City of Grand Rapids, MI

STORMWATER
ASSET MANAGEMENT AND
CAPITAL IMPROVEMENT PLAN

May 2013

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STORMWATER ASSET MANAGEMENT PLAN

MAY 2013

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City of Grand Rapids, MI

Environmental Protection Services Department

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Grand Rapids, MI. 49503

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ACRONYMS

BMP	Best Management Practice
BRE	Business Risk Exposure
CDA	Contributing Drainage Area
cfs	cubic feet per second
COF	Consequence of Failure
EEL	Estimated Effective Life
EPA	Environmental Protection Agency
ESD	Environmental Services Department
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GI	Green Infrastructure
IO	Infrastructure Optimization
KCDC	Kent County Drain Commissioner
LID	Low Impact Development
LOS	Level of Service
MACP	Manhole Assessment Certification Program
MARB	Market Avenue Retention Basin
MDEQ	Michigan Department of Environmental Quality
MDOT	Michigan Department of Transportation
MS4	Municipal Separate Storm Sewer System
NASSCO	National Association of Sewer Service Companies
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
PACP	Pipeline Assessment Certification Program
POF	Probability of Failure
RCP	Reinforced Concrete Pipe
ROW	Right-of-way
RUL	Remaining Useful Life
SCM	Stormwater Control Measure
SDWA	Safe Drinking Water Act
USDOT	United States Department of Transportation

I. EXECUTIVE SUMMARY

A 20 year citywide asset management plan was developed for the public stormwater infrastructure system. The plan demonstrates how the City's goal of establishing and delivering certain levels of service may be achieved through effective and sustainable management of the stormwater system. By developing a proactive long-term plan for stormwater asset management, the City will have a sustainable system ensuring the well-being of the community, environment and future generations.

The general scope of the asset management plan consists of three major items:

- Assessment of the existing stormwater assets
- Evaluation of levels of service the stormwater asset will meet
- Summary of efforts necessary to meet the desired level of service

Following the completion of these items, a Capital Improvement Plan was developed which provides an additional level of detail for projects and activities required to meet the level of service identified in this report.

Existing GIS information was utilized throughout the plan development along with condition assessment information, risk analysis and cost development. To aid in the analysis, the system information was organized and stored in a computer model. The computer model selected for this project was the Infrastructure Optimization (IO) toolset, developed by Woolpert LLC. The IO toolset is an ESRI® ArcGIS extension package. This toolset provides easy access to the information for planning purposes and a mechanism to keep the information updated over time.

The current value of the stormwater drainage system is estimated at $523 million. Ninety-five percent (95%) of the current investment in the drainage system is represented by the separate storm sewers, manholes and catch basins. The remaining five percent (5%) is attributable to the pump stations, force mains, siphons, culverts, ditches, basins and green infrastructure components. Table I-1 summarizes the quantity and baseline costs of each stormwater asset. Open channels, while utilized as part of the stormwater system, are primary natural watercourses and no original construction costs were available to assign a baseline cost. Baseline future system values for open channels and ditches were based on a proposed operation and maintenance program.

Table I-1 Asset Summary and Cost

System Component	Quantity (unit)	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Gravity Mains	2,030,660 feet	$365,757,000	$933,842,000
Manholes	10,748 each	$39,051,000	$105,349,000
Laterals	514,583 feet	$43,065,000	$113,942,000
Catch Basins	17,054 each	$55,910,000	$136,594,000
Pressurized Mains	664 feet	$131,000	$505,000
Siphons	339 feet	$250,000	$618,000
Culverts	3,600 feet	$1,649,000	$3,530,000
Outfalls	356 each	$1,669,000	$3,530,000
Open Channels	39.63 mile	NA	$2,570,000
Ditches	72 mile	$5,703,000	$1,223,000
Detention Basins	5 each	$1,725,000	$4,614,000
Pump Stations	11 each	$12,051,000	$26,236,000
Green Infrastructure	13 each	$1,842,000	$8,451,000
Total		**$528,803,000**	**$1,341,004,000**

NA = Not Available

The evaluation of risk and consequence of failure is primarily based on the age of the asset due to limited information. The intent is to transition the model from an age-based system to a condition based system as additional investigation and assessment information is collected.

A major factor in the quality of community life is the quality of the community's facilities, services and amenities. Level of service is a measure of the amount and/or quality of the public facility which must be provided to meet that community's basic needs and expectations. Three levels of service (LOS) beyond the existing operating procedures were analyzed. Each LOS is defined by criteria established for each asset group found in the system and are briefly summarized below.

- Level of Service A. Assumes complete system replacement at the end of the assets estimated effective life (100-years for sewers and manholes); a 10-year cycle for full system assessment; corrective maintenance on 50 percent of assets currently beyond their effective life; preventative maintenance on 10 percent of inspected assets; and 30 percent of the capital investment is attributed to green infrastructure practices.
- Level of Service B. Assumes extending the effective life of infrastructure by 50 percent through rehabilitation methods before complete system replacement (125-years for sewers and manholes); a 10-year cycle for system assessment on infrastructure over 50-years old; corrective maintenance on 30 percent of assets currently beyond their effective life; preventative maintenance on 10 percent of inspected assets; and 20 percent of the capital investment is attributed to green infrastructure practices.
- Level of Service C. Assumes doubling the effective life of infrastructure through rehabilitation methods before complete system replacement (150-years for sewers and manholes); a 10-year cycle for system assessment on infrastructure over 75-years old; corrective maintenance on 15 percent of assets currently beyond their effective life; preventative maintenance on 10 percent of inspected assets; and 10 percent of the capital investment is attributed to green infrastructure practices.

These criteria are based on standardized best practices that were established by other municipalities, and were designed to meet regulatory requirements, goals for renewal, and operations and maintenance. Table I-2 summarizes the annual funding requirements necessary to meet each level of service.

Table I-2 Level of Service Funding Requirements

Level of Service	Annual Funding Requirement
A	$22,868,000
B	$14,726,000
C	$10,377,000
Existing	$3,597,000

A 20-year capital improvement plan was developed using an assumed Level of Service B annual funding. The capital plan provides recommendations of priority areas where the funding should be spent on stormwater infrastructure over the next 20 years. The priority areas are based on a risk exposure analysis. Capital stormwater expenditures were aligned with planned spending by other City departments in order to maximize the City's investment dollars.

1. INTRODUCTION

PURPOSE AND INTENT

The City of Grand Rapids is implementing an asset management program for the stormwater drainage system. Asset management includes the planning, design, construction, operation and maintenance of infrastructure that performs a function for the City. In the case of the stormwater system, that function includes drainage and stormwater quality management. The purpose of asset management is to maintain a desired level of service at the lowest life cycle cost. The lowest life cycle cost refers to the best appropriate cost for rehabilitating, repairing, or replacing an asset. The benefits of asset management include:

- Improved understanding of service level options and costs
- An ability to better communicate and justify investments to stakeholders
- An ability to demonstrate responsible investment in infrastructure
- Improved knowledge of the timing and magnitude of future investments required to operate, maintain, renew, and acquire assets
- An ability to establish and evaluate performance benchmarks
- Coordination with other utilities

The general process of asset management involves defining:

- What are the assets? (Inventory)
- What are the assets worth? (Valuation)
- Where are the assets located? (Geographic Information System)
- How is the system operated? (Level of Service)
- What is the condition? (Probability and Consequence of Failure)
- What is needed to be done? (Construct, Maintain or Replace)
- How much will it cost? (Financial Plan)

Asset management is a continuous improvement process. One of the intents of this plan is to initiate a framework for recording and continuously updating information over time.

ASSET TYPES

This asset plan is focused on the separate stormwater drainage system which is used to manage the stormwater runoff that occurs as a result of rain and snow. The drainage system is comprised of both conveyance and storage components and includes:

- Pipes – gravity sewers and service laterals connecting to the catch basin inlets
- Structures
    - inlets such as catch basins which collect water from surface features (for example, roads and parking lots) and convey it to an underground drainage system
    - outlets which are located at points where the underground drainage system discharges to open channels or other waterbodies and commonly include flared end sections, grates, and gates

    - junction chambers, such as manholes, which connect various parts of the underground drainage system together
- Culverts and bridges connecting open channel sections typically under roadways
- Open channels and roadside ditches
- Storage basins including detention and retention basins
- Pump stations
- Green infrastructure practices such as bioretention, pervious pavement, and water harvesting systems

This stormwater asset management plan does not address riverine flood control components or issues. Assets commonly associated with river flood control include floodwalls, berms, levees, dams, and backflow preventers.

PROJECT APPROACH

The approach taken for this project included the following steps:

1. An asset inventory including the component locations.
2. An evaluation and rating of each asset.
3. Determination of unit price replacement and repair costs plus a complete valuation of the system.
4. Defining various levels of service and strategies for asset renewal.
5. Summary of efforts necessary to meet the desired level of service.

The city maintains a Geographic Information System (GIS) of the stormwater drainage system. The current GIS includes components for the storm sewers, pump stations, manholes, catch basins, stream crossings, detention basins, floodwall penetrations, open ditches, green infrastructure, streams, and storm discharge points. The GIS was used as the foundation for an inventory and location of the assets.

Limited information on the condition of the assets was available at the beginning of the project. To assist with the condition assessment the City investigated a sample set (2%) of manholes using a pole-mounted zoom camera. Additional condition assessments were conducted by the consulting team at 51 crossings along the open channel system. Approximately 100-feet of the open channel, upstream and downstream, was including in the stream crossing evaluations. The GIS was also populated with the installation year of each asset. The asset age and generalized condition information were used to determine a weighting factor for the probability of failure. A consequence of failure was determined for each asset, and considered factors such as proximity of the drainage system to buildings, roads, and areas of environmental concern.

A comprehensive unit price database was established for the repair and reconstruction of each asset. This database is the foundation for all of the valuation and costing information.

In order to evaluate options on how the system may be operated, four (4) different levels of service were defined. The various levels of service represent the frequency and strategy for renewal options along with operation and maintenance of the system. The financial impacts of the various levels of service were determined from the asset inventory, rating system, and unit price information. Annual costs were estimated for each level of service.

To aid in the analysis, the system information was organized and stored in a computer model. The computer model provides easy access to the information for planning purposes and a mechanism to keep the information updated over time.

Following the completion of these items, a Capital Improvement Plan was developed which provides an additional level of detail for projects and activities required to meet the level of service identified in this report.

REPORT ORGANIZATION AND RELATIONSHIP WITH OTHER PLANS

Chapter 2 provides an overview on the analysis methodology. Discussion focuses on the risk assessment including the probability and consequences of failure. Also included are reference information regarding the costing approach, the sources of data used, and the assessment procedures.

Chapter 3 includes detailed information for each asset group including an inventory, condition assessment, application of weighting factors, valuation details, and recommendations specific for improving the asset inventory information.

Level of service information is provided in Chapter 4. This includes the definitions for each level of service category defined, the system replacement and lifecycle analysis, along with operation and maintenance information.

Chapter 5 focuses on the sustainability issues associated with the stormwater drainage system. Additional discussion of the sustainability issues are also addressed in the Stormwater Master Plan document.

Chapter 6 provides information on how the asset management information was used to aid in the development of the capital improvement plan.

The capital improvement plan is summarized in Chapter 7..

Chapter 8 summarizes the conclusions and recommendations resulting from the planning efforts.

2. METHODOLOGY

OVERVIEW

The asset management plan was developed in part by utilizing Infrastructure Optimization (IO) Toolset software developed by Woolpert, Inc. This toolset is an ESRI® ArcGIS extension package that leverages the City's GIS data. The IO toolset calculates a business risk exposure (BRE) for the various assets using probability of failure (POF) and consequence of failure (COF) factors established for the asset information. Determining critical components is one of the primary goals of asset management and toolset provides a consistent methodology for evaluating assets. A BRE also aids in predicting and prioritizing maintenance, rehabilitation and replacement activities. The BRE is expressed as follows:

Probability of Failure (POF) x Consequence of Failure (COF) x Redundancy Factor (R)
= Business Risk Exposure (BRE)

The redundancy factor (*R*) is set within the program based on the existing system conditions, and is assumed to be equal to 1 for the majority of stormwater assets. Unique POF and COF factors are identified for each individual asset group utilizing attributes available in the GIS system. Each of these factors is assigned a weight with the sum of the weights equaling ten. These weighted factors are then used in calculating the rating. The factor weights for POF are based on the accuracy and level of confidence of the available data. The COF factors are based on characteristics relevant to the failure of an asset such as size and the proximity of the drainage asset to roads and buildings.

The first step was to review the data contained for each asset in the City's GIS database. A core piece of information needed to establish an asset in the system is the initial installation date, as discussed below under the effective life. The City populated the GIS with the install date based on record drawings and made assumptions where no records were available.

MAJOR VARIABLES

Estimated Effective Life

The installation date is used to track the percent consumed of an asset, defined as the age of the asset divided by the estimated effective life (EEL). The EEL is a user-defined value assigned to each asset based on the asset type and material of construction. The EEL for each type of asset was determined through review of existing data, and based on manufacturer recommendations and other studies completed on the subject. References used in the analysis are provided on page 75.

Adjustments may be made to the EEL on an individual asset based on available information. For example, most pipes are assumed to have an EEL of 100-years; if a 95-year old pipe is inspected and found to be in excellent condition, the EEL could be adjusted to 125-years. Preventive maintenance can also impact the EEL. If a sewer is lined with a material that has an EEL of 75-years, the new EEL of the sewer with the liner would be 75-years from the liner installation date.

Using the pipe installation date, the software calculates other information such as the Remaining Useful Life (RUL) and the Required Service Date. Table 2-1 provides the EEL assigned to various assets in the system.

Table 2-1 Estimated Effective Life for Various Assets

Asset	EEL (years)
Gravity Mains /Culverts (Concrete, Brick, Vitrified Clay, Ductile Iron)	100
Gravity Mains (HDPE, PVC, Truss Pipe)	75
Gravity Mains / Laterals /Culverts (Corrugated Metal)	65
Laterals (Concrete, Brick, Vitrified Clay, Ductile Iron)	50
Laterals (HDPE, PVC, Truss Pipe)	50
Pressurized Mains	75
Manholes (Brick and Concrete)	100
Catch Basins (Brick and Concrete)	50
Outfalls	75
Detention Basins - Open *	50
Infiltration Basins *	100
Pump Station – Pumps *	20
Pump Stations – Electrical *	50
Pump Stations – Mechanical *	50
Pump Stations – Structural *	50

*Asset type not in IO toolset

Some assets within the system have already reached or surpassed their EEL. In order to handle these assets within the toolset, the required service date was set to 2013. This reflects a current backlog of assets that have reached the end of their expected effective life and require assessment. Assessment of these assets should be given high priority. As condition assessments are performed, the EEL and required service dates should be adjusted accordingly.

Probability of Failure

The likelihood that an asset will fail is a function of various attributes such as the asset's condition, performance, reliability and maintenance history. Within the IO toolset attributes associated with the probability of failure are selected, assigned a numeric value, and assigned a weighting factor. Each of these factors is assigned a weight with the sum of the weights equaling ten. These weighted factors are then used in calculating the rating. The factor weights for POF are based on the accuracy and level of confidence of the available data. Table 2-2 provides a summary of the attributes, weights, and values assumed by asset types. Predominately the age, condition, and maintenance are used in the rating.

In some cases a weight of zero is applied, for example with the force main condition. This is due to lack of information on the current condition.

An example analysis is provided on page 15. The example illustrates how the weights and values are applied to compute the probability of failure.

Table 2-2 Probability of Failure Weights and Values by Asset Type

Attribute	Weights Linear System					Weights Structures			Values	
	Gravity Sewer	Lateral	Culvert	Force Main	Siphon	Manhole	Catch Basin	Outfall	Rating	Description
Percent Consumed	7.0	7.0	6.0	8.0	7.0	7.0	7.0	10.0	Age/EEL	Actual age divided by estimated effective life
Maintenance Condition	1.0	1.0	1.0	0.0	1.0	1.0	1.0	0.0	1	Excellent
									2	Good
									3	Fair
									4	Poor
									5	Failure Imminent
Structural Condition	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0	1	Excellent
									2	Good
									3	Fair
									4	Poor
									5	Failure Imminent
Shape	NA	NA	1.0	NA	NA	NA	NA	NA	1	Box
									2	Round
									5	Elliptical
End Section	NA	NA	NA	NA	NA	NA	NA	0.0	0	No end section
									1	Has end section
Total	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0		

NA = Not Applicable

Consequence of Failure

The COF is treated in a similar fashion as the POF. The COF is the financial or health and human safety cost resulting from asset failure. Examples of factors that might be associated with the COF include the proximity of the asset to critical facilities (e.g. hospitals), or the proximity to other infrastructure such as roads and buildings. The proximity to other infrastructure affects the COF due to the impact on repair costs (i.e. sewer pipes under roads cost more to fix than pipes under grassed fields). Within the IO toolset attributes associated with the COF are selected, assigned a numeric value, and assigned a weighting factor. The mathematics of how the weights and values are applied is the same as for the POF attributes.

A list of the COF factors used is discussed below. The specific attributes, weights, and values are discussed within each asset group beginning on page 11.

- Size – The size of a pipe, channel, or structure impacts the consequence of failure due to the amount of flow the system was intended to convey and cost of repair and replacement materials.
- Depth – The depth of a pipe will increase the consequence of failure due to larger disruption areas impacting roads and private property and higher construction costs due to larger excavations and shoring requirements.

- Proximity to Floodplains – This factor is based on the proximity of the pipe to the FEMA floodplains. A greater weight is given to a pipe found within the floodplain since a failure in this location will have a greater impact during an event, leading to accelerated street flooding and potential property damage.
- Proximity to Environmental Hazards – Environmental impact is based on the proximity to known brownfield sites or sites with known environmental issues such as leaking storage tanks, etc. A greater weight is given to pipes that may require replacement in these areas as contaminated soils may be present and require special handling and disposal during construction activities.
- Proximity to Buildings – Building footprints are available in GIS and were used to identify sewers which crossed beneath or directly adjacent to any buildings. The weight is increased for these pipes as the consequence of failure may have direct impact on nearby structures and can result in increased construction costs.
- Proximity to Roadways – Proximity to the roadway was determined using Transportation Act 51 attributes in the GIS, and a list of assumed ROW offsets used to identify typical road widths, since actual pavement extents are not available in GIS. Assets were grouped by those not under/near a roadway, and those under/near a minor road, major road, or railroad. Sewers that were within the influence of a roadway receive a greater weight. Depending on the criticality of the road and the proximity of the pipe, failure of the asset may have a greater impact on surrounding infrastructure and lead to greater construction and traffic control considerations.
- Presence of Appurtenances – If a manhole or structure is known to contain any type of backflow prevention devices, gate, etc. that is used to provide some control in the system, then an added weight is assigned for the consequence of failure. The loss of system control and added replacement/renewal costs factor into the increased weight. The GIS system has a flag option for backflow prevention which is used to identify these structures.
- Destination – The type of receiving water body will have an impact on the consequence of failure. The failure of an outfall along the Grand River could be more significant than one discharging to a minor drain, as difficulty of construction and permitting requirements typically increase. The type of stream was categorized based on observations made for the open channel assets found logged into the city database.
- Location – Outfalls located along the river wall have a different risk than those on a flat slope. Pipes along the river wall area were assigned a greater factor, and other outfalls were assigned lower factors based on how steep of a slope they are on.
- Channel Bank Slope – The shape slope of the channel bank of a stream or open channel has been related to the consequence of failure by assuming that channels with steep slopes may be more prone to bank erosion. The shape of the channel can dictate how difficult it may be to renew, re-grade, or re-cut the channel to improve performance and lead to higher costs.
- Type of Stream / Open Channel – The type of channel impacts the consequences of failure due to higher costs associated with permitting, design, and construction on repairs to large waters of the state compared to small roadside ditches.

COST DATA

Cost information is imperative in the valuation of the assets. Several different costs for each asset or groups of assets are computed including the following:

- Baseline Current Cost – This is the cost to replace an asset in kind using present costs. The entire system baseline cost is the sum of the present worth value of all assets.

- Baseline Future Cost – This is the replacement cost of each asset assuming assets are replaced in the year in which their remaining useful life is zero. Future costs are calculated using an inflation factor of 1.75%. The inflation factor was determined from the national inflation rate published by the federal government in December 2012.
- Renewal/Replacement (RR) Cost – The RR costs are user defined and based on the specific strategy for each asset. The strategy may include, for example, replacement, rehabilitation, or do nothing. Further discussion on the RR costs begins on page 35 with the level of service discussion.
- The baseline system cost can be evaluated against the cost to replace the assets at the end of their EEL. This provides a comparison between preventative maintenance costs and the replacement costs at time of failure.

