740
Garden City	3,751.3	--	--	3,751.3	27,647
Inkster *(part)*	2,462.5	1,040.1	--	3,502.6	25,243
Livonia	22,543.9	--	--	22,543.9	96,949
Northville	1,242.7	--	--	1,242.7	5,939
Northville Township	10,606.8	--	--	10,606.8	28,538
Novi *(part)*	16,537.7	--	--	16,537.7	43,216
Plymouth	1,294.3	--	--	1,294.3	9,022
Plymouth Township	10,121.6	--	--	10,121.6	27,598
Redford Township *(part)*	3,020.4	3,615.1	--	6,635.5	47,040
Romulus *(part)*	1,678.7	--	4,881.3	6,560.0	2,362
Salem Township *(part)*	--	--	347.7	347.7	--
Van Buren Township *(part)*	6,078.3	--	--	6,078.3	6,938
Wayne	3,357.1	--	--	3,357.1	17,597
Westland	11,611.7	--	--	11,611.7	84,123
RVSDS Total	120,696.8	5,798.9	5,229.0	131,724.7	404,816
WTUA Total	43,849.8	--	347.7	44,197.5	146,306

Notes:
(part) – Indicates that the acreages and population shown are only of the part of the community within the RVSDS
Other Area – Areas that only contribute industrial discharges into the RVSDS.

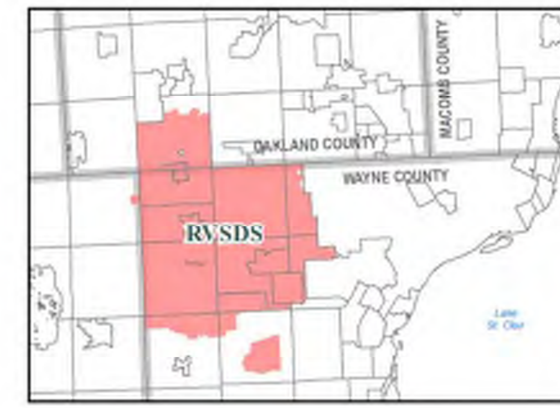


H:\2013\1315 -- Wayne County LTCAP Project Plan\Memos\H&H Report\Fig 2-1 - RVSDS District and Community Boundaries.mxd

Rouge Valley Sewage Disposal System

N W E S

0 0.5 1 2 3 4 Miles



Location Map

Legend

- RVSDS Service Area Boundary
- WTUA (Flow is sent to YCUA)
- Non-contributing/Unsewered
- Industrial Discharge
- Municipal Boundaries
- Interceptor

Figure 2-1
District and Community Boundaries

Prepared By:

Applied Science, Inc.

Date: 3/1/2017

3. System Monitoring Data

A system monitoring program (SMP) was implemented by Wayne County after the completion of the STCAP projects. The SMP went online in July 2012 and is scheduled to continue for the indefinite future as Wayne County utilizes this data for many other types of analyses and reviews. The data utilized for this analysis spanned from July 2012 through October 2016. In the fall of 2015, additional monitoring points were added to provide a finer resolution of flow rates along the Middle Rouge interceptor.

Sewage Flow

The sewage flow data collected by the SMP is comprised of a network of metering devices owned and operated either by Wayne County, the RVSDS communities and authorities, or the GLWA. Table 3-1 provides information on each of the metering device used for the analysis along with date range the data was available within the monitoring period. Figure 3-1 presents a map of the location of each flow monitoring device in the RVSDS. Figure 3-2 presents a schematic layout of the meter connectivity.

The flow data is recorded on a five minute interval and consists of a directly measured depth and velocity value and a computed flow rate. The flow meters undergo periodic dye-dilution testing to verify their accuracy and determine a corrective adjustment factor that is multiplied with each metered flow rate value within a given period. These adjustment factors and periods were applied to the data in the analysis and are presented in Table 3-2.

Two level sensors also exist in the system to provide set points and feedback for facility operation. These are located at Junction Chambers (JC) 2-8 and 1-18A and are also shown on Figure 3-1.

Precipitation

Similar to the sewage flow data, the precipitation data utilized for the SMP is comprised of a network of precipitation gages owned and operated by various entities. Precipitation data for the SMP was obtained from the following sources:

- The Great Lakes Water Authority (GLWA),
- The National Climatic Data Center (NCDC),
- The Western Townships Utilities Authority (WTUA),
- The Counties of Wayne and Oakland, and
- The Cities of Garden City, Livonia, and Novi.

Precipitation data were recorded as hundredths of an inch over various storage intervals depending on the source of the rainfall data with the majority being five minute interval data.

No adjustments were made to the rainfall data retrieved. However, the data were checked for errors during each event and any erroneous data was marked and excluded from the analysis of that event. Table 3-3 provides information on each precipitation gage and Figure 3-3 presents a map of the precipitation gage locations with respect to the RVSDS boundary.

Table 3-1
System Monitoring Flow Devices

Branch	Device ID	Operated By	Device Type	Beginning Date of Data Utilized For Analysis	Location
Middle Rouge	BG1	Novi	Badger 2100 Flume	7/1/2012	8 Mile Road
	5710	Oakland County	ADS Triton+	8/2/2016	South of 8 Mile Road east of Center Street
	5720	Oakland County	ADS Triton+	2/1/2016	8 Mile Road west of Novi Road
	A	WTUA	Sigma 910	7/1/2012	Sheldon Road south of North Territorial
	B	WTUA	Sigma 910	7/1/2012	Sheldon Road north of Ann Arbor Road
	C	WTUA	Sigma 910	7/1/2012	Ann Arbor Road west of Lilley Road
	FE22	WTUA	Accusonics 7510	7/1/2012	Eckles Road and Joy Road
	LC03D	Wayne County	ADS Triton+	2/29/2016	North of Warren Street and west of Beech Daly Road
	LC03U	Wayne County	ADS Triton+	2/29/2016	North of Warren Street and west of Beech Daly Road
	LC15D	Wayne County	ADS Triton+	3/15/2016	Outer Drive north of Ford Road
	LC15RD	Wayne County	ADS Triton+	2/19/2016	Beech Daly Road north of Warren Street
	LC15RU	Wayne County	ADS Triton+	2/29/2016	Beech Daly Road north of Warren Street
	LC15U	Wayne County	ADS Triton+	3/16/2016	Outer Drive north of Ford Road
	LC20D	Wayne County	ADS Triton+	3/15/2016	Hines Drive north of Ford Road
	LC20RD	Wayne County	ADS Triton+	2/19/2016	Hines Drive north of Ford Road
	LC20RU	Wayne County	ADS Triton+	3/16/2016	Ann Arbor Trail west of Evergreen Road
	LC20U	Wayne County	ADS Triton+	3/15/2016	Ann Arbor Trail west of Evergreen Road
	LV Basin	Wayne County	ADS Triton+	7/1/2012	Inkster Road north of Lyndon Boulevard
	LV11	Livonia	ADS Triton+	7/1/2012	Inkster Road south of Lyndon Street
	LV14	Livonia	ADS Triton+	7/1/2012	In field west of Inkster Road between Ann Arbor Trail and Edward Hines Drive
	LV-15	Livonia	ADS Triton+	7/1/2012	Merriman Road south of McKenzie Drive
	LV16	Livonia	ADS Triton+	7/1/2012	Joy Road between Farmington Road and Edward Hines Drive
	LV20	Livonia	ADS Triton	7/1/2012	Middlebelt Road north of Rayburn
	LV4	Livonia	ADS Triton+	7/1/2012	Five Mile and Alpine Drive
	M1	Garden City	ADS Triton	7/1/2012	Middlebelt Road north of Warren Road
	M2	Garden City	ADS Triton	7/1/2012	Merriman Road north of Warren Road
	P1	Wayne County	ADS Triton+	7/1/2012	5 Mile Road and Edward Hines Drive
	P3	Wayne County	ADS Triton+	7/1/2012	Edward Hines Drive east of I-275
	P7	Wayne County	ADS Triton+	7/1/2012	Ann Arbor Trail east of Parkside Drive
	P8	Wayne County	ADS Triton+	7/1/2012	Ann Arbor Trail east of Parkside Drive
	P9	Wayne County	ADS Triton+	7/1/2012	Edward Hines Drive east of Inkster Road
	P10	Wayne County	ADS Triton+	7/1/2012	Edward Hines Drive east of Inkster Road
	P11	Wayne County	ADS Triton+	7/1/2012	Edward Hines Drive east of Inkster Road
	P12	Wayne County	ADS Triton+	7/1/2012	Inkster Road north of Edward Hines Drive
	P13	Wayne County	ADS Triton+	7/1/2012	Telegraph Road and Cathedral Avenue
	P14	Wayne County	ADS Triton+	7/1/2012	Brady Road north of Willoway Road
	P15	Wayne County	ADS Triton+	7/1/2012	Ecorse Road and Hannan Road
	P26	Wayne County	ADS Triton+	7/1/2012	Edward Hines Drive east of I-275
	P28	Wayne County	ADS Triton+	3/16/2015	Inkster Road south of Rougeway Street
	P29	Wayne County	ADS Triton+	3/1/2015	Along Rouge River, Inkster Road south of Rougeway Street
	P30	Wayne County	ADS Triton+	9/11/2015	Hines Drive and Outer Drive
	P31	Wayne County	ADS Triton+	9/11/2015	Hines Drive and Outer Drive
	P32	Wayne County	ADS Triton+	9/11/2015	Hines Drive and Outer Drive
	P33	Wayne County	ADS Triton+	9/11/2015	Hines Drive west of Telegraph Road
	P34	Wayne County	ADS Triton+	9/11/2015	Hines Drive west of Telegraph Road
	P35	Wayne County	ADS Triton+	9/11/2015	Hines Drive west of Telegraph Road
	Parkway	Wayne County	ADS Triton+	--	South of 7 Mile Road east of Hines Drive

Table 3-1 (continued)
System Monitoring Flow Devices

Branch	Device ID	Operated By	Device Type	Beginning Date of Data Utilized For Analysis	Location
Lower Rouge	FE19	WTUA	Brooks Magnetic	7/1/2012	Haggerty Road north of Michigan Avenue
	L-34	Wayne County	ADS Triton+	--	Fourth and Elm Street
	P17	Wayne County	ADS Triton+	7/1/2012	North of Michigan Avenue near Heywood Street
	P19	Wayne County	ADS Triton+	7/1/2012	Josephine Street north of Michigan Avenue
	P20	Wayne County	ADS Triton+	7/1/2012	Michigan Avenue east of Henry Ruff Street
	P21	Wayne County	ADS Triton+	7/1/2012	Henry Ruff Street north of Michigan Avenue
	L-46	City of Inkster	Unknown	10/12/2012	City of Inkster Middlebelt Rd. RTB Regulator Chamber
	P24	Wayne County	ADS Triton+	7/1/2012	North of Michigan Avenue west of Telegraph Road
	P25	Wayne County	ADS Triton+	7/1/2012	South Gulley Road south of Hillcrest Drive
	WE14	Wayne County	ADS Triton	7/1/2012	Hawthorn Dog Park along Edward Hines Drive west of Merriman Road
	WE25	Wayne County	ADS Triton	7/1/2012	Thinbark Street and Upland Court
	WE28	Wayne County	ADS Triton	7/1/2012	Merriman Road north of Grand Traverse Street
RVSDS Outlet	WCS1A	Wayne County	ADS Triton+	4/15/2015	Oakwood Boulevard east of Dix Street
	WCS1	DWSD	Accusonics	7/1/2012	Fort Street south of Oakwood Boulevard
	WCS2	DWSD	MGD (ADFM)	7/1/2012	Ford Road and Evergreen Road
	WCS3	DWSD	MGD (ADFM)	7/1/2012	Southfield Road south of Hubbard Drive

Table 3-2
Dye-Dilution Test Summary

Meter	Period	Period Adjustment Factor	Dye Test Date	Adjustment Factor
BG-1	Installation to 9/23/2015	1.00	-	-
	9/23/2015 to Present	0.93	8/10/2016	0.93
LV-Basin	Installation to 1/1/2015	0.92	11/26/2013	0.92
	1/1/2015 to 12/22/2015	0.90	9/1/2015	0.89
	12/22/2015 to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.82	8/8/2016	0.82
P-1	Installation to 7/1/2013	1.00	-	-
	7/1/2013 to 4/8/2015	1.08	11/7/2013	1.08
	4/8/2015 to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.89	7/11/2016	0.89
P-7	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.67	8/9/2016	0.67
P-8	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	1.11	8/9/2016	1.11
P-9	Installation to 4/15/2015	1.13	11/7/2013	1.12
			10/8/2014	1.13
	4/15/2015 to Present	0.96	9/1/2015	0.96
P-10	Installation to 4/15/2015	1.03	4/23/2013	1.03
	4/15/2015 to Present	0.97	8/27/2015	0.97
P-11	Installation to 4/17/2015	0.93	4/23/2013	0.93
	4/17/2015 to Present	0.96	8/26/2015	0.96
P-12	Installation to 3/31/2015	0.90	4/22/2013	0.90
	3/31/2015 to Present	1.01	8/26/2015	1.01
P-13	Installation to 4/17/2015	1.04	5/2/2013	1.04
	4/17/2015 to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.93	7/18/2016	0.93
P-14	Installation to 4/16/2015	1.01	5/2/2013	1.01
	4/16/2015 to Present	1.00	9/10/2015	1.00

Table 3-2 (continued)
Dye-Dilution Test Summary

Meter	Period	Period Adjustment Factor	Dye Test Date	Adjustment Factor
P-15	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.84	6/23/2016	0.84
P-17	Installation to 4/9/2015	0.90	12/2/2013	0.84
			12/2/2013	1.00
	4/9/2015 to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.80	8/8/2016	0.80
P-19	Installation to 4/16/2015	0.96	11/25/2013	0.96
	4/16/2015 to Present	0.94	9/16/2015	0.94
P-20	Installation to 4/9/2015	0.98	11/25/2013	0.98
	4/9/2015 to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.99	6/24/2016	0.99
P-21	Installation to 4/9/2015	1.01	12/5/2013	1.01
	4/9/2015 to Present	0.94	9/16/2015	0.94
P-24	Installation to 11/16/2014	0.85	5/6/2013	0.88
			11/6/2013	0.83
	11/16/2014 to 1/1/2015	0.92	12/4/2014	0.92
	1/1/2015 to Present	0.87	9/8/2015	0.82
P-25	Installation to 4/9/2015	1.07	5/6/2013	1.07
	4/9/2015 to Present	0.95	9/8/2015	0.95
P-28	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.74	6/24/2016	0.74
P-29	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.81	7/27/2016	0.81
P-30	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.98	7/14/2016	0.98
P-31	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	1.00	7/7/2016	1.00
P-32	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.89	7/7/2016	0.89

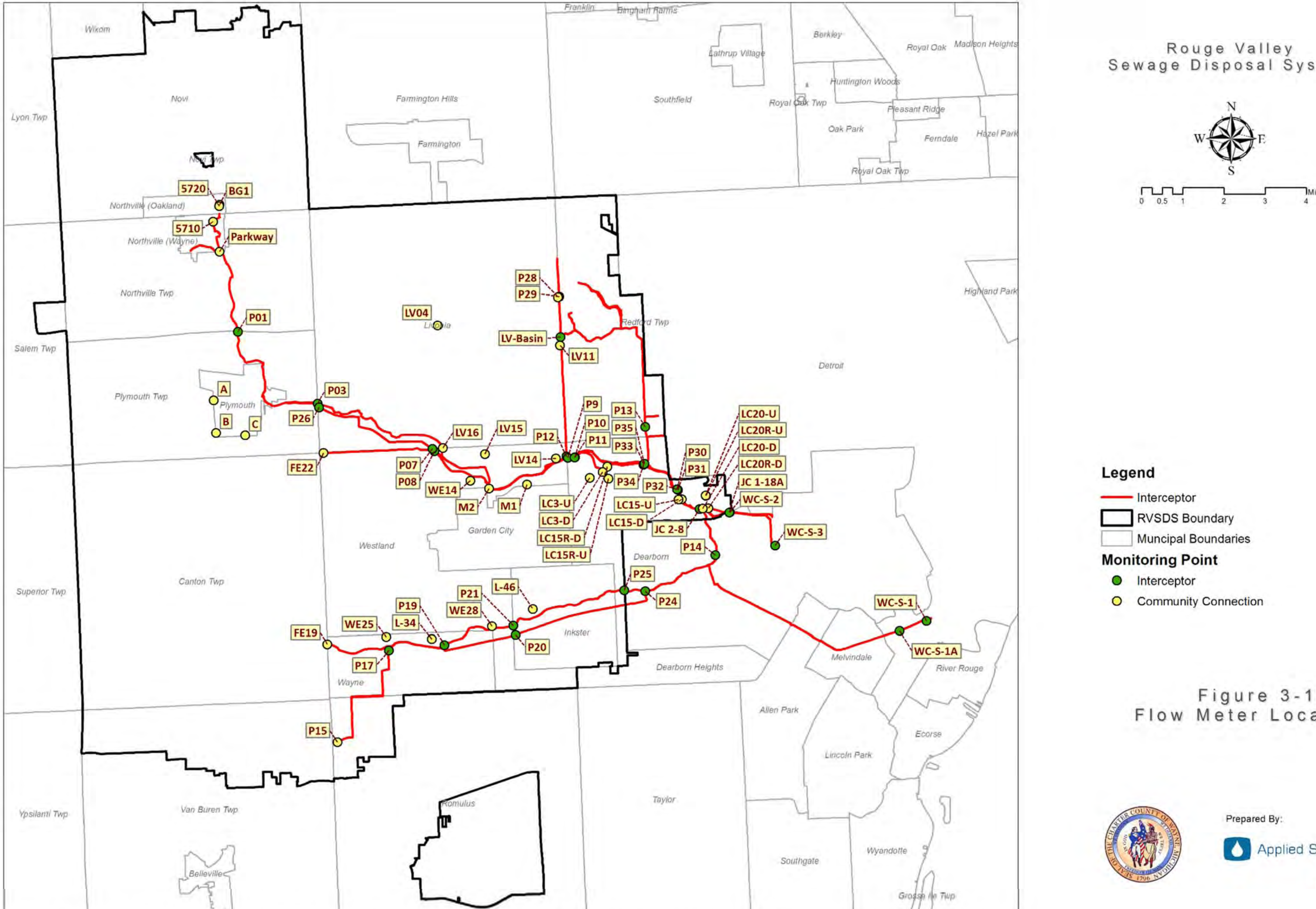
Table 3-2 (continued)
Dye-Dilution Test Summary

Meter	Period	Period Adjustment Factor	Dye Test Date	Adjustment Factor
P-33	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.86	7/14/2016	0.86
P-34	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.97	7/12/2016	0.97
P-35	Installation to 1/1/2016	1.00	-	-
	1/1/2016 to Present	0.94	7/12/2016	0.94
WE-28	Installation to 1/1/2015	1.00	-	-
	1/1/2015 to Present	0.72	10/15/2015	0.72

Table 3-3
System Monitoring Precipitation Gages

Gage ID	Operated By	Location
R10	Wayne County	11111 Wayne Road, Romulus
R11	Wayne County	14973 Northville Road, Northville Township
R12	Wayne County	7651 Merriman Road, Westland
R13	Wayne County	3501 Henry Ruff Road, Inkster
R14	Wayne County	Willow Run Airport, Van Buren Township
R15	Wayne County	20195 Trolley, Taylor
R18	Wayne County	130 4th Street, Belleville
R27	Wayne County	2001 Inkster Road, Inkster
R28	Wayne County	23800 Hines Drive, Dearborn Heights
R29	Wayne County	15145 Beech Daly Road, Redford
PG032	GLWA	20920 East Street, Southfield
PG033	GLWA	30365 Schoolcraft, Livonia
PG034	GLWA	20650 West Warren, Detroit
LV RG01	Livonia	Schoolcraft Road, Livonia
LV RG02	Livonia	Whispering Willows Golf Course, Livonia
LV RG03	Livonia	Buchanan School, 32140 Buchanan, Livonia
DTW	NCDC	Wayne County Metro Airport, Romulus
GC RG01	Garden City	Moeller Park, Garden City
WTUA LR EQ Basin	WTUA	3501 Haggerty Road, Canton
WTUA MR EQ Basin	WTUA	40905 Joy Road, Plymouth
Novi DPS	Novi	Novi Recycling Center, 26300 Lee BeGole, Novi
Novi Park Place	Novi	50399 9 Mile Road, Novi
0843	Oakland County	34189 12 Mile Road, Farmington Hills
0850	Oakland County	46351 West Road, Walled Lake

Rouge Valley Sewage Disposal System



Legend

- Interceptor
- RVSDS Boundary
- Muncipal Boundaries

Monitoring Point

- Interceptor
- Community Connection

Figure 3-1
Flow Meter Locations

Prepared By:

Applied Science, Inc.

Date: 5/18/2017

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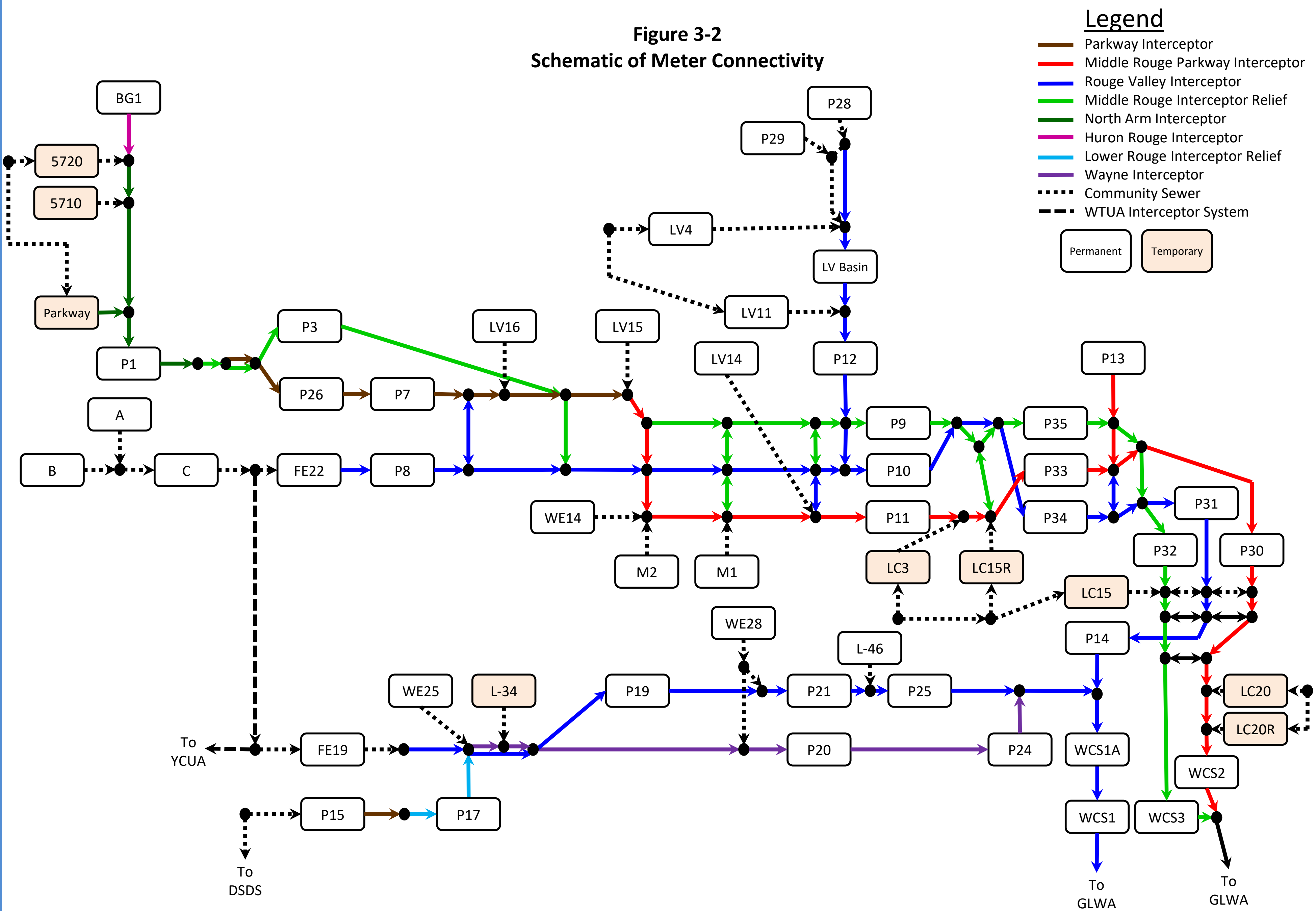
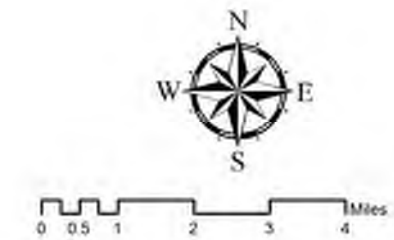
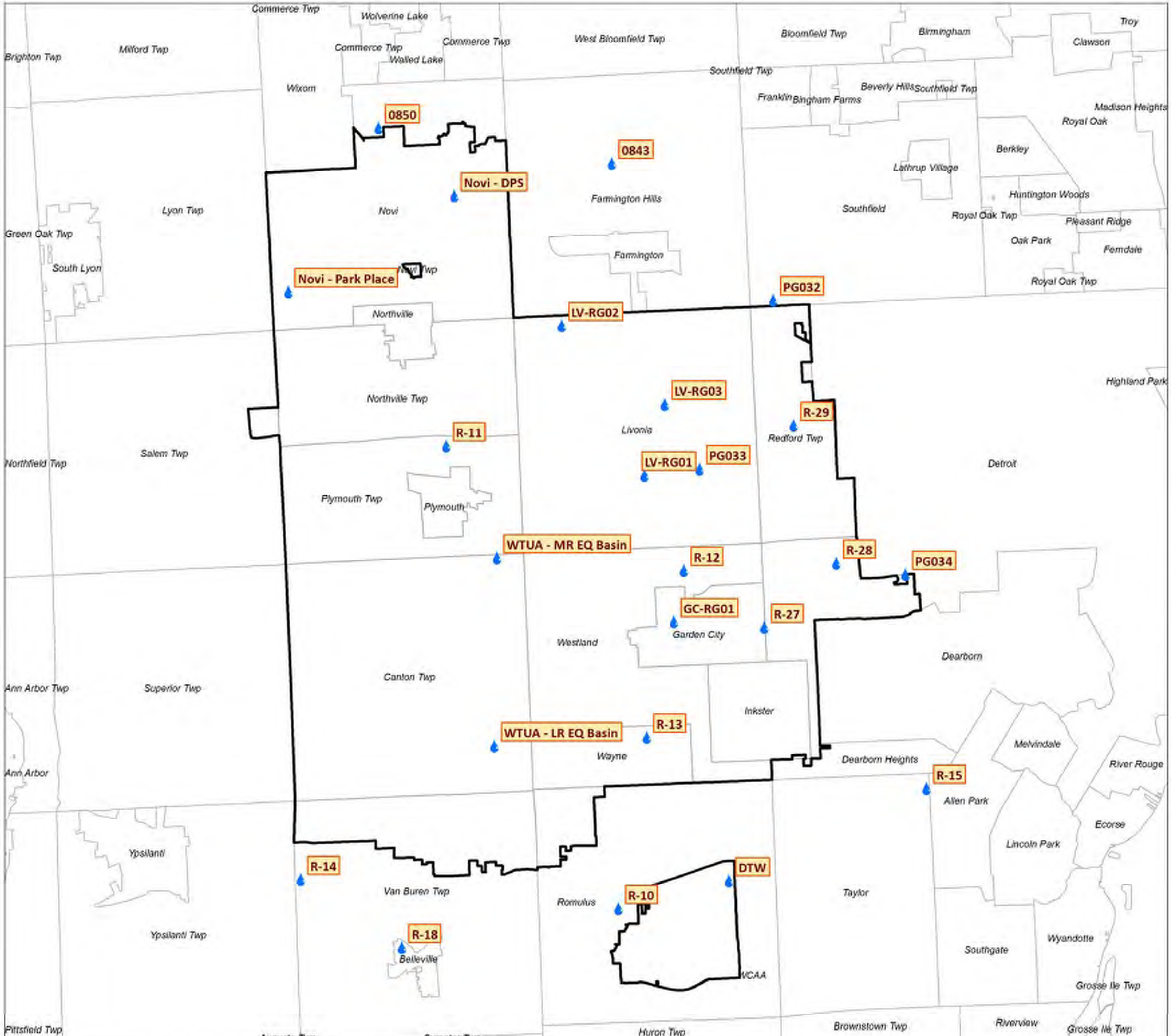
Figure 3-2
Schematic of Meter Connectivity



Rouge Valley
Sewage Disposal System





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Legend

- RVSDS Service Area Boundary
- Municipal Boundaries
- Rain Gage

Figure 3-3
Precipitation Gage
Locations

Prepared By:

Applied Science, Inc.

Date: 3/1/2017

4. Hydraulic Model Development

Three modeling software packages were reviewed for their potential utilization in developing the RVSDS model. These included:

- ***InfoWorks CS*** by Innovyze,
- ***InfoSWMM*** by Innovyze, and
- The ***Storm Water Management Model*** (SWMM) by the U.S. Environmental Protection Agency (EPA).

The computational models in these three programs are very similar. The main distinctions between them are that InfoWorks and InfoSWMM are both proprietary programs which are integrated within a Geographic Information System (GIS) environment, whereas SWMM is an open source program that is not directly integrated with GIS software. SWMM does still provide a Graphical User Interface with a spatial layout and the ability to manually align coordinates with GIS information.

SWMM version 5.1.012 was selected as the modeling platform of the RVSDS for the following reasons:

- SWMM is a free public domain software that is widely used by consulting firms and accepted by regulatory agencies;
- Model input data is stored as a tab delimited text files which are easy to share among consultants and Wayne County staff;
- The updated RVSDS model will be able to be integrated back into the Greater Detroit Regional Sewer System (GDRSS) model with minimal conversion efforts; and
- The ability to view the model network overlaid with other GIS attributes was not deemed necessary for the current modeling efforts, however the modeling information can be easily transferred into a GIS based modeling program in the future if needed.

In preparation of the model development, two previous hydraulic studies by Wade-Trim Associates were obtained and reviewed

- *North Huron Valley/Rouge Valley SSO Basis of Design Criteria Evaluation Report*, 2000
- *North Huron Valley/Rouge Valley Regional SSO Alternative Evaluation*, 2001

The first report provides the baseline flow conditions of the RVSDS system and the development and calibration of a SWMM model. The second report identifies hydraulic deficiencies and proposed regional alternatives for SSO mitigation. These regional alternatives and their associated costs provided a basis for discussions with the RVSDS client communities and for negotiations with the MDEQ towards entering an attainable ACO timeline.

A 2006 report titled *NHV/RV Middle Branch Antecedent Moisture Modeling Study* by OHM helped refine the alternatives and identified that a portion of the hydraulic deficiencies of the RVSDS may be due to deteriorated pipe conditions and/or river-dependent inflow. A recommendation of this report was to undertake a sanitary sewer evaluation study which ultimately led to dividing the efforts into the STCAP and LTCAP.

The Wade-Trim SWMM model of the RVSDS was incorporated into the GDRSS SWMM model in 2001 by CDM. The most recent iteration of the GDRSS model, dated December 2012, was obtained and the region representing the RVSDS was extracted from it. Since it originated from SWMM version 4 input data, this RVSDS model was somewhat generalized and did not contain the entire extent of the RVSDS interceptors. While such a model could yield overall flows and capacities of sewer reaches, the development of LTCAP improvements requires a more detailed understanding of the RVSDS for exact project locations and sizes to be specified. The model was fundamentally overhauled with the following improvements:

- Adding a representation for each of the pipes, regulators, siphons, manholes, and interconnections in the RVSDS interceptor system;
- Expanding the modeled sewer reaches to encompass the full extent of the RVSDS;
- Including existing storage facilities such as the equalization basins (EQs) and combined sewer retention treatment basins (RTBs);
- Providing a representation for each customer line connection to the interceptor system; and
- Using model control rules to simulate the actual operational procedures of facilities.

The information utilized to build the hydraulic model was derived from the following sources:

- As-built drawings of sewer contracts and field survey;
- Geographic information system (GIS) data;
- Local municipal line connection information;
- System inventories and figures;
- Operation and maintenance (O&M) manuals;
- Regulator, diversion chamber, and interconnection compilations; and
- Boundary condition commitments with GLWA.

As-built Drawings of Sewer Contracts and Field Survey

The hydraulic model was primarily developed from an extensive review of all available record as-built drawings and translation of the information into representative model elements. Table 4-1 presents a list of the sewer contracts incorporated into the model. Since construction of these sewer contracts spanned across several decades, the vertical datum used to represent invert elevations varied. This is an important aspect to keep track of for modeling purposes since all of these sewers must be properly aligned in the same datum when combined as a coherent whole. As municipal engineering projects of their day, there are three most likely base datums for these drawings:

1. The Detroit Datum,
2. The National Geodetic Vertical Datum of 1929 (NGVD29), and
3. The United States Lake Survey Datum of 1935 (USLSD35).

Base datum assumptions were made using the following hierarchy:

1. The datum was explicitly specified on the drawing. However, this still required some guesswork as the datum was typically stated as some kind of official name du jour instead of the actual base datum name. Using clarification documents from Wayne County, the following associations were made:
    i. Wayne County 1960 Publication Datum = NGVD29
    ii. Wayne County Bench Mark Datum (U.S.C & G.S.) = NGVD29
    iii. Wayne County Precise Datum = USLSD35
    iv. Wayne County Road Commissioner Precise Datum = USLSD35
    v. Wayne County Road Commissioner Benchmarks = NGVD29
2. The datum was not specified on the contract drawing set, however there is a common element such as an existing manhole that matches invert elevation with the same manhole on a drawing set that does specify the datum.
3. The datum is not specified and there is no contextual information that provides a definitive comparison. In this case the publishing entity and the date of the drawing set were used to assume the most likely datum:
    i. Any contract pre-1935 = NGVD29
    ii. Wayne County Road Commissioner contracts between 1935-1960 = USLSD35
    iii. Any contract emanating from a department of the City of Detroit with invert values typically ranging from 100-200 feet = Detroit Datum

Table 4-1 also provides the assumed datum for each of the contract drawings. All invert elevations were initially converted to NGVD29 using the following formulas:

- NGVD29 = Detroit Datum + 479.76 [ft]
- NGVD29 = USLSD35 - 0.51 [ft]

The current vertical datum standard for Wayne County is the North American Vertical Datum of 1988 (NAVD88). Conversion from NGVD29 to NAVD88 can be made using the following formula:

- NAVD88 = NGVD29 - **fac** [ft]

Where **fac** is a variable conversion factor that depends on the longitude and latitude of the location of the vertical point. The specific conversion factor for each structure within the RVSDS was determined using CORPSCON7, a free utility provided by the U.S. Army Corps of Engineers. By analyzing the furthest possible extents, this factor was found to range between 0.41 and 0.55 feet for the RVSDS.

In some cases, the various sources of elevation data could not be resolved. For these, a field survey was conducted and the results were used to provide the current elevation.

GIS Data

All modeled structures were cross-referenced with spatial information provided by the GIS data of the 2007 RVSDS sewer system evaluation survey (SSES). When a structure was found to have no representation in the SSES, an approximate location was determined using landmarks and distances shown on the record drawing. Figure 4-1 presents a screenshot of the model network which shows it covering the whole extent of the RVSDS and in the proper spatial alignment.

Local Municipal Line Connections

Local municipal line connections to the interceptor were included when the information was available. This ranged from modeling only the first few local manholes upstream of the RVSDS interceptor to modeling the majority of the local trunk sewer. This information was obtained from a record drawings, GIS data, or spreadsheets. In some cases, a model of the local sewer network already existed and was provided to the team for its inclusion into the RVSDS model. These include SWMM models of:

- The Lefler-Ready sewer district in Dearborn Heights provided by Wade-Trim Associates;
- The Huron Rouge Sewage Disposal System in the City of Novi provided by OHM; and
- The City of Inkster combined sewer system from a previous analysis undertaken by ASI.

System Inventories and Figures

System inventories and figures of structures and facilities that require periodic attention from the staff were provided by Wayne County maintenance personnel. These included unique restrictions, junction chambers, siphons, regulator chambers, and any known problem areas. These inventories were used as a checklist to ensure all known special structures and conditions were accounted for in the model.

Regulator, Diversion Chamber, and Interconnection Compilations

Owing to the fragmented undertaking of projects that addressed CSO and SSO in the RVSDS through the years. Vast and varied information exists on the points of overflow within the RVSDS. An effort was undertaken to build a comprehensive list of all points of overflow, both CSO and SSO, for all facilities tributary to the RVSDS, even if such facilities are located in local municipal systems. The results of this effort are presented in Table 4-2. The information used to build this list came from the following sources:

- Regulator modifications projects by the RVSDS;
- Local improvement, relief sewer, interconnection removal, sewer separation, and regulator modification projects undertaken by local municipalities;
- CSO demonstration RTB projects;
- A 2016 field study by OHM of the tipping plate pin setting of the regulators in the Redford Township combined system;
- Inventories from Wayne County maintenance staff;
- Discussions with representatives of local municipal sewer systems; and
- National Pollutant Discharge Elimination System (NPDES) overflow reports.

Operation and Maintenance Manuals

Due to the complex operation of the EQs, RTBs, and pumping stations, the dewatering and regulator flows from the facilities, when available, were represented as direct flow inputs into the model. However, when not available or for theoretical design events, the operational flows were modeled using protocols provided by system operators and O&M manuals. These protocols were implemented in the SWMM model using the control rule logical statement editor. The following facilities are represented in the RVSDS model:

- Lift Station 1A
- Redford RTB
- Dearborn Heights RTB
- Inkster RTB
- Middlebelt RTB
- Wayne EQ
- Livonia EQ

Boundary Condition Commitments with GLWA

The boundary conditions of the model for calibration storms were also directly input using recorded level data. This is due to the levels in the downstream end of the RVSDS system being largely driven by backwater from the GLWA water resource recovery facility operations. Wayne County is working with the GLWA to obtain an estimate of the levels at the RVSDS connection points for the theoretical 25 year, 24 hour design storm. Due to the complexities of the GLWA system, this estimated boundary condition is still forthcoming and will be developed as part of a Wastewater Master Plan currently being undertaken by the GLWA.

Table 4-1
Sewer Contracts Utilized for Hydraulic Model Development

Issuing Entity	Contract Name	Year Built	Assumed Datum
City of Dearborn Heights	Rouge River Wet Weather Combined Sewer Overflow Control Phase II • Collector Sewer and Regulator Modification • City of Dearborn Heights	2005	NGVD29
City of Detroit Department of Public Works	Northwest Interceptor • Southfield Section	1950	Detroit Datum
City of Detroit Department of Public Works	Oakwood Interceptor Tunnel	1937	Detroit Datum
City of Detroit Department of Public Works	Southfield Road Sewer • Section No. 1	1926	Detroit Datum
City of Detroit Department of Public Works	Southfield Road Sewer • Section No. A	1929	Detroit Datum
City of Inkster	1.9 M.G. Retention Treatment Facility Western Outfalls L-46 and 009	2008	NGVD29
City of Livonia	Sanitary Sewer Plan • Five Mile Road	1955	USLSD35
City of Wayne	City of Wayne • Equalization Basin Design	1997	NGVD29
Nankin Township, Michigan	30" Interceptor Sewer Extension • Nankin Township, Wayne Co., Michigan • Water Supply & Sewage Disposal System • Revenue Bond Project	1951	USLSD35
Oakland County Department of Public Works	Novi Sanitary Trunk Sewer • Huron-Rouge Sewage Disposal System	1963	NGVD29
Wayne County Department of Environment	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 1A • City of Dearborn Heights Lift Station	1997	NGVD29
Wayne County Department of Public Services	North Huron Valley/Rouge Valley Sewage Disposal System • Short Term Corrective Action Plan	2009	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • City of Dearborn Heights Local Improvements	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 1 • Middle Rouge Interceptor Relief • Southfield Connection to Ford Road	1989	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 2 • Middle Rouge Interceptor Relief • Ford Road to Telegraph Road	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 3 • Middle Rouge Interceptor Relief • Telegraph Road to Inkster Road	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 4A • Middle Rouge Interceptor Relief • Inkster Road to Merriman Road	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 5A • Middle Rouge Interceptor Relief • Farmington Road to Newburgh Road	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 5B • Middle Rouge Interceptor Relief • NewBurgh Road to Hannan Road (Ext.)	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 5C • Middle Rouge Interceptor Relief • Hannan Road (Ext.) to Haggerty Road	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 6 • Middle Rouge Interceptor Relief • Haggerty Road to Wilcox Road	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 7 • Middle Rouge Interceptor Relief • Inkster Arm Retention Facility City of Livonia	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 9 • Lower Rouge Interceptor Relief • Van Born Road • Michigan Avenue at C&O Railroad	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Watewater Control System • Contract No. 1B • Regulator Adjustments and Flow Metering	1990	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 1 • Retention Basin • Charter Township of Redford	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 1 • Retention Basin • City of Inkster	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 2 • Collector Sewers • Charter Township of Redford	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 2 • Collector Sewers • City of Inkster	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 3 • Retention Basin • City of Dearborn Heights	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 4 • Collector Sewers • City of Dearborn Heights	1994	NGVD29
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section I	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section IA	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section II	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section III	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section IV	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section V	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section VI	1955	USLSD35

Table 4-1 (continued)
Sewer Contracts Utilized for Hydraulic Model Development

Issuing Entity	Contract Name	Year Built	Assumed Datum
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section VII	1955	USLSD35
Wayne County Public Works	Huron Valley Treatment Works Grant • Contract No. 1 • North Arm Interceptor	1985	NGVD29
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 1	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 10	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 12	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 13	1962	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 14	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 15	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 16	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 2	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 3	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 4	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 5	1964	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 6	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 7	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 8	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 9	1963	USLSD35
Wayne County Road Commissioner	Michigan Avenue C.W.A. Sewer	1934	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Lola Valley Interceptor • Contract LVI-1 • Wayne County Sewage Treatment Project	1938	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-1	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-1A	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-2	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-3	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-4	1940	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-5	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Wayne County Sewage Treatment Project • The Wayne Interceptor • Contract No. W.I.-1	1937	USLSD35
Wayne County Road Commissioner	Wayne County Metropolitan Sewerage and Sewage Disposal System • Wayne-Romulus-Vanburen • Interceptor Sewer	1966	NGVD29

Table 4-2
Assumed Regulator Settings and Overflow Statuses

NPDES Permit ID	NPDES Permit No. (If Active)	Former Wayne County Regulator Number	Tributary Communities	Governing Regulating Element	Overflow Pathway	Tributary to Another Regulator?	Represented in RVSDS LTCAP Model?	Modeled Tributary Area (acres)				Coordinates		Location
								Tributary Line Connection Area IDs	Sanitary	Combined	Total	Latitude	Longitude	
Former RVSDS Regulators Transferred to WTUA System (Inactive)														
M-27	--	35	Plymouth Twp.	--	Bulkheaded	--	--	--	--	--	--	42°22'11.7"N	83°26'17.6"W	South bank of Middle Rouge River and Butternut Street
M-28	--	34	Plymouth Twp.	--	Bulkheaded	--	--	--	--	--	--	42°22'12.2"N	83°26'30.7"W	South bank of Middle Rouge River and Brownell Avenue
M-29	--	29	Plymouth Twp.	--	Bulkheaded	--	--	--	--	--	--	42°22'12.4"N	83°27'20.8"W	Riverside Drive 200 feet north of River Oaks Drive
M-30	--	32	Plymouth Twp.	--	Bulkheaded	--	--	--	--	--	--	42°23'5.5"N	83°27'46.1"W	Edward N. Hines Drive and Northville Road northwest of Wilcox Lake
M-31	--	31	Plymouth Twp.	--	Bulkheaded	--	--	--	--	--	--	42°23'33.8"N	83°28'5.5"W	Edward N. Hines Drive and Northville Road southwest of Phoenix Lake
M-32	--	30	Plymouth Twp.	--	Bulkheaded	--	--	--	--	--	--	42°23'32.8"N	83°27'53.1"W	Schoolcraft Road and Five Mile Road southeast of Phoenix Lake
Regulators Converted to Storm Only Service Areas (Inactive)														
M-23	--	54	Westland	--	--	--	--	--	--	--	--	42°20'34.9"N	83°20'57.7"W	Hawthorn Drive and N. Merriman Road
Regulators with Bulkheaded Overflows (Inactive)														
--	--	--	Dearborn Heights	--	Bulkheaded	TRUE	FALSE	Part of 15	Part of 15	Part of 15	Part of 15	42°18'59.0"N	83°17'47.1"W	Rear yard of 642 Dover Street
--	--	--	Dearborn Heights	--	Bulkheaded	TRUE	FALSE	Part of 15	Part of 15	Part of 15	Part of 15	42°18'54.4"N	83°17'48.4"W	Rear yard of 26200 Morton Street
--	--	--	Dearborn Heights	--	Bulkheaded	TRUE	FALSE	Part of 15	Part of 15	Part of 15	Part of 15	42°18'56.2"N	83°17'46.6"W	Seahan Drive between Dover Street and Kimloch Street
--	--	--	Dearborn Heights	--	Bulkheaded	TRUE	FALSE	Part of 15	Part of 15	Part of 15	Part of 15	42°18'56.0"N	83°18'6.9"W	Rear yard of 630 N. Charlesworth Street
--	--	--	Dearborn Heights	--	Bulkheaded	TRUE	FALSE	Part of 15	Part of 15	Part of 15	Part of 15	42°19'28.5"N	83°18'6.4"W	Doxtator Street and N. John Daly Road
--	--	--	Dearborn Heights	--	Bulkheaded	TRUE	FALSE	Part of 15	Part of 15	Part of 15	Part of 15	42°19'9.1"N	83°17'43.8"W	Wilson Drive 250 feet east of Lila Lane

Table 4-2 (continued)
Assumed Regulator Settings and Overflow Statuses

NPDES Permit ID	NPDES Permit No. (If Active)	Former Wayne County Regulator Number	Tributary Communities	Governing Regulating Element	Overflow Pathway	Tributary to Another Regulator?	Represented in RVSDS LTCAP Model?	Modeled Tributary Area (acres)				Coordinates		Location
								Tributary Line Connection Area IDs	Sanitary	Combined	Total	Latitude	Longitude	
Regulators with Bulkheaded Overflows (Inactive) ***(continued)***														
--	--	--	RVSDS	--	Permanently Gated Shut	FALSE	TRUE	Mulitple	Mulitple	Mulitple	Mulitple	42°19'42.7"N	83°14'29.4"W	Lift Station 1A - West bank of Main Rouge River 50 north of Ford Road
--	--	9	Dearborn Heights	--	Bulkheaded	FALSE	TRUE	15	1,776.9	--	1,776.9	42°20'4.6"N	83°15'32.3"W	West bank of Middle Rouge River 650 feet east of Outer Drive W.
--	--	9A	Dearborn Heights	--	Bulkheaded	FALSE	FALSE	Part of 15	Part of 15	Part of 15	Part of 15	42°19'54.6"N	83°16'19.2"W	George Avenue between N. Telegraph Road and N. Waverly Street
--	--	9B	Dearborn Heights	--	Bulkheaded	FALSE	FALSE	Part of 15	Part of 15	Part of 15	Part of 15	42°19'59.5"N	83°16'15.2"W	425 feet south of Hass Street between N. Waverly Street and N. Highland Street
--	--	9C	Dearborn Heights	--	Bulkheaded	FALSE	FALSE	Part of 15	Part of 15	Part of 15	Part of 15	42°19'59.1"N	83°16'15.1"W	375 feet south of Hass Street between N. Waverly Street and N. Highland Street
--	--	56A	Livonia	--	Bulkheaded	TRUE	FALSE	Part of 75	Part of 15	Part of 15	Part of 15	42°22'5.1"N	83°19'56.1"W	Elmira Street between Middlebelt Road and Karen
004	MI 0051471	--	Inkster	--	Bulkheaded	TRUE	FALSE	Part of 46	Part of 15	Part of 15	Part of 15	42°16'47.3"N	83°19'25.1"W	N. Durand Court and Irene Street
005	MI 0051471	--	Inkster	--	Bulkheaded	TRUE	FALSE	Part of 46	Part of 15	Part of 15	Part of 15	42°16'45.1"N	83°19'25.0"W	S. Durand Court and Irene Street
006	MI 0051471	--	Inkster	--	Bulkheaded	TRUE	FALSE	Part of 46	Part of 15	Part of 15	Part of 15	42°16'41.8"N	83°19'24.9"W	Crystal Court and Irene Street
007	MI 0051471	--	Inkster	--	Bulkheaded	TRUE	FALSE	Part of 46	Part of 15	Part of 15	Part of 15	42°16'38.5"N	83°19'24.6"W	N. Bridgeport Court and Irene Street
008	MI 0051471	--	Inkster	--	Bulkheaded	TRUE	FALSE	Part of 46	Part of 15	Part of 15	Part of 15	42°16'36.3"N	83°19'24.7"W	S. Bridgeport Court and Irene Street
L-34	--	53	Wayne/Westland	--	Bulkheaded	FALSE	TRUE	184	270.8	--	270.8	42°17'1.5"N	83°22'39.2"W	North bank of Lower Rouge River and 4th Street
L-35	--	52	Wayne	--	Bulkheaded	FALSE	TRUE	153	93.3	--	93.3	42°16'59.0N	83°22'31.2"W	South bank of Lower Rouge River 950 feet west of Josephine Street
L-36	--	50	Wayne	--	Bulkheaded	FALSE	TRUE	158	1,041.1	--	1,041.1	42°16'59.9"N	83°21'48.3"W	Michigan Avenue and Venoy Road
L-37	--	51	Wayne	--	Bulkheaded	FALSE	TRUE	160	43.6	--	43.6	42°17'16.0"N	83°21'18.4"W	Woodbrook Drive and Winfred Street