Unit Cost Development

Unit cost information for each asset was determined for inspection, maintenance, rehabilitation, and replacement activities. Other factors such as depth of installation and whether the asset was under a roadway were also taken into account in the unit cost development. By entering cost information to cover potential activities such as maintenance, inspection, and rehabilitation the software can be used to quickly generate an initial cost estimate given a defined project area. All costs are reported in 2013 dollars (Engineering News-Record cost index of 9453). The following resources were used in developing the unit cost information:

- Construction bid tabulations and contract documents from local projects.
- Construction bid tabulations and contract documents from non-local projects adjusting for geographic differences as appropriate.
- Manufacturers were contacted for assets in cases where bid tabulation data was not readily available.
- Costs for inspections, operation and maintenance activities were based on historical costs from the City of Grand Rapids and other communities.

Assumptions

The following assumptions were used when developing replacement costs.

- Materials – Various pipe materials exist with the collection system, for example brick, clay, metal, and concrete. Reinforced concrete was assumed for the replacement material in all cases except for ductile iron (DI) pipes. Ductile iron pipes were assumed to be replaced with PVC in cases with pipe diameters less than 12-inches and with ductile iron for the larger diameter pipes.
- Depth – The depth of a pipe can result in differing installation costs due to additional excavation and backfill, or changes in the strength requirements of the pipe. Three depth categories were assumed: shallow (less than or equal to 8-feet), medium (8 to 15 feet), and deep (greater than 15-feet). Assumptions for the pipe trench size for each depth were used to determine the additional cost. The depth of pipe was assumed due to incomplete inventory data. Refer to the discussion on Incomplete Attribute Information beginning on page 10 for additional information.
- Pavement Costs – Based on the trench width established by the depth assumptions above, a pavement removal and restoration cost was defined. Costs included the removal and construction of a new roadway and base. The process for determining if a pipe is or is not in a road is based on the GIS data.

- Soft Costs - Costs were included for engineering and construction contingencies as 15% and 25% respectively.

POPULATING INVENTORY DATA

Base Information

Base information associated with each asset was populated from the GIS. Base information includes the asset type; physical characteristics such as size, material, and depth; installation date; and proximity information to other assets. The specific information requirements for each asset are discussed with the asset group discussion beginning on page 11.

Incomplete Attribute Information

Assets with missing attribute information were populated based on assumptions. Where possible, information was assumed from adjacent resources. In situations where adjacent resource information was not available, attributes were assumed as follows:

- Material information was assumed for sewers by determining the date where the majority of storm sewers changed from clay to concrete. Sewers installed prior to this date were assumed to be clay, and those installed after this date were assumed to be concrete. Concrete as a pipe material was also assumed for pipes greater than 42-inches in diameter. A similar process was completed for manholes and catch basins.
- Sewers with no diameter listed were spot-checked and generally found to be collector sewers. The majority of collector sewers were found to be 12-inch diameter. Therefore sewers missing the diameter attributes were assumed to be 12-inches. These assumptions were checked for consistency with adjacent sewers, and corrections were made where appropriate. All laterals with no diameter were assumed to be 12-inch.
- Relative depth information was sparse, as most manholes had no measure down, and no surveyed rim elevation. Some assets had an upstream and downstream invert, but no rim elevation to relate a depth. To maintain consistency with other asset groups, the depth was broken down into shallow, medium, and deep groups. Shallow was classified as 0 to 8 feet deep and was applied to all pipes 36-inches in diameter and less. Medium was classified as 8 to 15 feet deep and was applied to all pipes greater than 36-inches and up to 72-inches in diameter. Deep was classified as greater than 15 feet deep and was applied to pipes 72-inches in diameter and above. Manholes were then assigned a depth based on the connecting pipes. All catch basins and laterals were assumed to be shallow.

The assumptions listed above were based on information currently available in GIS. Factors relying on assumptions were not assigned as much weight for use in calculating the POF and COF as factors based on observed or recorded data.

CONDITION ASSESSMENTS

Base Approach

A limited amount of condition assessments and investigations were conducted as a part of this project by both the City and the consultant. Assets investigated included manholes, sewers (as viewed through a zoom camera), open channels, stream crossings, storage basins, and pump stations. The information was used to develop condition assessment assumptions for the collection system. The condition assessment information was applied to the POF and COF evaluation factors. Details of the assessment information collected are discussed within each asset group beginning on page13.

Municipal Work Orders

The City has begun tracking maintenance calls and work orders in Cityworks®. Since this information is linked to specific assets in the GIS, selected information from Cityworks® may be read for use in the IO toolset. The data within the work order system was reviewed. The current dataset of information was too small and covered too many different categories to be of any significant use for this analysis. This could include creating a master list of common work orders and creating drop-down lists for staff to choose from to create consistency across the system.

CONTINUOUS IMPROVEMENT PROCESS

Use of the IO toolset is intended to be a continuous improvement process. As additional or updated inventory information becomes available, the data within the toolset is intended to be updated. As the scenarios within the IO toolset are rerun they will continue to evolve along with the updated information.

Future Factors

For each asset, unique factors were selected for use in determining the POF and COF. Some of the factors were developed to rely on existing information, while others were created with the intent as placeholders for future data collection. Factors identified for future data collection were temporarily assigned a weight of zero until data is available. These potential factors were set up to encourage the collection of this data going forward. An example factor for future use is the maintenance condition of the force mains. No information was available at the time of the report on the condition of the force mains, hence a maintenance condition could not be applied. However the condition should be included in the future. All of the factors are customizable and may be adjusted at any time. Future weighting factors are further discussed with each asset group description.

POF Based on Age versus Condition

Overall limited condition assessment information was available, which results in the POF being based principally on the age of the asset. In most asset management applications, once critical assets were identified, the age of the infrastructure is typically used to determine the order upon which to begin assessments. As the system is inspected and data is accumulated, the model should be converted to be based on the condition of the asset instead of the age. Managing assets based on their condition is a better long-term approach compared to managing based on age.

Costing Information

Costing information is completely customizable and may be edited at any time. The IO toolset allows for additional costs such as a percentage to increase to account for difficult installations or assumed dollar amounts to account for miscellaneous costs such as dewatering or special removals. These additional costs may be added as desired when analyzing various scenarios.

3. ASSET GROUPS

Stormwater assets were divided into groups to facilitate data analysis. Each asset group is evaluated separately. Details on each asset group, and how the various factors were calculated, are discussed in this section.

GRAVITY MAINS AND LATERALS

This asset group includes approximately 383 miles of gravity storm sewers and catch basin laterals maintained by the City. Storm sewers and catch basin laterals are grouped together because they are typically installed at the same time and have similar characteristics. They are expected to have similar life expectancy and rate of deterioration.

Condition Assessment

City staff conducted manhole inspections on approximately 2 percent of the manholes within the system. A pole-mounted zoom camera was used for recording manhole inspections and recording limited pipe inspections information by zooming in on the view down each pipe connected to the manhole. The zoom camera process is very efficient for performing detailed manhole inspections without having to physically enter the structure. However, it is less than optimal for determining the condition of the pipes between structures. A condition rating was assigned to the pipe based on the worst visible defect.

In order to establish a basis for condition and O&M rating assumptions, a large sample of these inspections were reviewed in a PACP format to provide structural and O&M scores for each pipeline. Sewers were rated on a scale of 1 to 5 with 1 indicating excellent condition and 5 indicating failure has already occurred or is imminent. Table 3-1 provides a breakdown of typical pipe conditions based on material, age, and diameter as observed in the inspection videos.

Table 3-1 Pipe Condition Assumptions

Age Range	Size	Structural Condition				Maintenance Condition			
		VCP	Concrete	Brick	PVC	VCP	Concrete	Brick	PVC
Greater than 100 years	8 to 30 inches	5	4	5	NA	3	2	4	NA
	36-inch and larger	4	3	4	NA	4	3	4	NA
76 to 100 years	8 to 30 inches	4	3	5	NA	3	2	4	NA
	36-inch and larger	3	3	4	NA	3	4	4	NA
51 to 75 years	8 to 30 inches	3	2	4	NA	2	2	4	NA
	36-inch and larger	3	3	4	NA	2	3	4	NA
26 to 50 years	8 to 30 inches	2	2	NA	2	2	1	NA	1
	36-inch and larger	3	3	NA	NA	2	2	NA	NA
25 years and less	8 to 30 inches	NA	1	NA	1	NA	1	NA	1
	36-inch and larger	NA	1	NA	1	NA	1	NA	NA

NA = Not Applicable

A similar process was repeated for catch basin laterals that were captured as part of the zoom camera inspections. This information is summarized in Table 3-2.

Table 3-2 Catch Basin Lateral Condition Assumptions

Age Range	Structural Condition			Maintenance Condition		
	VCP	Concrete	PVC	VCP	Concrete	PVC
Greater than 100 years	5	4	NA	3	2	NA
76 to 100 years	4	3	NA	2	2	NA
51 to 75 years	3	2	NA	2	2	NA
26 to 50 years	2	2	2	1	1	1
25 years and less	NA	1	1	NA	1	1

NA = Not Applicable

These tables were then used to establish assumed conditions for the existing storm sewers.

Probability and Consequence of Failure

A summary of the POF is provided in Table 2-2 on page 7. The COF factors, weights, and values used for gravity mains, catch basin service laterals, force mains, and siphons are summarized in Table 3-3.

Table 3-3 Consequence of Failure for Gravity, Laterals, Force Mains, and Siphons

COF Factors	Weights				Value	Rating Description
	Gravity	Laterals	Force Mains	Siphons		
Depth of Pipe	3.0	0.0	3.0	3.0	1	depth <= 8 feet
					3	8 < depth <= 15 feet
					10	depth > 15 feet
Pipe Size	3.0	4.0	3.0	3.0	2	size <= 12 inches
					10	12 < size <= 24 inches
					25	24 < size <= 42 inches
					35	42 < size <= 72 inches
					50	size > 72 inches
Proximity to Floodplain	0.5	1.0	0.5	0.5	0	Not with a floodplain
					1	Within the 100 year floodplain
					2	Within the 500 year floodplain
Proximity to Environmental Hazard	0.5	1.0	0.5	0.5	0	Not in close proximity to known hazardous size
					1	Within 100 feet of known hazardous site
					2	Within a site with known environmental hazards
Proximity to Buildings	2.0	3.0	2.0	2.0	0	More than 20 feet from a building
					1	Within 20 feet of a building
					2	Under a building
Proximity to Roadway	1.0	1.0	1.0	1.0	0	Outside of ROW
					10	Pipe is within ROW of minor road
					15	Pipe is within ROW of major road
					40	Pipe is under pavement of minor road
					50	Pipe is under pavement of major road
Total	10.0	10.0	10.0	10.0		

Graphical results for the gravity mains are provided in Appendix A.

Example Analysis and Results

As an example of the data and analysis, consider the stormwater pipe on Louis Street NW between Ottawa Avenue and Fulton Street (Asset ID 3238), Figure 3-1. The pipe is a 72-inch box shaped brick sewer built in 1922. Refer to Figure 3-2 for the attributes, weights, and values used in this example. Three attributes were selected to determine the POF: the percent of useful life consumed, the maintenance condition, and the structural condition.

Figure 3-1 Example Louis Street Sewer Location (Asset ID 3238)

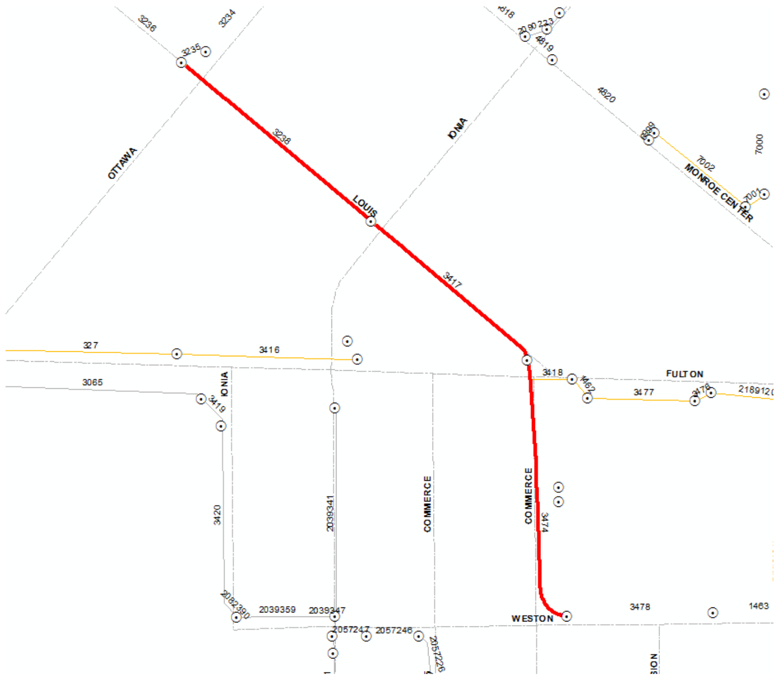
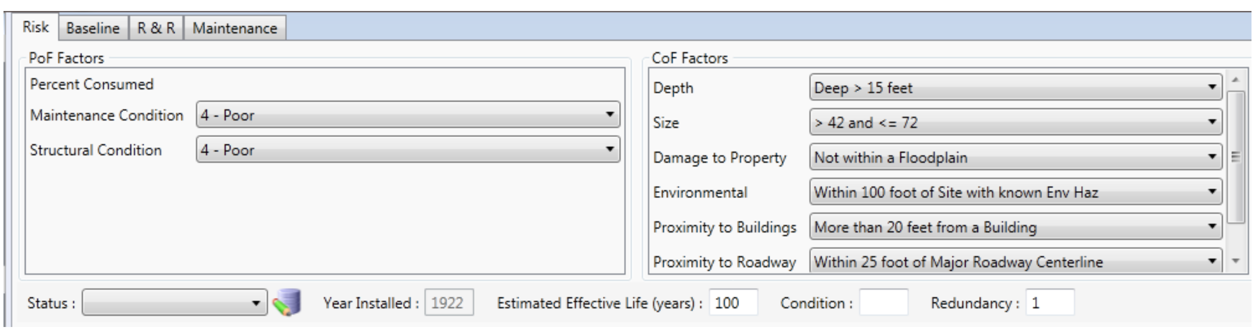


Figure 3-2 Example Louis Street Sewer Risk Variables (Asset ID 3238)



Percent of useful life consumed is calculated as the asset age divided by the estimated effective life. In this example the asset age is 91-years (2013 minus the year built, 1922). The estimated effective life is 100-years, from Table 2-1. The percent of useful life consumed is then 91 years divided by 100 years or 0.91. Each attribute is also weighted according to their influence on the POF and based on the confidence with the attribute information. In this example the percent of useful life consumed is given a weighting factor is 7.0, from Table 2-2. The weighted value is then calculated as the percent of useful life (0.91) times the factor weight (7.0) or 6.37.

The maintenance and structural condition assessment are assigned a value from 1 to 5; with 1 being excellent condition and 5 indicating that failure is imminent. Different factors may use a different scale range, but all scales are converted to values from zero to one. Hence, on a 5 point scale an asset with an assigned score of 3 is converted to a value of 0.6 (3 out of 5 = 0.6).

For the example on Louis Street (Asset ID 3238), the maintenance condition assessment yielded a *poor* rating, or a numeric score of 4. Based on a 5 point scale, the maintenance condition rating is converted to a value of 0.8 (4 out of 5 equals 0.8). A weight of 1.0 is assigned to the maintenance attribute, Table 2-2. The weighted value is then calculated as the rating value (0.8) times the weight (1.0) or 0.8.

The structural condition attribute is treated similar as the maintenance condition. For the Louis Street example (Asset ID 3238), the structural condition assessment rating was *poor*, or a numeric score of 4. The rating value is converted to 0.8, based on the 5 point scale (4 out of 5 equals 0.8). A weight of 2.0 is assigned to the structural attribute, refer to Table 2-2. The weighted value is then calculated as the rating value (0.8) times the weight (2.0) or 1.6.

The weighted values for the POF factors are then summed to give a total for the asset. For the Louis Street example (Asset ID 3238) the total POF factor is 8.77 (percent consumed 6.37, plus the maintenance condition 0.8, plus the structural condition 1.6). Sometimes the POF factor is expressed on a scale from zero to 100, in which case the factor would be expressed as 87.7.

Table 3-4 Example Probability of Failure Calculation

POF Factors (Table 2-2)	**Rating Description** (Table 2-2)	**Value**	**Weight** (Table 2-2)	**Weighted Value**
Percent Consumed	Actual age divided by the estimated effective life	$\frac{Age}{EEL} = \frac{91\ years}{100\ years} = 0.91$	7.0	0.91 * 7.0 = 6.37
Maintenance Condition	1 = Excellent 2 = Good 3 = Fair **4 = Poor** 5 = Failure Imminent	$\frac{Value}{Range} = \frac{4}{5} = 0.8$	1.0	0.8 * 1.0 = 0.8
Structural Condition	1 = Excellent 2 = Good 3 = Fair **4 = Poor** 5 = Failure Imminent	$\frac{Value}{Range} = \frac{4}{5} = 0.8$	2.0	0.8 * 2.0 = 1.6
Total			10.0	8.77 *(or 87.7 on a scale of 1-100*)

The consequence of failure calculations are based on a similar weighting process as the probability of failure calculations. Refer to Table 3-5 for a summary of the consequence of failure calculations for the Louis Street example. The example sewer is a 72-inch pipe; more than 15 feet deep; not in a floodplain; within 100-feet of a potential environmental hazard; more than 20 feet away from a building; and is located within 25-feet of the centerline of a major road.

Table 3-5 Example Consequence of Failure Calculation

COF Factor (Table 3-3)	**Rating Description** (Table 3-3)	**Value**	**Weight** (Table 3-3)	**Weighted Value**
Depth of Pipe	1 = depth <= 8 feet 3 = 8 < depth <= 15 feet **10 = depth > 15 feet**	$\frac{Value}{Range} = \frac{10}{10} = 1.0$	3.0	1.0 * 3.0 = 3.00
Pipe Size	2 = size <=12 inches 10 = 12 < size <= 24 inches 25 = 24 < size <= 42 inches **35 = 42 < size <= 72 inches** 50 = size > 72 inches	$\frac{Value}{Range} = \frac{35}{50} = 0.7$	3.0	0.7 * 3.0 = 2.10
Proximity to Floodplain	**0 = Not in a floodplain** 1 = Within 100 year floodplain 2 = Within 500 year floodplain	$\frac{Value}{Range} = \frac{0}{2} = 0$	0.5	0 * 0.5 = 0.00
Proximity to Environment al Hazard	0 = Not within close proximity **1 = Within 100 feet** 2 = Contained onsite	$\frac{Value}{Range} = \frac{1}{2} = 0.5$	0.5	0.5 * 0.5 = 0.25
Proximity to Buildings	**0 = More than 20 feet away** 1 = Within 20 feet 2 = Under a building	$\frac{Value}{Range} = \frac{0}{2} = 0$	2.0	0 * 2.0 = 0.00
Proximity to Roadway	0 = Not influencing roadway 3 = Within 15 feet of centerline, minor **8 = Within 25 feet of centerline, major** 10 = Within 50 feet of railroad	$\frac{Value}{Range} = \frac{8}{10} = 0.8$	1.0	0.8 * 1.0 = 0.80
Total			10.0	6.15 *(or 61.5 on a scale of 1-100)*

The resulting BRE was calculated to be 53.9. Refer to page 5 for a discussion on the BRE. BRE is calculated as the product of the probability of failure (8.77) and the consequence of failure (6.15).

Example figures of POF, COF and BRE for this example location are provided in Figure 3-3 thru Figure 3-5.

Figure 3-3 Probability of Failure Gravity Mains Example

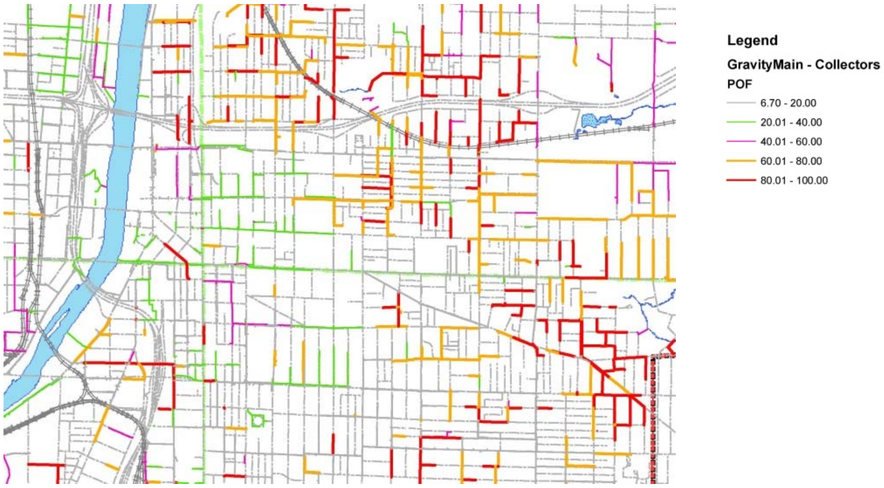


Figure 3-4 Consequence of Failure Gravity Mains Example

Figure 3-5 Business Risk Evaluation Gravity Mains Example

Estimated Effective Life Summary

Using the asset installation date and the EEL for each asset, the IO tool generates a consumed life, remaining service life, and required service date. Table 3-6 shows the approximate number of gravity mains and laterals assets by various age brackets. Using the results in the table, if the majority of assets were assigned an EEL of 100 years, there are already 268 gravity mains and 1,248 laterals that have exceeded their assumed life span.

Table 3-6 Gravity Mains and Laterals By Age

Asset Age (years)	0-25 years	26-50 years	51-75 years	76-100 years	Greater than 100 years
Gravity Mains	4,631	2,637	2,225	2,114	268
Catch Basin Laterals	7,309	2,963	3,299	3,960	1,248

There are 2,382 gravity mains and 5,208 catch basin laterals that are 75 years and older, corresponding to 99.7 and 26.0 miles respectively. This represents approximately 26% of the overall system with less than 25% of the EEL remaining.

Value of Current Assets

Table 3-7 summarizes the current and future system values for gravity mains and catch basin laterals. Refer to page 8 for the cost development methodology discussion.

Table 3-7 Value of Gravity Mains and Laterals

Asset	Quantity	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Gravity Mains	2,030,660 feet	$365,757,000	$933,842,000
Laterals	514,583 feet	$43,065,000	$113,942,000

Figure 3-6 and Figure 3-7 illustrate the replacement costs per year based on the required service date for a 100-year timeframe. The baseline cost is based strictly on replacement costs, though in many cases pipes will only require rehabilitation or no action at all. The high annual replacement costs observed between 2090 and 2110 are a result of the recent sewer separation program associated with the CSO program.

Figure 3-6 Annual Cost to Replace Gravity Mains at End of Estimated Effective Life

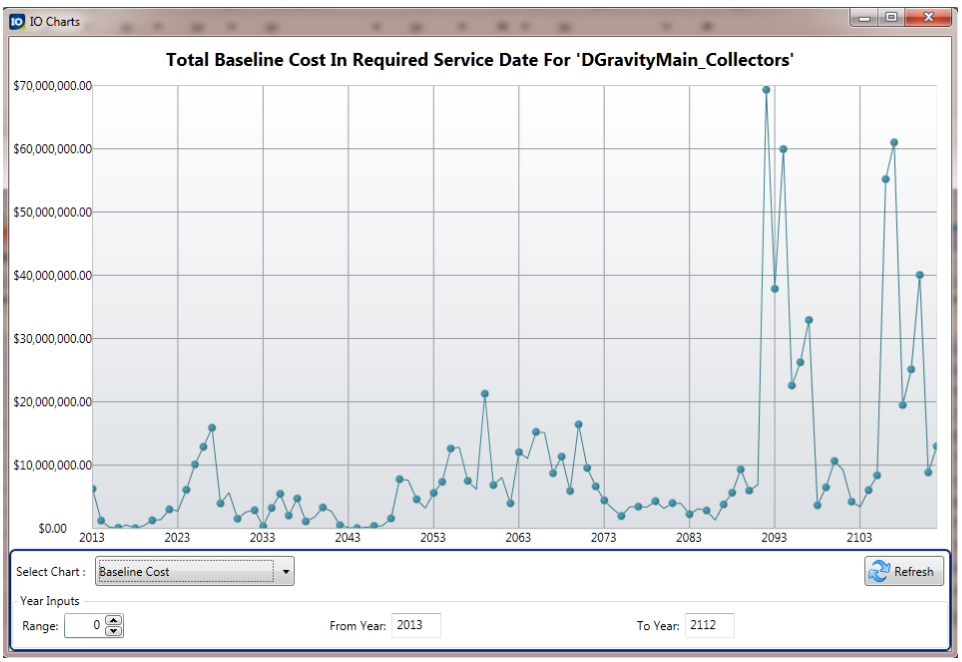
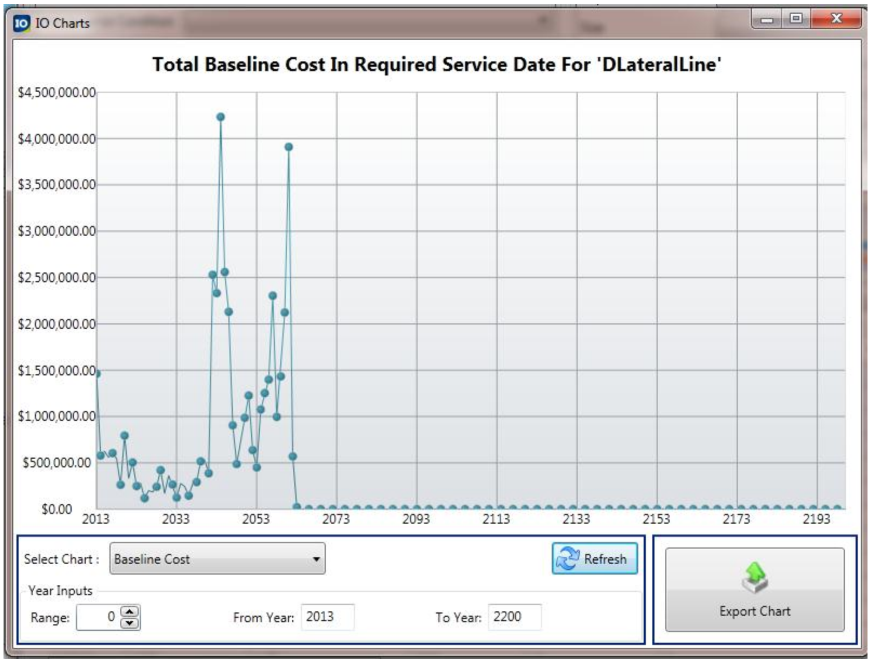


Figure 3-7 Annual Cost to Replace Laterals at End of Estimated Effective Life



PRESSURIZED MAINS

Two pressurized stormwater mains are included in the dataset. One is a 65-foot segment of force main at the Caledonia Stormwater Lift Station. Considering this lift station is identical to several others found in the City where the force main is not indicated separately in the GIS, this force main was considered integral to the lift station and not a separate asset. The second pressured stormwater main is the Albany Stormwater Pump Station discharge line which is approximately 665-feet long and discharges to a 54-inch sewer in Buchanan Avenue. Due to the length of this force main, it was considered as a separate asset.

The pressurized mains may eventually be evaluated using a similar set of criteria as for gravity mains, but with a lower weight for the O&M condition, since the interior of a force main should not be subjected to the same O&M problems found in a gravity main. Pressurized mains are much more difficult to inspect without taking the main out of service for a period of time, and are commonly evaluated by exterior inspection. POF and COF factors are provided in Table 2-2 and Table 3-3 respectively. The sewer material is ductile iron, and the pipe was assumed to have an EEL of 100-years. Table 3-8 summarizes the baseline and future system value for the pressurized mains.

Table 3-8 Value of Pressurized Main

Asset	Quantity	Estimated End of Service	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Pressurized Main: Albany Stormwater Pump Station	665 feet	2104	$131,000	$505,000

SIPHONS

Two siphons are included in the drainage system. Each siphon is represented by three segments including the drop, run, and rise of the siphon. The first asset is a 60-inch siphon across Monroe Avenue near Sligh Boulevard, which has an estimated end of service in 2068. The second asset is a 24-inch siphon crossing 28th Street at Jefferson Drive with an EEL of 2077. POF and COF factors are provided in Table 2-2 and Table 3-3 respectively. Table 3-9 summarizes the current value, future replacement costs, and inspection and maintenance costs.

Table 3-9 Value of Siphons

Asset	Quantity	Estimated End of Service	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
60-inch	51 feet	2068	$86,000	$195,050
24-inch	288 feet	2077	$163,060	$422,835
Total	339 feet		$249,060	$617,885

MANHOLES, AND CATCH BASINS

This asset group includes 10,554 manholes and chambers, and 17,798 catch basins. 154 storm crocks are included in the manhole, and catch basins database in GIS, and were evaluated with the catch basins.

Condition of Assets

The City has completed condition assessments of approximately 194 storm manholes via zoom camera inspection which were used to generate structural and O&M condition ratings. Manholes were rated on a scale of 1 to 5 with 5 indicating failure has already occurred or is imminent and 1 indicating excellent condition. Table 3-10 provides a breakdown of typical manhole conditions based on material, age, and diameter as observed in the reports. Catch basins were assigned conditions based on adjacent manhole condition ratings and assumptions.

Table 3-10 Assumed Condition Ratings for Manholes and Catch Basins

Age Range	Structural	O&M
> 101 years	5	4
76-100 years	4	3
51-75 years	3	2
26-50 years	2	1
0-25 years	1	1

Probability and Consequence of Failure

A summary of the POF is provided in Table 2-2 on page 7. The COF factors, weights and values used for manholes and catch basins are summarized in Table 3-11.

Table 3-11 Consequence of Failure for Manholes and Catch Basins

COF Factors	Weight MH	Weight CB	Value	Rating Description
Depth of Structure	2.5	0.0	1	depth <= 8 feet
			3	8 < depth <= 15 feet
			10	depth > 15 feet
Structure Diameter	2.5	3.0	2	size <= 12 inches
			10	12 < size <= 24 inches
			25	24 < size <= 42 inches
			35	42 < size <= 72 inches
			50	size > 72 inches
Proximity to Floodplain	0.5	1.0	0	Not within a floodplain
			1	Within the 100 year floodplain
			2	Within the 500 year floodplain
Proximity to Environmental Hazard	0.5	1.0	0	Not in close proximity to known hazardous site
			1	Within 100 feet of known hazardous site
			2	Within a site with known environmental hazards
Proximity to Buildings	2.0	4.0	0	More than 20 feet from a building
			1	Within 20 feet of a building
			2	Under a building
Proximity to Roadway	1.0	1.0	0	Outside of ROW
			10	Pipe is within ROW of minor road
			15	Pipe is within ROW of major road
			40	Pipe is under pavement of minor road
			50	Pipe is under pavement of major road
Complex Structure	1.0	NA	0	Structure has appurtenances inside
			1	No appurtenances inside the structure
Total	10.0	10.0		

Estimated Effective Life Summary

The recorded age for manholes and catch basins are displayed in Table 3-12. The age range used for manholes and catch basins was the same as that used for gravity sewers. Comparison of this data with the gravity sewer data confirms that approximately 26% of each asset group comprising the collection system was installed over 75 years ago.

The estimated effective life of a manhole was assumed to be 100-years and catch basins were assumed to be 50 years (Table 2-1). Based on this assumption, approximately 2.1% of the manholes and 45.4% of the catch basins in the system have currently exceeded their expected life.

Table 3-12 Manholes and Catch Basins by Age

Asset Age (years)	0-25 years	25-50 years	50-75 years	75-100 years	>100 years	Total
Manholes	4,411	2,338	1,857	1,917	225	10,748
Catch Basins	6,383	2,925	3,265	3,997	484	17,054
Total	10,794	5,263	5,122	5,914	709	27,802

Value of Current Assets

Table 3-13 summarizes the current and future system values for manholes and catch basins. Figure 3-8 and Figure 3-9 show the cost to replace manholes and catch basins at the end of the estimated service life over a 100 year timeframe. These costs may differ from final design estimates due to the need to increase the number of manholes and catch basins to improve drainage.

Table 3-13 Value of Manholes, Catch Basins, and Structures

Asset	Quantity	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Manholes	10,748	$39,051,000	$105,349,000
Catch Basins	17,054	$55,910,000	$136,594,000
Total	27,802	$94,961,000	$241,943,000

Figure 3-8 Annual Cost to Replace Manholes at End of Estimated Effective Life

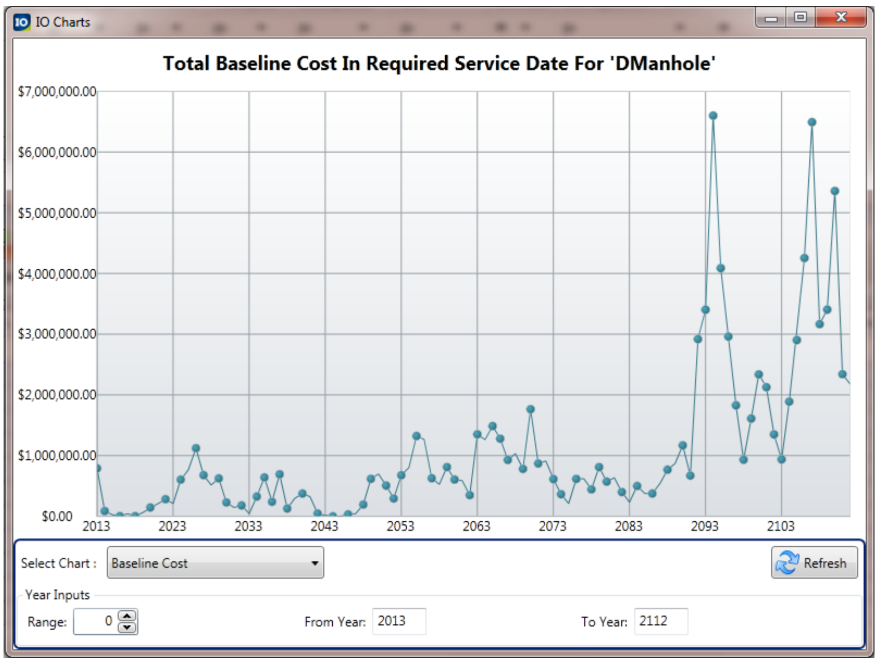
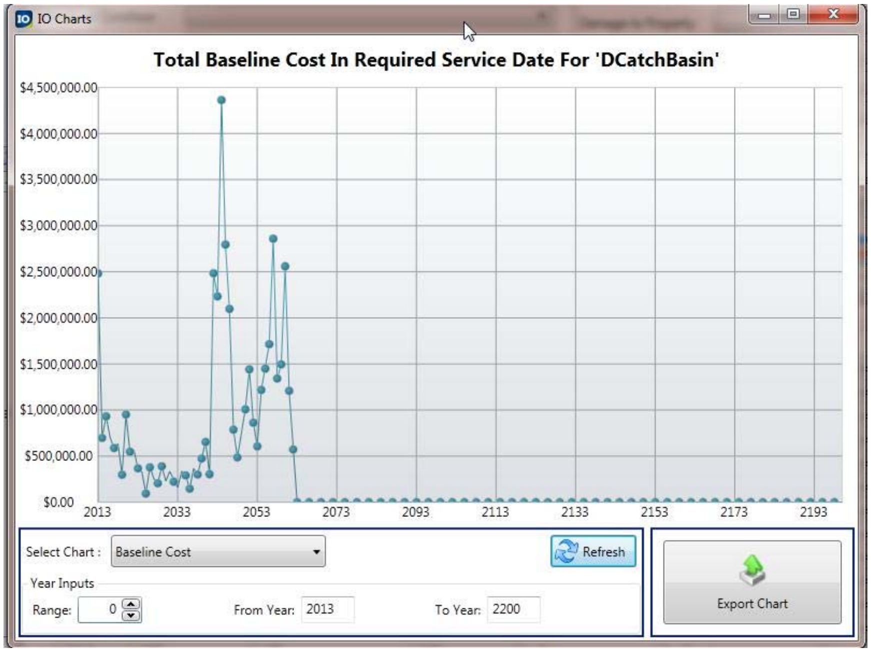


Figure 3-9 Annual Cost to Replace Catch Basins at End of Estimated Effective Life



STREAM CROSSINGS AND CULVERTS

Forty-seven (47) stream crossings are identified in the GIS. These are defined as structures spanning streams or open channels at the intersection of public roads. This asset group includes culverts ranging from 10-inches in diameter up to 12-foot by 12-foot box culverts. These assets are generally isolated and have different deterioration rates than the streams and open channels they span, making the life expectancy independent of adjacent assets. The crossings are critical to the system as failure can lead to significant disruption through flooding and closure of roadways.

Condition of Current Assets

Historical condition assessment records were not available for the culverts. In order to supplement the data available in the GIS database, field inspections were completed for 30 culverts during open channel inspections and used to confirm assumptions. In order to remain consistent, the culverts were assigned a structural and O&M condition following the same process used for the gravity mains and laterals. During the field visits, some assets were found to be in disrepair and were noted for capital improvements.

Probability and Consequence of Failure

A summary of the POF is provided in Table 2-2 on page 7. The COF factors, weights, and values used are summarized in Table 3-14.

Table 3-14 Culvert Consequence of Failure Factors

COF Factors	Weight	Value	Rating Description
Depth of Pipe	3.0	1	depth <= 8 feet
		3	8 < depth <= 15 feet
		10	depth > 15 feet
Pipe Size	3.0	2	size <= 12 inches
		10	12 < size <= 24 inches
		25	24 < size <= 42 inches
		35	42 < size <= 72 inches
		50	size > 72 inches
Proximity to Floodplain	0.5	0	Not within a floodplain
		1	Within the 100 year floodplain
		2	Within the 500 year floodplain
Proximity to Environmental Hazard	0.5	0	Not in close proximity to known hazardous site
		1	Within 100 feet of known hazardous site
		2	Within a site with known environmental hazards
Stream Type	1.0	1	Ditch
		3	Stream
Type of Crossing	2.0	5	Crosses minor road
		15	Crosses major road or railroad
Total	10.0		

Estimated Effective Life Summary

The recorded age for culverts was based on the same values assigned to gravity mains. Table 3-15 shows the number of culverts broken down by the age ranges previously established. Culverts were found to be either reinforced concrete or corrugated metal. Culverts made of reinforced concrete were assumed to have an EEL of 100 years. Corrugated metal culverts were assumed to have an EEL of 65 years. Eleven (11) of the 47, or 23 percent, of culverts in the City system have currently exceeded their expected life.

Table 3-15 Culverts by Age

Asset Age (years)	0-25 years	25-50 years	50-75 years	75-100 years	Total
Number of Culverts	4	16	24	3	47
Percent of Culverts	9%	34%	51%	6%	100%

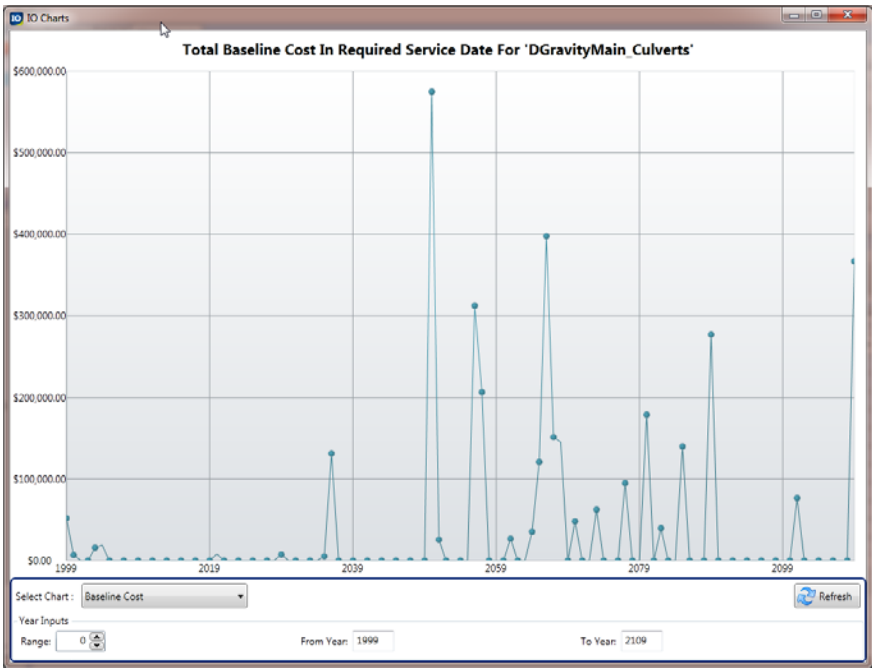
Value of Current Assets

Additional costs for end sections, headwalls, riprap, bank restoration, and pavement replacement were included in the replacement cost calculations. Table 3-16 summarizes the current and future system values for the culverts. Figure 3-10 shows the value of assets that with an expiring EELs each year over the next 100 years.

Table 3-16 Value of Stream Crossings and Culverts

Asset	Quantity	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Culverts (stream crossings)	47	$1,649,000	$3,530,000

Figure 3-10 Annual Cost to Replace Culverts at End of Estimated Effective Life



OUTFALLS

A discharge point feature class is included in the GIS and indicates where pipes or streams discharge to systems owned or operated by other jurisdictions, such as the Kent County Drain Commissioner (KCDC) or waters of the state. These discharge points may be enclosed and underground or may be points open at the surface. Enclosed discharge points represent a pipe-to-pipe connection that doesn't necessarily occur at a manhole structure. Enclosed discharge points are assumed to be part of the sewer network and are not handled as individual assets in this plan. The open discharge points are considered outfalls along open bodies of water and are tracked, inspected, and reviewed in separate ways from gravity mains.