Table 4-2 (continued)
Assumed Regulator Settings and Overflow Statuses

NPDES Permit ID	NPDES Permit No. (If Active)	Former Wayne County Regulator Number	Tributary Communities	Governing Regulating Element	Overflow Pathway	Tributary to Another Regulator?	Represented in RVSDS LTCAP Model?	Modeled Tributary Area (acres)				Coordinates		Location
								Tributary Line Connection Area IDs	Sanitary	Combined	Total	Latitude	Longitude	
Regulators with Bulkheaded Overflows (Inactive) *(continued)*														
L-49	--	62	Inkster	--	Bulkheaded	TRUE	FALSE	Part of 34	Part of 34	Part of 34	Part of 34	42°16'47.2"N	83°20'02.0"W	Andover Street and Burton Street
M-12	--	64	RVSDS	--	Bulkheaded	FALSE	TRUE	Mulitple	Mulitple	Mulitple	Mulitple	42°19'52.1"N	83°14'49.8"W	Former Master Control - North bank of Middle Rouge River 700 feet west of confluence with Main Rouge River
M-20	--	58	Garden City/Westland	--	Bulkheaded	FALSE	TRUE	27	1,923.8	--	1,923.8	42°20'34.9"N	83°19'54.6"W	South bank of Middle Rouge River 20 feet west of Middlebelt Road
M-26	--	28	Livonia	--	Bulkheaded	FALSE	TRUE	63	66.4	--	66.4	42°21'33.0"N	83°24'8.2"W	Ann Arbor Trail and Levan Road
Sanitary Sewer Regulators with SSO to River (Active, Uncontrolled)														
M-21	MI 0051551	56	Livonia	16" Ø Shear Gate	16.3' wide weir	FALSE	TRUE	75	1,287.7	--	1,287.7	42°20'53.6"N	83°19'1.6"W	North bank of Rouge River 1,200 feet west of Inkster Road
M-22	MI 0051560	55	Livonia	12" Ø Shear Gate	4.69' wide weir	FALSE	TRUE	74 & 191	1,143.6	--	1,143.6	42°20'33.8"N	83°20'58.5"W	Hawthorn Drive and N. Merriman Road
M-24	MI 0051543	59	Garden City/Westland	18" by 18" wall opening	(2) 1'H x 2'W emergency ports	FALSE	TRUE	26	1,868.3	--	1,868.3	42°20'12.7"N	83°21'2.5"W	Bridge Street and Merriman Road
M-25	MI 0051551	57	Livonia	12" Ø Shear Gate	3.52' wide weir	FALSE	TRUE	73	1,187.9	--	1,187.9	42°21'5.1"N	83°22'20.5"W	Ann Arbor Trail and Edward N Hines Drive southeast of Nankin Lake
Combined Sewer Regulators with CSO to River (Active, Uncontrolled)														
--	--	--	Inkster	8" ø pipe	Section removed above springline	TRUE	FALSE	Part of 29	Part of 29	Part of 29	Part of 29	42°18'8.7"N	83°19'12.7"W	Harrison Street and Glenwood Street
010	MI 0051471	I-10	Inkster	30" ø pipe	Section removed above springline	TRUE	TRUE	46 & Part of 52	46 & Part of 52	46 & Part of 52	46 & Part of 52	42°17'18.7"N	83°17'37.7"W	Yale Street and Meadowdale Avenue
011	MI 0051837	I-11	Inkster	48" ø pipe	Section removed above springline	TRUE	TRUE	46 & Part of 52	46 & Part of 52	46 & Part of 52	46 & Part of 52	42°17'27.0"N	83°17'25.5"W	Beech Daly Road 175 feet north of Princeton Street
45A	MI 0051829	45A	Redford Twp.	60" ø pipe	(2) ?' wide weirs	TRUE	FALSE	Part of 122	Part of 122	Part of 122	Part of 122	42°22'4.6"N	83°16'35.6"W	Ashcroft-Sherwood Drain 200 feet west of Telegraph Road
L-41	MI 0051462	13	Dearborn Heights/Inkster	15.8" CH Reg-U-Flo	10' wide weir	FALSE	TRUE	46 & 52	141.7	275.0	416.8	42°17'48.7"N	83°17'26.4"W	Michigan Avenue and Beech Daly Road

Table 4-2 (continued)
Assumed Regulator Settings and Overflow Statuses

NPDES Permit ID	NPDES Permit No. (If Active)	Former Wayne County Regulator Number	Tributary Communities	Governing Regulating Element	Overflow Pathway	Tributary to Another Regulator?	Represented in RVSDS LTCAP Model?	Modeled Tributary Area (acres)				Coordinates		Location
								Tributary Line Connection Area IDs	Sanitary	Combined	Total	Latitude	Longitude	
Combined Sewer Regulators with CSO to River (Active, Uncontrolled) *(continued)*														
L-42	MI 0051462	11	Dearborn Heights/Inkster	6"W x 12"H Milwaukee	4.5' wide weir	FALSE	TRUE	23	2.8	101.2	104.0	42°18'13.2"N	83°17'26.5"W	North bank of Lower Rouge River and Beech Daly Road (extended)
L-43	MI 0051489	12	Dearborn Heights	12" Ø pipe	18" Ø pipe	FALSE	TRUE	22	--	36.0	36.0	42°17'52.1"N	83°17'25.3"W	S. Beech Daly Street between Oakland Drive and Michigan Avenue
M-13	MI 0051489	8	Dearborn Heights	12"W x 9"H Milwaukee	24" Ø pipe	FALSE	TRUE	16	--	85.1	85.1	42°19'54.0"N	83°15'11.5"W	Edward N Hines Drive and Parkland Street (extended)
M-14	MI 0051489	7	Dearborn Heights	8" Ø pipe	30" Ø pipe	FALSE	TRUE	17	--	71.6	71.6	42°19'50.4"N	83°15'13.2"W	South bank of Middle Rouge River and Valley Street (extended)
U-1	MI 0051489	46	Dearborn Heights	8.35" CH Reg-U-Flo	24" Ø pipe	FALSE	TRUE	11	--	73.8	73.8	42°21'25.8"N	83°15'58.2"W	Joy Road and Hazelton
U-2	MI 0051535	45	Redford Twp.	24" Tipping Gate, Pin 6	19.67' wide weir	FALSE	TRUE	122	873.0	1,593.6	2,466.6	42°21'51.4"N	83°16'8.3"W	Ashcroft-Sherwood Drain and W. Chicago Street
U-3	MI 0051535	40	Redford Twp.	8.3" CH Reg-U-Flo	24" Ø pipe	FALSE	TRUE	114	--	66.3	66.3	42°23'55.3"N	83°18'34.7"W	West bank of Bell Branch southeast of Five Mile Road and Meadowbrook Road
U-4	MI 0051535	41	Redford Twp.	10.2" C Reg-U-Flo	24" Ø pipe	FALSE	TRUE	115	--	31.2	31.2	42°23'36.0"N	83°18'50.3"W	North bank of Bell Branch 200 feet east of Inkster Road and 150 feet south of Meadowbrook Road
U-5	MI 0051535	39	Redford Twp.	8.7" CH Reg-U-Flo	5' wide weir	FALSE	TRUE	113	--	147.8	147.8	42°24'4.1"N	83°18'34.7"W	East bank of Bell Branch 100 feet south of Keeler
U-9	MI 0051535	43	Redford Twp.	13.01" CH Reg-U-Flo	9.5' wide weir	FALSE	TRUE	120	123.3	181.3	304.6	42°23'47.3"N	83°17'10.5"W	Graham Road and Sarasota
U-10	MI 0051535	44	Redford Twp.	8.5" CH Reg-U-Flo	24" Ø pipe	FALSE	TRUE	121	--	115.5	115.5	42°23'42.6"N	83°17'9.9"W	South bank of Tarabusi Creek and Sarasota (extended)
U-11	MI 0051535	42	Redford Twp.	24" Tipping Gate, Pin 11	3.75' wide weir	FALSE	TRUE	116	275.9	436.7	712.6	42°23'27.0"N	83°17'48.3"W	Ross Drive and Shaw Drain 300 feet west of Beech Daly
Combined Sewer Regulators with CSO to RTB (Active, Controlled)														
--	--	36A	Redford Twp.	36" ø pipe	Diverted to Redford Twp. RTB	TRUE	FALSE	Part of 105	Part of 105	Part of 105	Part of 105	42°25'28.2"N	83°18'55.7"W	North bank of Upper Rouger River between Inkster Road and Seminole
--	--	38A	Redford Twp.	12" ø pipe	Diverted to Redford Twp. RTB	TRUE	FALSE	Part of 107	Part of 107	Part of 107	Part of 107	42°24'29.3"N	83°17'47.7"W	North bank of Upper Rouger River southwest of Lola Drive and Beech Daly

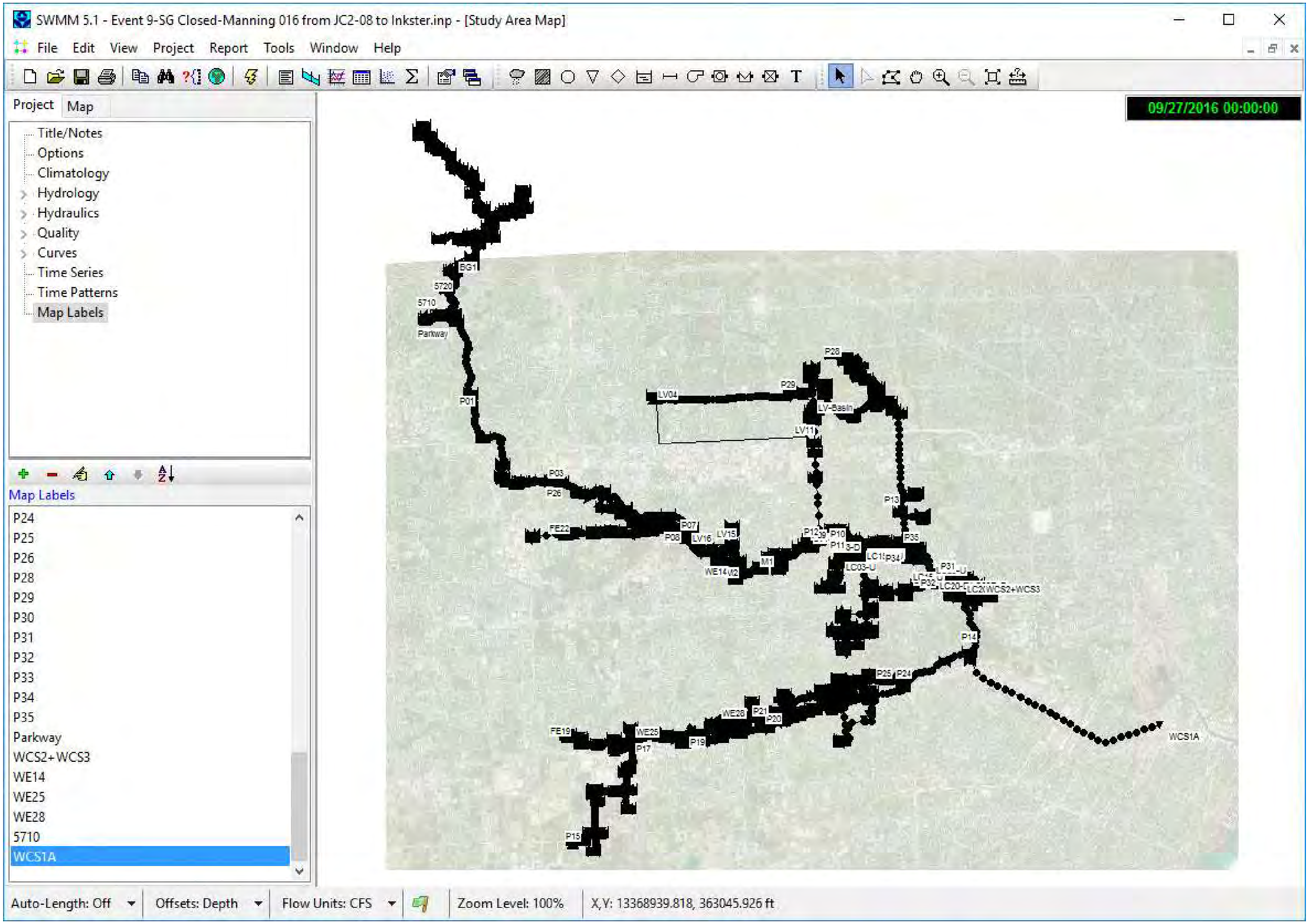
Table 4-2 (continued)
Assumed Regulator Settings and Overflow Statuses

NPDES Permit ID	NPDES Permit No. (If Active)	Former Wayne County Regulator Number	Tributary Communities	Governing Regulating Element	Overflow Pathway	Tributary to Another Regulator?	Represented in RVSDS LTCAP Model?	Modeled Tributary Area (acres)				Coordinates		Location
								Tributary Line Connection Area IDs	Sanitary	Combined	Total	Latitude	Longitude	
Combined Sewer Regulators with CSO to RTB (Active, Controlled) *(continued)*														
009	--	I-2	Inkster	36" Ø pipe	Diverted to Middlebelt Road RTB	FALSE	TRUE	Part of 28	Part of 28	Part of 28	Part of 28	42°17'55.0"N	83°19'47.4"W	Middlebelt Road 50 feet north of Barrington Street
001	--	I-5	Inkster	John Daly PS	Diverted to Inkster RTB	FALSE	TRUE	Part of 49	Part of 49	Part of 49	Part of 49	42°18'7.9"N	83°18'12.4"W	North bank of Lower Rouge River and Arlington Street (extended)
002	--	I-6	Inkster	John Daly PS	Diverted to Inkster RTB	FALSE	TRUE	Part of 49	Part of 49	Part of 49	Part of 49	42°18'4.6"N	83°18'4.3"W	North bank of Lower Rouge River 150 feet west of John Daly Street
003	--	I-9	Inkster	John Daly PS	Diverted to Inkster RTB	FALSE	TRUE	50	--	32.7	32.7	42°18'6.7"N	83°17'53.9"W	N. River Park Drive and Meadowbrook Street
3A	--	3A	Dearborn Heights	12" Ø pipe	Diverted to Dearborn Heights RTB	TRUE	TRUE	199	--	16.8	16.8	42°20'43.7"N	83°17'19.3"W	Rouge River Drive 150 feet east of N. Gulley Road
L-38	--	22	Inkster	8.3" CH Reg-U-Flo	Diverted to Inkster RTB	FALSE	TRUE	43	--	65.3	65.3	42°17'39.7"N	83°18'28.5"W	Michigan Avenue 600 feet east of Inskter Road
L-39	--	21	Inkster	8.1" CH Reg-U-Flo	Diverted to Inkster RTB	FALSE	TRUE	45 & 46	425.2	106.5	531.7	42°17'40.6"N	83°18'18.5"W	Michigan Avenue and Sylvia Street
L-40	--	I-3	Inkster	8" Ø pipe	Diverted to Inkster RTB	FALSE	TRUE	44	17.7	--	17.7	42°17'43.5"N	83°18'21.6"W	West Street Between S. River Park Drive and Michigan Avenue
L-44	--	I-8	Inkster	8" Ø pipe	Diverted to Inkster RTB	FALSE	TRUE	48	--	19.1	19.1	42°17'46.2"N	83°18'1.7"W	John Daly Street between Oakland Street and Michigan Avenue
L-45	--	63	Inkster	15" Ø pipe	Diverted to Inkster RTB	FALSE	TRUE	193	--	6.8	6.8	42°17'49.8"N	83°18'1.7"W	John Daly Street between West Hills Drive and Oakland Street
L-46	--	18	Inkster	10" Vortex Valve	Diverted to Middlebelt Road RTB	FALSE	TRUE	28	217.8	407.6	625.4	42°17'37.2"N	83°19'46.7"W	Middlebelt Road 400 feet south of Golf Course Entrance
L-47	--	19	Inkster	6"W x 5"H Brown & Brown	Diverted to Inkster RTB	FALSE	TRUE	31	--	37.8	37.8	42°17'54.8"N	83°18'27.0"W	West bank of Lower Rouge River and Crescent Street (extended)
L-48	--	20	Inkster	12"W x 9"H Milwaukee	Diverted to Inkster RTB	FALSE	TRUE	29	273.5	114.2	387.7	42°17'51.9"N	83°18'48.3"W	North bank of Lower Rouge River and Magnolia Drive (extended)
M-15	--	5	Dearborn Heights	6.5" Vortex Valve	Diverted to Dearborn Heights RTB	FALSE	TRUE	10	--	87.7	87.7	42°20'49.6"N	83°16'34.1"W	North bank of Middle Rouge River and Woodbine Street
M-16	--	4	Dearborn Heights	6" Vortex Valve	Diverted to Dearborn Heights RTB	FALSE	TRUE	12	--	73.3	73.3	42°20'38.4"N	83°16'26.0"W	South bank of Middle Rouge River 25 feet west of Telegraph Road

Table 4-2 (continued)
Assumed Regulator Settings and Overflow Statuses

NPDES Permit ID	NPDES Permit No. (If Active)	Former Wayne County Regulator Number	Tributary Communities	Governing Regulating Element	Overflow Pathway	Tributary to Another Regulator?	Represented in RVSDS LTCAP Model?	Modeled Tributary Area (acres)				Coordinates		Location
								Tributary Line Connection Area IDs	Sanitary	Combined	Total	Latitude	Longitude	
Combined Sewer Regulators with CSO to RTB (Active, Controlled) *(continued)*														
M-17	--	6	Dearborn Heights	6" Vortex Valve	Diverted to Dearborn Heights RTB	FALSE	TRUE	9	--	29.4	29.4	42°20'48.6"N	83°16'42.7"W	South bank of Middle Rouge River and Fenton Avenue (extended)
M-18	--	3	Dearborn Heights	7.3" Vortex Valve	Diverted to Dearborn Heights RTB	FALSE	TRUE	7 & 199	--	168.8	168.8	42°20'46.9"N	83°17'0.6"W	South bank of Middle Rouge River and N. Silvery Lane (extended)
M-19	--	10	Dearborn Heights	6" Vortex Valve	Diverted to Dearborn Heights RTB	FALSE	TRUE	4	--	35.4	35.4	42°20'40.1"N	83°17'28.7"W	East bank of Middle Rouge River between Kennedy Street and N. Gulley Street
M-33	--	2	Dearborn Heights	6" Vortex Valve	Diverted to Dearborn Heights RTB	FALSE	TRUE	13	--	116.9	116.9	42°20'40.5"N	83°16'5.8"W	North bank of Middle Rouge River 100 feet east of Warrendale
U-6	--	36	Redford Twp./Livonia	36" Tipping Gate, Pin 6	Diverted to Redford Twp. RTB	FALSE	TRUE	105	1,108.8	914.3	2,023.1	42°24'34.7"N	83°18'2.1"W	East bank of Upper Rouge River between Kinloch and Wakenden (extended)
U-7	--	37	Redford Twp.	8" Tipping Gate, Pin 3	Diverted to Redford Twp. RTB	FALSE	TRUE	106	--	51.4	51.4	42°24'24.8"N	83°17'48.0"W	Pomona Drive 75 feet north of Puritan
U-8	--	38	Redford Twp.	10" Tipping Gate, Pin 3	Diverted to Redford Twp. RTB	FALSE	TRUE	107	86.8	77.0	163.8	42°24'29.8"N	83°17'48.7"W	North bank of Upper Rouger River southwest of Lola Drive and Beech Daly
Combined Sewer Regulators with CSO to RTB and River (Active, Partially Controlled)														
--	--	--	Inkster	30" Ø pipe	Splits flow between L-39 and L-41	TRUE	TRUE	46	566.9	42.1	609.0	42°16'58.4"N	83°18'8.0"W	Carlysle Street and Princess Avenue

Figure 4-1
Screenshot of SWMM Model Network



5. Tributary Service Areas

In order to develop hydrologic input parameters for the model, a detailed understanding of the tributary service areas for each load point was needed. A complete re-delineation of the tributary area of each community connection to the RVSDS was undertaken. To make these delineations, maps of historic community sewage districts were used as a starting point and updated or refined using the latest sewer network GIS information from each community. Figure 5-1 presents a map of the delineated community connection service areas. Appendix A presents a detailed schematic of the RVSDS with each community connection called out. Table 5-1 presents the acreages for each community connection. For connections with tributary areas that cover more than a single community, the acreages are provided for each community separately. When a local model was provided with detailed loading points, the local model inputs were delineated from the parent line connection area and are included with the local model input ID appended to the RVSDS line connection ID after an underscore. The acreages are split into categories based on the type of collection system:

- Sanitary: Only sanitary sewage is conveyed by the collection system.
- Combined: Storm water and sanitary sewage share the same collection system; these areas utilize regulator structures at their connection to the interceptor.
- Other: Various types of industrial flows that are discharged into the interceptor such as landfill leachate or airplane de-icing glycol. These areas only contribute flows in dry weather and were not included in the total meter district area.

Once service areas were delineated for each community connection, service areas for each system monitoring point were developed. Since the RVSDS contains flow divisions and parallel interceptor arms, there are many cases where flow meter additions and subtractions were required in order to yield a distinct service area. Since hydrologic factors require a distinct service area, these formulas remained throughout the analysis and include the following:

- [WCS2] + [WCS3] + [P14]
- [P24] + [P25]
- [P20] + [P21]
- [LV11] + [LV4]
- [LV Basin] - [LV4]
- [C] - [B] - [A]
- [P3] + [P26]
- [P9] + [P10] + [P11]
- [P30] + [P31] + [P32]
- [P33] + [P34] + [P35]
- [LC3] + [LC15R] + [LC15]
- [LC20] + [LC20R]
- [5720] + [Parkway]

Figure 5-2 presents the delineated meter service areas. For analysis purposes, the meter districts were divided into two different categories:

- **Independent meter districts**: Districts that have no meter districts upstream, therefore the flow observed in the meter data is entirely attributable to that meter district.
- **Dependent meter districts**: Districts that have one or more meter districts upstream that flow into them, therefore the flow is attributable to multiple sources and subtraction of the upstream flow from the total metered flow must be employed to yield parameters specific to the meter district. The term **cumulative** is used when specifying the total flow or area and the term **incremental** is used when specifying the total flow or area minus the upstream flow or area.

Table 5-2 presents the incremental acreages for each meter service areas along with the district type and any next upstream meters.

Table 5-1
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Total Contributing Area (acres)
1	Dearborn Heights	81.8	--	81.8
2	Dearborn Heights	88.0	--	88.0
3_320	Dearborn Heights	110.5	--	110.5
3_3209	Dearborn Heights	11.6	--	11.6
3_323	Dearborn Heights	17.3	--	17.3
3_3239	Dearborn Heights	42.0	--	42.0
3_325	Dearborn Heights	11.6	--	11.6
3_3259	Dearborn Heights	131.6	--	131.6
3_330	Dearborn Heights	17.0	--	17.0
3_3309	Dearborn Heights	169.0	--	169.0
3_333	Dearborn Heights	53.2	--	53.2
3_3339	Dearborn Heights	86.7	--	86.7
3_335	Dearborn Heights	39.2	--	39.2
4	Dearborn Heights	--	35.4	35.4
5	Dearborn Heights	17.0	--	17.0
6	Dearborn Heights	98.0	--	98.0
7	Dearborn Heights	--	152.1	152.1
8	Dearborn Heights	143.9	--	143.9
9	Dearborn Heights	--	29.5	29.5
10	Dearborn Heights	--	87.8	87.8
11	Dearborn Heights	--	73.9	73.9
12	Dearborn Heights	--	73.2	73.2
13	Dearborn Heights	--	116.9	116.9
14	Dearborn Heights	32.6	--	32.6
15_105	Dearborn Heights	29.8	--	29.8
15_110	Dearborn Heights	246.2	--	246.2
15_125	Dearborn Heights	115.6	--	115.6
15_1259	Dearborn Heights	81.9	--	81.9
15_135	Dearborn Heights	116.8	--	116.8
15_1359	Dearborn Heights	107.7	--	107.7
15_137	Dearborn Heights	84.7	--	84.7
15_140	Dearborn Heights	31.4	--	31.4
15_220	Dearborn Heights	13.5	--	13.5
15_235	Dearborn Heights	45.5	--	45.5
15_238	Dearborn Heights	44.3	--	44.3
15_240	Dearborn Heights	50.7	--	50.7
15_2409	Dearborn Heights	50.6	--	50.6

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Total Contributing Area (acres)
15_245	Dearborn Heights	81.0	--	81.0
15_2459	Dearborn Heights	29.4	--	29.4
15_250	Dearborn Heights	45.0	--	45.0
15_255	Dearborn Heights	35.6	--	35.6
15_270	Dearborn Heights	31.7	--	31.7
15_273	Dearborn Heights	40.1	--	40.1
15_275	Dearborn Heights	58.0	--	58.0
15_280	Dearborn Heights	1.7	--	1.7
15_285	Dearborn Heights	61.6	--	61.6
15_290	Dearborn Heights	19.9	--	19.9
15_295	Dearborn Heights	60.6	--	60.6
15_405	Dearborn Heights	20.1	--	20.1
15_4059	Dearborn Heights	75.7	--	75.7
15_410	Dearborn Heights	19.9	--	19.9
15_510	Dearborn Heights	62.4	--	62.4
15_515	Dearborn Heights	76.4	--	76.4
15_520	Dearborn Heights	38.8	--	38.8
16	Dearborn Heights	--	85.0	85.0
17	Dearborn Heights	--	71.7	71.7
18	Dearborn Heights	33.9	--	33.9
19	Dearborn Heights	33.9	--	33.9
20	Dearborn Heights	106.5	--	106.5
21	Dearborn Heights	99.4	--	99.4
22	Dearborn Heights	--	36.0	36.0
23	Dearborn Heights	--	101.2	101.2
23	Inkster	2.8	--	2.8
24	Dearborn Heights	42.0	--	42.0
25	Dearborn Heights	25.4	--	25.4
26	Garden City	1,841.6	--	1,841.6
26	Westland	26.7	--	26.7
27	Westland	14.2	--	14.2
27	Garden City	1,909.6	--	1,909.6
28	Inkster	109.8	407.7	517.5
28	Westland	107.9	--	107.9
29	Inkster	273.5	114.2	387.7
30	Inkster	4.3	--	4.3
31	Inkster	--	37.8	37.8

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Total Contributing Area (acres)
32	Inkster	103.3	--	103.3
33	Inkster	58.5	--	58.5
33	Westland	15.7	--	15.7
34	Inkster	242.9	--	242.9
34	Westland	124.7	--	124.7
35	Inkster	47.7	--	47.7
36	Inkster	16.5	--	16.5
37	Inkster	32.9	--	32.9
38	Inkster	33.8	--	33.8
39	Inkster	28.3	--	28.3
40	Inkster	12.1	--	12.1
41	Inkster	7.7	--	7.7
42	Inkster	9.0	--	9.0
43	Inkster	--	65.4	65.4
44	Inkster	17.7	--	17.7
45	Inkster	--	74.9	74.9
46	Inkster	566.9	42.2	609.1
47	Inkster	20.2	--	20.2
48	Inkster	--	19.0	19.0
49	Inkster	241.2	30.4	271.6
50	Inkster	--	32.7	32.7
51	Inkster	40.3	--	40.3
52	Inkster	546.6	209.2	755.8
52	Dearborn Heights	--	264.6	264.6
53	Inkster	5.4	--	5.4
54	Inkster	9.6	--	9.6
55	Inkster	4.4	--	4.4
56	Inkster	5.6	--	5.6
57	Inkster	21.5	--	21.5
58	Livonia	148.9	--	148.9
59	Livonia	40.2	--	40.2
60	Livonia	472.9	--	472.9
61	Livonia	161.3	--	161.3
62	Livonia	28.6	--	28.6
63	Livonia	66.3	--	66.3
64	Livonia	89.2	--	89.2
65	Livonia	78.0	--	78.0

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Total Contributing Area (acres)
66	Livonia	30.8	--	30.8
67	Livonia	51.0	--	51.0
68	Livonia	43.5	--	43.5
69	Livonia	14.5	--	14.5
70	Livonia	142.4	--	142.4
71	Livonia	96.1	--	96.1
72	Livonia	78.9	--	78.9
73	Livonia	1,187.8	--	1,187.8
74	Livonia	792.3	--	792.3
74	Westland	5.2	--	5.2
75	Livonia	1,287.6	--	1,287.6
76	Livonia	2,343.0	--	2,343.0
77	Livonia	5,113.6	--	5,113.6
78	Livonia	143.4	--	143.4
79	Livonia	1,901.1	--	1,901.1
80	Livonia	3,436.9	--	3,436.9
81	Livonia	3,469.3	--	3,469.3
82	Livonia	38.0	--	38.0
83	Livonia	775.7	--	775.7
84	Livonia	20.7	--	20.7
85	Livonia	21.7	--	21.7
86	Livonia	37.9	--	37.9
87	Livonia	11.0	--	11.0
88	Livonia	12.6	--	12.6
89	Northville	40.6	--	40.6
90	Northville	89.8	--	89.8
91	Northville	22.7	--	22.7
92	Northville	78.8	--	78.8
93	Northville	404.2	--	404.2
93	Northville Township	18.2	--	18.2
94	Northville Township	4.5	--	4.5
94	Northville	373.8	--	373.8
95	Northville	109.1	--	109.1
96_01	Novi	217.2	--	217.2
96_02	Novi	76.0	--	76.0
96_03	Novi	98.5	--	98.5
96_04	Novi	46.5	--	46.5

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Total Contributing Area (acres)
96_05	Novi	43.4	--	43.4
96_06	Novi	50.4	--	50.4
96_07	Novi	1,005.7	--	1,005.7
96_08	Novi	48.7	--	48.7
96_09	Novi	15.3	--	15.3
96_10	Novi	27.5	--	27.5
96_11	Novi	14.4	--	14.4
96_12	Novi	15.7	--	15.7
96_13	Novi	95.5	--	95.5
96_14	Novi	49.1	--	49.1
96_15	Novi	7.0	--	7.0
96_16	Novi	3.7	--	3.7
96_17	Novi	62.3	--	62.3
96_18	Novi	50.1	--	50.1
96_19	Novi	10.0	--	10.0
96_20	Novi	572.0	--	572.0
96_21	Novi	11.9	--	11.9
96_22	Novi	227.5	--	227.5
96_23	Novi	68.6	--	68.6
96_24	Novi	14.5	--	14.5
96_25	Novi	15.7	--	15.7
96_26	Novi	77.8	--	77.8
96_27	Novi	3,455.0	--	3,455.0
96_28	Novi	63.8	--	63.8
96_29	Novi	18.4	--	18.4
96_30	Novi	1,138.0	--	1,138.0
96_31	Novi	39.8	--	39.8
96_32	Novi	9.3	--	9.3
96_33	Novi	2,166.7	--	2,166.7
96_34	Novi	60.5	--	60.5
96_35	Novi	154.7	--	154.7
96_36	Novi	36.5	--	36.5
96_37	Novi	584.9	--	584.9
96_38	Novi	3,276.5	--	3,276.5
96_39	Novi	49.9	--	49.9
96_40	Novi	29.0	--	29.0

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Total Contributing Area (acres)
96_41	Novi	127.3	--	127.3
96_42	Novi	1,015.0	--	1,015.0
96_43	Novi	481.3	--	481.3
96_44	Novi	3.6	--	3.6
96_45	Novi	154.5	--	154.5
96_46	Novi	182.5	--	182.5
96_47	Novi	17.7	--	17.7
96_48	Novi	21.6	--	21.6
96_49	Novi	526.5	--	526.5
97	Plymouth	105.8	--	105.8
98	Plymouth	93.2	--	93.2
99	Plymouth	603.1	--	603.1
100	Plymouth	46.6	--	46.6
101	Plymouth	445.6	--	445.6
102	Plymouth Township	99.2	--	99.2
103	Plymouth Township	109.7	--	109.7
104	Redford Township	210.7	--	210.7
105	Redford Township	701.0	914.3	1,615.3
105	Livonia	407.8	--	407.8
106	Redford Township	--	51.4	51.4
107	Redford Township	86.9	77.0	163.9
108	Redford Township	27.5	--	27.5
109	Redford Township	35.2	--	35.2
110	Redford Township	13.4	--	13.4
111	Redford Township	48.7	--	48.7
112	Redford Township	228.9	--	228.9
113	Redford Township	--	147.7	147.7
114	Redford Township	--	66.2	66.2
115	Redford Township	--	31.2	31.2
116	Redford Township	276.0	436.7	712.7
117	Redford Township	16.3	--	16.3
118	Redford Township	30.0	--	30.0
119	Redford Township	39.7	--	39.7
120	Redford Township	123.3	181.3	304.6
121	Redford Township	--	115.5	115.5
122	Redford Township	873.0	1,593.7	2,466.7
123	Redford Township	58.8	--	58.8

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Total Contributing Area (acres)
124	Redford Township	35.9	--	35.9
125	Redford Township	149.1	--	149.1
126	Redford Township	66.0	--	66.0
127	Romulus	36.6	--	36.6
128	Romulus	175.4	--	175.4
129	Romulus	377.3	--	377.3
130	Romulus	253.7	--	253.7
131	Romulus	191.4	--	191.4
132	Romulus	34.1	--	34.1
133	Romulus	145.5	--	145.5
134	Romulus	23.5	--	23.5
135	Romulus	441.3	--	441.3
136	Van Buren Township	6,078.3	--	6,078.3
137	Wayne	157.6	--	157.6
138	Wayne	69.9	--	69.9
139	Wayne	66.1	--	66.1
140	Wayne	185.6	--	185.6
141	Wayne	57.6	--	57.6
142	Wayne	307.4	--	307.4
143	Wayne	5.3	--	5.3
144	Wayne	11.5	--	11.5
145	Wayne	7.5	--	7.5
146	Wayne	40.1	--	40.1
147	Wayne	156.7	--	156.7
148	Wayne	80.8	--	80.8
149	Wayne	73.8	--	73.8
150	Wayne	97.1	--	97.1
151	Wayne	177.3	--	177.3
152	Wayne	9.3	--	9.3
153	Wayne	93.4	--	93.4
154	Wayne	3.9	--	3.9
155	Wayne	20.7	--	20.7
156	Wayne	35.3	--	35.3
157	Wayne	12.0	--	12.0
158	Wayne	1,041.1	--	1,041.1
159	Wayne	26.5	--	26.5
160	Wayne	43.6	--	43.6

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Total Contributing Area (acres)
161	Wayne	337.9	--	337.9
162	Westland	22.1	--	22.1
163	Westland	39.9	--	39.9
164	Westland	75.3	--	75.3
165	Westland	21.2	--	21.2
166	Westland	90.2	--	90.2
167	Westland	35.2	--	35.2
168	Westland	11.3	--	11.3
169	Westland	27.0	--	27.0
170	Westland	13.7	--	13.7
171	Westland	2.3	--	2.3
172	Westland	4.0	--	4.0
173	Westland	33.0	--	33.0
174	Westland	4,107.8	--	4,107.8
175	Westland	29.0	--	29.0
176	Westland	197.1	--	197.1
177	Westland	20.7	--	20.7
178	Westland	144.5	--	144.5
179	Westland	167.2	--	167.2
180	Westland	30.5	--	30.5
181	Westland	156.1	--	156.1
182	Westland	187.2	--	187.2
183	Westland	2,599.7	--	2,599.7
183	Wayne	82.7	--	82.7
184	Wayne	38.8	--	38.8
184	Westland	231.9	--	231.9
185	Westland	422.5	--	422.5
185	Wayne	4.3	--	4.3
186	Westland	1,637.2	--	1,637.2
187	Westland	21.0	--	21.0
188	Westland	27.7	--	27.7
189	Westland	29.5	--	29.5
190	Westland	516.8	--	516.8
191	Westland	346.0	--	346.0
192	Westland	42.7	--	42.7
193	Inkster	--	6.9	6.9
194	Canton Township	51.8	--	51.8

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Total Contributing Area (acres)
195	Canton Township	194.7	--	194.7
196	Canton Township	21,015.7	--	21,015.7
197	Plymouth Township	9,912.6	--	9,912.6
197	Northville Township	10,584.3	--	10,584.3
197	Canton Township	1,859.2	--	1,859.2
197	Northville	62.3	--	62.3
199	Dearborn Heights	--	16.9	16.9
200	Wayne	110.9	--	110.9
201	Wayne	2.9	--	2.9
202	Northville	38.7	--	38.7
203	Northville	22.7	--	22.7
204	Westland	27.1	--	27.1
	Total	**120,697.2**	**5,799.6**	**126,496.8**

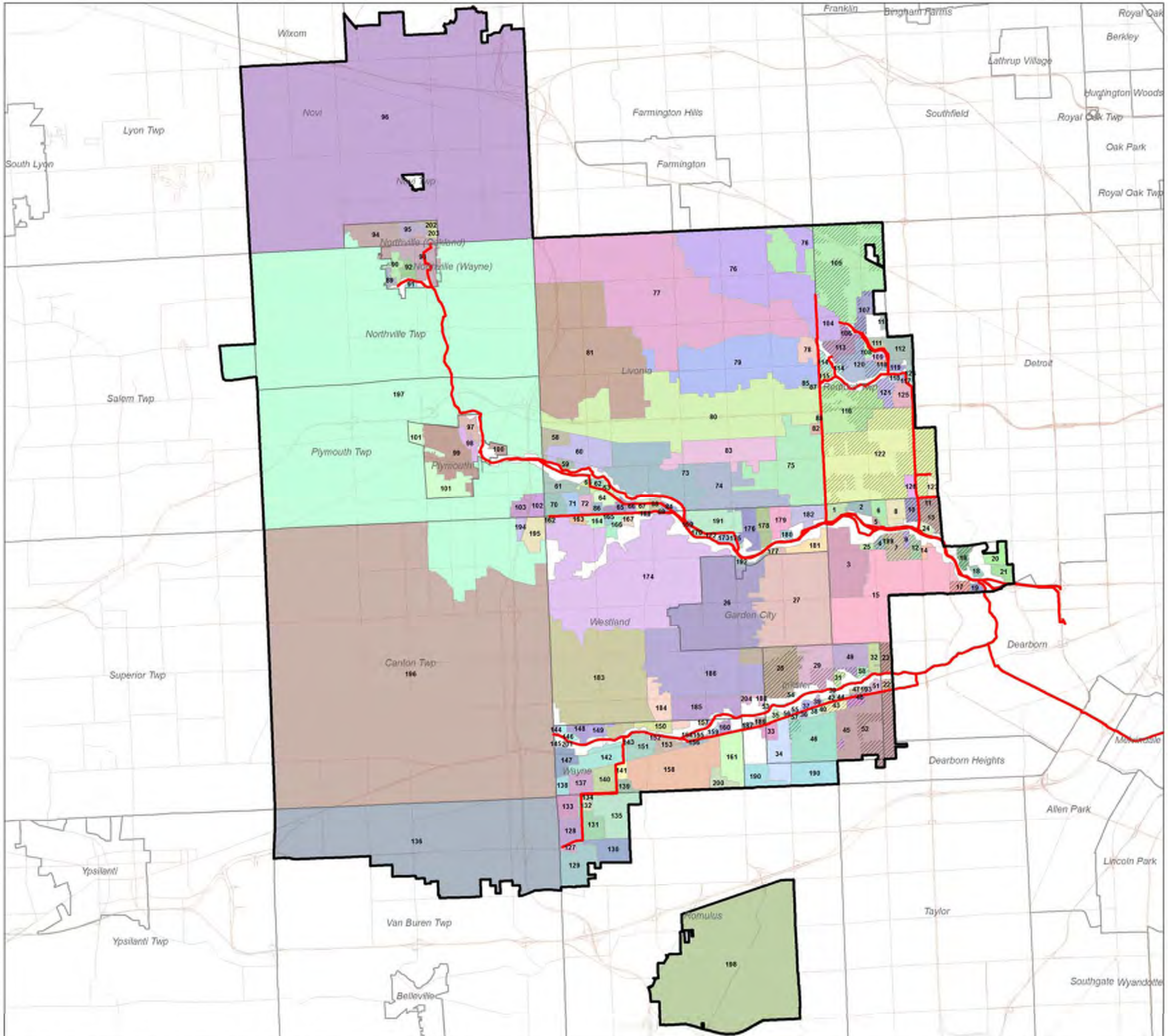
Table 5-2
Meter District Incremental Tributary Service Areas

Meter District	Type	Next Upstream Meters	Tributary Area (ac)		
			Sanitary	Combined	Total
[WCS2]+[WCS3]+[P14]	Dependent	*[LC15], [LC20], [LC20R], [P30], [P31], [P32]*	93.2	156.7	**249.9**
[P30]+[P31]+[P32]	Dependent	*[P13], [P33], [P34], [P35]*	140.6	351.8	**492.4**
[P33]+[P34]+[P35]	Dependent	*[LC3], [LC15R], [P9], [P10], [P11]*	428.7	233.9	**662.6**
[P9]+[P10]+[P11]	Dependent	*[LV14], [LV15], [LV16], [M1], [M2], [P3], [P7], [P8], [P12], [WE14]*	1,372.5	--	**1,372.5**
[P12]	Dependent	*[LV Basin], [LV11]*	826.3	--	**826.3**
[LV_Basin]-[LV4]	Dependent	*[P28], [P29]*	2,064.0	--	**2,064.0**
[P3]+[P26]	Dependent	*[P1]*	848.7	--	**848.7**
[P1]	Dependent	*[BG1], [Parkway], [5710], [5720]*	--	--	**--**
[P20]+[P21]	Dependent	*[P19]*	2,239.7	--	**2,239.7**
[P24]+[P25]	Dependent	*[P20], [P21]*	3,148.0	1,442.2	**4,590.2**
[P19]	Dependent	*[FE19], [L-34], [P17], [WE25]*	754.3	--	**754.3**
[P17]	Dependent	*[P15]*	2,528.3	--	**2,528.3**
[P7]	Independent	--	1,245.9	--	**1,245.9**
[P8]	Independent	--	650.5	--	**650.5**
[P13]	Independent	--	3,362.2	3,615.0	**6,977.2**
[P15]	Independent	--	6,078.3	--	**6,078.3**
[P28]	Independent	--	2,343.0	--	**2,343.0**
[P29]	Independent	--	5,113.6	--	**5,113.6**
[LC3-U]+[LC15-U]+[LC15R-U]	Independent	--	2,466.3	--	**2,466.3**
[LC20-U]+[LC20R-U]	Independent	--	205.9	--	**205.9**

Table 5-2 (continued)
Meter District Incremental Tributary Service Areas

Meter District	Type	Next Upstream Meters	Tributary Area (ac)		
			Sanitary	Combined	Total
[BG1]	Independent	--	16,538.0	--	**16,538.0**
[5710]	Independent	--	373.8	--	**373.8**
[5720]+[Parkway]	Independent	--	829.3	--	**829.3**
[C-B-A]	Independent	--	445.6	--	**445.6**
[M1]	Independent	--	1,909.6	--	**1,909.6**
[M2]	Independent	--	1,911.0	--	**1,911.0**
[LV11]+[LV4]	Independent	--	6,906.2	--	**6,906.2**
[LV14]	Independent	--	1,287.6	--	**1,287.6**
[LV15]	Independent	--	797.5	--	**797.5**
[LV16]	Independent	--	1,187.8	--	**1,187.8**
[LV20]	Independent	--	13.1	--	**13.1**
[L-34]	Independent	--	270.7	--	**270.7**
[WE14]	Independent	--	4,107.8	--	**4,107.8**
[WE25]	Independent	--	2,682.4	--	**2,682.4**
[WE28]	Independent	--	1,637.2	--	**1,637.2**
		Total RVSVS:	**76,807.6**	**5,799.6**	**82,607.2**
[FE19]	Independent	--	21,015.7	--	**21,015.7**
[FE22]	Independent	--	22,873.8	--	**22,873.8**
		Total WTUA:	**43,889.5**	**--**	**43,889.5**
		Grand Total:	**120,697.1**	**5,799.6**	**126,496.7**

Rouge Valley Sewage Disposal System



N
W E
S

0 0.5 1 2 3 4 Miles

Legend

- Interceptor
- Line Connection Area
- Community Boundary
- Combined Area
- Service Area Boundary
- Roads

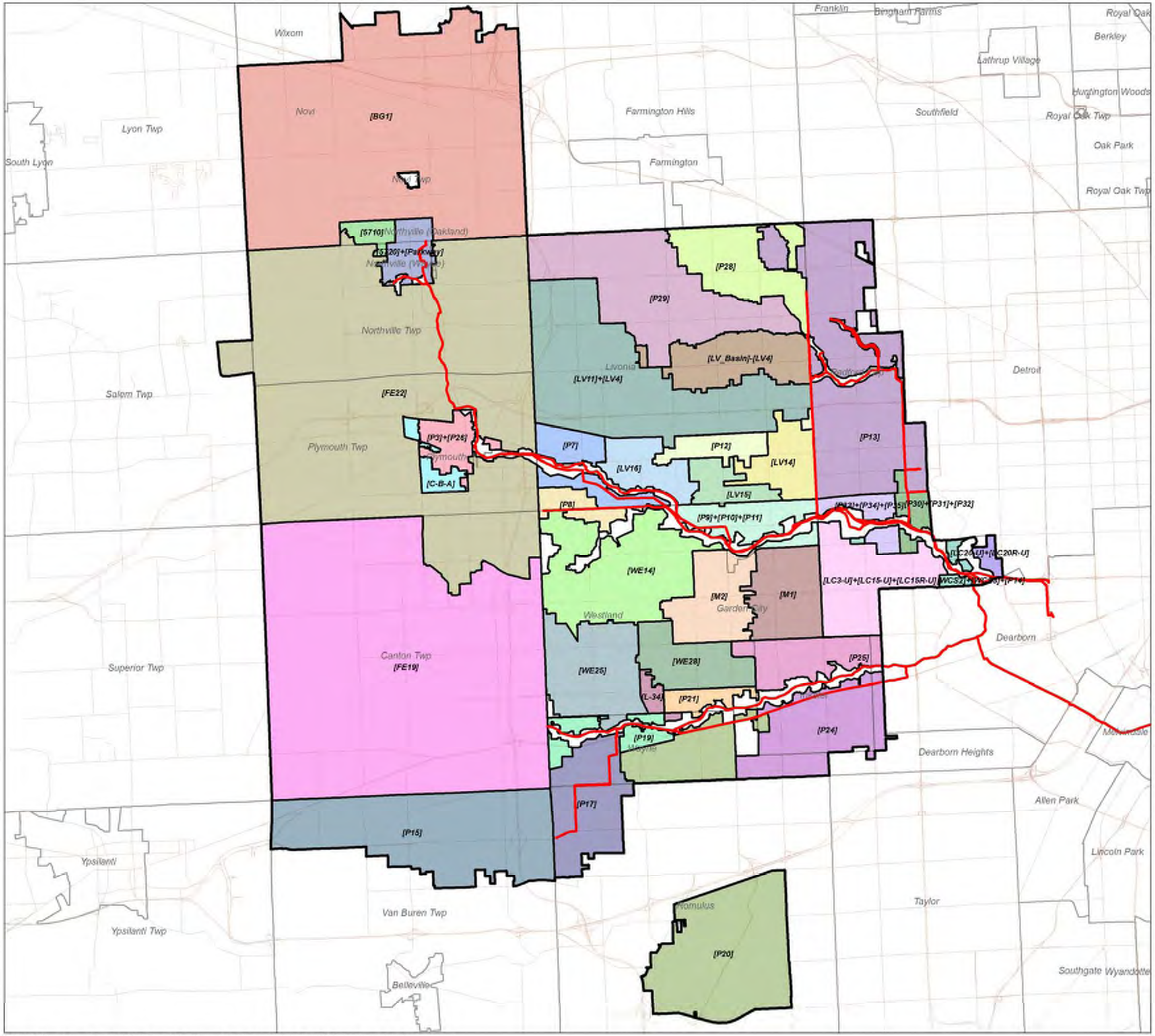
Figure 5-1
Line Connection Service Areas

Prepared By:

Applied Science, Inc.

Date: 3/3/2017

H:\2013\1315 -- Wayne County LTCAP Project Plan\Memos\H&H Report\Fig 5-1 - RVSDS Line Connection Areas.mxd



Rouge Valley Sewage Disposal System

N W E S

0 0.5 1 2 3 4 Miles

Legend

- Interceptor
- Meter District
- Community Boundary
- Service Area Boundary
- Roads

Figure 5-2
Meter District Tributary Service Areas

Prepared By:

Applied Science, Inc.

Date: 3/3/2017

6. Dry Weather Flows

Determining the typical dry weather flows (DWF) provides the foundation for understanding flows and their distribution in the RVSDS. The data from the SMP was reviewed and DWF values were determined for each meter district. These values were then apportioned throughout the community connections in the SWMM model.

Methodology

A single set of dry days was used to estimate the dry weather flow rates for all of the meters. The dry weather days were determined by analyzing the daily flow rate traces for meters near the downstream end of the interceptor system. The meters used for this analysis include: the summation of Meters [P9] + [P10] + [P11] which represent the Middle Rouge interceptor system near Inkster Road, Meters [P24] + [P25] which represent the Lower Rouge interceptor system, and Meters [WCS1] + [WCS2] + [WCS3] which represent the entire RVSDS. These meter sums were chosen because they are near the downstream end of the interceptor system, include some dewatering flow rates, and provide a well-defined difference between wet and dry days to allow for a confident sort. Two methods were used for screening out dry and wet weather days using average daily flow rates.

The first method was designed to flag days that exhibited abrupt changes in average daily flow rate from the preceding or following days. This criterion was selected because wet weather events will significantly raise the average daily flow rate when compared to the preceding day. Likewise, the average daily flow rate on the day following a wet weather event will exhibit a decrease as the flow rates subside.

The second method was designed to flag additional wet weather days that were typically found during large, multiple day events that elevated the metered flow rates for a few days. When this happens, the days in the middle of the event are not flagged by the first method because there is no change in the already elevated flow rate. For this method, the average daily flow rate on dry days was constrained to remain below two standard deviations of the three month average flow rate. Any day with a daily average above this was flagged as a wet day. The monitoring period data was analyzed in quarterly increments: January through March, April through June, July through September, and October through December.

Selection of Dry Weather Flow Period

The typical dry weather flow in a sewer network can vary in the short-term based on individual recession periods from rainfall events that occur and in the long-term based on the overall hydrologic conditions for that season or year. The entire monitoring period was reviewed in order to determine the appropriate conditions for determining dry weather flow parameters to be applied in the model. This is to ensure that dry weather flow parameters are not utilized that are representative of an unreasonably dry or wet period in the overall experience of the system.

First, rainfall conditions were reviewed using the monthly precipitation and the departure from normal at DTW from information provided by the NCDC. The Table 6-1 presents these values. Second, the monthly average dry weather flow rates for Meters [WCS1] + [WCS2] + [WCS3] from 2012 through 2016 are listed on Table 6-2.

After a review of these metrics, 2014 was selected as the appropriate period for deriving dry weather flow parameters. On average, the dry weather flow rates for 2014 were the highest of the five year record by slightly more than one standard deviation of the average. These two comparisons show that determining DWF values using data from the analysis period provides a conservative estimate.