The City's GIS identifies 465 open discharge points. Thirty-six (36) of the points did not include a pipe size or other information aside from an illicit discharge elimination program (IDEP) ID. The majority of these points were located immediately downstream of an end-of-pipe discharge point and were omitted from analysis. Seventy-three (73) points were identified at the ends of culverts, pipes blind-tied to culverts, or discharge points on assets not owned by the City. These points are included with the gravity main or culvert asset analysis. Three hundred fifty-six (356) open discharge points were identified as valid physical assets, and were considered with this plan.

Condition of Assets

Condition assessment information at the outfalls was not available. Condition information from gravity sewers cannot be applied to the outfalls as they are materially different. Site visits are recommended for each asset to evaluate the structural condition of the asset.

Probability and Consequence of Failure

A summary of the POF is provided in Table 2-2 on page 7. The COF factors, weights and values used for manholes and catch basins are summarized in Table 3-17.

Table 3-17 Outfall Consequence of Failure Factors

COF Factors	Weight	Value	Actual Weight Applied	Rating Description
Structure Diameter	8.0	2	0.3	size <= 12 inches
		10	1.6	12 < size <= 24 inches
		25	4.0	24 < size <= 42 inches
		35	5.6	42 < size <= 72 inches
		50	8.0	size > 72 inches
Proximity to Floodplain	1.0	0	0.0	Not within a floodplain
		1	0.5	Within the 100 year floodplain
		2	1.0	Within the 500 year floodplain
Proximity to Environmental Hazard	1.0	0	0.0	Not in close proximity to known hazardous site
		1	0.5	Within 100 feet of known hazardous site
		2	1.0	Within a site with known environmental hazards
Location	0.0	1	0.0	Flat discharge
		2	0.0	Shallow slope <= 30 deg
		5	0.0	Steep slope > 30 deg
		10	0.0	River wall
Discharge Destination	0.0	1	0.0	Dry ditch
		5	0.0	Stream
		10	0.0	Wetland or major waterbody
Total	10.0			

Estimated Effective Life Summary

An EEL of 75 years was assigned to all outfalls. This is lower than the EEL for sewers and manholes, due to other factors which may impact the life of an outfall structure, such as bank erosion. Many existing outfalls were not designed with the same requirements for permanent erosion control measures and energy dissipation, meaning the failure of the bank may occur before the outfall fails. Table 3-18 shows that approximately 10% of the outfalls in the system have currently exceeded their EEL.

Table 3-18 Outfalls by Age

Asset Age (years)	0-25 years	25-50 years	50-75 years	75-100 years	100+ years	Total
Number of Outfalls	74	168	76	26	12	356
Percent of Outfalls	21%	47%	22%	7%	3%	100%

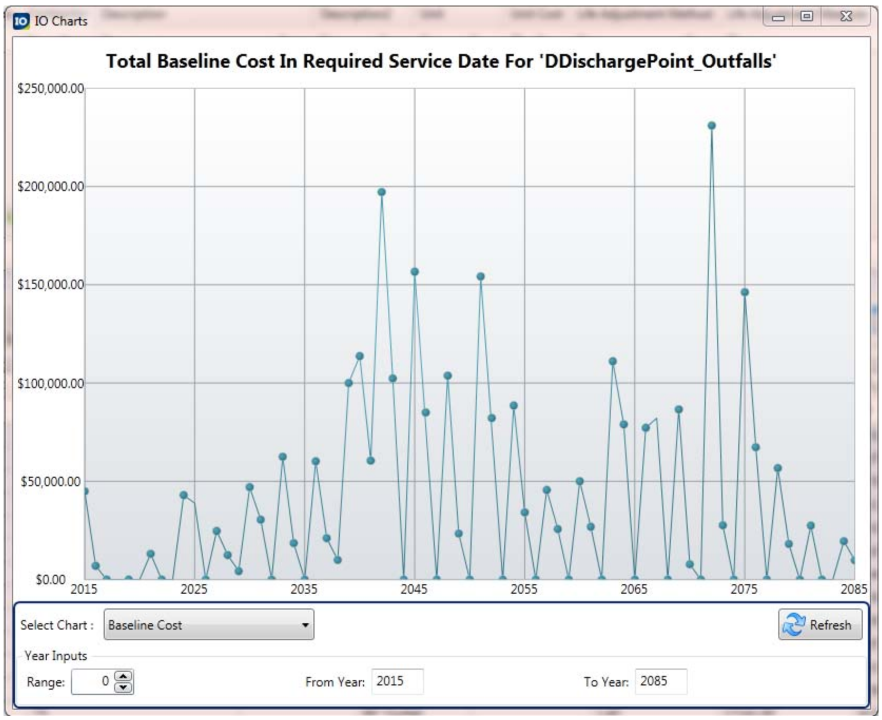
Value of Current Assets

Additional costs for associated items of work such as permanent erosion control measures and dewatering were included. Table 3-19 summarizes the baseline and future system value for the culverts. Figure 3-11 shows the value of assets that will have expiring EELs each year for a 100-year timeframe.

Table 3-19 Value of Outfalls

Asset	Quantity	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Outfalls	356	$1,669,000	$2,938,000

Figure 3-11 Annual Replacement Cost of Outfalls at End of Estimated Effective Life



Floodwall Penetrations

Many storm drains discharge directly to the Grand River through the concrete floodwall that lines the river through the heart of the City. These penetrations are not listed as separate assets, but are included with the adjacent sewer. Some of these penetrations are outfitted with a backflow prevention device as well that may impact the COF and increase costs for maintenance and replacement. A separate analysis is underway to identify and provide condition assessments of the floodwall penetrations. The condition information related to these assets should be added into City GIS database as soon as the inventory information is available.

OPEN CHANNELS AND ROADSIDE DITCHES

There are a total of 39.6 miles of open channels identified in the City's GIS. There are additional open channels not included in this analysis which are under the jurisdiction of either the Kent County Drain Commissioner or the Michigan Department of Transportation.

In addition to the streams, there are also roadside ditches used for stormwater drainage. Typical maintenance issues with roadside ditches include excessive vegetation, sediment accumulation, bank erosion, and debris accumulation. Shallow roadside ditches in residential areas also commonly have driveway culverts which can become buried and plugged if not maintained.

Condition of Assets

A field investigation was conducted in November 2012 to gather condition assessment data. The field investigations consisted of visiting accessible stream crossings and performing an upstream and downstream inventory of the stream or open channel that included gathering information on the background, substrate, morphology, channel dynamics, physical appearance, in stream cover, stream corridor, adjacent land uses and a sketch of the cross section. Based on the limited locations investigated and the wide variability observed in conditions, global (or average) condition assessment results were not applied to unvisited areas. Significant observations included the following:

- A complete bank failure along the north side of Eastcastle Drive just west of Breton Road along the upper tributary to the Burton-Breton Branch of Plaster Creek has led to the collapse of the 12 inch outlet from the existing storm drain.
- Significant bank erosion has caused many trees to fall, resulting in debris and garbage accumulation impacting the path of flow in the Burton-Breton Branch of Plaster Creek upstream of 32nd Street.
- Significant erosion and overgrowth was observed along portions of Lamberton Creek between 3 Mile Road and Perkins Avenue. The condition of several steel-plate corrugated metal culverts was questionable. Several residents voiced concerns and complaints to staff during field inspections.
- An exposed pipe was observed obstructing the flow in the bottom of Hogadone Creek just downstream of a storm drain outfall on the southeast corner of Seventh Street and Oakleigh Avenue.
- Outfall pipes with separated joints were observed along the south bank of Indian Mill Creek near the end of Richmond Avenue due to bank erosion.
- A culvert crossing on Leffingwell Avenue, not included in the GIS, was located approximately 850 feet north of Bradford Street. Erosion and stabilization issues were observed in the open channels on both sides of the road. The level of erosion may be impacting an existing sanitary sewer manhole on the upstream side.

Probability and Consequence of Failure

Insufficient attribute data were available to adequately use the POF and COF analysis approach for this section of the report. For future applications the POF factors applied to open channel sections are similar to those discussed for other assets (refer to page 6). COF factors for future applications are suggested to include: the channel size, shape and bank slope along with the proximity to roads, buildings and environmental hazards.

Estimated Effective Life Summary

An EEL is not necessarily applicable to open channel systems. The most effective method of managing the asset involves regular condition assessments.

Value of Current Assets

Open channel systems, such as streams and creeks, are never truly replaced. Asset 'replacement' in this case would consist of renewal activities such as cleaning, reestablishing grade, benching slopes, installing permanent erosion control measures or a number of additional solutions depending on the problems identified during the assessment.

Condition inspection costs are estimated at approximately $64,000 for the 40 miles of open channel ($1,600 per mile). Roadside ditches require a lower level of inspection, resulting in an approximate cost of $44,000 for the 72 miles of ditches ($600 per mile). While the City may not ultimately be responsible for all of the maintenance and repair to these channels, an initial assessment would be beneficial for planning purposes. The baseline future system value below represents the total cost of system renewal based on the level of service assumptions made for these assets.

Table 3-20 Value of Open Channels and Ditches

Asset	Quantity	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Open Channels	40 miles	NA	$2,570,000
Ditches	72 miles	$5,703,000	$1,223,000
Total	112 miles		$3,793,000

DETENTION AND RETENTION BASINS

Five (5) detention basins were included in the asset assessment and are identified in Table 3-21. There are additional detention basins within the City that were not included because they are owned or operated by other agencies or part of neighborhood plat developments. No specific GIS feature class is included in the GIS for detention basins. Underground detention basins were included with the green infrastructure assets.

Condition of Assets

A visual assessment of the Woodlawn detention basin was completed. Results of this inspection are summarized in Table 3-21.

Table 3-21 Stormwater Detention Basin Inventory

Name/Location	Date Installed	Type	Comments
Woodlawn Detention Basin – NE corner of Woodlawn Ave and 28th St	1999	Open	A broken pipe between the forebay and pond was observed to be causing erosion of berm.
Kreiser Street Detention Basin	1993	Open	Silver Creek Stormwater Detention Facility. Proposed wetland restoration noted in GIS.
Calvin Avenue Detention Basin	1994	Open	Silver Creek Stormwater Detention Facility.
Otsego Detention Basin	1995	Open	Silver Creek Stormwater Detention Facility.
Corduroy Detention Basin	1994	Open	Coldbrook Creek Regional Retention.

Probability and Consequence of Failure

Insufficient attribute data were available to adequately use the POF and COF analysis approach for this portion of the report. For future applications, the POF factors applied to detention basins are similar to those discussed for other assets (refer to page 6). COF factors for future applications are suggested to include: the size, shape, side slopes, and material along with the proximity to roads, buildings and environmental hazards. In addition the various components of a storage facility should be considered. For example, the inlet structure, sediment forebay, primary storage cell, and outlet control structure could be included with the basin attributes or individually.

Estimated Effective Life Summary

The EEL for the detention basins was not calculated for this analysis. The EEL of a detention or retention basin should be based on a composite of the different elements found in each asset. The ancillary structures like inlets, outlets and overflow structures and elements such as underdrains may have a different EEL and may be evaluated as a portion of the overall asset. The basins listed in this report are less than 20 years old, with no history of problems. During the field inspection for the Woodlawn Detention Basin, some potential problems were observed as outlined in Table 3-21.

Value of Current Assets

Replacement costs for detention basins are difficult to determine, based on the fact that these are typically large assets, and are unlikely to be physically replaced. They are more likely to be maintained or renewed. Including inlet and outlet improvements, the five (5) detention basins in the City system were estimated to cost approximately $1,725,000 to construct.

Renewal of an existing open detention or retention basin would include excavation costs for expansion or debris/sediment removal and topsoil and seeding costs for reestablishing vegetation. In some cases basins may be modified to improve water quality, which would incur a different set of costs. Typical maintenance for a standard operating open basin includes removing debris, cleaning of the underdrain, and removing sediment from the inlets and outlets. Mowing of the site and other landscaping may also be required.

Table 3-22 Value of Detention and Retention Basins

Asset	Quantity	Estimated End of Service	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Woodlawn Detention Basin – NE corner of Woodlawn Ave and 28th St	1	61	$225,000	$649,000
Kreiser Street Detention Basin	1	55	$400,000	$1,039,000
Calvin Avenue Detention Basin	1	56	$400,000	$1,057,000
Otsego Detention Basin	1	57	$400,000	$1,076,000
Corduroy Detention Basin	1	56	$300,000	$793,000
Total	5		$1,725,000	$4,614,000

PUMP STATIONS

The City owns and operates a total of 11 stormwater pumping stations. The eight (8) stations listed below are used during a major rainfall event to pump stormwater to the river during periods where the river level is too high to allow free gravity discharge.

- Caledonia – Constructed in 1999

- Palmer – Constructed in 1999
- Ann St (Indian Mill Creek) – Constructed in 1999
- Market Ave - Riverside – Constructed in 2008
- Wealthy – Constructed in 1996
- Front/Scribner – Constructed in 1991
- Ken-O-Sha – Constructed in 2006
- Academy (KCDC) – Constructed in 2000. Owned by the KCDC and maintained by the City.

These lift stations are not all designed to be constantly used, but are critical components in that they provide flood relief in the system during high river levels so reliable operation is mandatory. The best way to manage these types of assets is to maintain high levels of operation to ensure that there will be no excessive downtime due to repairs. It is not recommended to run assets such as pump stations to the predicted failure date.

The remaining stormwater pump stations (Alpine (1973), MARB (1995) and Albany (2000)) are in operation regardless of the river level and are used to convey flows to nearby gravity systems for sites and areas that lack adequate grade for gravity drainage.

Table 3-23 provides a summary of the pump stations.

Table 3-23 Pump Station Summary

Station	Install Year	Installation Cost	Pump Model	Capacity (GPM)	TDH (feet)	HP	Pump Qty
Academy[1]	2000	$150,000					
Albany	2000	$700,000	ABS - AFP 2021 GP	1400	30	23	2
Alpine	1973	$600,000	Worthington Pump - B284TP10	300		15	3
Ann St		$550,000	Flygt - P7045/600	4000	9	17.4	3
Caledonia	1999	$550,000	Flygt - P7045/600	4000	9	17.4	3
Front / Scribner	1991	$5,100,000	Flygt - PL7115	50500	15.2	250	6
Ken-O-Sha	2006	$550,000	Flygt - P7045/600	4000	9	17.4	3
MARB	1995	$275,000	Flygt - CP3152	1500	29	20	2
Market Ave - Riverside	2008	$850,000	ABS - VUP 0501.10 ME 520/6-51.60 FM	10770	18	70	4
Palmer	1999	$550,000	Flygt - P7045/600	4000	9	17.4	3
Wealthy	1996	$2,325,167	Flygt - PL7115	50500	15.2	250	10

[1]Pump Station is owned by the KCDC and maintained by the City.

Condition of Assets

Pump station inspection data is maintained in written records. Inspections conducted by Tetra Tech with the assistance of City staff included general site observations and photographs, and were used to confirm the general condition of each facility. Generally, all of the pump stations are in good condition as the City performs routine maintenance due to the criticality of these assets. Considering the nature of pump stations, the focus on replacement costs was on pump condition and replacement.

Analysis and Estimated Effective Life Summary

Insufficient attribute data were available to adequately use the POF and COF analysis approach for this report. Pump stations involve multiple assets and elements such as the pumps, force main, electrical components, wet well, etc. Each of the elements has different probabilities and consequences of failures as well as different estimated effective life spans. For example the pumps are often replaced several times before structural issues arise in the facility. The relatively recent construction, minimal use, and routine maintenance of these stations have left them in good operating condition.

Value of Current Assets

The initial installation cost for each stormwater pump station is provided in Table 3-24, along with a breakdown of components and the future system value projection.

The City presently budgets $40,000 for the annual maintenance and inspection of their pump stations. This budget was based on bi-weekly inspections for eight (8) of the pump stations, estimating approximately $200 each visit.

Table 3-24 Value of Pump Stations

Facility	Install Year	Install Cost[3]	Baseline System Value (Current Cost)					Baseline Future System Value (Replacement Cost at Failure)
			Pumps (25 year EEL)	Electrical (75 year EEL)	Mechanical (75 year EEL)	Structure (75 year EEL)[2]	Total	
Academy[1]	2000	$150,000	NA	NA	NA	NA	NA	NA
Albany	2000	$700,000	$39,200	$100,000	$100,000	$460,800	$700,000	$2,023,000
Alpine	1973	$600,000	$19,500	$100,000	$100,000	$380,500	$600,000	$802,000
Ann St	1999	$550,000	$76,200	$100,000	$100,000	$273,800	$550,000	$1,465,000
Caledonia	1999	$550,000	$76,200	$100,000	$100,000	$273,800	$550,000	$1,465,000
Front/ Scribner	1991	$5,100,000	$933,000	$250,000	$150,000	$3,767,000	$5,100,000	$10,468,000
Ken-O-Sha	2006	$550,000	$76,200	$100,000	$100,000	$273,800	$550,000	$1,802,000
MARB	1995	$125,000	$39,200	$30,000	$30,000	$25,800	$125,000	$265,000
Market Ave - Riverside	2008	$850,000	$216,400	$150,000	$100,000	$383,600	$850,000	$2,736,000
Palmer	1999	$550,000	$76,200	$100,000	$100,000	$273,800	$550,000	$1,465,000
Wealthy	1996	$2,326,000	$1,555,000	$250,000	$175,000	$346,000	$2,326,000	$3,745,000
Total		$12,051,000	$3,107,100	$1,280,000	$1,055,000	$6,458,900	$11,901,000	$26,236,000

[1]Pump Station is owned by the KCDC and maintained by the City.

GREEN INFRASTRUCTURE

The City has recently begun implementing green infrastructure as part of their stormwater system, and is poised to increase installations as part of the overall City Sustainability Plan. Green infrastructure is designed to help reduce the volume of stormwater runoff and to improve the quality of the water discharged to surface waters.

Asset Inventory

Current installations that are maintained by the City include permeable pavement, subsurface storage systems, rain gardens and naturalized landscapes. The name, owner, installation date, and type of installation are provided in Table 3-25. The City has also recently constructed stormwater filter strips in the parking lot of the West Downtown Development Authority and bioretention islands along Plainfield Avenue, however detailed information regarding these projects was not available during preparation of this report.

Table 3-25 Green Infrastructure Inventory

Green Infrastructure Project Name	Owner	Date Installed	Type
Environmental Services Engineering Parking Lot	City	3/1/2004	Permeable Pavement
Joe Taylor Park	City	10/1/2010	Subsurface Storage System
River of Stars	City	9/1/2002	Rain Garden
Potters House School Rain Garden	City	5/1/2011	Rain Garden
River of Dreams	City	6/1/2008	Rain Garden
Roosevelt Park Riparian planting	City	4/1/2011	Naturalized Landscape
Mid Towne Village Subsurface Storage	Mid Towne Village, LLC	8/1/2010	Subsurface Storage System
GRCHS Rain Garden and Butterfly Garden	Grand Rapids Christian High School	5/1/2008	Rain Garden
DeVries Hall rain garden	Calvin College	5/1/2007	Rain Garden
Rain Garden at Christian Reformed Church Headquarters	Christian Reformed Church	10/1/2010	Rain Garden
Native gardens and walking paths at Christian Reformed Church Headquarters	Christian Reformed Church	6/1/2012	Naturalized Landscape
Tree Planting at Christian Reformed Church Headquarters	Christian Reformed Church	7/1/2011	Naturalized Landscape
West DDA Parking	DDA		Filter Strips
Plainfield Avenue Bioretention Islands	Creston Business Assoc.	9/1/2012	Bioretention

Condition of Assets

Records of past operation and maintenance activities at the sites were not available for this report. Based on the recent installation, condition assessments were not conducted of these assets. The assets were assumed to be in adequate condition.

Estimated Effective Life Summary

Since there are a variety of different types of green infrastructure, and these types of projects are usually site-specific, it is difficult to assess these as a single asset group. For these reasons, these assets were not modeled in the IO toolset. As the City's green infrastructure expands, these assets may be revisited to determine if they should be entered into the IO toolset.

Green infrastructure projects are site-specific and dependent on the quality of the design and installation process. An accurate EEL is difficult to assign. Each installation should be monitored and observed during actual rainfall events to document the operation and performance. Routine maintenance is mandatory to ensure optimal performance.

Value of Current Assets

Table 3-26 summarizes the current and future system values for the green infrastructure practices owned by the City.

Table 3-26 Value of Green Infrastructure

Asset	Quantity	Estimated End of Service	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Environmental Services Engineering Parking	1	2029	$209,400	$276,400
Joe Taylor Park	1	2110	$1,000,000	$5,380,700
River of Stars	1	2052	$10,100	$19,900
Potters House School Rain Garden	1	2052	$1,700	$3,900
River of Dreams	1	2058	$66,500	$145,200
Roosevelt Park Riparian Planting	1	2061	$15,400	$35,500
GRCHS Rain Garden and Butterfly Garden	1	2058	$10,000	$21,900
Native Gardens at Christian Reformed Church	1	2062	$5,100	$12,000
Rain Garden at Christian Reformed Church	1	2060	$17,100	$38,700
Tree Planting at Christian Reformed Church	1	2061	$26,000	$59,800
Mid Towne Village Subsurface Storage 1	1	2060	$189,700	$1,020,800
Mid Towne Village Subsurface Storage 2	1	2060	$250,700	$1,349,000
Devries Hall Rain Garden	1	2057	$40,300	$86,500
West DDA Parking	1	NA	NA	NA
Plainfield Avenue Bioretention Islands	1	NA	NA	NA
Total	15[1]		$1,842,000	$8,451,000

[1]System values only available for 13 practices

ASSET GROUP REPLACEMENT COST

The baseline system value, represented as the total replacement cost, is estimated to be $528.8 million. Table 3-27 summarizes this information by asset group. Approximately seventy percent (70%)of the current system value is associated with the gravity sewer system.

Table 3-27 Current System Replacement Value by Asset

Asset	Quantity	Baseline System Value (Current Cost)	Baseline Future System Value (Replacement Cost at Failure)
Gravity Mains	2,030,660 (ft)	$365,757,000	$933,842,000
Manholes	10,748 (ea)	$39,051,000	$105,349,000
Laterals	514,583 (ft)	$43,065,000	$113,942,000
Catch Basins	17,054 (ea)	$55,910,000	$136,594,000
Pressurized Mains	664 (ft)	$131,000	$505,000
Siphons	339 (ft)	$250,000	$618,000
Culverts	3,600 (ft)	$1,649,000	$3,530,000
Outfalls	356 (ea)	$1,669,000	$3,530,000
Open Channels	40 (mi)	NA	$2,570,000
Roadside Ditches	72 (mi)	$5,703,000	$1,223,000
Detention Basins	5 (ea)	$1,725,000	$4,614,000
Pump Stations	11 (ea)	$12,051,000	$26,236,000
Green Infrastructure	13 (ea)	$1,842,000	$8,451,000
Total		$528,803,000	$1,341,004,000

4. LEVEL OF SERVICE

A major factor in the quality of community life is the quality of the community's facilities, services and amenities. Level of service is a measure of the amount and/or quality of the public facility which must be provided to meet that community's basic needs and expectations.

The City is developing a Community Based Stormwater Program. The City, with the cooperation of the West Michigan Environmental Action Council (WMEAC), has developed a baseline for the existing level of service (LOS) offered by the City, and established the framework for proposed increased levels of service. Tetra Tech used the baseline condition and this framework to develop and expand three (3) different LOS for the stormwater system. The LOS recommended were based on a set of goals for the stormwater system which are summarized in the table below.

Table 4-1 Level of Service Goals

Community Outcomes	City Responsibility
Healthy natural resources. Rivers, streams and lakes.	Reducing volumes and pollutant loads in stormwater discharge.
Improved recreational opportunities for residents.	By reducing the impact of floods on housing, business and recreational areas.
A stronger economy.	Working with developers to provide cost effective stormwater solutions.
Making Grand Rapids even more attractive place to live.	Improving the operation, functionality, and usefulness of infrastructure and responding to concerns and problems as quickly as possible.

LEVEL OF SERVCE COMPONENTS

For the purposes of this asset management plan, various components are used in describing the level of service. These components include operation and maintenance activities of the various asset groups, system renewal of the asset groups, and other activities. Each of these components is further discussed within the level of service categories (beginning on page 39) and includes projected annual costs (beginning on page 46). Additional description information on the components is provided below.

Operation and Maintenance

The operation and maintenance activities are further subdivided into the inspection, preventative maintenance, and corrective maintenance activities.

- Inspection. The initial assessment and ongoing inspection of the stormwater system are crucial components to implementing a comprehensive, sustainable O&M program. The initial assessment phase focuses on establishing a detailed inventory and assessment of the assets. In addition, reoccurring inspection is required to continue to evaluate the system.
- Preventative Maintenance. Preventative maintenance is work that is intended to extend the estimated service life through activities such as lining, root removals, sealing cracks and leaks, or installing pipe and manhole liners. Non-structural activities such as cleaning sediment and debris out of pipelines and cleaning out catch basin sumps can be identified as preventative maintenance as it improves the efficiency of operation.
- Corrective Maintenance. Corrective, or reactive, maintenance includes all repairs to correct defects or failures identified in the system during routine inspections. This may be the replacement of a failed pipe or structure, a point repair, or replacing a broken frame and cover on

a structure. Anything shy of full replacement is intended to extend the service life of an asset and is considered corrective maintenance. Corrective maintenance is different from planned renewal, because there is no way to completely plan for all potential failures that may occur at any given time. Corrective maintenance costs were determined by identifying the assets that have already or will meet the end of their EEL during the inspection period and assuming that a percentage of those assets will fail over that timeframe.

System Renewal

System renewal addresses the replacement of an asset at the end of its estimated effective life. Table 2-1 (page 6) identified the assumed EEL. Various level of service categories assume that the EEL would be extended either through preventative or corrective maintenance activities. At some point, the system is assumed to be replaced. Average annual replacement costs are based on the total system replacement cost divided by the respective estimated effective lifespan of the individual assets.

Other Activities

Additional miscellaneous activities are included in the level of service categories and cost estimates. These include the following:

Street Sweeping

Street sweeping is an important maintenance activity to address the water quality of stormwater runoff. Street sweeping is considered a good housekeeping practice under the NPDES stormwater permit. To ensure compliance, the City implements a street sweeping program and tracks the annual lane miles swept and amount of debris removed. The City currently spends approximately $750,000 on street sweeping annually.

For the purpose of this report, streets are not considered a stormwater asset and hence the maintenance activity for street sweeping is considered separately from the defined asset groups. Contrast this with an activity such as cleaning catch basins. Since catch basins are one of the stormwater asset groups, the maintenance cleaning activity is associated with the preventative maintenance information for catch basins.

Studies and Planning Projects

Part of managing the stormwater assets involves conducting studies and planning projects such as analyzing the flow capacity of the drainage system; planning for the impacts of climate change; maintaining and updating stormwater drainage requirements; and applying for grants. A placeholder is provided in this report and in the projected annual costs by level of service category. Additional details regarding the specific studies and planning projects are included in the 2013 Stormwater Master Plan.

Regulatory and Developmental Compliance

Compliance with the NDPES stormwater permit and proactively managing and regulating the stormwater runoff from development and redevelopment activities are important components of the budget. This activity also includes properly implementing and enforcing the recommended policies in the Stormwater Master Plan and Technical Reference Manual. With an added focus on installing green infrastructure, and tighter controls on the limit of post-development runoff allowed to enter the City system, these reviews are going to become increasingly thorough and time consuming. In addition to reviewing plans, the City will need to ensure proper construction and ongoing maintenance practices are applied on private property projects.

LEVEL OF SERVICE CATEGORIES

To achieve the goals above, levels of service were established that provide a reliable, responsive and sustainable stormwater system. The system must be capable of handling the current conditions, and also be able to grow and adapt to the changing needs.

Four levels of service are represented by increasing levels of annual spending requirements for the following basic services: capital/renewal projects, O&M, street sweeping, planning, regulatory compliance and development regulation. Below is a general description of each level of service.

Existing Level of Service

This is the baseline level of service. The current funding level provides for minimum O&M activities and corrective action for only the most critically failed portions of the system. Capital funding is limited to work with other City department infrastructure projects and for assessments from the Kent County Drain Commissioner. Refer to Table 4-2 for additional details.

Table 4-2 Existing Level of Service Definition

Asset	Inspection	Corrective	Preventative	System Renewal
Gravity Mains		Respond to failures and complaints for all sewer components.		
MH				
Laterals				
Catch basins		Clean 2500 annually and perform corrective maintenance.		
Force Mains	Visual inspection every 2 weeks during pump station inspection.			
Siphons	Clean and inspect annually.			
Culverts		Clean debris, corrective maintenance.		
Open Channel		Clean debris, corrective maintenance.		
Ditches				
Discharge Points	Inspect all discharge points every 5 years per MS4 requirements.			
Creek gates	Inspect annually, clean as needed.			
Detention Basins	No recorded site inspections.	Routine maintenance 3 times per year.		
Infiltration Basins		Clean and corrective maintenance every 10 years.		
Lift Stations	Inspect facility every 2 weeks. Facility log kept on site.			
Hydro Separators	Clean and inspect annually.			
Green Infra				

Level of Service C

This LOS is intended to allow the City to determine critical infrastructure and identify high priority areas. Refer to Table 4-3. Key elements of this LOS include:

- Funding would increase for O&M to allow for the assessment of the entire collection system greater than 75 years old every 10 years. Funding also assumes performing corrective maintenance where necessary and preventative maintenance on 10 percent of all inspected assets.
- Inspection of 50 percent of culverts annually, along with replacing or renewing the worst 5 percent.
- Inventory and inspection of approximately 4 miles each of open channels and ditches annually with funding for preventative maintenance, and establishing a minimal annual renewal program.
- Inspection of all discharge points every 5 years, with corrective maintenance to repair or replace the top 10 percent worst condition each year. And preventative maintenance on 5 percent of inspected outfalls annually.
- Inspections and routine maintenance on other system assets would be organized so that pertinent data are collected and stored in the GIS database.
- 10 percent of all new capital spending would be directed towards green infrastructure.
- Regulatory spending would be increased to establish a public education program.
- Capital spending would be based on an assumed system replacement every 150 years, with catch basins and laterals assigned a 100 year replacement cycle.

Table 4-3 Level of Service C Definition

Asset	Inspection	Corrective	Preventative	System Renewal
Gravity Mains	PACP CCTV inspect pipes greater than 75 years old over 10-year period.	Replace 15% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected sewers over 10 years. Clean 20% of all assets annually.	Replace every 150 years.
MH	Inspect manholes greater than 75 years old over 10-year period.	Replace 15% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected sewers over 10 years. Clean 20% of all assets annually.	Replace every 150 years.
Laterals	Inpect CB laterals greater than 75 years old over 10-year period.	Replace 15% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected laterals over 10 years. Clean 20% of all assets annually.	Replace every 100 years.
Catch basins	Clean and inspect 25% annually (Approx. 4264). Record and monitor debris levels for cleaning prioritization.	Replace 15% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected catch basins over 10 years.	Replace every 100 years.
Force Mains	Visual inspection every 2 weeks during pump station inspection. PACP CCTV inspect every 15 years.			Replace every 100 years.
Siphons	Clean and inspect annually.			Replace every 150 years.
Culverts	CCTV/walk/inspect 50% of culverts annually.	Replace/rehabilitate top 5% by POF.	Clean 20% of all assets annually.	Replace every 150 years.
Open Channel	Walk, inventory and inspect 4 miles of open channel annually.		Remove debris at 1 site per mile inspected.	Restore 7.5% minor, 3% moderate and 1% severe construction for length inspected each year.
Ditches	Inspect 4 miles of roadside ditch annually.		Clean 20% of all assets annually.	Grade or clean 10% of length inspected.
Discharge Points	Inspect all discharge points every 5 years per MS4 requirements.	Replace top 10% by POF each cycle.	Stabilize bank and erosion control at 5% of assets each cycle.	Replace every 150 years.
Creek gates	Inspect annually, clean as needed. Record and monitor conditions for prioritization.			Costs included with adjacent assets.
Detention Basins	Complete site inspection 3 times annually including routine maintenance.			Facility renovation every 100 years. Includes re-grading, seeding, renew inlet/outlet structures.
Infiltration Basins	Clean and inspect every 5 years.			Replace system every 150 years.
Lift Stations	Inspect facility every 2 weeks. Log inspection data in GIS every 6 months.			Replace pumps every 30 years, structural, mechanical and electrical components replaced every 100 years.
Hydro Separators	Clean and inspect annually. Record debris accumulation for prioritizing cleaning schedule and frequency.			Replace every 150 years.
Green	Inspect and perform			Invest 10% of all

Asset	Inspection	Corrective	Preventative	System Renewal
Infrastructure	recommended maintenance annually.			collection system capital renewal costs on GI. GI=+25% increase to construction costs.

Level of Service B

This LOS will provide a more direct basis for determining and tracking preventative maintenance. Refer to Table 4-4. Key elements of this LOS include:

- Funding would increase for O&M to allow for the assessment of the entire collection system greater than 50 years old every 10 years performing corrective maintenance where necessary and preventative maintenance on 10 percent of all inspected assets.
- Inspection of 50 percent of culverts annually, replacing or renewing the worst 10 percent.
- Inventory and inspection of approximately 5 miles each of open channels and ditches annually with funding for additional preventative maintenance and a more robust annual renewal program.
- Inspection of all discharge points every 3 years, with corrective maintenance to repair or replace the top 10 percent worst condition each year and preventative maintenance on 5 percent of inspected outfalls annually.
- Inspections and routine maintenance on other system assets would be organized so that pertinent data are collected and stored in the GIS database, with periodic testing and cleaning incorporated with the site visits.
- 20 percent of all new capital spending would be directed towards green infrastructure with a goal of pursuing runoff reduction and improved water quality.
- Regulatory spending would be increased to allow for more involved public education and outreach programs.
- Capital spending would be based on an assumed system replacement every 125 years, with catch basins and laterals assigned a 75 year replacement cycle.

Table 4-4 Level of Service B Definition

Asset	Inspection	Corrective	Preventative	System Renewal
Gravity Mains	PACP CCTV inspect pipes greater than 50 years old over 10-year period.	Replace 30% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected sewers over 10 years.	Replace every 125 years.
MH	Inspect manholes greater than 50 years old over 10-year period.	Replace 30% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected manholes over 10 years.	Replace every 125 years.
Laterals	Inspect CB laterals greater than 50 years old over 10-year period.	Replace 30% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected laterals over 10 years.	Replace every 75 years.
Catch basins	Clean and inspect 35% annually (Approx. 5969). Record and monitor debris levels for cleaning prioritization.	Replace 30% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected catch basins over 10 years.	Replace every 75 years.
Force Mains	Visual inspection every 2 weeks during pump station inspection. PACP CCTV inspect every 10 years.			Replace every 100 years.
Siphons	Clean and inspect annually.			Replace every 125 years.
Culverts	CCTV/walk/inspect 50% of culverts annually.	Replace/rehabilitate top 10% by POF.		Replace every 125 years.
Open Channel	Walk, inventory and inspect 5 miles of open channel annually.		Remove debris at 3 site per mile inspected.	Restore 15% minor, 10% moderate and 2% severe construction for length inspected each year.
Ditches	Inspect 5 miles of roadside ditch annually.			Grade or clean 10% of length inspected.
Discharge Points	Inspect all discharge points every 3 years to satisfy MS4 requirements.	Replace top 10% by POF each cycle.	Stabilize bank and erosion control at 10% of assets each cycle.	Replace every 125 years.
Creek gates	Inspect annually, clean as needed. Record and monitor conditions for prioritization.			Costs included with adjacent assets.
Detention Basins	Complete site inspection 3 times annually including routine maintenance.			Facility renovation every 75 years. Includes re-grading, seeding, renew inlet/outlet structures
Infiltration Basins	Clean, inspect and complete infiltration test every 5 years.			Replace system every 125 years.
Lift Stations	Inspect facility every 2 weeks. Integrate bi-weekly inspection data with GIS.			Replace pumps every 25 years, structural, mechanical and electrical components replaced every 75 years.
Hydro Separators	Clean and inspect annually. Record debris accumulation for prioritizing cleaning schedule and frequency.			Replace every 125 years.
Green Infrastructure	Inspect and perform recommended maintenance 3 times annually.			Invest 20% of all collection system capital renewal costs on GI. GI=+25% increase to construction costs.

Level of Service A

This is the highest LOS analyzed. Refer to Table 4-5. Key elements of this LOS include:

- Funding would increase for O&M to allow for the assessment of the entire collection system every 10 years performing corrective maintenance where necessary and preventative maintenance on 10 percent of all inspected assets.
- Inspection of all culverts annually, replacing or renewing the worst 10 percent.
- Inventory and inspection of approximately 6 miles each of open channels and ditches annually with funding for additional preventative maintenance and a comprehensive annual renewal program.
- Inspection of all discharge points every 3 years, with corrective maintenance to repair or replace the top 10 percent worst condition each year and preventative maintenance on 10 percent of inspected outfalls annually.
- Inspections and routine maintenance on other system assets would be increased and organized so that pertinent data is collected and stored immediately in the GIS database, with systematic testing and cleaning procedures incorporated with the site visits.
- 30 percent of all new capital spending would be directed towards green infrastructure applying distinct benchmarks for project performance in reducing runoff volumes and increasing water quality.
- Regulatory spending would be increased to allow for more involved public education and outreach programs, with City sponsored events such as watershed clean ups increased and attempt to incentivize public involvement.
- Capital spending would be based on an assumed system replacement every 100 years, with catch basins and laterals assigned a 50 year replacement cycle.

Table 4-5 Level of Service A Definition

Asset	Inspection	Corrective	Preventative	System Renewal
Gravity Mains	PACP CCTV inspect system over 10-year period.	Replace 50% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected sewers over 10 years.	Replace every 100 years.
MH	Inspect manholes over 10-year period.	Replace 50% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected manholes over 10 years.	Replace every 100 years.
Laterals	PACP CCTV inspect CB laterals over 10-year period.	Replace 50% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected laterals over 10 years.	Replace every 50 years.
Catch basins	Clean and inspect 50% annually (Approx. 8527). Record and monitor debris levels for cleaning prioritization.	Replace 50% of assets that have reached end of EEL over 10 years.	Perform rehabilitation to extend EEL for 10% of inspected catch basins over 10 years.	Replace every 50 years.
Force Mains	Visual inspection every 2 weeks during pump station inspection. PACP CCTV inspect every 5 years.			Replace every 75 years.
Siphons	Clean and inspect annually.			Replace every 100 years.
Culverts	CCTV/walk/inspect all culverts annually.	Replace/rehabilitate top 10% by POF.		Replace every 100 years.
Open Channels	Walk, inventory and inspect 6 miles of open channel annually.		Remove debris at 5 site per mile inspected.	Restore 25% minor, 15% moderate and 3% severe construction for length inspected each year.
Ditches	Inspect 6 miles of roadside ditch annually.			Grade or clean 10% of length inspected.
Discharge Points	Inspect all discharge points every 3 years to satisfy MS4 requirements.	Replace top 10% by POF each cycle.	Stabilize bank and erosion control at 15% of assets each cycle.	Replace every 100 years.
Creek gates	Inspect annually, clean as needed. Record and monitor conditions for prioritization.			Costs included with adjacent assets.
Detention Basins	Complete site inspection 3 times annually including routine maintenance.			Facility renovation every 50 years. Includes re-grading, seeding, renew inlet/outlet structures
Infiltration Basins	Clean, inspect and complete infiltration test every 3 years.			Replace system every 100 years.
Lift Stations	Inspect facility every 2 weeks. Integrate bi-weekly inspection data with GIS.			Replace pumps every 20 years, structural, mechanical and electrical components replaced every 50 years.
Hydro Separators	Clean and inspect annually. Record debris accumulation for prioritizing cleaning schedule and frequency.			Replace every 100 years.
Green Infrastructure	Inspect and perform recommended maintenance 6 times annually.			Invest 30% of all collection system capital renewal costs on GI. GI=+25% increase to construction costs.

Continuous Improvement Process

The level of service definitions should be periodically reviewed and updated. Specifically as the condition assessment information transitions from an age based approach to condition based, the definitions used to identify the various levels of service should be updated accordingly.

PROJECTED ANNUAL COST

The projected annual costs to provide these levels of service are shown in Table 4-6 through Table 4-9.