Results

From 2014 data, two DWF conditions were determined: the springtime high and the yearly average. These two values provide insight into how much groundwater infiltration a meter district may experience during the wet springtime months. Table 6-3 presents the incremental dry weather and per-capita flow rates by meter district along with the meter math utilized to calculate the values. Some dependent meter districts were grouped together with upstream districts to provide larger incremental populations to determine the values from. The following groupings were made:

Group [P12] includes upstream meters [LV4], [LV11], [LV20], and [LV Basin]

Group [P9] + [P10] + [P11] includes upstream meters [P1], [P3], [P7], [P8], and [P26]

Group [P20] + [P21] includes upstream meter [P19]

The cumulative springtime high dry weather flow rate for March 2014 and the 2014 annual average dry weather flow rates for each meter district are provided in Table 6-4. The cumulative dry weather flow rates are presented for all months in 2014 in Table 6-5. Two combinations of meters can be used to calculate the total outlet flow from the RVSDS:

Total RVSDS Outlet = [WCS2] + [WCS3] + [P14] + [P24] + [P25] + [C - B - A] - [FE19] - [FE22]

Total RVSDS Outlet = [WCS1] + [WCS2] + [WCS3] + [C - B - A] - [FE19] - [FE22]

These two options are also included on Table 6-5 and are in very close agreement.

New and Temporary Meter Locations

New and temporary flow meters have been installed in several RVSDS areas to enhance the resolution of the system understanding and the model. Because these meters were installed after the period used to develop dry weather flows, a modified analysis was necessary for these locations. These new meter districts were assigned a land area based proportion of the dry weather flow for the larger district that they were formerly a part of.

Table 6-1
Monthly Precipitation and Departure from Normal at Detroit Metropolitan Airport

Month	Monthly Total Precipitation (inches)						Departure from Normal[1] (inches)					
	2012	2013	2014	2015	2016	Average	2012	2013	2014	2015	2016	Average
January	3.00	3.45	2.92	1.45	1.34	2.43	1.04	1.49	0.96	-0.51	-0.62	0.47
February	1.91	2.83	2.82	1.35	2.02	2.19	-0.11	0.81	0.80	-0.67	0.00	0.17
March	2.95	0.74	1.49	0.80	4.86	2.17	0.67	-1.54	-0.79	-1.48	2.58	-0.11
April	2.15	5.29	2.57	2.61	2.31	2.99	-0.75	2.39	-0.33	-0.29	-0.59	0.09
May	1.72	2.54	4.87	5.54	2.20	3.37	-1.66	-0.84	1.49	2.16	-1.18	-0.01
June	1.31	6.01	4.00	5.32	1.30	3.59	-2.21	2.49	0.48	1.80	-2.22	0.07
July	3.67	4.14	2.43	1.76	1.57	2.71	0.30	0.77	-0.94	-1.61	-1.80	-0.66
August	2.25	5.98	6.32	3.16	5.62	4.67	-0.75	2.98	3.32	0.16	2.62	1.67
September	2.47	1.20	4.71	1.29	6.28	3.19	-0.80	-2.07	1.44	-1.98	3.01	-0.08
October	2.32	3.48	2.36	1.97	2.98	2.62	-0.20	0.96	-0.16	-0.55	0.46	0.10
November	0.72	1.82	1.67	2.06	2.10	1.67	-2.07	-0.97	-1.12	-0.73	-0.69	-1.12
December	2.64	2.42	1.41	3.01	2.16	2.33	0.18	-0.04	-1.05	0.55	-0.30	-0.13
Total	**27.11**	**39.90**	**37.57**	**30.32**	**34.74**	**33.93**	**-6.36**	**6.43**	**4.10**	**-3.15**	**1.27**	**0.46**

Notes:

1. Normal values were computed over the period from 1981 through 2010.

Table 6-2
Cumulative Dry Weather Flow Rates at RVSDS Outlet for 2012 through 2016

Month	Meters [WCS1] + [WCS2] + [WCS3] (cfs)					
	2012	2013	2014	2015	2016	Average
January	114.1	74.3	94.4	80.8	90.1	90.7
February	107.3	90.6	84.5	68.5	83.9	87.0
March	108.5	97.2	116.8	86.7	114.5	104.7
April	86.6	108.6	110.9	94.7	109.4	102.0
May	76.3	91.2	108.4	83.7	91.3	90.2
June	64.0	87.2	95.9	102.3	66.1	83.1
July	63.9	97.1	71.9	73.5	58.2	72.9
August	63.0	73.5	78.2	64.4	61.6	68.1
September	59.1	72.3	88.4	58.6	59.5	67.6
October	59.8	67.5	77.6	57.0	78.4	68.0
November	60.1	87.9	69.2	65.9	80.0	72.6
December	62.1	92.5	80.4	69.2	80.3	76.9
Total	**76.9**	**86.6**	**89.7**	**75.4**	**81.1**	**82.0**

Table 6-3
Incremental Dry Weather Flow Rates

Branch	Meter District / Group	Meter Math	Census 2010 Population	Dry Weather Flow Rate: Springtime High March 2014 (cfs)	Springtime High March 2014 (gpcd)	Annual Average Year 2014 (cfs)	Annual Average Year 2014 (gpcd)
Middle Rouge	[BG1]	*[BG1]*	43,217	7.79	116	7.21	108
	[C-B-A]	*[C]-[B]-[A]*	3,074	2.11	442	1.97	414
	[FE22]	*[FE22] - [C-B-A]*	-	8.89	-	5.68	-
	[LV16]	*[LV16]*	5,147	2.17	272	1.80	226
	[WE14]	*[WE14]*	26,724	6.36	154	5.54	134
	[LV15]	*[LV15]*	6,570	2.82	277	2.18	215
	[M2]	*[M2]*	13,739	4.47	210	3.36	158
	[M1]	*[M1]*	14,943	3.82	165	2.65	114
	[LV14]	*[LV14]*	7,738	2.55	213	1.92	160
	Group [P12]	*[P12]*	68,311	15.26	144	13.08	124
	Group [P9] + [P10] + [P11]	*[P9] + [P10] + [P11] - [P12] - [M1] - [M2] - [WE14] - [LV14] - [LV15] - [LV16] - [BG1] - [FE22]*	33,818	7.12	136	4.27	82
	[P13]	*[P-13]*	48,847	15.23	202	11.04	146
	[WCS2] + [WCS3] + [P14]	*[WCS2] + [WCS3] + [P14] - [P9] - [P10] - [P11] - [P13]*	36,637	11.18	197	8.76	154
Lower Rouge	[P15]	*[P15]*	6,938	1.67	155	1.24	115
	[P17]	*[P17] - [P15]*	2,623	1.36	335	1.19	295
	[FE19]	*[FE19]*	-	0.00	-	0.00	-
	[WE25]	*[WE25]*	16,269	3.72	148	2.80	111
	Group [P20] + [P21]	*[P20] + [P21] - [P17] - [FE19] - [WE25]*	37,944	9.97	170	7.38	126
	[P24] + [P25]	*[P24] + [P25] - [P20] - [P21]*	32,245	8.34	167	6.86	137
		Total RVSDS:	**404,784**	**114.83**	**183**	**88.95**	**142**

Table 6-4
Cumulative Dry Weather Flow Rates

Branch	Meter	Year 2010 Population	Dry Weather Flow Rate			
			Springtime High March 2014		Annual Average Year 2014	
			(cfs)	(gpcd)	(cfs)	(gpcd)
Middle Rouge	[BG1]	43,217	7.79	116	7.21	108
	[P1]	49,143	8.72	115	8.08	106
	[P3] + [P26]	55,091	9.74	114	9.30	109
	[P7]	4,814	2.41	324	2.07	279
	[C - B - A]	3,074	2.11	442	1.97	414
	[FE22]	-	10.99	-	7.66	-
	[P8] - [FE22]	4,395	1.05	155	0.63	94
	[LV16]	5,147	2.17	272	1.80	226
	[WE14]	26,724	6.36	154	5.54	134
	[LV15]	6,570	2.82	277	2.18	215
	[M2]	13,739	4.47	210	3.36	158
	[M1]	14,943	3.82	165	2.65	114
	[LV14]	7,738	2.55	213	1.92	160
	[LV Basin] - [LV4]	39,591	8.81	144	6.66	109
	[LV11] + [LV4]	28,266	9.04	207	7.41	169
	[P12]	68,311	15.26	144	13.08	124
	[P9] + [P10] + [P11] - [FE22]	223,281	52.37	152	42.01	122
	[P13]	48,847	15.23	202	11.04	146
	[WCS2] + [WCS3] + [P14] - [FE22]	308,765	78.78	165	61.81	129
Lower Rouge	[P15]	6,938	1.67	155	1.24	115
	[P17]	9,561	3.03	205	2.43	165
	[FE19]	-	0.00	-	0.00	-
	[WE25]	16,269	3.72	148	2.80	111
	[P19] - [FE19]	32,127	8.16	164	6.18	124
	[WE28]	14,096	1.72	79	1.55	71
	[P20] + [P21] - [FE19]	63,774	16.72	169	12.63	128
	[P24] + [P25] - [FE19]	96,019	25.05	169	19.49	131
Outlet	[WCS2] + [WCS3] + [P14] + [P24] + [P25] + [C - B - A] - [FE19] - [FE22]	68.43	261.61	53.79	205.88	68.43
	[WCS1] +[WCS2] + [WCS3] + [C - B - A] - [FE19] - [FE22]	69.75	266.25	54.24	207.43	69.75

Table 6-5
Cumulative Dry Weather Flow Rates by Month

Branch	Meter	Dry Weather Flow Rate (cfs)												
		Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Average Annual
Middle Rouge	[BG1]	7.04	6.97	7.79	7.46	7.54	7.65	6.93	6.97	7.14	6.97	6.93	7.23	7.21
	[P1]	7.88	7.66	8.72	8.50	8.59	8.75	7.76	7.71	7.97	7.74	7.62	7.97	8.08
	[P3]	9.63	9.20	9.61	9.88	10.08	9.74	8.76	8.72	8.90	8.54	8.33	8.92	9.20
	[P26]	0.12	0.08	0.11	0.09	0.12	0.19	0.08	0.12	0.14	0.09	0.08	0.08	0.11
	[P7]	2.03	1.84	2.41	2.35	2.41	2.38	2.03	2.07	2.14	1.81	1.66	1.78	2.07
	[A]	0.60	0.63	0.59	0.50	0.50	0.46	0.39	0.37	0.39	0.40	0.37	0.37	0.46
	[B]	1.19	1.10	1.38	1.39	1.38	1.36	1.11	0.87	0.98	1.02	0.87	1.04	1.15
	[C]	3.34	3.16	4.07	4.04	3.99	4.10	3.36	3.34	3.59	3.36	3.03	3.51	3.58
	[FE22]	7.54	6.69	10.99	9.47	9.30	8.87	6.49	6.59	7.40	6.52	5.48	6.49	7.66
	[P8]	8.13	7.14	12.04	10.00	9.72	9.55	7.03	7.14	8.11	7.14	6.33	7.20	8.30
	[LV16]	1.81	1.70	2.17	2.29	2.18	1.93	1.49	1.70	1.95	1.58	1.35	1.49	1.80
	[WE14]	5.67	5.26	6.36	6.22	6.18	5.94	4.92	5.31	5.46	5.11	4.88	5.22	5.54
	[LV15]	2.23	1.97	2.82	2.74	2.77	2.24	1.61	1.86	2.40	1.86	1.73	1.97	2.18
	[M2]	3.39	2.97	4.47	4.32	4.35	3.64	2.62	3.07	3.30	2.83	2.43	2.89	3.36
	[M1]	2.83	2.72	3.82	3.48	3.22	2.66	2.00	2.01	2.21	2.23	2.03	2.45	2.65
	[LV14]	1.90	1.69	2.55	2.43	2.43	1.92	1.39	1.66	2.20	1.72	1.50	1.63	1.92
	[LV4]	4.71	4.10	5.63	5.70	5.40	4.92	3.64	4.26	4.88	4.07	3.59	3.85	4.57
	[LV20]	0.09	0.11	0.09	0.11	0.11	0.09	0.08	0.08	0.11	0.09	0.11	0.12	0.11
	[LV Basin]	11.36	10.17	14.44	14.30	13.70	12.65	8.72	9.71	11.02	9.63	8.70	10.15	11.22
	[LV11]	2.83	2.48	3.41	3.20	3.10	2.85	2.55	2.77	3.02	2.60	2.52	2.79	2.85
	[P12]	12.52	10.43	15.26	16.38	16.61	15.06	10.88	11.93	13.41	11.66	10.82	11.78	13.08
	[P9]	5.09	4.20	8.10	7.41	6.97	5.90	3.27	3.72	4.89	3.99	3.39	4.23	5.09
	[P10]	30.31	28.03	37.26	35.62	34.89	32.28	25.67	26.98	29.75	26.84	24.88	27.40	30.00
	[P11]	14.83	13.70	17.99	17.01	16.86	15.54	12.43	13.33	14.77	13.05	11.90	13.36	14.57
	[P13]	11.73	10.37	15.23	15.51	14.75	10.29	7.01	8.08	10.65	10.00	8.56	10.22	11.04
	[P14]	45.67	42.74	52.96	52.15	51.13	47.68	39.83	42.18	46.13	42.62	39.47	43.93	45.56
Lower Rouge	[P15]	1.39	1.33	1.67	1.47	1.42	1.11	0.99	1.04	1.16	1.05	1.05	1.13	1.24
	[P17]	2.57	2.49	3.03	2.65	2.69	2.65	2.18	1.98	2.38	2.12	2.18	2.29	2.43
	[FE19]	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	[WE25]	3.02	2.63	3.72	3.48	3.50	3.14	2.35	2.48	2.51	2.28	2.14	2.46	2.80
	[P19]	6.72	6.16	8.16	7.21	6.97	6.10	4.58	4.94	5.77	5.76	5.63	6.05	6.18
	[WE28]	1.30	1.16	1.72	1.63	1.81	1.55	1.08	1.58	1.95	1.75	1.47	1.58	1.55
	[P21]	9.37	8.54	11.25	10.11	10.14	9.26	6.92	7.40	8.19	7.26	6.86	7.71	8.59
	[P25]	13.98	12.65	15.88	14.09	15.53	13.68	9.54	9.21	12.69	11.13	10.51	12.28	12.60
	[P20]	4.63	4.57	5.46	5.96	5.26	4.12	3.30	3.19	3.64	3.08	2.59	2.83	4.04
	[P24]	7.46	7.62	9.18	8.81	7.83	6.87	6.05	6.11	6.67	5.70	5.02	5.46	6.89
RVSDS Outlet	[WCS1]	68.42	63.70	80.05	77.29	76.22	69.55	55.56	58.92	65.59	59.30	54.35	59.85	65.74
	[WCS2]	15.82	13.44	19.40	18.96	19.29	16.46	11.52	12.41	14.61	12.29	10.05	13.75	14.85
	[WCS3]	10.20	7.38	17.41	14.67	12.93	9.95	4.91	6.89	8.27	6.05	4.80	5.20	9.07
	[WCS1] +[WCS2] + [WCS3]	94.44	84.54	116.86	110.91	108.44	95.94	71.98	78.24	88.47	77.65	69.21	78.79	89.64
	[WCS2] + [WCS3] + [P14] + [P24] + [P25]	93.13	83.84	114.83	108.68	106.69	94.64	71.84	76.84	88.39	77.79	69.85	80.62	88.95

7. Wet Weather Event Identification

The precipitation data for all wet weather events in the monitoring period were analyzed to identify which events were significant enough to merit further analysis in the development of hydrologic parameters. This is an important consideration because as events become greater in scale they are less influenced by the effects of antecedent moisture conditions, typically have lower spatial variability, and there is a more apparent distinction between the wet weather flow rates in the meter data. This leads to increased confidence when projecting any determined hydrologic parameters to the design event level.

Any event with an inter-event time less than 24 hours and an average precipitation depth greater than one inch was considered significant. Originally, the period from 2012 through 2014 was analyzed to determine these events. Subsequently, new and temporary flow meters have been installed in several RVSDS areas to enhance the resolution of the system understanding and the model. Because these meters were installed after the period used to for the initial event selection, rainfall from Summer 2016 was also reviewed and only two additional events were added to the group. Table 7-1 presents the 23 significant events considered during the monitoring period.

From this group of significant events, a second selection was made to determine which events would be used for hydrologic parameter development. The significant events were first reviewed for spatial uniformity. A coefficient of variation (CV) was determined event by computing the standard deviation of precipitation depth and dividing it by the arithmetic average for each significant event. Table 7-2 presents the spatial uniformity statistics for each significant event.

Next, the significant events were reviewed in how the rainfall was distributed over time. For analysis purposes, it is ideal that the event occurred over a single peak of intensity. This allows a clear cause-and-effect relationship to be distinguished between the rainfall and the response of the sewer system. This helps better determine the shape of inflow hydrographs and the expected travel times through the system.

The flood frequency of the Rouge River was also considered when selecting events. Table 7-3 shows the return estimated flood frequency in months, based on the 15-minute peak flow rate of the Rouge River during each significant event.

Each significant event was reviewed independently against the factors described above. In general, the events selected for hydrologic parameter development had large rainfall amounts, low CVs, and occurred as a single burst. In total, nine of the significant events shown highlighted on Tables 7-1 and 7-2 were selected for further use in the hydrologic analysis.

Table 7-1
Rain Gauge Volume by Significant Event

Significant Event No.	Start Date Time	Stop Date Time	DWSD			Garden City	Livonia			Wayne County										DTW	WTUA		Novi		Oakland County	
			PG032	PG033	PG034	RG01	RG01	RG02	RG03	R10	R11	R12	R13	R14	R15	R18	R27	R28	R29		LR EQ Basin	MR EQ Basin	DPS	Park Place	0843	0850
1	7/26/12 12:00 AM	7/28/12 6:00 AM	2.25	2.46	2.15	1.41	2.68	2.39		0.85	1.28	2.31	1.28	0.29	2.26	0.47	1.64	2.55	2.46	1.26					1.85	1.57
2	8/9/12 2:00 AM	8/11/12 10:00 AM	1.68	1.43	1.50	1.14	1.43	1.86		0.86	1.43	0.00	1.09	1.06	1.34	1.01	1.41	1.45	1.70	0.80					1.44	2.06
3	1/28/13 12:00 AM	1/31/13 12:00 AM	1.61	1.43	1.18	1.33	1.48	1.34		0.54	1.77	1.72	0.80	0.00	2.15	1.40	0.95	1.49	0.19	1.33					3.25	1.83
4	2/26/13 12:00 AM	3/1/13 12:00 AM	1.06	1.07	1.57	1.07	1.10	0.95		1.31	0.78	1.40	0.92	0.00	1.66	1.55	1.56	1.55	1.47	1.63					0.17	0.87
5	4/10/13 12:00 AM	4/12/13 6:00 AM	2.05	1.96	2.10	1.67	1.95	1.61		0.00	2.15	2.10	0.00	2.14	2.01	2.01	2.29	2.15	2.24	1.92	1.91	1.89			0.00	2.00
6	4/17/13 12:00 PM	4/19/13 12:00 PM	1.97	1.90	2.17	1.69	1.73	1.70		0.14	1.67	1.69	0.00	2.12	1.67	2.75	2.17	0.91	2.03	1.81	1.76	1.77			1.91	1.84
7	5/27/13 12:00 PM	5/29/13 12:00 AM	1.07	1.43	1.11	0.98	1.22	1.02		0.00	0.83	1.12	0.92	0.90	0.96	0.93	0.93	1.13	1.04	0.99	0.83	0.93			0.92	0.58
8	6/12/13 12:00 PM	6/13/13 12:00 PM	1.77	2.05	1.40	1.69	1.78	1.05		1.54	1.30	1.89	1.26	1.46	1.43	0.88	0.00	1.67	1.84	1.73	1.09	1.39			0.86	1.49
9	6/25/13 6:00 AM	6/29/13 12:00 AM	1.69	2.16	1.54	1.87	2.26	2.20		2.08	1.93	2.20	1.09	1.97	1.40	2.29	0.00	1.92	2.14	2.58	2.02	2.00			1.85	1.70
10	7/8/13 12:00 PM	7/10/13 6:00 PM	0.51	2.53	3.09	1.55	1.98	0.18		0.58	1.50	1.94	0.85	1.91	1.38	0.81	0.00	2.00	1.04	0.74	1.05	2.55			1.27	0.43
11	7/15/13 12:00 PM	7/16/13 6:00 PM	0.16	1.09	1.69	0.32	0.25	0.02		0.27	0.14	0.10	0.19	0.27	1.49	0.63	0.00	1.56	1.50	0.28	0.16	0.12			0.33	0.13
12	8/12/13 6:00 AM	8/13/13 6:00 AM	0.68	0.86	0.87	0.98	0.87	0.75		0.00	0.95	0.95	1.00	2.35	1.62	2.16	0.00	0.92	0.90	2.46	1.53	0.99			0.88	0.98
13	10/30/13 6:00 PM	11/1/13 6:00 AM	1.50	1.67	1.64	1.71	1.48	1.42		2.07	1.56	1.80	1.68	2.04	1.93	1.84	1.97	2.02	1.78	2.02	1.80	1.62			1.58	0.08
14	12/19/13 12:00 AM	12/22/13 12:00 PM	0.47	0.53	0.56	1.15	0.32	1.40		1.61	1.97	1.46	0.00	1.48	1.48	1.57	1.63	1.72	1.53	1.47					1.60	1.58
15	4/29/14 12:00 AM	4/30/14 6:00 AM	1.26	1.20	1.35	1.10	0.71	0.87		0.97	0.98	1.23	0.00	0.95	1.25	0.80	1.32	1.28	1.26	1.10					0.58	0.97
16	5/12/14 6:00 AM	5/15/14 12:00 PM	1.72	1.93	0.00	1.44	1.81	2.89		2.54	3.06	1.50	0.00	1.72	1.76	1.66	1.95	1.66	1.85	2.34					2.62	2.61
17	5/27/14 12:00 PM	5/28/14 6:00 PM	1.23	1.24	0.00	1.77	1.39	1.57		1.08	0.95	1.50	0.00	0.71	1.53	0.24	2.02	1.20	1.41	1.75					1.05	0.74
18	6/18/14 12:00 AM	6/19/14 6:00 PM	1.26	1.97	1.16	1.67	1.76	2.00		0.16	1.78	1.88	0.00	1.52	2.54	1.20	2.37	2.24	2.63	2.01					1.70	0.00
19	8/11/14 6:00 AM	8/13/14 12:00 AM	3.12	3.58	4.90	5.11	2.80	3.66		4.26	3.09	4.74	0.00	2.52	4.73	2.20	6.07	6.05	3.53	4.85	2.94	4.35	2.15	0.88	3.08	1.64
20	9/10/14 6:00 AM	9/11/14 12:00 AM	1.02	0.98	1.74	1.63	1.52	1.32		1.54	1.36	1.60	1.66	1.79	1.77	1.77	1.70	1.71	1.57	1.41	1.51	1.56			1.43	1.42
21	11/22/14 6:00 AM	11/24/14 6:00 PM	1.22	1.18	2.06	1.38	1.07	1.24		1.39	1.32	1.30	1.35	1.43	1.65	1.22	1.40	1.50	1.34	1.30	1.21	1.16				1.56
22	8/15/16 2:00 PM	8/17/16 12:00 PM	0.57	2.33	1.81	2.23	1.64	1.93	0.00	2.05	0.00	2.35	1.65	2.07	2.02	1.51	2.33	2.34	2.28	2.16	1.70	0.00	1.68		1.90	2.25
23	9/28/16 12:00 AM	10/3/16 12:00 AM	1.21	4.21	3.77	1.33	4.17	3.86	4.15	2.98	0.00	3.58	0.00	2.87	3.34	3.30	3.37	3.99	4.72	4.03	4.15	3.49	2.93		3.91	3.25

Key
Suspect Data
Missing Data

Table 7-2
Summary Statistics of Significant Events

Significant Event No.	RDI/I Analysis Event No.	Start Date Time	Stop Date Time	Duration (hours)	Rainfall Depth (inches)				Coefficient of Variation
					Minimum	Numerical Average	Maximum	Std. Dev	
1	-	7/26/12 12:00 AM	7/28/12 6:00 AM	54	0.29	1.76	2.68	0.72	41%
2	1	8/9/12 2:00 AM	8/11/12 10:00 AM	56	0.80	1.37	2.06	0.33	24%
3	-	1/28/13 12:00 AM	1/31/13 12:00 AM	72	1.18	1.54	2.15	0.26	17%
4	-	2/26/13 12:00 AM	3/1/13 12:00 AM	72	0.78	1.27	1.66	0.30	24%
5	2	4/10/13 12:00 AM	4/12/13 6:00 AM	54	1.61	2.01	2.29	0.17	9%
6	3	4/17/13 12:00 PM	4/19/13 12:00 PM	48	1.67	1.91	2.75	0.27	14%
7	4	5/27/13 12:00 PM	5/29/13 12:00 AM	36	0.83	1.01	1.43	0.14	14%
8	5	6/12/13 12:00 PM	6/13/13 12:00 PM	24	1.05	1.55	2.05	0.28	18%
9	-	6/25/13 6:00 AM	6/29/13 12:00 AM	90	1.40	1.99	2.58	0.28	14%
10	-	7/8/13 12:00 PM	7/10/13 6:00 PM	54	0.43	1.46	3.09	0.76	52%
11	-	7/15/13 12:00 PM	7/16/13 6:00 PM	30	0.02	0.53	1.69	0.57	107%
12	-	8/12/13 6:00 AM	8/13/13 6:00 AM	24	0.68	1.19	2.46	0.55	46%
13	6	10/30/13 6:00 PM	11/1/13 6:00 AM	36	1.42	1.76	2.07	0.20	12%
14	-	12/19/13 12:00 AM	12/22/13 12:00 PM	84	0.47	1.37	1.97	0.44	32%
15	-	4/29/14 12:00 AM	4/30/14 6:00 AM	30	0.58	1.07	1.35	0.22	21%
16	-	5/12/14 6:00 AM	5/15/14 12:00 PM	78	1.44	2.06	3.06	0.51	25%
17	-	5/27/14 12:00 PM	5/28/14 6:00 PM	30	0.24	1.26	2.02	0.44	35%
18	-	6/18/14 12:00 AM	6/19/14 6:00 PM	42	1.16	1.86	2.63	0.45	24%
19	7	8/11/14 6:00 AM	8/13/14 12:00 AM	42	0.88	3.65	6.07	1.37	38%
20	8	9/10/14 6:00 AM	9/11/14 12:00 AM	18	1.32	1.57	1.79	0.15	9%
21	-	11/22/14 6:00 AM	11/24/14 6:00 PM	60	1.07	1.34	1.65	0.14	11%
22	-	8/15/16 2:00 PM	8/17/16 12:00 PM	46	1.51	2.03	2.35	0.28	14%
23	9	9/28/16 12:00 AM	10/3/16 12:00 AM	120	2.87	3.70	4.72	0.50	14%