Table 4-6 Projected Annual Cost - Existing Level of Service

Assets	Inspection	Prevention Maintenance	Corrective Maintenance	System Renewal	Total
Gravity Mains			$200,000	$1,537,000	$1,737,000
Manholes					$0
Laterals					$0
Catch basins			$600,000		$600,000
Pressurized Mains					$0
Siphons					$0
Culverts (stream crossings)			$20,000		$20,000
Open Channels			$5,000		$5,000
Roadside Ditches					$0
Discharge Points					$0
Creek gates					$0
Detention Basins			$5,000		$5,000
Infiltration Basins (underground)					$0
Lift Stations	$40,000				$40,000
Hydro Separators					$0
Green Infrastructure					$0
Subtotal of asset classes	*$40,000*	*$0*	*$830,000*	*$1,537,000*	*$2,407,000*
O&M (inspection, corrective and preventative maintenance)					$870,000
Capital Renewal (system renewal)					$1,537,000
Street Sweeping					$780,000
Planning					$0
Regulatory Compliance					$250,000
Development Regulation					$160,000
Total					**$3,597,000**

Table 4-7 Projected Annual Costs - Level of Service C

Assets	Inspection	Prevention Maintenance	Corrective Maintenance	System Renewal	Total
Gravity Mains	$110,000	$647,000	$299,000	$2,439,000	$3,495,000
Manholes	$6,100	$28,000	$12,000	$261,000	$307,100
Laterals	$11,500	$60,000	$13,000	$431,000	$515,500
Catch basins	$639,000	$14,000	$24,000	$560,000	$1,237,000
Pressurized Mains	$200			$1,000	$1,200
Siphons	$2,100			$1,700	$3,800
Culverts (stream crossings)	$9,700	$43,000		$11,000	$63,700
Open Channels	$7,000	$3,000		$102,000	$112,000
Roadside Ditches	$2,100			$19,100	$21,200
Discharge Points	$28,000	$1,200	$66,000	$12,000	$107,200
Creek gates	$13,200			$0	$13,200
Detention Basins	$6,500			$11,300	$17,800
Infiltration Basins (underground)	$200			$7,000	$7,200
Lift Stations	$57,200			$2,219,000	$2,276,200
Hydro Separators	$4,000			$700	$4,700
Green Infrastructure	$9,000			$505,000	$514,000
Subtotal of asset classes	*$905,800*	*$796,200*	*$414,000*	*$6,580,800*	*$8,696,800*
O&M (inspection, corrective and preventative maintenance)					$2,116,000
Capital Renewal (system renewal)					$6,581,000
Street Sweeping					$1,020,000
Planning					$200,000
Regulatory Compliance					$300,000
Development Regulation					$160,000
Total					**$10,377,000**

Table 4-8 Projected Annual Cost - Level of Service B

Assets	Inspection	Prevention Maintenance	Corrective Maintenance	System Renewal	Total
Gravity Mains	$212,000	$1,207,000	$598,000	$2,927,000	$4,944,000
Manholes	$6,100	$55,000	$23,000	$313,000	$397,100
Laterals	$20,100	$104,000	$25,000	$575,000	$724,100
Catch basins	$894,000	$26,000	$48,000	$746,000	$1,714,000
Pressurized Mains	$300			$1,400	$1,700
Siphons	$2,100			$2,000	$4,100
Culverts (stream crossings)	$9,700	$86,000		$14,000	$109,700
Open Channels	$11,000	$11,000		$291,000	$313,000
Roadside Ditches	$3,200			$72,000	$75,200
Discharge Points	$47,000	$6,000	$142,000	$14,000	$209,000
Creek gates	$13,200			$0	$13,200
Detention Basins	$6,500			$15,000	$21,500
Infiltration Basins (underground)	$500			$8,000	$8,500
Lift Stations	$64,400			$2,531,000	$2,595,400
Hydro Separators	$4,000			$900	$4,900
Green Infrastructure	$25,000			$1,314,000	$1,339,000
Subtotal of asset classes	*$1,319,100*	*$1,495,000*	*$836,000*	*$8,825,000*	*$12,474,400*
O&M (inspection, corrective and preventative maintenance)					$3,651,000
Capital Renewal (system renewal)					$8,825,000
Street Sweeping					$1,140,000
Planning					$600,000
Regulatory Compliance					$350,000
Development Regulation					$160,000
Total					**$14,726,000**

Table 4-9 Projected Annual Cost - Level of Service A

Assets	Inspection	Prevention Maintenance	Corrective Maintenance	System Renewal	Total
Gravity Mains	$482,000	$3,252,000	$996,000	$3,658,000	$8,388,000
Manholes	$16,200	$175,000	$37,000	$391,000	$619,200
Laterals	$80,500	$262,000	$41,000	$862,000	$1,245,500
Catch basins	$1,276,500	$94,000	$80,000	$1,119,000	$2,569,500
Pressurized Mains	$500			$1,800	$2,300
Siphons	$2,100			$2,500	$4,600
Culverts (stream crossings)	$19,300	$86,000		$17,000	$122,300
Open Channels	$11,000	$18,000		$681,000	$719,000
Roadside Ditches	$5,000			$191,000	$196,000
Discharge Points	$47,000	$27,000	$142,000	$1,700	$217,700
Creek gates	$13,200			$0	$13,200
Detention Basins	$6,500			$22,500	$29,000
Infiltration Basins (underground)	$900			$10,000	$10,900
Lift Stations	$85,800			$3,136,000	$3,221,800
Hydro Separators	$4,000			$1,000	$5,000
Green Infrastructure	$49,000			$2,694,000	$2,743,000
Subtotal of asset classes	*$2,102,500*	*$3,920,000*	*$1,296,000*	*$12,788,500*	*$20,107,000*
O&M (inspection, corrective and preventative maintenance)					$7,319,000
Capital Renewal (system renewal)					$12,789,000
Street Sweeping					$1,200,000
Planning					$1,000,000
Regulatory Compliance					$400,000
Development Regulation					$160,000
Total					**$22,868,000**

5. SUSTAINABILITY

The City has charged their staff with adapting operations to become more sustainable with regards to natural and financial resources. The level of funding required to complete full system replacement is so large that a strategic, sustainable approach is required. With the City near full developmental capacity in most areas, and the existing stormwater infrastructure already exhibiting signs of strain, the City must adopt an approach that not only addresses inadequate and aging assets, but also moves towards stormwater reduction. To help meet goals of enhancing the quality of the natural environment, policies must promote improved stormwater quality.

Applying policies to provide incentive to homeowners and businesses to reduce the amount of discharge must be combined with high performing infrastructure. There are many acceptable techniques for replacing existing gray infrastructure with green infrastructure to both reduce the volume of stormwater runoff and improve the water quality discharged to the receiving waters. This will help achieve the triple bottom line for economic, social and environmental impact. This plan incorporates the benchmarks set in the sustainability plan in several ways, including:

ECONOMIC BENEFITS

- Reducing flow rates and eliminating the need for major capital improvements such as storage facilities and increases in pipe capacity.
- Proactive inspection and design policies, coupled with effective O&M programs to reduce the number of emergency calls and allows for controlled approach to renewal.
- Increased implementation of green infrastructure best management practices leads to local job growth and talent attraction and retention.

SOCIAL BENEFITS

- Reduced runoff and a well maintained system will reduce the occurrences of flooding and reduce complaints.
- Well planned, integrated capital improvement projects can minimize disruption to residents and businesses.
- Implementation of green infrastructure best management practices creates attractive, green public spaces, more trees, and cleaner streets.
- Improved local water quality helps maintain public health and safety and enhances recreational activities.

ENVIRONMENTAL BENEFITS

- Improved runoff quality can lead to higher water quality in surface waters.
- Reductions in stormwater runoff preserve and restore ecological habitats, biodiversity, and stream stability.

6. PROPOSED ASSESSMENT PROGRAM

INTRODUCTION

The largest portion of the 20-year capital improvement plan will include renewal of existing assets through projects which have yet to be defined. The majority of the stormwater assets include gravity sewers and associated manholes. To effectively determine which assets require renewal, a comprehensive assessment program is required. Considering a large percentage of the stormwater system should be in acceptable condition, money spent on inspection can be a very good investment. For a relatively low cost, a significant number of assets can be inspected to enable making decisions on whether to rehabilitate or replace assets, or in many cases do nothing.

Information obtained from the assessment program should be incorporated into the GIS for use in the IO toolset to identify assets with the highest probability and consequence of failure. This will provide a ranking of assets that require attention, and then renewal projects may be identified. Accumulation of CCTV inspection data will also assist in identifying trends in the data regarding asset condition as a function of age, material, and general geographic locations.

For the assessment program, Level of Service B was selected as the baseline for developing projects and costs.

METHODOLOGY

Annual Inspections Assignments

Level of Service B indicates that the all assets greater than 50-years would be investigated over a 10-year period. The gravity sewers and associated infrastructure make up the bulk of the assets, and were the primary focus of the assessment program. Assets that met the Level of Service B definition (Table 4-4) were identified and prioritized. The prioritized assessment list was then divided into fiscal years based on the annual assessment spending budget.

Proposed Renewal Strategy

For the purpose of estimating future expenditures the assets to be rehabilitated or replaced are based on the following assumptions:

1. Assets with an EEL less than or equal to 10 years will be replaced. Pipes were assumed to be replaced with the same size pipe.
2. Assets with an EEL greater than 10 years and less than or equal to 25 years will be rehabilitated. This assumes these assets will receive a liner to extend the effective life.
3. Twenty five percent (25%) of assets with an EEL greater than 25 years will require rehabilitation.
4. Gravity mains that are smaller than current City design standards (12 inch diameter) will be replaced with a 12 inch pipe.

The actual repair or replacement method selected would be based on the results of the assessment phase. The actual renewal strategy selected should also take into consideration a hydraulic evaluation and other infrastructure improvements.

RESULTS

Based on Level of Service B (page 42) , a total of 4,953 reaches of gravity sewer were identified for the assessment program The annual assessment cost for performing this level of service is approximately

$212,000. The assets requiring evaluation were prioritized and distributed over the proposed ten year program schedule. The results of prioritizing the assessment of the gravity mains are provided on system maps in Appendix B. An excerpt of these maps is shown in Figure 6-1 to illustrate the level of detail provided.

Figure 6-1 Assessment Strategy Example Map

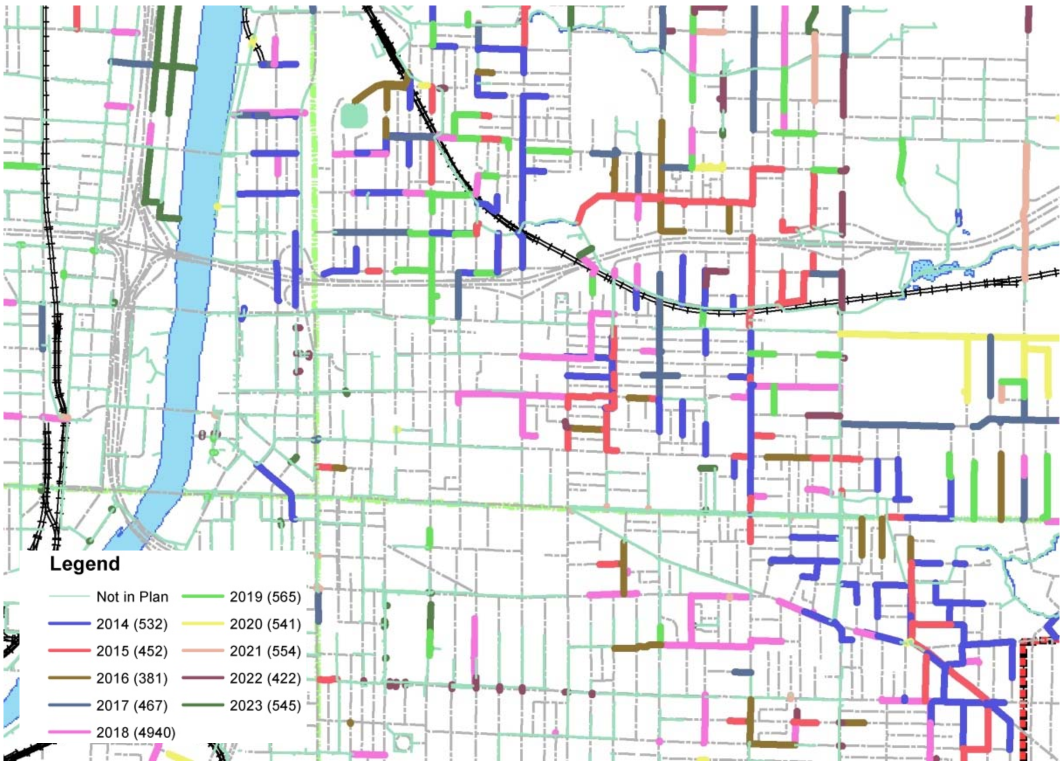


Table 6-1 summarizes the number and length of gravity mains to be assessed each year. Using the proposed renewal strategy (page 53), an estimated annual renewal cost is provided. Renewal costs initially begin high and decrease over time because the oldest pipes are assessed first and are replaced instead of rehabilitated based on the proposed renewal strategy. As the program progresses, the amount of deficient sewers is expected to decrease as the effective life of the system increases.

Table 6-1 Projected 10-Year Gravity Main Assessment

Year	FY	Number of Reaches	Pipe Assessment Length (LF)	Cost for Selected Renewal
1	2014	532	117,159	$14,233,000
2	2015	452	98,633	$15,383,000
3	2016	381	87,094	$17,635,000
4	2017	467	103,480	$14,557,000
5	2018	494	103,331	$14,682,000
6	2019	565	115,766	$8,371,000
7	2020	541	113,964	$3,329,000
8	2021	554	118,038	$3,562,000
9	2022	422	87,020	$4,673,000
10	2023	545	107,023	$4,355,000
	Totals:	**4,953**	**1,051,508**	**$100,780,000**

DISCUSSION

Planning Work Following Assessments

Based on the lack of historical assessment data or a defined asset improvement program, an initial 'catching up' phase is expected where more work is identified than can be repaired in a given fiscal year. Some recommended factors to use in determining a prioritization for construction projects include:

- Assets that are at or near failure.
- Assets that are critical to operation, such as trunk sewers.
- Assets found within sensitive areas such as business districts or areas of environmental concern.
- Coordination with other infrastructure projects.

During detailed design for these projects, projects should be assembled by grouping together similar types of work. For example initiating a sewer rehabilitation program to line pipes and restore structures along the collection system separately from replacement projects which require open cut construction. Other factors to consider would be general location of the proposed repairs to confine the project to specific geographic areas in order to minimize disruption to businesses and residents.

Once the oldest parts of the system are assessed, there will be a gradual reduction in major defects, until the types of problems found shift from structural issues in old and poorly constructed sewers to maintenance issues. Pipe and manhole assets that aren't in failure mode can usually be repaired or improved using trenchless techniques such as cleaning, root removals and lining to significantly extend the expected life of a sewer, which should then be recorded in the GIS database so a work history can be followed for each asset. This allows tracking of which pipes were renewed, and also helps to identify recurring problems so that more or less frequent inspections can be made. A 10-year inspection cycle was proposed for the initial assessment phase to account for the large quantity of assets to be inspected.

Planning for Years 10 Through 20

After the first 10-year inspection period, the results of the assessment program should be evaluated to determine where to focus the remaining asset investigation. Potential options for years 10 through 20 of the capital improvement plan include:

- Begin inspection of assets less than 50-years old.
- Re-inspect assets greater than 50-years old that were not renewed during the previous assessment cycle.
- Establish a frequent cleaning and inspection program for assets which exhibited high sedimentation to monitor the accumulation of debris in problem areas.

7. CAPITAL IMPROVEMENTS

INTRODUCTION

This section of the report identifies capital projects for assessment, design, and construction. A Level of Service B was selected as the baseline for developing projects and costs. Key differences between LOS B and existing operations include:

- Inspect all elements of the collection system including gravity mains, laterals, manholes, and catch basins over 50 years old within a 10 year period.
- Completion of a thorough inventory and inspection of all open channels and roadside ditches in the system, including culverts and outfalls found along each channel.
- Increased inspection and maintenance procedures for detention/retention basins, pump stations and green infrastructure.
- Implement a comprehensive system renewal program that repairs failed or failing infrastructure, and includes systematic assessment and replacement or rehabilitation of aging assets.
- Emphasize low impact design and green infrastructure to assist in flow volume reduction and improvements to water quality

The activities shown in Table 4-4 were used to develop funding requirements to meet this level of service. Funding needed for each level of service B is detailed in Table 4-8, on page 48 and is summarized below in Table 7-1. The capital improvement plan was based on this cost, and activities and projects were selected to meet this level of annual spending.

Table 7-1 Projected Annual Cost Level of Service B Summary

Stormwater Activity	Annual Funding Requirement
Capital Renewal	$8,825,000
O&M	$3,651,000
Street Sweeping	$1,140,000
Planning	$600,000
Regulatory Compliance	$350,000
Development Regulation	$160,000

METHODOLOGY

Specific capital improvement projects were selected for the 20-year plan using various methods based on historical information, recent field investigations, and the results of the asset inventory and risk assessment. Three main categories of projects were identified, including:

- Capital projects initiated by other departments
- Previously identified stormwater projects
- Miscellaneous identified projects

Capital Projects For Other Utilities

The City has capital improvement projects scheduled through 2018. These already defined projects from the Streets, Sewage, and Water departments may overlap with potential stormwater improvement projects. Performing road, sewer, and water projects together may benefit the City by providing engineering and construction cost savings. Completing all needed improvements in an area also helps avoid issues such as a sewer failure beneath a recently resurfaced road. Key considerations and benefits for the different project types are shown below.

Streets Projects

Street projects are categorized as full reconstruction or resurfacing projects. Full reconstruction projects are ideal projects for also making stormwater improvements as there will not be added restoration costs for pavement replacement associated with sewer construction.

Resurfacing projects will receive less priority though are still considered. If the adjacent stormwater asset has less remaining life than the expected pavement repair, the stormwater project should be included with the street project. Costs to do any open cut replacement can be minimized due to less pavement to restore to the top of the milled profile of the surface. Excavation limits could also be limited to what is deemed necessary, rather than having to replace an entire lane or road width to avoid unsightly pavement patches which tend to settle and fail at accelerated rates.

Sewage Projects

In most cases sanitary sewers are located deeper than the storm sewers. Repair of sanitary sewers often impacts both the pavement and adjacent stormwater infrastructure. Performing necessary stormwater improvements in conjunction with sanitary projects can provide greater efficiency in design, and allow for correction of sub-optimal system layouts. Ancillary project costs such as mobilization and pavement restoration can be shared with a combined project, providing an overall cost savings.

Water Projects

Water Department projects provide similar benefits to projects initiated by the Sewage Department, in that pavement and traffic control costs may be split amongst participating parties. Watermain design standards for separation from other utilities and installation methods used to maintain the existing water main service during replacements may also result in good opportunities to evaluate and improve system layout and efficiencies.

Project Evaluation

The City has identified 307 proposed capital improvement projects through 2018. These projects were reviewed to determine if there were adjacent stormwater assets that may need renewal based on the EEL. This evaluation resulted in 44 projects likely requiring stormwater improvements. Planning level cost estimates were based on the renewal strategy discussed on page 59..

Previously Identified Projects

The City provided previous stormwater studies (refer to Table 7-2) for review, including the 1994 Stormwater Master Plan, the 1987 Drainage and Erosion Report, and available sub-watershed studies. These studies identified a variety of recommended stormwater improvement projects. These projects were compared with an outstanding unfunded projects list created by the City in 2010 to verify which recommended improvements were not completed. The projects described in the earlier studies generally only included planning level details, and did not include conceptual design information. Based on the available information, the following steps were taken to add these projects to the CIP:

- GIS was used to verify the recommended projects that have not been completed.
- The IO software was used to evaluate the overall risk of the stormwater assets in the recommended project areas, and generate a priority ranking. Even though projects were ranked, all applicable projects were included in the CIP.

- Costs were generated for each project using previously identified costs, and cost-forwarded to the present day using the Engineering News Record construction price index.

Due to the lack of detailed information and the amount of time that has passed since these projects were identified, these areas should be reviewed prior to project development. This will help verify the need and extent of each project so new costs may be determined.

Table 7-2 Historical Reports

Report Title	Date	Prepared For	Prepared By
Drainage/Erosion Report City of Grand Rapids	September 1987	City of Grand Rapids	City Engineer
Coldbrook Creek SMP	July 1985	Kent County Drain Commissioner	Fishbeck, Thompson, Carr & Huber
Buck Creek and Plaster Creek Watershed Management Plan	October 1988 & January 1991	Kent County Drain Commissioner	Camp Dresser & McKee
Report on Combined Sewer System Study	October 1, 1990	City of Grand Rapids	Fishbeck, Thompson, Carr & Huber; Black & Veatch
Palmer Drain Watershed Study	June 1992	City of Grand Rapids	Prein & Newhof
Indian Mill Creek Watershed Stormwater Management Plan Summary, Conclusions and Recommendations – Draft	October 27, 1993	Alpine Charter Township City of Grand Rapids City of Walker	McNamee, Porter & Seeley
Indian Mill Creek SMP	March 1994	City of Grand Rapids	McNamee, Porter & Seeley
Stormwater Master Plan	November 1994	City of Grand Rapids	McNamee, Porter & Seeley
Report on Improvements to the Whiskey Creek Watershed	February 1999	City of Grand Rapids City of Kentwood and Kent County Drain Commissioner	Black & Veatch
Report on Whiskey Creek Watershed Analysis	October 2004	City of Grand Rapids City of Kentwood and Kent County Drain Commissioner	Black & Veatch

Miscellaneous Projects

As part of preparing the asset management plan, several areas were identified by the City or during field investigations as areas with historical or recent problems. A conceptual solution was identified for each problem area to generate overall project costs. Project costs were developed using the conceptual plan entered into the IO toolset.

Renewal Strategy

To estimate the amount of work that will be found during the assessment project, a renewal strategy was established to generate cost estimates. The capital improvement portion of the IO tool allows the user to assign different proposed work activities directly to the assets using an established scenario, or set of criteria. The Engineer can use this scenario to evaluate all of the assets in a given area and determine the cost to complete the proposed activity or activities which may include inspections, replacement, or cured-in-place lining on an asset-by-asset basis. To better quantify the potential spending requirements for the assets inspected during the assessment program, assumptions were made to represent the potential work that may be required. Table 7-3 shows the assumptions made for the stormwater collection system

Table 7-3 Renewal Strategy

Remaining Useful Life	Assumed Action
≤ 10 Years	Replacement
> 10 Years and ≤ 25 Years	Rehabilitation (lining)
> 25 Years	Do Nothing (unless assessment identifies defects)

Replacement pipes are assumed to be the same size as the existing system. This assumed strategy was input into the tool as a scenario and the costs generated were considered to be anticipated spending needs for comparison against the baseline asset replacement value. The actual repair or replacement method selected would be based on the results of the assessment phase. The actual renewal strategy selected should also take into consideration a hydraulic evaluation and other infrastructure improvements.

Cost Determination

Unit cost information for each asset was determined for inspection, maintenance, rehabilitation, and replacement activities. Other factors such as depth of installation and whether the asset was under a roadway were also taken into account in the unit cost development. By entering cost information to cover potential activities such as maintenance, inspection, and rehabilitation the software can be used to quickly generate an initial cost estimate given a defined project area. Unless otherwise noted, all costs are reported in 2013 dollars. The following resources were used in developing the unit cost information:

- Construction bid tabulations and contract documents from local projects.
- Construction bid tabulations and contract documents from non-local projects adjusting for geographic differences as appropriate.
- Manufacturers were contacted for assets in cases where bid tabulation data was not readily available.

Costs for inspections, operation and maintenance activities were based on historical costs from the City of Grand Rapids and other communities.

CAPITAL PROJECTS FOR OTHER UTILITIES

A five-year list of 427 proposed capital improvement projects for construction through 2018 was reviewed. From this list projects that are receiving funding and that would be conducive to renewing stormwater assets were identified. This resulted in 80 individual line items from the list, of which 10 were Drain Commissioner reimbursement funds and 25 that were repeated as multiple year projects, resulting in 44 unique projects. Each of these project areas was assigned costs for system inspection, full system replacement, and replacement based on the strategy summarized in Table 7-3. It is recommended to plan for the assessment cost in the first year and the full replacement cost; 50% per year for 2 years following the assessment. Unspent funds can be placed in a reserve and used the following year, or for additional system inspection in other high risk areas. Replacement and rehabilitation budgets should be updated following the assessment.

Table 7-4 summarizes the estimated stormwater costs for the various capital projects identified by other departments for the next five years. Table 7-5 shows the same cost information but tabulates the information by fiscal year.

Table 7-4 Stormwater Costs for Department 5-year Capital Improvement Projects

Project #	Fiscal Year	Project Name	Stormwater Rank	Baseline Current Replacement Value ($1000s)	Baseline Future Replacement Cost ($1000s)	Renewal Strategy Cost ($1000s)	Inspection Cost ($1000s)
1746	2016-18	Plaster Creek Sanitary Trunk Sewer	M/H	$624	$1,242	$71	$13
2879	2016-17	Alpine Ave - Leonard St to Richmond St	L	$1,194	$4,010	$58	$16
2883	2016-17	Alpine Ave - Richmond St to Nason St	H	$782	$1,615	$21	$13
2925	2016-17	Fulton St - Fuller Ave to Benjamin Ave	L	$252	$898	$40	$4
2929	2016-17	Fulton St - Lafayette Ave to College Ave	M	$268	$866	$42	$5
2933	2016-17	Fulton Ave - Woodward Ave to Lakeside Ave	M	$1,064	$3,291	$162	$13
2947	2016-17	Leonard St - Alpine Ave to Turner Ave	L	$825	$2,522	$84	$13
2952	2016-17	Leonard St - Hillburn Ave to Country Club Ave	M	$186	$458	$13	$1
1426	2017	Garfield Ave - Butterworth Ave to Fulton St	L	$343	$1,115	$52	$6
1821	2017	Nason - Will to Turner	L	$18	$59	$9	$1
2887	2017-18	Burton St - Breton Ave to East Beltline	M	$1,594	$3,398	$232	$25
2937	2017	Kalamazoo Ave - 36th St to Forrester Ave	M/H	$1,476	$3,169	$256	$21
2956	2017-18	Leonard St - Plainfield Ave to Lafayette Ave	M	$78	$196	$26	$2
2960	2017-18	Leonard St - Walker Ave to Alpine Ave	L/M	$1,482	$4,137	$92	$21
2964	2017-18	Michigan St - College Ave to Eastern Ave	L/M	$709	$2,081	$241	$12
2968	2017-18	Michigan St - Diamond Ave to Fuller Ave	L	$339	$1,097	$105	$6
2975	2017-18	Monroe Ave - Lyon St to Michigan St	L	$912	$3,330	$166	$10
1406	2018	Albany-Ionia -Shelby Water Main Replacement	H	$127	$177	$83	$3
1423	2018	Langley - Plymouth to Kalamazoo Watermain	H	$212	$408	$170	$4
1425	2018	Forrester St - Water Main Replacement	M	$84	$119	$91	$2
1431	2018	Garfield Ave and Crosby St Water Main	L	$237	$640	$59	$4
2508	2018	Broadway Sanitary Trunk Sewer	H	$4,506	$13,773	$372	$56
Total				**$34,054**	**$85,755**	**$9,267**	**$501**

** All costs are reported in thousands of dollars ($1,000s)

Table 7-5 Stormwater Costs for Department 5-year Capital Improvement Projects by Fiscal Year

No.	Project Name	2015 ($1000s)	2016 ($1000s)	2017 ($1000s)	2018 ($1000s)
1746	Plaster Creek Sanitary Trunk Sewer	$13	$24	$24	$24
2879	Alpine Ave - Leonard St to Richmond St	$16	$29	$29	
2883	Alpine Ave - Richmond St to Nason St	$13	$11	$11	
2925	Fulton St - Fuller Ave to Benjamin Ave	$4	$20	$20	
2929	Fulton St - Lafayette Ave to College Ave	$5	$21	$21	
2933	Fulton Ave - Woodward Ave to Lakeside Ave	$13	$81	$81	
2947	Leonard St - Alpine Ave to Turner Ave	$13	$42	$42	
2952	Leonard St - Hillburn Ave to Country Club Ave	$1	$7	$7	
1426	Garfield Ave - Butterworth Ave to Fulton St		$6	$52	
1821	Nason - Will to Turner		$1	$9	
2887	Burton St - Breton Ave to East Beltline		$25	$116	$116
2937	Kalamazoo Ave - 36th St to Forrester Ave		$21	$128	$128
2956	Leonard St - Plainfield Ave to Lafayette Ave		$2	$13	$13
2960	Leonard St - Walker Ave to Alpine Ave		$21	$46	$46
2964	Michigan St - College Ave to Eastern Ave		$12	$121	$121
2968	Michigan St - Diamond Ave to Fuller Ave		$6	$53	$53
2975	Monroe Ave - Lyon St to Michigan St		$10	$83	$83
1406	Albany - Ionia - Shelby Water Main Replacement			$3	$83
1423	Langley - Plymouth to Kalamazoo Watermain			$4	$170
1425	Forrester St - Water Main Replacement			$2	$91
1431	Garfield Ave and Crosby St Water Main			$4	$59
2508	Broadway Sanitary Trunk Sewer			$56	$372
Total		**$78**	**$339**	**$925**	**$1,359**

** All costs are reported in thousands of dollars ($1,000s)

PREVIOUSLY IDENTIFIED PROJECTS

Capital improvement projects previously identified are summarized in Table 7-6. The source information includes the 1994 Stormwater Master Plan and the Stormwater Asset Management Plan Basis created by the City in 2010. The Plan Basis document also included additional miscellaneous projects the Environmental Services Department identified through complaints and O&M records. The analysis included verifying which projects were not completed and checking the risk level of the stormwater assets in each area. The projects described were limited to planning level recommendations such as adding system storage, increasing pipe capacity, and repairing erosion in open channels and ditches. While costs were previously provided, insufficient information is available describing the cost derivation. Table 7-7 provides a description of problems identified by the City. Additional details for the miscellaneous project list are required in order to estimate costs from IO toolset.

Due to the lack of detailed information of these projects and the nearly twenty years that have passed since the majority of the improvements were identified in the 1994 SWMP, it is suggested that these areas are be reviewed to verify the need and extent of each project so new costs may be assessed. Projects including replacement of sewers or construction of new sewers may be treated in a similar manner as the capital project areas discussed in the previous section. These areas may be inspected through an annual O&M program, or included in nearby or adjacent projects.

Table 7-6 Previously Identified Stormwater Improvement Projects

Project FY	Project Name	Description	Watershed	Budget (1994 $)	Est. Cost (2013 $)	Comments
2015	Indian Mill Creek Dredging	Dredging	Indian Mill Creek	$100,000 (1)	$436,000	MDEQ allowed partial dredging per 1994 SWMP, remaining portion still needs to be completed as drain is severely overgrown. Assume base cost doubled due to increased regulatory requirements and 20+ years of additional sedimentation.
2016	Burton-Breton Branch of Plaster Creek - Channelization and Cleaning	Channelization and Cleaning	Burton-Breton	$180,000 (2)	$253,300	City provided limits of project and noted that bank stabilization has already occurred. Project only includes cleaning and channelization.
2016	Burton-Breton Branch of Plaster Creek - Enlargement of Culverts	Enlargement of Culverts crossing Okemos Dr and Annchester Drive	Burton-Breton	$1,000,000 (2)	$198,300	Project previously included check dams and work along the drain. Check dams removed, but drain to be cleaned immediately downstream of the culvert replacements.
2016	Indian Mill Creek Flap Gate at Jennette Ave	Backflow Prevention	Indian Mill Creek	$10,000	$18,000	Install flap gate after Indian Mill Creek dredging and cleaning is complete.
2017	Oakleigh Ave in Hogadone District - Channelization and Cleaning	Storm Sewer	Hogadone	$150,000	$261,000	Flooding in backyards along Oakleigh between Lake Michigan Drive and 7th St. Channelization and cleaning of the drain required between 7th St and Lake Michigan Drive.
2019	Maplegrove Detention Pond	Detention	Plaster Creek	$300,000	$522,000	City has purchased the property, but has not initiated construction of the project.

Note (1): 1987 Pricing, doubled updated cost to reflect more stringent permitting and regulations
Note (2): Costs updated per City Comments and changes to project

Table 7-7 Miscellaneous Projects

FY	Project Name	Description	Proposed Solution	Estimated Project Cost
2015	Colton Dr Culvert Replacement	2639 Colton Dr SE, humped driveway culvert, roadside ditches in disrepair and filled in.	Replace culvert and driveway approach, regrade ditch on both sides of Colton from Covington to Ardmore.	$15,100
2015	Eastcastle Drain Improvements	Outfall and bank failure Eastcastle Drive just west of Breton Road	Replace outfall and repair erosion damage along outfall discharge path to stream.	$15,600
2016	Capilano Stormwater Improvements	2701 Capilano - 18" Culvert to open ditch, both in massive disrepair	Replace 18" pipe back to MH and clean and channelize the open channel to the downstream culvert.	$41,400
2016	Outfall replacement Indian Mill Creek at Richmond	Separated outfall in Indian Mill Creek near Richmond Ave	Replace outfall and repair erosion , complete bank stabilization at Indian Mill Creek	$6,600
2017	Moreland and Longmeadow Stormwater Improvements	2552 Longmeadow - erosion since subdivision to the east was built, increased flow from Moreland to Longmeadow.	Extend curb and gutter and new storm sewer on Moreland west to the bend.	$138,200
2017	Coldbrook Drain Rehabilitation - Michigan Ave and Fuller	KCDC enclosed bridge under Michigan at Fuller Ave	Propose more permanent rehabilitation solution and costs, approximately 100' of 114" x 75" pipe across Michigan Street ROW.	$250,000
2018	Plaster Creek Bank Erosion	Plaster Creek Erosion along Union Ave just north of 28th St - Bank restoration along approx 1500' of plaster creek. Bank cut approximately 10 feet back at bends and roughly 7 feet high.	Full design channel protection and naturalized bank stabilization	$506,500
2018	Eastridge Stormwater Improvements	711 Eastridge Dr. SE, Inadequate storm drainage, steep slopes	Assuming surface flooding, propose adding catch basins at intersection of Eastridge and Eastview. Upsize downstream pipes to outfall.	$94,000
2018	Shawmut Hills Baseball Diamond Stormwater Improvements	Baseball Diamond, 610 Fairfield - Shawmut Hills	Regrade ditches along houses on Fairfield and Burrit. Including addition of underground infiltration basin to store runoff.	$74,300
2019	Leffingwell Culvert and Erosion Repair	Culvert at Leffingwell Ave 850' north of Bradford St. significant bank erosion at crossing, erosion in stream US, impacting sewer manhole.	Perform bank stabilization and add spillways for road runoff to eliminate future erosion. Channelization of bank upstream of crossing to avoid/protect manhole.	$15,100
2019	Brookshire Outfall Replacement and Erosion Repair	30" outfall failed causing major bank erosion	Replace outfall and stabilize bank.	$70,700

20-YEAR CAPITAL IMPROVEMENT PLAN

Projects that were identified using the aforementioned methods were then sorted and compiled into the capital improvements. Each type of project was prioritized in a different way. Projects related to other department capital works had assessment costs designated the year before anticipated construction, with construction costs broken up for multi- year projects. Previously identified system deficiencies were assigned to a year based on which projects were considered a high priority. Since most of these projects will require additional examination, they were scheduled later in the proposed sequence. The assessment program is intended to begin immediately in order to begin accumulating condition assessment information as soon as possible. The capital improvement plan for this report has been based upon providing a B Level of Service as described in Table 4-4 (page 43).

The detailed 20-year capital improvement plan broken down to the fundamental spending categories is shown in Table 7-8 (years 2013 through 2022) and Table 7-9 (years 2023 through 2032). Appendix C contains location maps for the various capital projects.

Information regarding the planning and regulatory compliance line items contained with the 20-year capital improvement plan tables are provided in the Stormwater Master Plan (2013).

Table 7-8 20-Year Plan (FY 2014-2023)

*All costs reported in $1,000s

Description	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Total Project Costs (based on proposed year)										
Capital Projects for Other Utilities	$120	$74	$339	$925	$1,359	$1,500	$1,500	$1,500	$1,500	$1,500
Previously Identified Projects	$0	$436	$470	$261	$0	$522	$0	$0	$0	$0
Assessment Program Repairs	$0	$3,949	$3,732	$3,198	$2,717	$2,726	$3,419	$3,505	$3,592	$3,681
Miscellaneous Projects	$0	$31	$48	$286	$675	$86	$0	$0	$0	$0
Lift Station Fund	$0	$2,531	$2,575	$2,620	$2,666	$2,713	$2,760	$2,809	$2,858	$2,908
Green Infrastructure	$0	$1,314	$1,337	$1,360	$1,384	$1,408	$1,433	$1,458	$1,484	$1,510
Drainage Improvements and Misc. Repairs	$175	$175	$178	$181	$184	$188	$191	$194	$198	$201
KCDC Assessments	$45	$45	$46	$47	$47	$48	$49	$50	$51	$52
Emergency Repairs	$1,197	$250	$254	$259	$263	$268	$273	$277	$282	$287
Subtotal Capital Renewal	*$1,537*	*$8,825*	*$8,980*	*$9,137*	*$9,297*	*$9,459*	*$9,625*	*$9,793*	*$9,965*	*$10,139*
O&M Costs										
Collection System	$800	$3,222	$3,278	$3,335	$3,394	$3,453	$3,513	$3,575	$3,637	$3,701
Open Channels, Culverts, Outfalls	$25	$329	$335	$341	$347	$353	$359	$365	$372	$378
Detention Basins	$5	$7	$7	$7	$7	$8	$8	$8	$8	$8
Pump Stations	$40	$64	$66	$67	$68	$69	$70	$71	$73	$74
Green Infrastructure	$0	$29	$30	$30	$31	$31	$32	$32	$33	$33
Subtotal O&M	*$870*	*$3,651*	*$3,715*	*$3,780*	*$3,846*	*$3,913*	*$3,982*	*$4,052*	*$4,122*	*$4,195*
Street Sweeping	$780	$1,140	$1,160	$1,180	$1,201	$1,222	$1,243	$1,265	$1,287	$1,310
Planning	$0	$600	$611	$621	$632	$643	$654	$666	$678	$689
Regulatory Compliance	$250	$350	$356	$362	$369	$375	$382	$388	$395	$402
Development Regulation	$160	$160	$163	$166	$169	$171	$174	$178	$181	$184
Totals	**$3,597**	**$14,726**	**$14,984**	**$15,246**	**$15,513**	**$15,784**	**$16,060**	**$16,342**	**$16,628**	**$16,919**

Table 7-9 20-Year Plan (FY 2024-2033)

*All costs reported in $1,000s

Description	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Total Project Costs (based on proposed year)										
Capital Projects for Other Utilities	$2,000	$2,000	$2,000	$2,000	$2,000	$2,500	$2,500	$2,500	$2,500	$2,500
Previously Identified Projects	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Assessment Program Repairs	$3,272	$3,364	$3,458	$3,554	$3,651	$3,250	$3,351	$3,453	3,557	3,663
Miscellaneous Projects	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lift Station Fund	$2,959	$3,010	$3,063	$3,117	$3,171	$3,227	$3,283	$3,341	$3,399	$3,459
Green Infrastructure	$1,536	$1,563	$1,590	$1,618	$1,646	$1,675	$1,705	$1,734	$1,765	$1,796
Drainage Improvements and Misc. Repairs	$205	$208	$212	$216	$219	$223	$227	$231	$235	$239
KCDC Assessments	$53	$54	$54	$55	$56	$57	$58	$59	$60	$61
Emergency Repairs	$292	$297	$303	$308	$313	$319	$324	$330	$336	$342
Subtotal Capital Renewal	*$10,316*	*$10,497*	*$10,681*	*$10,868*	*$11,058*	*$11,251*	*$11,448*	*$11,648*	*$11,852*	*$12,060*
O&M Costs										
Collection System	$3,766	$3,832	$3,899	$3,967	$4,037	$4,107	$4,179	$4,252	$4,327	$4,402
Open Channels, Culverts, Outfalls	$385	$391	$398	$405	$412	$420	$427	$434	$442	$450
Detention Basins	$8	$8	$8	$9	$9	$9	$9	$9	$9	$10
Pump Stations	$75	$77	$78	$79	$81	$82	$84	$85	$86	$88
Green Infrastructure	$34	$34	$35	$36	$36	$37	$38	$38	$39	$40
Subtotal O&M	*$4,268*	*$4,343*	*$4,419*	*$4,496*	*$4,575*	*$4,655*	*$4,736*	*$4,819*	*$4,903*	*$4,989*
Street Sweeping	$1,333	$1,356	$1,380	$1,404	$1,428	$1,453	$1,479	$1,505	$1,531	$1,558
Planning	$701	$714	$726	$739	$752	$765	$778	$792	$806	$820
Regulatory Compliance	$409	$416	$424	$431	$439	$446	$454	$462	$470	$478
Development Regulation	$187	$190	$194	$197	$200	$204	$208	$211	$215	$219
Totals	**$17,215**	**$17,516**	**$17,822**	**$18,134**	**$18,452**	**$18,775**	**$19,103**	**$19,437**	**$19,778**	**$20,124**

8. CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

A 20-year citywide asset and capital management plan was developed for the public stormwater infrastructure system. The plan demonstrates how the City's goal of establishing and delivering certain levels of service may be achieved through effective and sustainable management of the stormwater system. By developing a proactive long-term plan to stormwater asset management, the City will have a sustainable system ensuring the well-being of the community, the environment, and future generations.

The general process by which the asset management plan was developed began with an inventory and assessment of the existing stormwater assets. The inventory was primarily based on the existing GIS. Assessment information for each asset group was populated from field inspection information. Next a risk analysis was conducted, including determining the probability and consequence of failure for each asset. Unit costs information was assigned to each asset group for inspection, maintenance, rehabilitation, and replacement.

Four levels of service were identified. These include three new levels of service (A, B and C) along with the current, or existing level of service. The unit price information was then used to estimate the inspection, maintenance, rehabilitation, and replacement costs for each asset group. The annual financial budget was estimated for each level of service. For planning purposes a Level of Service B was assumed.

The risk analysis was based primarily on the age of the assets due to the limited assessment information. A 10-year assessment program was developed for each level of service, as a means to transition the program from an age based system to a condition based approach. Different levels of effort were assumed for each level of service. A detailed 10-year assessment program was developed and indicated which assets should be inspected each year based on the B Level of Service assumption.

Stormwater capital improvement projects were identified from projects initiated from other departments, from previous studies and reports, through the assessment work done, and based on staff knowledge of the drainage system. Detailed costs budgets were developed for each of the identified projects based on the asset management system put into place. A comprehensive 5-year capital improvement plan was identified along with suggested budgeting information for 20-years.

To aid in the analysis, the system information was organized and stored in a computer model. The computer model provides easy access to the information for planning purposes and a mechanism to keep the information updated over time.

CONCLUSIONS

The current value of the stormwater drainage system is estimated at $523 million. Ninety-six percent (96%) of the current investment in the drainage system is represented by the separate storm sewers, manholes, and catch basins. The remaining four percent (4%) is attributable to the pump stations, force mains, siphons, culverts, basins and green infrastructure components. Twenty-six percent (26%) of the gravity main system has less than twenty-five (25%) of its estimated effective life remaining.