Table 7-3
Rouge River Flood Frequency in the STCAP Monitoring Period

Significant Event No.	RDI/I Analysis Event No.	Start Date	End Date	Peak 15-minute Flow Rate (cfs)		Estimated Flood Frequency (months)	
				Middle Rouge USGS Gage #04167000	Lower Rouge USGS Gage #04168000	Middle Rouge USGS Gage #04167000	Lower Rouge USGS Gage #04168000
1	-	7/26/2012	7/29/2012	619	594	5	3
2	1	8/9/2012	8/11/2012	291	288	1	1
3	-	1/28/2013	1/31/2013	590	606	4	3
4	-	2/26/2013	3/2/2013	239	277	1	1
5	2	4/10/2013	4/13/2013	652	809	5	5
6	3	4/17/2013	4/20/2013	828	992	9	7
7	4	5/27/2013	5/29/2013	252	196	1	1
8	5	6/12/2013	6/14/2013	706	624	6	3
9	-	6/25/2013	6/29/2013	690	727	5	4
10	-	7/8/2013	7/11/2013	690	935	5	6
11	-	7/15/2013	7/16/2013	214	216	1	1
12	-	8/12/2013	8/14/2013	269	448	1	2
13	6	10/30/2013	11/2/2013	442	621	3	3
14	-	12/19/2013	12/23/2013	485	891	3	5
15	-	4/29/2014	5/1/2014	343	344	1	1
16	-	5/12/2014	5/17/2014	925	742	11	4
17	-	5/27/2014	5/29/2014	497	715	3	4
18	-	6/18/2014	6/20/2014	722	776	6	5
19	7	8/11/2014	8/13/2014	1,890	1,590	8.9*	3.3*
20	8	9/10/2014	9/11/2014	627	801	5	5
21	-	11/22/2014	11/25/2014	463	643	3	3
22	-	8/15/2016	8/17/2016	696	630	6	3
23	9	9/28/2016	10/3/2016	687	762	5	4

8. River-Dependent Inflow

The presence of river-dependent inflow in wet weather has long been suspected in the Middle Rouge interceptor network, particularly along the extent between Inkster Road and the Middle Rouge outlet. Since both rainfall derived inflow and infiltration (RDI/I) and river-dependent inflow are generated simultaneously during wet weather, delineations between the two have been difficult to quantify. This was exacerbated by an initial lack of monitoring locations prior to 2016 in this critical reach.

The RVSDS meter network was enhanced in 2016 through the installation of additional long-term meters that allowed the interceptor reach from Inkster Road to the Middle Rouge outlet to be divided into the following three segments:

- Inkster Road to Telegraph Road
  - *Upstream*: Meters P9, P10, P11
  - *Downstream*: Meters P33, P34, P35
- Telegraph Road to Outer Drive
  - *Upstream*: Meters P13, P33, P34, P35
  - *Downstream*: Meters P30, P31, P32
- Outer Drive to the Middle Rouge outlet
  - *Upstream*: Meters P30, P31, P32
  - *Downstream*: Meters P14, WC-S-2, WC-S-3

The differential flow between each set of interceptor meters was reviewed. After deducting for flows entering in from community connections, any remaining flow could be potentially river-dependent inflow. During the September 29, 2016 wet weather event, such river-dependent inflow was visible in the Inkster Road to Telegraph Road reach and is presented in Figures 8-1 and 8-2. Other events likely generated river-dependent inflow, however this method of differential metering required a significant enough event to overcome the metering accuracy and timing issues that arise when subtracting flow rate data.

To provide an additional independent method of detecting river-dependent inflow through the 2016 growing season, temporary flow meters were installed on the following five community line connections with extents in the floodplain:

- Line Connection No. 3 (LC-3)
- Line Connection No. 15 (LC-15)
- Line Connection No. 15 Relief (LC-15R)

- Line Connection No. 20 (LC-20)
- Line Connection No. 20 Relief (LC-20R)

Two meters were installed on each line connection, one at the downstream end as close to the interceptor as possible, and one upstream at the first manhole of the sewer that is no longer in the floodplain. Between each pair of line connection meters, no other sewer connections existed; therefore, any difference in flow rate was assumed to be river-dependent inflow.

For a total of 18 wet weather events, the meters on LC-3 and LC-15 indicated some amount of river-dependent inflow. Of interest was the September 29, 2016 event which yielded a peak hourly river-dependent inflow of 10.3 cfs (Figure 8-3) based on the line connection metering and a total of 36.3 cfs if the differential interceptor metering of the Inkster Road to Telegraph Road reach is included. This suggests that LC-3 and LC-15 account for approximately 28.5% of the peak river-dependent inflow in this region for this event. This percentage was used to determine the other events where the river-dependent inflow was below the detection limit of the interceptor metering efforts.

Finally, this river-dependent inflow estimation accounts for approximately 3.2 river miles between Inkster and Telegraph Roads. Through a review of the data, no river-dependent inflow appeared to be occurring in the Telegraph Road to Outer Drive extent. However, in the Outer Drive to Middle Rouge outlet extent the metering data was inconclusive due to the poor quality of meters WC-S-2 and WC-S-3. It is likely that river inflow is occurring in this extent which covers 1.6 river miles. Therefore, to estimate a total Middle Rouge peak river-dependent inflow the Inkster to Telegraph Roads extent values were multiplied by 1.5 to yield the total estimated river-dependent inflow of the Middle Rouge Interceptor.

Table 8-1 presents the peak river-dependent inflow for each extent along with the peak river level attained at the USGS Gage 041687000. Figure 8-4 presents a scatterplot of the estimated total Middle Rouge Interceptor peak river-dependent inflow versus river level. The scatterplot also includes the river depth at various return frequencies so that a projection of river-dependent inflow could be made for both historic and theoretical design events. A correlation was developed through the points to provide an approximate direct relationship between river level and river-dependent inflow.

Table 8-1
Estimated River Inflow Quantities

Event Ordinal	Event Start Date/Time	Event Stop Date/Time	Peak Hourly River-Dependent Inflow Rate (cfs)			Peak Hourly River Depth at USGS Gage 04167000 (ft)
			From LC-3 and LC-15 Only *(Extent 1)*	Between Inkster and Telegraph Roads including LC-3 and LC-15 *(Extent 2)*	All of Middle Rouge Interceptor downstream of Inkster Road *(Extent 3)***	
1	3/24/2016 11:00	3/27/2016 22:00	7.1	24.8*	37.2	8.1
2	3/27/2016 22:00	3/31/2016 0:00	5.9	20.8*	31.2	6.1
3	3/31/2016 0:00	4/5/2016 0:00	5.8	20.4*	30.6	7.8
4	5/12/2016 18:00	5/17/2016 0:00	3.6	12.8*	19.1	6.6
5	6/4/2016 18:00	6/8/2016 0:00	4.2	14.7*	22.1	6.6
6	7/31/2016 18:00	8/1/2016 0:00	4.1	14.4*	21.6	5.0
7	8/13/2016 12:00	8/14/2016 18:00	4.8	16.8*	25.2	5.5
8	8/16/2016 0:00	8/17/2016 12:00	6.2	21.7*	32.5	8.3
9	8/17/2016 12:00	8/19/2016 0:00	3.9	13.6*	20.5	6.1
10	8/27/2016 12:00	8/29/2016 0:00	4.1	14.2*	21.4	6.3
11	9/7/2016 12:00	9/9/2016 0:00	1.7	6.0*	9.1	4.2
12	9/10/2016 0:00	9/12/2016 0:00	6.4	22.3*	33.5	6.8
13	9/28/2016 18:00	10/4/2016 0:00	10.3	36.3	54.5	8.2
14	10/12/2016 18:00	10/14/2016 0:00	0.7	2.6*	3.8	3.3
15	10/16/2016 6:00	10/17/2016 6:00	1.1	4.0*	6.0	3.4
16	10/20/2016 0:00	10/24/2016 0:00	2.3	8.1*	12.1	6.3
17	10/27/2016 12:00	10/30/2016 0:00	3.2	11.4*	17.0	4.7
18	10/30/2016 0:00	11/1/2016 0:00	2.9	10.1*	15.2	4.4

* = estimated assuming all events follow Event 13 ratio between Extent 1 and Extent 2 values (28.5%).

** = estimated assuming Extent 3 value is 1.5 times Extent 2 value based on river miles

Figure 8-1
Differential Flow Rate Calculation for Interceptor between Inkster and Telegraph Roads

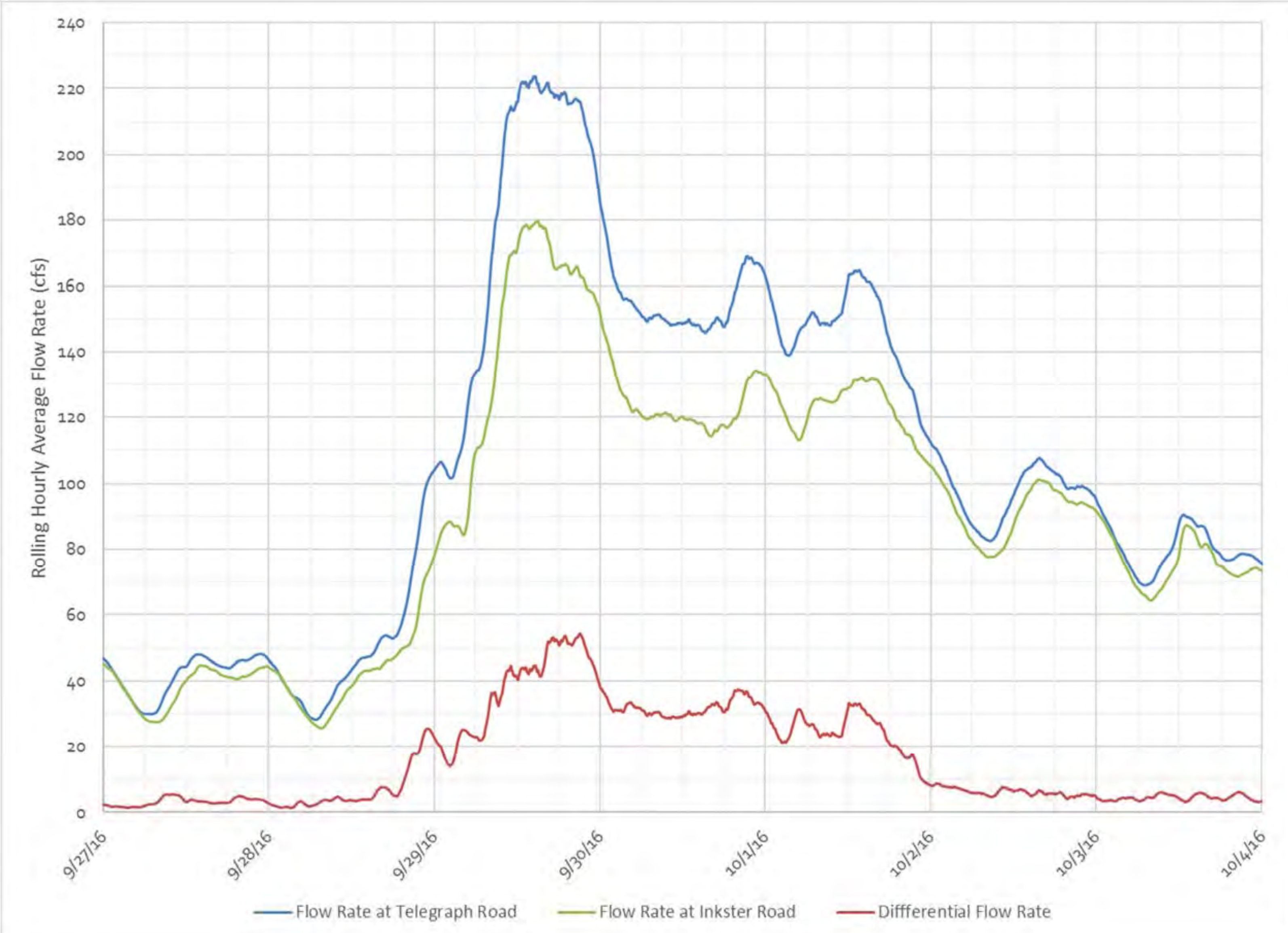


Figure 8-2
Suspected River-Dependent Inflow Calculation for Interceptor between Inkster and Telegraph Roads

Figure 8-3
Suspected River-Dependent Inflow Calculation for Community Line Connection Meters

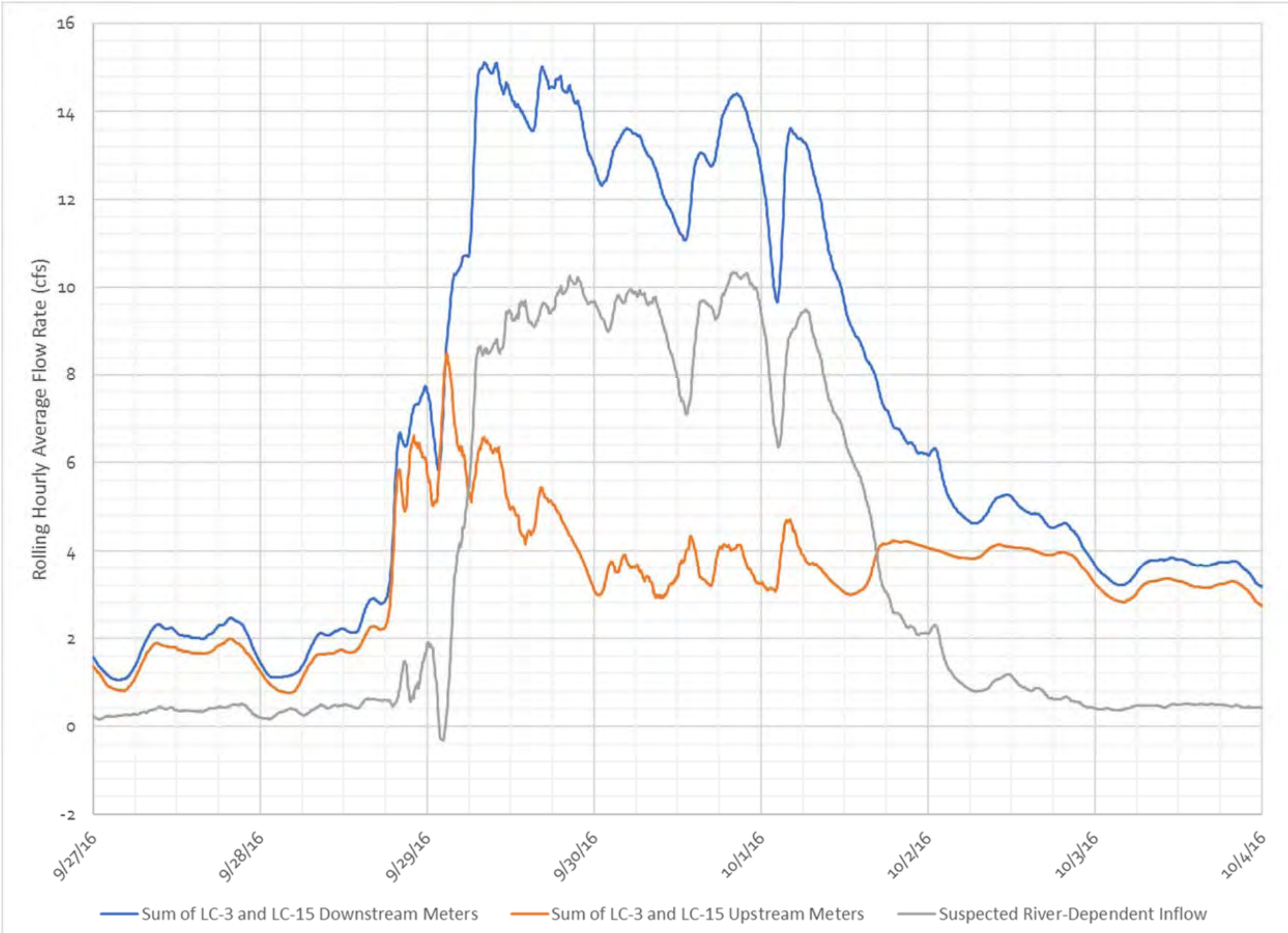
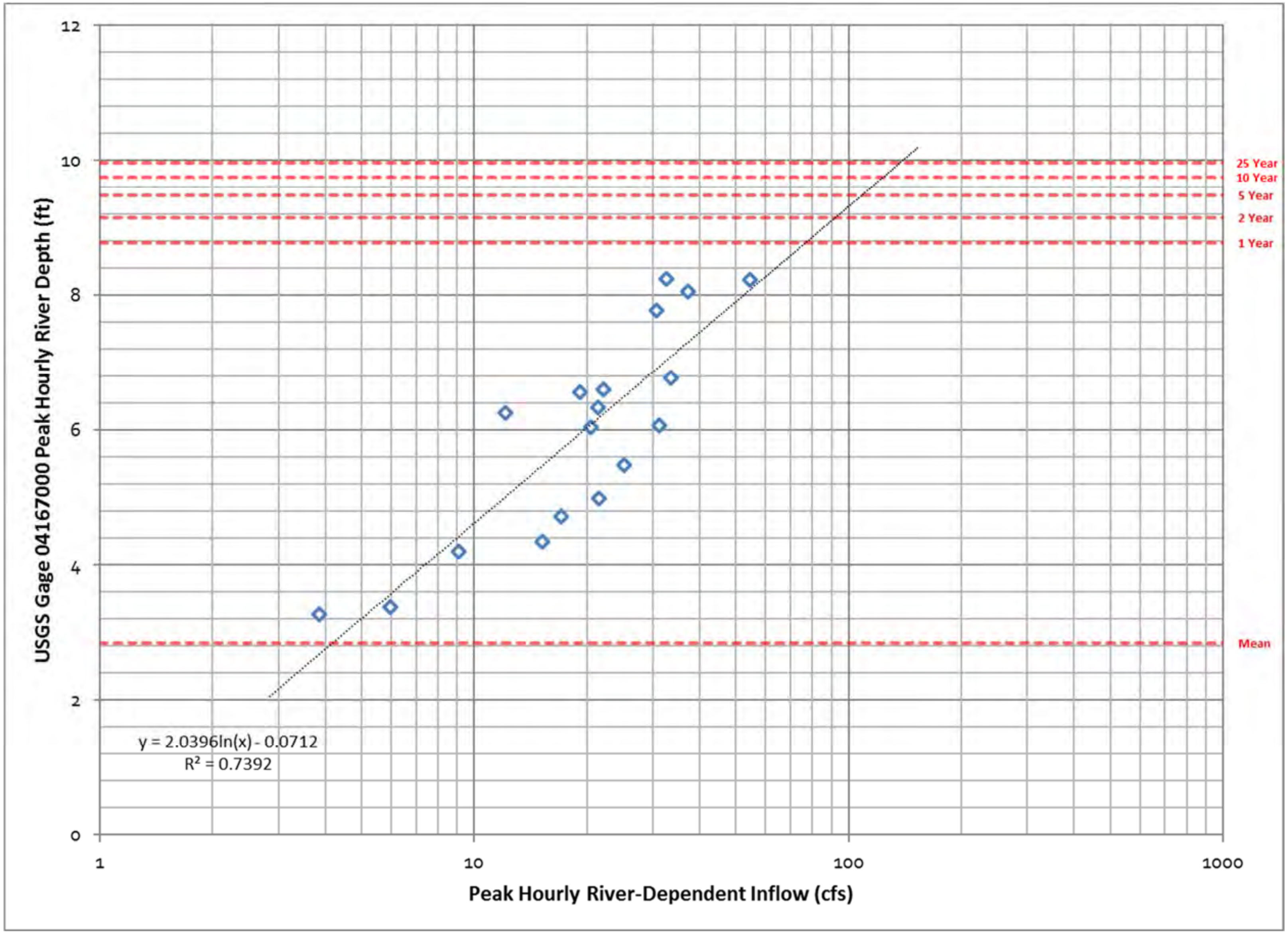


Figure 8-4
Scatterplot of Estimated River-Dependent Inflow versus River Depth



9. Hydrograph Volume Parameters

The parameters that determine the volume of flows generated by a sewage district are determined through an analysis of flow meter data whereby various components of sewage flow are quantified.

Flow Rate Decomposition

The U.S. EPA Sanitary Sewer Overflow Analysis and Planning Toolbox (SSOAP) program was used for decomposition of the total meter flow rate data into its various constituents. SSOAP is a public domain analysis software that was developed by the U.S. EPA. SSOAP may be downloaded for free from the U.S. EPA's website at:

http://www.epa.gov/nrmrl/wswrd/wq/models/ssoap/index.html#download

The flows in a sanitary sewer are divided into the following categories by SSOAP:

- Dry Weather Flows (DWF)
  - Base wastewater (sanitary) flow (BWWF)
  - Groundwater Infiltration (GWI)
- Wet Weather Flows
  - Rainfall derived inflow and infiltration (RDI/I)

First, an average diurnal dry weather flow pattern is determined by statistically selecting dry weather flow days and averaging the value of each timestep on every dry weather day. The dry weather day statistics used in the analysis removed any days that met the following criteria:

- Days with an average flow rate that was greater than two standard deviations of all daily averages;
- Days with less than 100% of the flow rate data; and
- Days during daylight savings time as this creates a skew that SSOAP does not currently have the ability to account for.

The GWI during dry weather days is assumed to be equal to the nighttime minimum flow rate. The GWI during wet weather days is aligned with the recorded data preceding the event and increased until over the event until it matches the recession of the event. Subtracting the total metered flow rate from the estimated DWF trace yields the estimated RDI/I trace for the event.

Event Rainfall

Because of the large land area of the RVSDS and the availability of numerous precipitation gages, the Thiessen polygon method was used to compute a weighted average rainfall depth for each meter district. This method helps reduce the effects of any spatial variability that may have occurred during each event. Since the set of rain gages that were in service varied between each event, the polygons were delineated specifically for each event for the gages in service during that event. The polygons were created using the ESRI ArcMap 10.4 GIS software and are presented in Appendix B along with their weighting values. Table 9-1 presents the computed Theissen polygon area-weighted event rainfall depths by meter district.

Capture Coefficients

The capture coefficient is the fraction of rainfall that fell over the meter district that becomes RDI/I. It is calculated as the quotient of an RDI/I volume and rainfall (both given in inches over the meter district). SWMM utilizes a capture coefficient, along with the shape parameters discussed in the next section, for calculating the volume generated by RDI/I that is to be input into the system model.

The RDI/I trace that was estimated using SSOAP was used to calculate the total event RDI/I volume for each of the nine hydrologic analysis events for each meter. The RDI/I volume was then divided by the event rainfall volume and the meter districts area to determine the event capture coefficient.

Multiple pathways exist for RDI/I to enter the sewer system. For sanitary systems this is mainly through:

- Infiltration through defects in the pipe joints and the sewer and manhole walls;
- Inflow into manholes from either defective, perforated, or missing lids; and
- Inflow from illicit or grandfathered in storm connections from catchbasins, footing drains, and downspouts.

The capture coefficients and RTK parameters in the model attempted to only represent RDI/I from the sources listed above. Capture coefficients can however become affected by two other sources of RDI/I:

(1) If the monitoring location is tributary to regulated flows from combined sewer systems, no single capture coefficient could be used since the flows from each combined sewer system are uniquely impacted by their specific regulator settings. In these districts, the model representation was split between using a capture coefficient from a neighboring district for the sanitary areas and using the subcatchment elements and known regulator settings for the combined areas. The flows generated by this combination were then confirmed during the model calibration.

(2) If the monitoring location is tributary to structures in the floodplain and is experiencing river-dependent inflow, the capture coefficient will be significantly elevated. When available, river-dependent inflow volume estimations were removed from the capture coefficient computation.

(3) If the monitoring location is tributary to upstream diversions into other systems or SSO, the capture coefficient will not reflect this lost flow. Two diversions into other systems exist. The first is upstream of Meters FE29 and FE22 where WTUA can make the operational decision to send flow to either the RVSDS or YCUA. Since WTUA has provided notice that they intend to disconnect from RVSDS by July 1, 2017, the need for deriving hydrologic parameters from these two connections has been eliminated. The second is a diversion upstream of Meter P15 where wet weather flows from Van Buren Township can be diverted to the Downriver Sewage Disposal System; however, this diversion was not operated in the analysis period and therefore the hydrologic parameters were not affected.

Table 9-2 presents the cumulative capture coefficient and Table 9-3 presents the incremental capture coefficients calculated for every meter district for every event.

- Meter District P9+P10+P11 includes upstream Meter P8. This was required as the incremental area of P8 was not sufficiently large enough to accurately determine its capture coefficient.
- Meter L-46 was included in The Meter District P24+P25 area since L-46 is tributary to the regulated flow from a single combined sewer area and the dewatering flow from the Middlebelt RTB. This leads to the flow response being too inconsistent to develop capture coefficients.
- Meter L-34 was included in the Meter District P19 area as L-34 did not have data for the monitoring period.

Combined Sewer Areas

Combined sewer areas were represented in the model using subcatchment elements. The parameters for these subcatchments were taken directly from the GDRSS model and are presented in Table 9-4. The directly connected impervious area (DCIA) percentages were updated to reflect the most recent delineation of community connection service areas by intersecting each area with the Southeast Michigan Counsel of Governments (SEMCOG) land use data. Table 9-5 presents the assumed DCIA percentage for each land use category. Table 9-6 presents the area-weighted DCIAs for each combined sewer area in the RVSDS.

The model does not include a representation of the local sewer networks for the combined districts. Therefore, the peak flow rates generated from the subcatchments may not experience the routing and attenuation provided by these local networks. The GDRSS model parameters were found to inundate the regulators to the point of predicted flooding to grade at the regulators, which is not known to be occurring in reality. In order to more properly represent flows contributed from combined sewer areas, hydraulic adjustments were made to limit the flow rates to the CSO regulators. A flow rate cap was used on the subcatchment routing channel in the model to represent this limitation. The flow rate cap was set to allow a maximum velocity of 5 feet per second through the cross-sectional area of the incoming pipes to the CSO regulator. In some cases where there were multiple combined sewer areas upstream of one regulator, the flow rate cap had to be apportioned to each subcatchment routing channel based on land area. In cases where there were also sanitary inputs upstream of CSO regulators, the apportionment was adjusted to allow for the entire sanitary flow contribution to reach the regulator. Table 9-7 presents the influent flow rate cap attributed to each CSO regulator.

Table 9-1
Thiessen Polygon Rainfall Depths in Inches

Branch	Meter District	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8	Event 9
		8/9/2012	4/10/2013	4/17/2013	5/27/2013	6/12/2013	10/30/2013	8/11/2014	9/10/2014	9/29/2016
Middle Rouge	[BG1]	1.97	1.93	1.81	0.69	1.39	1.50	2.16	1.40	3.39
	[P1]	1.45	2.13	1.67	0.84	1.29	1.55	1.97	1.36	--
	[5710]	--	--	--	--	--	--	--	--	3.66
	[5720]+[Parkway]	--	--	--	--	--	--	--	--	3.86
	[P3]+[P26]	1.43	2.10	1.69	0.85	1.32	1.57	3.32	1.40	3.49
	[C-B-A]	1.43	2.00	1.73	0.89	1.35	1.60	3.83	1.48	3.49
	[FE22]	1.45	2.12	1.67	0.84	1.29	1.55	3.13	1.36	3.57
	[LV16]	1.43	1.97	1.72	1.21	1.79	1.52	3.04	1.53	4.10
	[WE14]	1.16	1.82	1.72	0.98	1.60	1.69	4.75	1.60	3.54
	[LV15]	1.42	2.06	1.71	1.15	1.88	1.73	4.32	1.58	3.72
	[M2]	1.14	1.71	1.69	0.99	1.71	1.72	5.07	1.63	3.56
	[M1]	1.35	2.16	2.05	0.95	1.74	1.91	5.79	1.68	3.39
	[LV14]	1.82	2.00	1.85	1.35	2.00	1.71	3.90	1.59	4.04
	[LV Basin]-[LV4]	1.67	1.86	1.82	1.14	1.55	1.52	3.42	1.44	4.26
	[LV11]+[LV4]	1.53	1.89	1.75	1.17	1.60	1.51	3.21	1.46	4.07
	[P12]	1.43	1.96	1.83	1.34	1.93	1.59	3.24	1.53	4.19
	[P28]	--	--	--	--	--	--	--	--	4.22
	[P29]	--	--	--	--	--	--	--	--	4.02
	[P9]+[P10]+[P11]	1.35	2.00	1.75	1.04	1.65	1.70	4.43	1.58	3.56
	[P13]	1.63	2.16	2.02	1.08	1.79	1.76	3.99	1.60	4.52
	[LC3U]+[LC15RU]+[LC15U]	--	--	--	--	--	--	--	--	3.58
	[P33]+[P34]+[P35]	--	--	--	--	--	--	--	--	3.98
	[LC20U]+[LC20RU]	--	--	--	--	--	--	--	--	3.77
	[P30]+[P31]+[P32]	--	--	--	--	--	--	--	--	3.99
	[WCS2]+[WCS3]+[P14]	1.45	2.20	2.17	1.05	1.63	1.96	5.93	1.71	3.79

Table 9-1 (continued)
Thiessen Polygon Rainfall Depths in Inches

Branch	Meter District	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8	Event 9
		8/9/2012	4/10/2013	4/17/2013	5/27/2013	6/12/2013	10/30/2013	8/11/2014	9/10/2014	9/29/2016
Lower Rouge	[P15]	0.99	2.00	2.01	0.87	1.24	1.89	2.76	1.63	3.59
	[P17]	0.90	1.95	1.79	0.85	1.24	1.89	3.38	1.52	3.76
	[FE19]	1.18	1.93	1.81	0.87	1.23	1.77	3.33	1.56	3.77
	[WE25]	1.13	1.85	1.74	0.87	1.26	1.77	3.56	1.55	4.09
	[P19]	1.07	1.82	1.74	0.88	1.21	1.74	3.71	1.59	4.15
	[WE28]	1.12	1.67	1.69	0.96	1.53	1.70	5.11	1.64	3.52
	[P20]+[P21]	1.09	1.82	1.76	0.92	1.25	1.69	4.60	1.65	3.57
	[P24]+[P25]	1.18	2.19	2.07	0.93	1.29	1.76	5.75	1.67	3.45

Table 9-2
Cumulative Capture Coefficients

Branch	Meter District	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8	Event 9
		8/9/2012	4/10/2013	4/17/2013	5/27/2013	6/12/2013	10/30/2013	8/11/2014	9/10/2014	9/29/2016
Middle Rouge	[BG1]	0.05%	0.25%	0.43%	0.13%	0.27%	0.16%	0.14%	0.23%	0.21%
	[P1]	0.13%	0.34%	0.63%	0.15%	0.37%	0.20%	0.15%	0.31%	--
	[5710]	--	--	--	--	--	--	--	--	0.53%
	[5720]+[Parkway]	--	--	--	--	--	--	--	--	0.92%
	[P3]+[P26]	0.15%	0.43%	0.71%	0.18%	0.38%	0.22%	0.12%	0.33%	0.34%
	[P7]-$[P26]_R$	0.33%	1.65%	2.94%	0.60%	2.66%	0.67%	1.68%	0.92%	0.68%
	[C-B-A]	1.27%	3.09%	5.48%	0.73%	0.77%	1.63%	4.49%	2.86%	4.12%
	[LV16]	1.56%	3.28%	3.65%	3.02%	3.65%	2.18%	2.69%	3.10%	2.32%
	[WE14]	N/A	1.17%	1.61%	0.60%	1.16%	0.36%	1.17%	0.88%	1.03%
	[LV15]	3.32%	6.20%	9.92%	3.84%	6.02%	4.23%	5.83%	7.36%	7.44%
	[M2]	1.46%	6.55%	9.36%	2.19%	6.08%	3.11%	5.48%	6.01%	5.06%
	[M1]	3.70%	10.33%	16.00%	4.08%	10.54%	5.45%	6.66%	6.95%	11.02%
	[LV14]	1.13%	4.61%	6.32%	1.62%	5.16%	2.76%	3.71%	5.47%	3.92%
	[LV Basin]-[LV4]	0.35%	0.67%	0.86%	0.63%	0.59%	0.35%	0.55%	0.72%	1.01%
	[LV11]+[LV4]	0.70%	2.05%	2.61%	0.60%	1.55%	1.01%	0.93%	1.09%	1.47%
	[P12]	0.42%	1.27%	1.72%	0.46%	1.06%	0.73%	1.11%	0.97%	1.21%
	[P28]	--	--	--	--	--	--	--	--	0.98%
	[P29]	--	--	--	--	--	--	--	--	0.78%
	[P9]+[P10]+[P11]	0.99%	2.44%	3.87%	0.92%	2.14%	1.19%	1.57%	1.89%	1.68%
	[P13]	1.47%	3.16%	4.57%	2.71%	3.34%	2.07%	3.07%	3.24%	3.56%
	[LC3U]+[LC15RU]+[LC15U]	--	--	--	--	--	--	--	--	5.44%
	[P33]+[P34]+[P35]	--	--	--	--	--	--	--	--	2.64%
	[LC20U]+[LC20RU]	--	--	--	--	--	--	--	--	16.61%
	[P30]+[P31]+[P32]	--	--	--	--	--	--	--	--	2.83%
	[WCS2]+[WCS3]+[P14]	1.26%	3.29%	4.46%	1.69%	4.91%	1.39%	2.13%	2.70%	2.84%

Table 9-2 (continued)
Cumulative Capture Coefficients

Branch	Meter District	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8	Event 9
		8/9/2012	4/10/2013	4/17/2013	5/27/2013	6/12/2013	10/30/2013	8/11/2014	9/10/2014	9/29/2016
Lower Rouge	[P15]	0.14%	0.39%	0.49%	0.19%	0.33%	0.19%	0.18%	0.27%	0.15%
	[P17]	0.21%	0.46%	0.71%	0.26%	0.35%	0.23%	0.27%	0.34%	0.30%
	[WE25]	N/A	1.72%	2.15%	0.75%	1.61%	0.73%	1.56%	1.45%	0.88%
	[P19]	0.24%	1.10%	1.70%	0.40%	1.10%	0.55%	1.01%	1.10%	0.38%
	[WE28]	N/A	3.04%	4.98%	0.80%	2.44%	0.98%	2.78%	2.33%	2.63%
	[P20]+[P21]	0.40%	1.99%	2.59%	0.82%	1.65%	0.98%	1.50%	1.59%	1.10%
	[P24]+[P25]	1.24%	3.93%	6.68%	1.52%	2.49%	1.87%	1.86%	2.44%	0.87%
Total RVSDS		**1.67%**	**4.80%**	**6.86%**	**1.75%**	**5.44%**	**1.20%**	**2.19%**	**3.16%**	**2.31%**

Table 9-3
Incremental Capture Coefficients

Branch	Meter District	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8	Event 9
		8/9/2012	4/10/2013	4/17/2013	5/27/2013	6/12/2013	10/30/2013	8/11/2014	9/10/2014	9/29/2016
Middle Rouge	[BG1]	0.05%	0.25%	0.43%	0.13%	0.27%	0.16%	0.14%	0.23%	0.21%
	[P1]	0.98%	1.94%	2.98%	0.62%	1.39%	0.77%	0.09%	1.30%	--
	[5710]	--	--	--	--	--	--	--	--	0.53%
	[5720]+[Parkway]	--	--	--	--	--	--	--	--	0.92%
	[P3]+[P26]	0.59%	2.05%	2.53%	0.83%	0.81%	0.83%	0.78%	0.91%	0.89%
	[P7]-[P26]$_R$	0.33%	1.65%	2.94%	0.60%	2.66%	0.67%	1.68%	0.92%	0.92%[1]
	[C-B-A]	1.27%	3.09%	5.48%	0.73%	0.77%	1.63%	4.49%	2.86%	4.12%
	[LV16]	1.56%	3.28%	3.65%	3.02%	3.65%	2.18%	2.69%	3.10%	2.32%
	[WE14]	N/A	1.17%	1.61%	0.60%	1.16%	0.36%	1.17%	0.88%	1.03%
	[LV15]	3.32%	6.20%	9.92%	3.84%	6.02%	4.23%	5.83%	7.36%	7.44%
	[M2]	1.46%	6.55%	9.36%	2.19%	6.08%	3.11%	5.48%	6.01%	5.06%
	[M1]	3.70%	10.33%	16.00%	4.08%	10.54%	5.45%	6.66%	6.95%	11.02%
	[LV14]	1.13%	4.61%	6.32%	1.62%	5.16%	2.76%	3.71%	5.47%	3.92%
	[LV Basin]-[LV4]	0.35%	0.67%	0.86%	0.63%	0.59%	0.35%	0.55%	0.72%	1.76%
	[LV11]+[LV4]	0.70%	2.05%	2.61%	0.60%	1.55%	1.01%	0.93%	1.09%	1.47%
	[P12]	0.85%	5.34%	6.45%	0.63%	4.81%	1.94%	0.86%	1.82%	1.50%
	[P28]	--	--	--	--	--	--	--	--	0.98%
	[P29]	--	--	--	--	--	--	--	--	0.78%
	Group [P9]+[P10]+[P11]	1.27%	11.42%	13.77%	0.27%	3.18%	1.82%	1.40%	4.43%	4.81%
	[P13]	1.47%	3.16%	4.57%	2.71%	3.34%	2.07%	3.07%	3.24%	3.56%
	[LC3U]+[LC15RU]+[LC15U]	--	--	--	--	--	--	--	--	5.44%
	[P33]+[P34]+[P35]	--	--	--	--	--	--	--	--	5.44%[2]
	[LC20U]+[LC20RU]	--	--	--	--	--	--	--	--	16.61%
	[P30]+[P31]+[P32]	--	--	--	--	--	--	--	--	5.44%[2]
	[WCS2]+[WCS3]+[P14]	4.77%	16.84%	21.32%	9.47%	40.93%	4.99%	14.11%	13.88%	5.44%[2]

Table 9-3 (continued)
Incremental Capture Coefficients

Branch	Meter District	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8	Event 9
		8/9/2012	4/10/2013	4/17/2013	5/27/2013	6/12/2013	10/30/2013	8/11/2014	9/10/2014	9/29/2016
Lower Rouge	[P15]	0.14%	0.39%	0.49%	0.19%	0.33%	0.19%	0.18%	0.27%	0.15%
	[P17]	0.34%	0.58%	1.10%	0.44%	0.40%	0.33%	0.56%	0.45%	0.68%
	[WE25]	N/A	1.72%	2.15%	0.75%	1.61%	0.73%	1.56%	1.45%	0.88%
	[P19]	1.48%	3.28%	7.57%	0.75%	4.29%	2.51%	4.97%	5.79%	5.79%[1]
	[WE28]	N/A	3.04%	4.98%	0.80%	2.44%	0.98%	2.78%	2.33%	2.63%
	[P20]+[P21]	N/A	6.27%	6.06%	3.23%	3.90%	3.31%	4.13%	4.00%	3.66%
	[P24]+[P25]	4.30%	11.97%	22.47%	4.03%	5.64%	5.16%	4.18%	5.48%	3.72%[3]
Total RVSDS		**1.67%**	**4.80%**	**6.86%**	**1.75%**	**5.44%**	**1.20%**	**2.19%**	**3.16%**	**2.31%**

Replacement methods when incremental captures did not yield reasonable value:

1. Used Event 8 incremental capture coefficient
2. Used [LC3U]+[LC15RU]+[LC15U] incremental capture coefficient
3. Used GDRSS model 25 year, 24 hour design event incremental capture coefficient for this same meter district

Table 9-4
Subcatchment Parameters Obtained from GDRSS Model

Runoff Parameters

Average surface slope:	1%
Average surface length:	100 ft
Manning's coefficient of impervious areas:	0.014
Manning's coefficient of pervious areas:	0.2
Depression storage of impervious areas:	0.06 in
Depression storage of pervious areas:	0.29 in
Percent of impervious area with no depression storage:	25%

Infiltration Parameters

Infiltration method:	Horton
Maximum growing season infiltration rate:	2.9 in/hr
Maximum non-growing season infiltration rate:	0.2 in/hr
Minimum infiltration rate:	0.2 in/hr
Decay constant:	4.68 hr^{-1}
Time to fully dry*:	~~0.01781 days~~ 9.8 days

*Time to fully dry in GDRSS subcatchment parameters was found to be incorrect and was adjusted as shown.

Table 9-5
DCIA Assumptions for SEMCOG Land Use Categories

Land Use Category	DCIA
Commercial	32%
Governmental / Institutional	32%
Industrial	49%
Airport	90%
Multiple-Family Residential	20%
Single-Family Residential	10%
Parks, Recreation, and Open Space	0%
Transportation, Communication, Utility	60%
Agricultural	0%
Water	0%

Table 9-6
Area Weighted DCIA Percentages

Community Connection ID	Community	Commercial	Governmental / Institutional	Industrial	Airport	Multiple-Family Residential	Single-Family Residential	Parks, Recreation, and Open Space	TCU	Agricultural	Water	Area Weighted DCIA
4	Dearborn Heights	--	--	--	--	--	25.7	--	9.7	--	--	23.7%
7	Dearborn Heights	7.3	0.3	0.7	--	--	96.0	0.1	47.6	--	--	26.9%
9	Dearborn Heights	1.2	--	--	--	--	19.4	--	8.8	--	--	25.9%
10	Dearborn Heights	11.0	1.1	0.4	--	1.0	42.2	--	32.0	--	--	31.6%
11	Dearborn Heights	3.8	5.1	--	--	--	37.1	--	27.8	--	--	31.5%
12	Dearborn Heights	4.4	4.1	0.4	--	--	41.0	--	23.4	--	--	28.7%
13	Dearborn Heights	2.8	--	--	--	--	72.7	--	41.4	--	--	28.2%
16	Dearborn Heights	6.4	--	--	--	--	46.3	0.3	32.1	--	--	30.5%
17	Dearborn Heights	5.1	--	--	--	--	41.6	0.1	24.8	--	--	28.9%
22	Dearborn Heights	4.0	--	--	--	--	20.7	--	11.3	--	--	28.1%
23	Dearborn Heights	--	--	--	--	--	79.5	--	21.7	--	--	20.7%
28	Inkster	8.1	51.4	--	--	1.0	245.9	2.3	98.9	--	--	25.3%
29	Inkster	2.8	--	--	--	--	76.1	1.0	34.3	--	--	25.5%
31	Inkster	2.5	--	--	--	--	24.3	--	11.0	--	--	26.0%
43	Inkster	21.2	2.2	3.7	--	4.5	15.8	--	17.9	--	--	34.5%
45	Inkster	8.8	3.0	10.8	--	--	25.8	0.5	26.0	--	--	36.4%
46	Inkster	10.7	7.8	--	--	--	11.2	--	12.4	--	--	34.4%
48	Inkster	6.1	--	--	--	--	5.8	--	7.2	--	--	35.9%
49	Inkster	0.6	--	--	--	--	20.6	--	9.1	--	--	25.5%
50	Inkster	--	--	--	--	--	23.8	--	8.9	--	--	23.6%
52	Dearborn Heights	34.0	21.6	33.6	--	--	100.1	--	75.2	--	--	33.8%
52	Inkster	9.7	16.1	--	--	7.2	122.6	--	53.7	--	--	25.9%
105	Redford Township	40.6	39.7	9.5	--	--	558.9	5.9	259.3	--	--	26.5%
106	Redford Township	--	9.4	--	--	--	25.2	--	16.8	--	--	30.4%
107	Redford Township	0.4	--	--	--	--	52.1	0.2	24.3	--	--	25.9%
113	Redford Township	--	9.3	--	--	--	91.9	--	46.6	--	--	27.1%
114	Redford Township	0.3	0.8	--	--	--	24.8	23.2	17.2	--	--	19.8%
115	Redford Township	0.4	--	--	--	--	21.0	--	9.8	--	--	26.0%
116	Redford Township	2.3	37.8	20.4	--	--	227.0	--	149.2	--	--	30.9%
120	Redford Township	5.2	8.8	--	--	--	106.4	--	60.9	--	--	28.5%
121	Redford Township	--	--	--	--	--	77.4	--	38.1	--	--	26.5%
122	Redford Township	106.9	143.1	207.4	--	2.1	699.5	5.7	428.7	--	0.2	32.0%
193	Inkster	--	--	--	--	--	5.0	--	1.8	--	--	23.2%
199	Dearborn Heights	0.8	--	--	--	--	9.1	--	6.9	--	--	31.6%

Table 9-7
Cap on Influent Flows to Each RVSDS Regulator

Reach	NPDES Permit ID	Incoming Pipe Diameter 1 (ft)	Incoming Pipe Diameter 2 (ft)	Total Cross Sectional Area of Incoming Pipe (ft^2)	Flow Cap to CSO Regulator (cfs)
Middle Rouge	M-3A	1	--	0.79	3.93
	M-13	2	--	3.14	15.71
	M-14	2.5	0.83	5.45	27.27
	M-15	3.5	--	9.62	48.11
	M-16	3	--	7.07	35.34
	M-17	2.5	--	4.91	24.54
	M-18	4.5	--	15.90	79.52
	M-19	0.83	2.5	5.45	27.27
	M-33	2.5	--	4.91	24.54
	U-1	2	--	3.14	15.71
	U-2	5.5	3	30.83	154.13
	U-3	2	--	3.14	15.71
	U-4	2	--	3.14	15.71
	U-5	3	--	7.07	35.34
	U-6	5	--	19.63	98.17
	U-7	2	--	3.14	15.71
	U-8	2	--	3.14	15.71
	U-9	2.5	--	4.91	24.54
	U-10	2	--	3.14	15.71
	U-11	3.5	--	9.62	48.11

Table 9-7 (continued)
Cap on Influent Flows to Each RVSDS Regulator

Reach	NPDES Permit ID	Incoming Pipe Diameter 1 (ft)	Incoming Pipe Diameter 2 (ft)	Total Cross Sectional Area of Incoming Pipe (ft^2)	Flow Cap to CSO Regulator (cfs)
Lower Rouge	John Daly PS	4.5	3	22.97	114.86
	L-38	3.25	3.5	17.92	89.58
	L-39	5.5	--	23.76	118.79
	L-40	1.25	--	1.23	6.14
	L-41	4	--	12.57	62.83
	L-42	4.5	--	15.90	79.52
	L-43	1	2	3.93	19.63
	L-44	1	--	0.79	3.93
	L-45	1.25	--	1.23	6.14
	L-46	5	--	19.63	98.17
	L-47	2.75	--	5.94	29.70
	L-48	4	--	12.57	62.83

10. Hydrograph Shape Parameters

Once the volume of wet weather flow is quantified by determining the capture coefficients as detailed in the previous section, the distribution of this volume over time was quantified. This is achieved by utilizing a unit hydrograph method. SWMM uses the RTK method for distributing the RDI/I generated by a sanitary area during wet weather.

R, T, and K are the parameters that define the size and shape of the response hydrograph. The first parameter, R, is the capture coefficient. The second parameter, T, is the time (in hours) from the start of rainfall to the peak of the unit hydrograph. The last parameter, K, is the ratio of time to recession to the time to peak.

SWMM uses the summation of three RTK unit hydrographs to create a response. For this analysis, the values of the three RTK unit hydrographs were constrained to typically fall in the ranges shown in Table 10-1 to represent the fast, medium, and slow responses in the sewer system. This allows a quantification to be made as to how flashy the inflow occurs and allows for comparisons to be made to other meter districts.

An optimization spreadsheet was developed that uses Microsoft Excel's Solver Add-in Analysis Tool to adjust RTK parameters within the bounds of Table 9-1 until the sum of the squares of the difference between the metered and computed RDI/I responses was minimized. This spreadsheet allows RTK parameters to be fit to one or multiple events by specifying a weighting factor for each. It also displays how well the RTK parameters fit other events that were not used in the determination for verification purposes.

The RTK parameters were developed using the September 10, 2014 event (Hydraulic Analysis Event No. 8). Event 8 was a spatially uniform, single peaked event. Multiple peak events were excluded from the optimization because of the difficulty in determining a single set of parameters that provide flow rates that match all peaks. Table 10-2 presents the optimized RTK parameters used as input into the SWMM model for the independent meter districts and Appendix C presents the detailed optimizer spreadsheet results for each analyzed flow meter.

The shaping factors for the RTK unit hydrographs were only determined for the independent flow meters. This is because determining these parameters for dependent meters requires removing the influence of upstream meters through subtraction. Because of travel time differences and inherent meter inaccuracies, this subtraction leads to much uncertainty in the results. Instead, the RTK parameters for the dependent districts were assigned the average values of the independent districts.

Meter P13 was excluded from the analyzed independent meters since it is highly affected by combined sewage flows; instead, it was assigned the average RTK parameters. Likewise, a few meter districts were observed during the calibration process to not perform well with the average RTK parameters. Instead, these meter districts were assigned the following RTK parameters from a neighboring independent meter district:

- Meter District [LC20U]+[LC20RU] was assigned the Meter [LV14] RTK parameters
- Meter District [LC3U]+[LC15RU]+[LC15U] was assigned the Meter [LV14] RTK parameters
- Meter District [P20]+[P21] was assigned Meter [WE28] RTK parameters

Table 10-1
Typical Ranges of RTK Parameters for Analysis

Triangle No.	R (fraction)		T (hrs)		K (ratio)	
	Lower	Upper	Lower	Upper	Lower	Upper
(1) Fast	0.00	1.00	0.25	1.50	1.00	3.00
(2) Medium	0.00	1.00	1.50	3.00	1.00	6.00
(3) Slow	0.00	1.00	3.00	8.00	1.00	12.00

Table 10-2
RTK Parameters for Independent Meter Districts

Meter	R Fraction of Total Capture			T, Time to Peak (hours)			K, Recession Multiplier		
	1	2	3	1	2	3	1	2	3
[BG1]	0.00	0.51	0.49	1.50	2.89	3.82	3.00	1.00	6.35
[LVBASIN]-[LV4]	0.07	0.53	0.40	1.25	3.00	7.00	1.00	2.80	2.71
[LV11]+[LV4]	0.18	0.35	0.47	0.38	1.50	3.00	3.00	4.23	6.85
[LV14]	0.27	0.29	0.44	0.64	2.47	7.59	3.00	3.30	3.37
[LV15]	0.20	0.48	0.32	0.90	3.00	3.00	3.00	6.00	11.37
[LV16]	0.21	0.27	0.52	0.31	1.58	5.93	3.00	3.11	4.19
[M1]	0.24	0.06	0.71	1.26	1.50	3.75	3.00	3.00	6.52
[M2]	0.07	0.41	0.52	0.60	2.27	7.75	3.00	3.78	3.52
[P15]	0.01	0.38	0.61	1.12	1.51	5.40	1.77	5.95	5.36
[WE14]	0.08	0.26	0.66	1.50	3.00	3.75	3.00	6.00	1.19
[WE25]	0.16	0.22	0.63	1.10	2.76	3.25	3.00	1.87	8.50
[WE28]	0.18	0.51	0.30	1.50	3.00	3.00	3.00	2.69	11.23
Total Average	**0.14**	**0.36**	**0.50**	**1.02**	**2.39**	**4.72**	**2.73**	**3.68**	**5.97**
Lower Rouge Only	0.12	0.37	0.51	1.24	2.42	3.88	2.59	3.51	8.36
Middle Rouge Only	0.15	0.35	0.49	0.95	2.38	5.00	2.78	3.74	5.17

11. Model Calibration

An initial calibration attempt in summer 2015 was made to the September 14, 2014 event (Hydrologic Analysis Event No. 8); however, in the Middle Rouge interceptors between Inkster Road and the RVSDS outlet, the results of this effort predicted depths that did not reach observed depths with any reasonable hydraulic parameters. Possible explanations determined at that time included:

- Existence of unknown blockages or restrictions;
- Inadequate venting of air;
- Greater than expected hydraulic losses occurring along the pipes and in structures; and
- River-dependent inflow.

Each possible explanation was reviewed in the extended monitoring period. First, a field investigation of select siphons, low-head crossings, and major confluences was completed in 2015 and 2016. The results of these investigations revealed no significant blockages or restrictions except for sediment taking up approximately 20% of the pipe depth in Siphon No. 4. The representation of this siphon was updated in the model to account for this and yielded a minimal impact.

Any inadequate venting of air was addressed through the construction of seven new ventilation structures along the Middle Rouge interceptor. It is difficult to determine the hydraulic issues arising from air movements and represent such an improvement in the hydraulic model as air calculations are not included in the model's computations. However, these venting points will only improve the hydraulics of the pipes and the result of which will hopefully manifest in future monitoring data.

It was determined that the most likely cause for this discrepancy was a combination of greater than expected hydraulic losses and unaccounted for river-dependent inflow. With the river-dependent inflow now accounted for thanks to the improved metering efforts, a successful calibration attempt was made to the September 29, 2016 event (Hydrologic Analysis Event No. 9). For this calibration, the Manning's roughness coefficient was raised from 0.014 typically assumed for concrete pipe in the RVSDS to 0.016 along the three parallel Middle Rouge interceptors from Telegraph to the Middle Rouge outlet. This increase to roughness coefficient is not intended to be an indication that this pipe is particularly rough. Instead, it is a representation that there are additional hydraulic losses in this part of the system that could be due to some combination of higher than normal actual pipe roughness, debris accumulation, partial blockages in the interceptors or in the balancing pipes between the interceptors, or greater than expected losses occurring in structures.

Direct Timeseries Inputs

Some flow components of the RVSDS consist of either operational decisions specific to the calibration event or complicated hydrologic phenomena that have more simplified representations in the design event model. Therefore, loading these flows as a timeseries is the easiest way to build the total flow experienced in the RVSDS and achieve a proper calibration. These included:

- The underlying DWF portion of the monitoring data delineated using SSOAP, distributed by the area of each tributary line connection;
- The river-dependent inflow determined directly by the temporary line connection meters and estimated by the relationship to river level developed in Section 8, distributed evenly to each structure in the floodplain;
- Discharges from RTB dewatering activities obtained from SCADA;
- Discharges from WTUA as recorded by Meters FE-19 and FE-22; and
- The backwater condition imposed by the GLWA system as recorded by Meters JC 1-18A and WC-S-1A.

Special Observations and Assumptions

The recorded depth at Meter JC 2-8 in the lower end of the Middle Rouge near LS1A was found to still be higher than the model result. This was perplexing as LS1A is designed to maintain the levels in this region in the fashion that the model was predicting. Two reasons for this unexpected backwater were surmised:

- Clogging of the inlet screens at Sluice Gates 1 and 2; and/or
- The weir plate at Junction Chamber 1 is installed at too high of a level.

In spring 2015, the influent weir at Junction Chamber 1 was inspected by Wade Trim and it was found that no weir plate was installed and that the crest of the base weir wall is at the springline of the interceptor. The model was updated to this representation and it yielded little impact. It was assumed then that the issue must be clogging of the screens. In order to match the depths observed during the calibration event, the screens at Sluice Gates 1 and 2 were assumed to be fully blinded. Such conditions have been directly observed in the field after wet weather events and it is recommended that the screens be monitored to better understand the frequency and extent that such clogging occurs. Under such conditions, the model predicts that LS1A is unable to deliver its rated capacity of 250 cfs.

Calibration Results

Tables 11-1 through 11-5 present summary values for the calibration results and Appendix D presents the meter to model calibration plots for each individual meter and Appendix E presents the meter to model calibration plots for each meter summation. The following thresholds were set to define acceptable calibration between the recorded and modeled values:

- Within 20% of the maximum flow rate,
- Within 15% of the total volume, and
- Within 20% of the maximum depth.

When these thresholds were exceeded, the model input parameters were reviewed and revised as necessary. Some cases were identified whereby the threshold could reasonably be exceeded without further need for parameter adjustment. These cases are identified and described in the calibration result tables.

Maximum HGL profiles were created for each reach of the RVSDS and are presented in Appendix F. These profiles also include the maximum metered depths at each monitoring point.

Table 11-1
Summary of Flow Rate Calibration Results for Individual Meters for the September 14, 2014 Event

Reach	Individual Meters	Maximum Flow Rate (cfs) Metered	Maximum Flow Rate (cfs) Modeled	Difference	See Notes
Middle Rouge	BG1	17.8	17.2	-3%	
	5720	0.9	0.4	-58%	A
	5710	1.0	1.0	2%	
	Parkway	--	2.5	--	
	P01	19.9	20.7	4%	
	P03	22.6	20.0	-12%	
	P26	3.8	4.4	14%	
	FE22	17.5	17.4	0%	
	P08	24.9	22.9	-8%	
	P07	3.6	6.1	69%	B
	LV16	6.2	5.5	-10%	
	LV15	9.9	9.8	-1%	
	WE14	10.4	10.7	3%	
	M2	13.0	14.4	11%	
	M1	21.3	24.1	13%	
	LV14	10.6	9.8	-8%	
	P28	7.4	6.4	-14%	
	P29	12.4	11.6	-6%	
	LV04	8.8	9.4	7%	
	LVBasin	26.8	26.0	-3%	
	LV11	17.3	17.3	0%	
	P12	47.0	44.2	-6%	
	P09	25.9	27.7	7%	
	P10	87.1	94.3	8%	
	P11	36.1	35.4	-2%	
	LC03U	3.8	1.9	-50%	C
	LC03D	7.1	6.2	-12%	
	LC15RU	21.8	11.8	-46%	C
	LC15RD	24.2	17.0	-30%	C
	LC15U	6.2	9.7	57%	C
	LC15D	9.2	15.5	69%	C
	P13	46.3	51.6	11%	
	P33	40.2	43.2	7%	
	P34	96.4	95.2	-1%	
	P35	50.4	48.4	-4%	
	P30	58.7	58.9	0%	

Notes

A. This Is a new meter with somewhat questionable data for this event. The peak metered flow rate appears to be a single erroneous spike.

B. The peak flow rate measured at the next upstream location, Meter P26, is in good agreement. In order to also be in good agreement at Meter P7 there would need to be practically no incremental flow rates. It is believed that Meter P7 is underreporting peak flow rates and the current dye-dilution adjustment factor of 0.67 may not apply to wet weather flow rates.

C. Individually these meters vary between under and over reporting the flow rates, however, summed together they represent the total flow coming out of a single Dearborn Heights area. This total flow rate is in good agreement and if the individual arms are to be brought into better agreement a more thorough representation of the Dearborn Heights system needs to be implemented in the RVSDS model. This was deemed outside of the scope of this current modeling effort.

Table 11-1 (continued)
Summary of Flow Rate Calibration Results for Individual Meters for the September 14, 2014 Event

Reach	Individual Meters	Maximum Flow Rate (cfs)		Difference	See Notes
		Metered	Modeled		
Middle Rouge	P31	118.6	108.9	-8%	
	P32	57.6	69.6	21%	D
	LC20U	4.8	5.1	6%	
	LC20RU	1.4	1.5	14%	
	LC20D	2.3	2.1	-10%	
	LC20RD	4.0	4.5	12%	
	P14	104.8	110.6	6%	
Lower Rouge	FE19	7.1	7.1	0%	
	P15	2.6	2.7	4%	
	P17	6.9	6.8	-1%	
	WE25	7.7	7.0	-9%	
	L-34	--	2.3	--	
	P19	23.2	22.2	-4%	
	WE28	6.2	6.3	1%	
	P20	13.9	15.3	10%	
	P21	29.6	30.1	2%	
	L-46	5.1	4.8	-6%	
	P24	15.9	29.5	86%	E
	P25	42.3	41.7	-1%	
	WCS1A	169.4	165.2	-2%	
	WCS1	177.7	165.2	-7%	

Notes

D. This meter is one of three parallel interceptor neighbors that when viewed as a total do not exceed the threshold. Therefore, by itself, this meter was allowed to exceed the threshold.

E. The flow rates observed at the upstream and downstream meters suggest that this meter is under-reporting wet weather flow rates. Particularly since the next downstream location, Meter WC-S-1A, is in good agreement and there are no flow inputs between them.

Table 11-2
Summary of Flow Rate Calibration Results for Meter Summations for the September 14, 2014 Event

Meter Summations	Maximum Flow Rate (cfs)		Difference	See Notes
	Metered	Modeled		
P03+P26	26.3	24.4	-8%	
LV04+LV11	25.8	26.4	3%	
P09+P10+P11	145.2	154.4	6%	
LC03U+LC15RU+LC15U	28.3	22.8	-20%	
LC03D+LC15RD+LC15D	39.1	36.2	-7%	
P33+P34+P35	183.5	181.7	-1%	
P30+P31+P32	230.2	237.1	3%	
P30+P31+P32+LC15U	232.6	245.4	6%	
LC20U+LC20RU	6.1	6.7	10%	
LC20D+LC20RD	6.2	6.6	6%	
P14+WCS2+WCS3	226.5	289.8	28%	A
P20+P21	42.3	45.4	7%	
P24+P25	52.5	69.8	33%	B
P14+P24+P25+WCS2+WCS3	275	356.9	30%	B
WCS1A+WCS2+WCS3	299.9	355.1	18%	
WCS1+WCS2+WCS3	304.9	355.1	16%	

Notes

A. It is suspected that the measured flow rate at either or both Meters WC-S-2 and WC-S-3 is being under-reported. The incremental hydrologic parameters derived for this meter district yielded unreasonable results and instead this district was assigned the parameters from a neighboring area. The throughput predicted by the model at LS1A was reviewed against SCADA information and found to be in good agreement.

B. The discrepancy at these monitoring locations is driven by the individual result for Meter P24, explained prior in Table 11-1 Note E.

Table 11-3
Summary of Volume Calibration Results for Individual Meters for the September 14, 2014 Event

Reach	Individual Meters	Volume (ft^3) Metered	Volume (ft^3) Modeled	Difference	See Notes
Middle Rouge	BG1	2,551,392	2,617,915	3%	
	5720	41,749	48,809	17%	A
	5710	192,123	194,581	1%	
	Parkway	--	303,704	--	
	P01	3,128,961	3,158,946	1%	
	P03	3,990,513	3,981,205	0%	
	P26	265,347	254,689	-4%	
	FE22	3,082,833	3,078,253	0%	
	P08	4,297,281	4,277,287	0%	
	P07	545,076	680,577	25%	B
	LV16	1,010,187	962,530	-5%	
	LV15	1,711,215	1,688,103	-1%	
	WE14	2,356,197	2,395,498	2%	
	M2	2,572,224	2,618,674	2%	
	M1	3,785,163	3,801,480	0%	
	LV14	1,498,011	1,496,634	0%	
	P28	1,091,352	811,643	-26%	C
	P29	1,668,051	1,629,282	-2%	
	LV04	1,654,965	1,736,457	5%	
	LVBasin	5,056,278	5,002,907	-1%	
	LV11	2,128,773	1,966,494	-8%	
	P12	8,036,751	7,938,572	-1%	
	P09	4,458,180	5,686,345	28%	D
	P10	15,157,695	17,650,279	16%	D
	P11	8,179,026	7,584,737	-7%	
	LC03U	529,440	279,450	-47%	E
	LC03D	1,182,687	955,343	-19%	E
	LC15RU	2,271,900	1,851,977	-18%	E
	LC15RD	2,393,661	2,161,251	-10%	
	LC15U	713,991	1,633,240	129%	E
	LC15D	2,058,408	2,943,645	43%	E
	P13	8,162,352	10,254,192	26%	E
	P33	9,016,035	8,768,931	-3%	
	P34	16,387,743	16,845,621	3%	
	P35	10,288,812	11,252,110	9%	
	P30	11,625,546	10,189,219	-12%	

Notes

A. The volume that passes through this meter is largely driven by the hydraulics of the local City of Northville system were a diversion structure exists that sends flow either towards this meter or to the Parkway meter. A more detailed representation of this local system would improve this calibration but was deemed outside of the scope of this modeling effort.

B. Same reasoning as Table 11-1 Note B.

C. The discrepancy in volume is driven by the DWF trace apportionment. The total DWF summed together from Meters LV4, P28, and P29 exceeded that measured at the next downstream location, Meter LVBasin. Therefore, the Meter LVBasin DWF was distributed to the upstream meter districts by area. This lead to Meter P28 being underpredicted but everything else in agreement.

D. The discrepancy in volume is largely driven by the sanitary flow trace which is an apportionment of Meters P30, P31, and P32 by area.

E. Same reasoning as Table 11-1 Note C.

Table 11-3 (continued)
Summary of Volume Calibration Results for Individual Meters for the September 14, 2014 Event

Reach	Individual Meters	Volume (ft^3) Metered	Volume (ft^3) Modeled	Difference	See Notes
Middle Rouge	P31	21,464,613	23,103,693	8%	
	P32	11,125,953	15,145,542	36%	F
	LC20U	516,153	519,452	1%	
	LC20RU	124,503	173,164	39%	G
	LC20D	248,937	128,706	-48%	G
	LC20RD	407,172	562,446	38%	G
	P14	25,006,167	25,540,934	2%	
Lower Rouge	FE19	1,595,844	1607,890	1%	
	P15	468,183	493,055	5%	
	P17	1,000,101	1048,494	5%	
	WE25	1,265,562	1282,565	1%	
	L-34	--	310,686	--	
	P19	4,098,213	3,994,391	-3%	
	WE28	872,343	870,424	0%	
	P20	2,025,468	2,764,835	37%	H
	P21	5,372,025	5,139,343	-4%	
	L-46	578,148	679,809	18%	I
	P24	3,088,416	5,745,770	86%	J
	P25	6,891,747	7,218,499	5%	
	WCS1A	38,291,577	37,573,570	-2%	
	WCS1	39,249,279	37,614,333	-4%	

Notes

F. Same reasoning as Table 11-1 Note D.

G. Same reasoning as Table 11-1 Note C.

H. This meter is one of two parallel interceptor meters that when viewed as a total do not exceed the threshold. Therefore, by itself, this meter was allowed to exceed the threshold.

I. This meter is affected by Middlebelt RTB dewatering and regulated flow from a combined sewer area. It did not have hydrologic parameters directly computed for it but was rather included in the overall area of Meters P24+P24.

J. Same reasoning as Table 11-1 Note E.

Table 11-4
Summary of Volume Calibration Results for Meter Summations for the September 14, 2014 Event

Meter Summations	Volume (ft^3)		Difference	See Notes
	Metered	Modeled		
P03+P26	4,255,860	4,235,894	0%	
LV04+LV11	3,783,738	3,702,951	-2%	
P09+P10+P11	27,794,901	30,921,361	11%	
LC03U+LC15RU+LC15U	3,515,331	3,764,667	7%	
LC03D+LC15RD+LC15D	5,634,756	6,060,239	8%	
P33+P34+P35	35,692,590	36,866,662	3%	
P30+P31+P32	44,216,112	48,438,454	10%	
P30+P31+P32+LC15U	44,930,103	50,071,693	11%	
LC20U+LC20RU	640,656	692,616	8%	
LC20D+LC20RD	656,109	691,152	5%	
P14+WCS2+WCS3	44,802,081	54,675,845	22%	A
P20+P21	7,397,493	7,904,178	7%	
P24+P25	9,980,163	12,964,269	30%	B
P14+P24+P25+WCS2+WCS3	54,782,244	67,640,114	23%	A
WCS1A+WCS2+WCS3	58,087,491	66,708,482	15%	A
WCS1+WCS2+WCS3	59,045,193	66,749,245	13%	A

Notes

A. Same reasoning as Table 11-2 Note A.

B. Same reasoning as Table 11-2 Note B.

Table 11-5
Summary of Depth Calibration Results for the September 14, 2014 Event

Reach	Individual Meters	Maximum Depth (ft)		Difference	See Notes
		Metered	Modeled		
Middle Rouge	BG1	--	1.83	--	
	5720	0.61	0.24	-61%	A
	5710	0.44	--	--	
	Parkway	--	1.00	--	
	P01	1.71	1.63	-5%	
	P03	1.84	1.13	-39%	B
	P26	0.72	0.96	33%	B
	FE22	1.87	1.59	-15%	
	P08	1.87	1.85	-1%	
	P07	1.52	1.65	9%	
	LV16	1.15	1.16	1%	
	LV15	2.49	1.72	-31%	C
	WE14	1.83	1.51	-17%	
	M2	1.87	2.07	11%	
	M1	7.74	6.20	-20%	
	LV14	1.30	1.29	-1%	
	P28	4.82	--	--	
	P29	4.58	--	--	
	LV04	2.20	1.56	-29%	C
	LV-Basin	--	3.38	--	
	LV11	2.87	1.30	-55%	C
	P12	5.41	4.95	-8%	
	P09	5.23	5.02	-4%	
	P10	5.90	5.57	-6%	
	P11	5.73	5.31	-7%	
	LC03-U	2.01	0.87	-57%	C
	LC03-D	5.26	4.47	-15%	
	LC15R-U	4.91	4.17	-15%	
	LC15R-D	5.92	5.87	-1%	
	LC15-U	7.94	6.24	-21%	C
	LC15-D	4.63	4.17	-10%	
	P13	6.74	7.02	4%	
	P33	5.24	5.07	-3%	
	P34	7.63	7.80	2%	
	P35	6.45	6.92	7%	
	P30	5.69	5.07	-11%	

Notes

A. Same reasoning as Table 11-1 Note A.

B. Both metered and modeled depths are within the pipe diameter. As such, the threshold was allowed to be exceeded.

C. Although the RVSDS model includes a representation of this pipe and therefore calculates a depth, this meter is located in a local municipal pipe. Reviewing and adjusting the hydraulics of such pipes to achieve a better calibration result was deemed outside the scope of the current modeling efforts.

Table 11-5 (continued)
Summary of Depth Calibration Results for the September 14, 2014 Event

Reach	Individual Meters	Maximum Depth (ft)		Difference	See Notes
		Metered	Modeled		
Middle Rouge	P31	7.20	6.90	-4%	
	P32	6.90	6.84	-1%	
	LC20-U	2.46	0.99	-60%	C
	LC20R-U	2.09	1.06	-49%	C
	LC20-D	2.54	1.90	-25%	C
	LC20R-D	3.16	2.78	-12%	
	JC2-08	7.51	6.81	-9%	
	LS1A Wet Well	10.16	10.00	-2%	
	P14	8.38	8.64	3%	
Lower Rouge	FE19	--	--	--	
	P15	1.13	0.96	-15%	
	P17	1.20	1.56	30%	B
	WE25	1.37	1.35	-2%	
	L-34	--	1.74	--	
	P19	2.42	2.38	-2%	
	WE28	1.19	1.29	9%	
	P20	2.73	2.85	4%	
	P21	2.13	1.94	-9%	
	L-46	--	1.09	--	
	P24	1.53	1.41	-8%	
	P25	2.61	2.72	4%	
	WCS1A	20.44	20.44	0%	

12. Design Event Model Setup

From the calibrated model, a theoretical design event model was set up to represent the existing conditions of the RVSDS during a 25 year, 24 hour design storm. The following selections of hydrologic parameters were chosen for this set up:

- Total rainfall volume of 4 inches falling uniformly over the RVSDS services area and distributed over 24 hours using an SCS Type II hyetograph.
- Average year 2014 dry weather flow rates as presented in Table 6-3 and assigned to each model input as a constant value apportioned by tributary service area.
- RTK parameters derived from Hydrologic Analysis Event No. 8 and applied as discussed in Section 10 of this report.
- Incremental capture coefficients typically from the larger of either Hydrologic Analysis Event No. 8 or 9. Table 12-1 presents these selections along with explanatory notes.
- A theoretical river-dependent inflow assuming a peak 10 year river level. This inflow hydrograph was assumed to follow the shape of the May 25, 2011 event. This event actually exceeded a 10 year river level and was scaled down accordingly until it matched. Using the correlation presented in Figure 8-4, the scaled river depth was converted to an inflow rate. The peak river-dependent inflow was input into the model such that it aligned in time with the peak RDI/I flow rate at the RVSDS outlet.

This event simulation was set up and run and found to be providing stable computational results. Further use of the design event model and alternatives analysis results are presented in the LTCAP SRF Project Plan report by OHM.

Table 12-1
Selection of 25 Year, 24 Hour Design Event Capture Coefficients

Branch	Meter District	25 Year, 24 Hour Design Event Capture Coefficient	See Notes
Middle Rouge	[BG1]	0.23%	A
	[P1]	1.30%	A
	[5710]	0.53%	A
	[5720]+[Parkway]	0.92%	A
	[P3]+[P26]	0.91%	A
	[P7]	0.92%	A
	[C-B-A]	2.86%	B
	[P8]	0.75%	C
	[LV16]	3.10%	A
	[WE14]	1.03%	A
	[LV15]	7.44%	A
	[M2]	6.01%	A
	[M1]	6.95%	C
	[LV14]	5.47%	A
	[LV_BASIN]-[LV4]	1.76%	A
	[LV11]+[LV4]	1.47%	A
	[P12]	1.82%	A
	[P28]	0.98%	E
	[P29]	0.78%	E
	[P9]+[P10]+[P11]	4.81%	A
	[P13]	3.01%	F
	[LC3-U]+[LC15-U]+[LC15R-U]	5.44%	E
	[P33]+[P34]+[P35]	5.44%	G
	[LC20-U]+[LC20R-U]	16.61%	A
	[P30]+[P31]+[P32]	5.44%	G
	[WCS2]+[WCS3]+[P14]	5.44%	G
Lower Rouge	[P15]	0.27%	A
	[P17]	0.68%	A
	[WE25]	1.45%	A
	[P19]	5.79%	A
	[WE28]	2.63%	A
	[P20]+[P21]	4.00%	A
	[P24]+[P25]	3.72%	F

Notes for Selection

A. Used larger capture coefficient of either Hydrologic Analysis Event No. 8 and 9 to serve as worst case.

B. Used capture coefficient for Hydrologic Analysis Event No. 8 because 9 had erroneous data.

C. Used capture coefficient from GDRSS 25yr,24hr model because meter district was too small for incremental calculations.

D. Used capture coefficient for Hydrologic Analysis Event No. 8 because 9 was uncharacteristically large.

E. Used capture coefficient for Hydrologic Analysis Event No. 9 because data did not exist for events prior.

F. Used capture coefficient from GDRSS 25yr,24hr model because meter district was too affected by flows form combined areas.

G. Used capture coefficient of neighboring Meter District [LC3-U]+[LC15-U]+[LC15R-U] because meter district was too affected by river-dependent inflow.

Figure 12-1
Theoretical Total River Inflow Hydrograph for 25 Year, 24 Hour Design Event