The asset management system developed offers a powerful tool for managing the stormwater assets and developing cost budgets for future work. Some asset groups have better information than others, for example not much information was known on the open channel systems. A limited amount of information was available on the conditions of assets.

Infrastructure asset management is best accomplished when comprehensive inventory and assessment information is known. An aged based assessment approach is a good starting point when first setting up an asset management program. Asset management based on actual condition assessment is the preferred long term approach.

The comprehensive review and planning allowed for detailed development of annual budgets. The annual budgets take into account the 10-year assessment program to establish asset conditions, routine maintenance, anticipated rehabilitation and replacement costs, and the detailed capital improvement plans. The budgets allow for proactive management of the stormwater drainage system. In addition, the tools developed allow for efficient cost estimating for assessing and planning for future stormwater work when other projects are identified, for example when a street project is planned.

Although a capacity analysis was not included in the asset management or in the current capital improvement projects, the framework has been established to allow for incorporation of this information at a later date. A separate stormwater management plan was prepared that discusses the capacity analysis as well as other planning, policies, and design ideas for the stormwater system.

NEXT STEPS

Asset management is a continuous improvement process. As stormwater assets are added or modified and as additional information is obtained, the City's GIS and IO Toolset should be updated. Maintaining up-to-date information is crucial to successfully managing the separate stormwater drainage system.

The next steps should include:

- Continuously update and improve the dataset of information. This includes the inventory and assessment information for the various assets stored in the City's GIS and subsequently linked to the IO Toolset.
- Transition the management approach from an age based to a condition based system. The transition should occur as part of the proposed assessment program.
- As additional information is collected, periodically review and update the IO Toolset parameters. The parameters include: the weights and values assigned to the probability and consequence of failure variables; unit price cost information; planned project areas; and the renewal strategy variables.
- Use the IO Toolset as a planning and cost estimating tool for operation, maintenance, rehabilitation and renewal projects.
- Prepare and update financial budgets.

RECOMMENDATIONS

From a big picture perspective, a fundamental recommendation is to start proactively managing the stormwater system. Historically construction of the system has occurred with major development and major infrastructure projects such as the CSO program. This can be visually seen in Figure 3-6, on page 19, as the peaks of the estimated replacement costs periodically over time. Proactively managing the system will help level out the annual expenditures.

Streambank Erosion Strategy

Proactively managing the stormwater system is extended to include the open channel system within the city limits. As observed during the assessment phase of this project, significant erosion is occurring in parts of the open channel system. Often streambank erosion is due to unstable hydrology resulting from poorly managed stormwater runoff from development. Much of the open channel system is designated as Waters of the State and is regulated by the State of Michigan and the Army Corp of Engineers. Complicating matters, the City often does not have legal easements of the land containing the open channels. Historically, the state and federal agencies have not taken a proactive role in resolving streambank erosion issues. Development of a long term strategy to manage eroding streambanks is recommended.

Transition to Condition Based Asset Management

As previously discussed, transitioning the age-based asset system to a condition-based system is recommended. Specific assessment and data management recommendations to address this issue are presented in the following sections.

Sewer Assessment

Establish an annual cleaning and CCTV inspection program designed to complete a full inspection of the entire system every 10 years. The present day cost to clean and inspect all gravity mains in the system is approximately $4,819,000, barring potential additional costs like heavy cleaning. Catch basin laterals are not recommended for cleaning and CCTV. Cleaning and inspecting laterals would be an additional cost of approximately $804,000. CCTV inspections should be done using the PACP scoring system. PACP scoring provides for a consistent inspection and evaluation process, so all sewers inspected will have consistent structural and O&M condition information. The frequency of re-inspection can be modified based on results achieved from the initial investigation of the entire system. Cleaning and CCTV should be prioritized based on the risk assessment.

Manhole and Catch Basin Assessment

All existing manholes and catch basins should be inventoried, checked for connectivity and inspected using Manhole Assessment Certification Program (MACP). The MACP scoring system provides for a consistent inspection and evaluation process so that all structures inventoried have consistent structural and O&M condition ratings. The frequency of re-inspection can be modified based on results upon completion of the entire system.

Culvert Assessment

All stream crossings should be cleaned and CCTV inspected using the PACP rating system. The frequency of re-inspection can be modified based on results upon completion of the entire system and the selected level of service. Estimated cost to clean and inspect the culverts in the system is approximately $20,000, not including potential extra work like heavy cleaning.

Outfall Assessment

An inspection and inventory of the outfalls is recommended. Information should be collected on the condition of both the outfall and adjacent stream bank. These inspections could be completed by the same crew tasked with performing open channel inspections. The estimated cost to inspect these assets individually is approximately $34,000 including time to travel to individual site locations. If these assets are inspected during open channel investigations, the inspection cost is approximately $19,000.

Open Channel and Ditch Inventory and Assessment

The open channels and roadside ditches should be inspected and assessed for condition. There is no attribute data currently entered for open channels and roadside ditch assets in the GIS database. The recommended first step is a full survey of all streams and open channels within the City limits. The survey should include points defining the beginning and ends, and representative cross-sections. It is recommended to conduct the survey based on the needs of a hydraulic model. This provides a consistent methodology and will minimize future data needs if a model analysis is performed. Breaking the assets into logical groupings such as segments between stream crossings, or other significant markers will also assist in managing particulars lengths of the open channels. Problem locations should be recorded GPS coordinates. Inspections of the open channels may be done in conjunction with the recommended outfall inspections.

Green Infrastructure Assessment

The City has a limited number of green infrastructure installations to date. As more green infrastructure practices are implemented, having a program to track new installations and routine O&M activities performed will be crucial to the long-term performance and success of these practices. It is recommended that standard checklists be used for inspections. The *Low Impact Development Manual for Michigan* contains example checklists.

Data Management

Collection of data is recommended to be completed through the use of electronic devices that run GIS Arc applications. This will allow field staff to have the system information readily available to confirm locations and asset inventory information. Data entry forms should be embedded in the application to ensure consistent and pertinent data collection with minimal post-processing.

Available attribute information such as date installed, material, size, shape, and elevations from existing record drawings or current inventories should be added to the GIS. Maintaining the information in a central database will ensure consistency and will help to minimize assumptions. Some of the information recommended for use may need to be obtained during asset inspections and inventories. Plans for gathering the data should be finalized, with a clear work plan for obtaining the correct information, and staff training to implement the program. This recommendation applies to all of the various asset groups such as gravity mains, laterals, manholes, catch basins, stream crossings, culverts, outfalls, etc.

Various assets should be separated out from grouped features in GIS. For instance, culverts, siphons, and pressurized mains are all included under gravity mains. Pulling these subtypes out of the group will allow for flexibility in tailoring specific factors for each unique asset group.

Some assets such as siphons and pressurized mains are broken into several segments with unique asset IDs. While this may be useful for accurately portraying differences in slope, etc. it can be counterproductive in the IO tool and produce duplicate results when performing GIS queries. If multi-segment assets are maintained, comments should be included with references to the associated segments.

GIS information from other departments should be integrated together. It is reasonable to keep specific information unique to each department's GIS database; however, information such as the actual road outline, pavement type, and thickness would be beneficial for use in compiling project specific costs.

Information regarding the capacity of conveyance (pipes, culverts and open channels) and storage basin elements could be kept in GIS and used as a potential factor in the IO software. If a stormwater system capacity analysis is completed, conveyance and storage elements that do not meet the requirements could be weighted higher for the probability of failure, consequence of failure, or be used to assume a larger system for a renewal strategy. For example undersized culverts can lead to increased flooding and accelerated erosion at the inlet and outlet of the crossing.

For stream crossing and culverts, additional data such as the presence/type of end sections, headwalls, and permanent erosion control measures should be indicated.

Approximately 36 out of 465 outfalls do not have a size associated with them. The majority of the outfall sizes can be obtained by checking the size of the pipe they are attached to, but many are not connected to a pipe in GIS. The consistent feature of these assets was that they were all labeled as IDEP points. It is recommended that all outfalls are assigned the proper information, and to include a flag within the asset for IDEP to avoid confusion, or create a separate layer for IDEP points. Several connections that were identified as open discharge points, were actually closed discharge points, or blind ties to culverts, and should be reviewed when clarifying the layer.

Seventy-two (72) miscellaneous blind ties and culvert end sections are noted to be a discharge point. A review of how these assets are classified is recommended in order to develop a better system for tracking the preferred asset attributes and ongoing programs like IDEP.

An asset class for storage basins is recommended to be added to the GIS database. Attribute data should be populated like any other asset group. How components such as inlets, outlets, sedimentation basins, and various chambers of the storage basins are recorded should be planned in advance.

The City currently conducts inspections on the pumps and piping in each of their stormwater facilities on a bi-weekly basis. Documentation of these inspections is currently kept in the station along with pump run logs, but the data isn't currently entered to the GIS system. A full station assessment should be conducted during a typical inspection and all pertinent data such as the pumps information and individual run times should be logged into the GIS system so that information can be readily available. A pump subtype should be added to the pump stations so that specific attributes relating to the pumps can be stored separately from the station facility itself. Information such as the pump curves and operating set points could also be linked to the assets in GIS.

The GIS database for green infrastructure should continue to be maintained and updated as new practices are constructed. As-built drawings should be maintained in a central location to access as needed.

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APPENDIX A. GRAVITY MAINS RISK ASSESSMENT

A1. PROBABILITY OF FAILURE MAPS

Figure A-1 Gravity Mains Probability of Failure NW

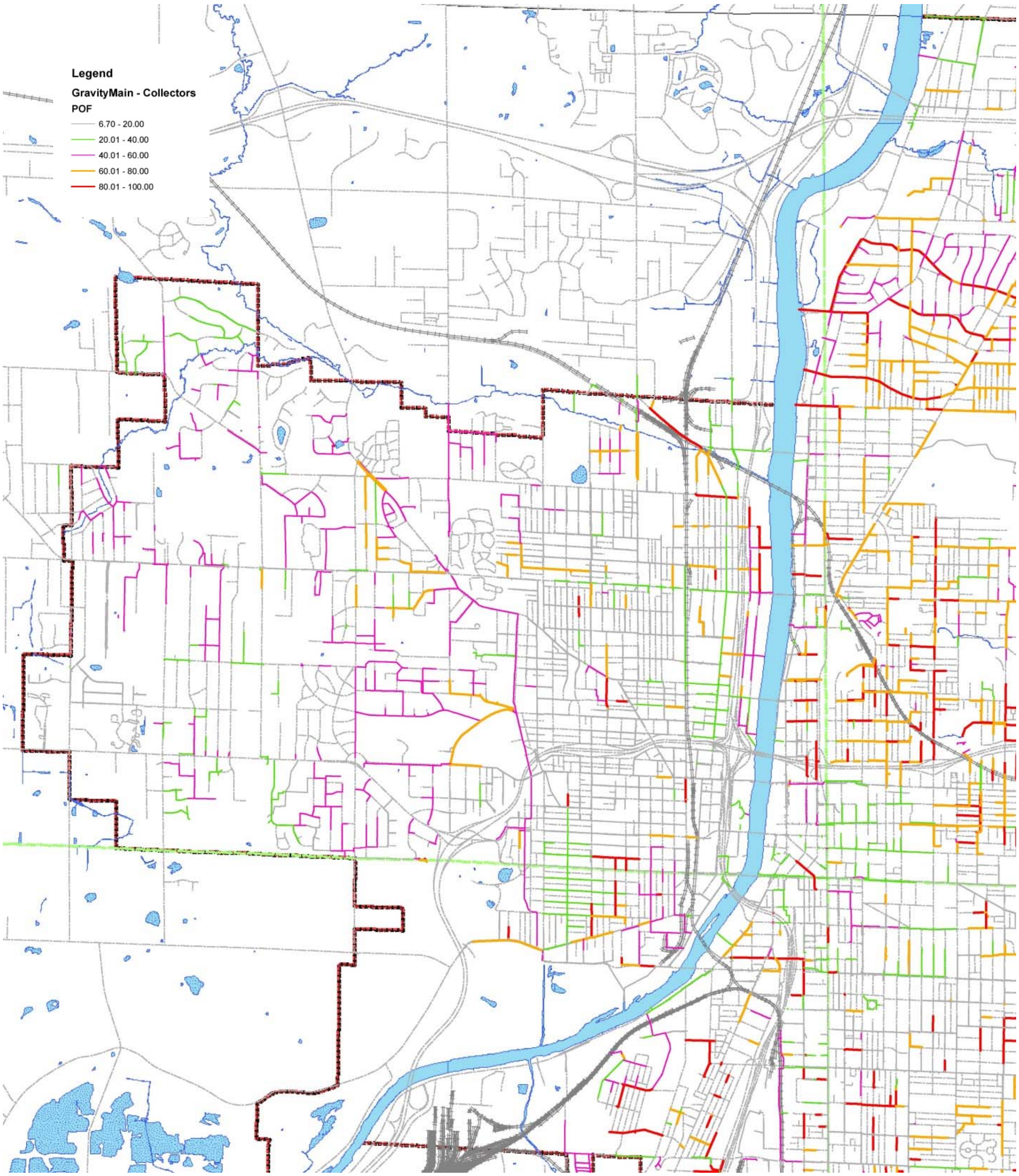


Figure A-2 Gravity Mains Probability of Failure NE

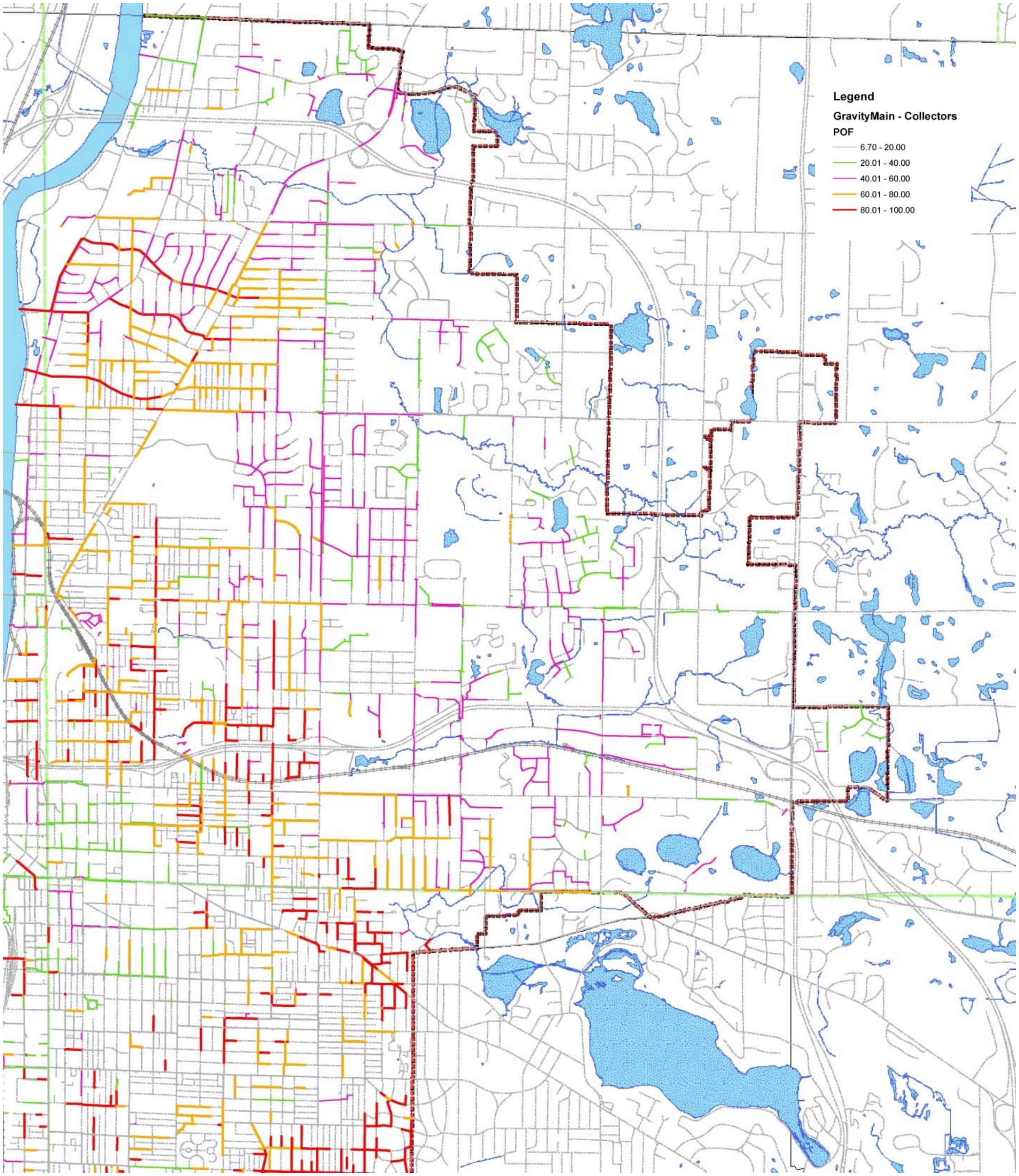


Figure A-3 Gravity Mains Probability of Failure SW

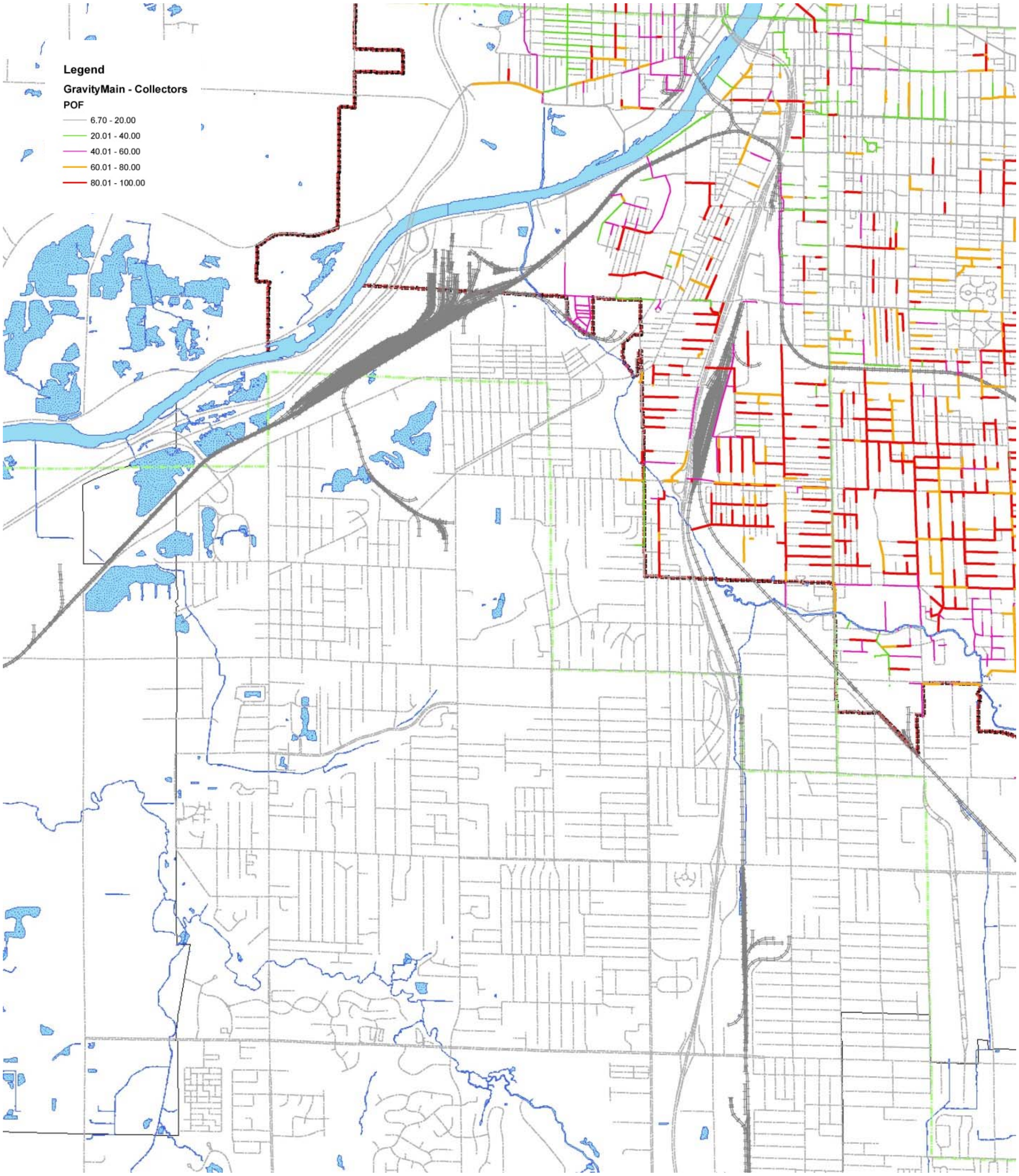
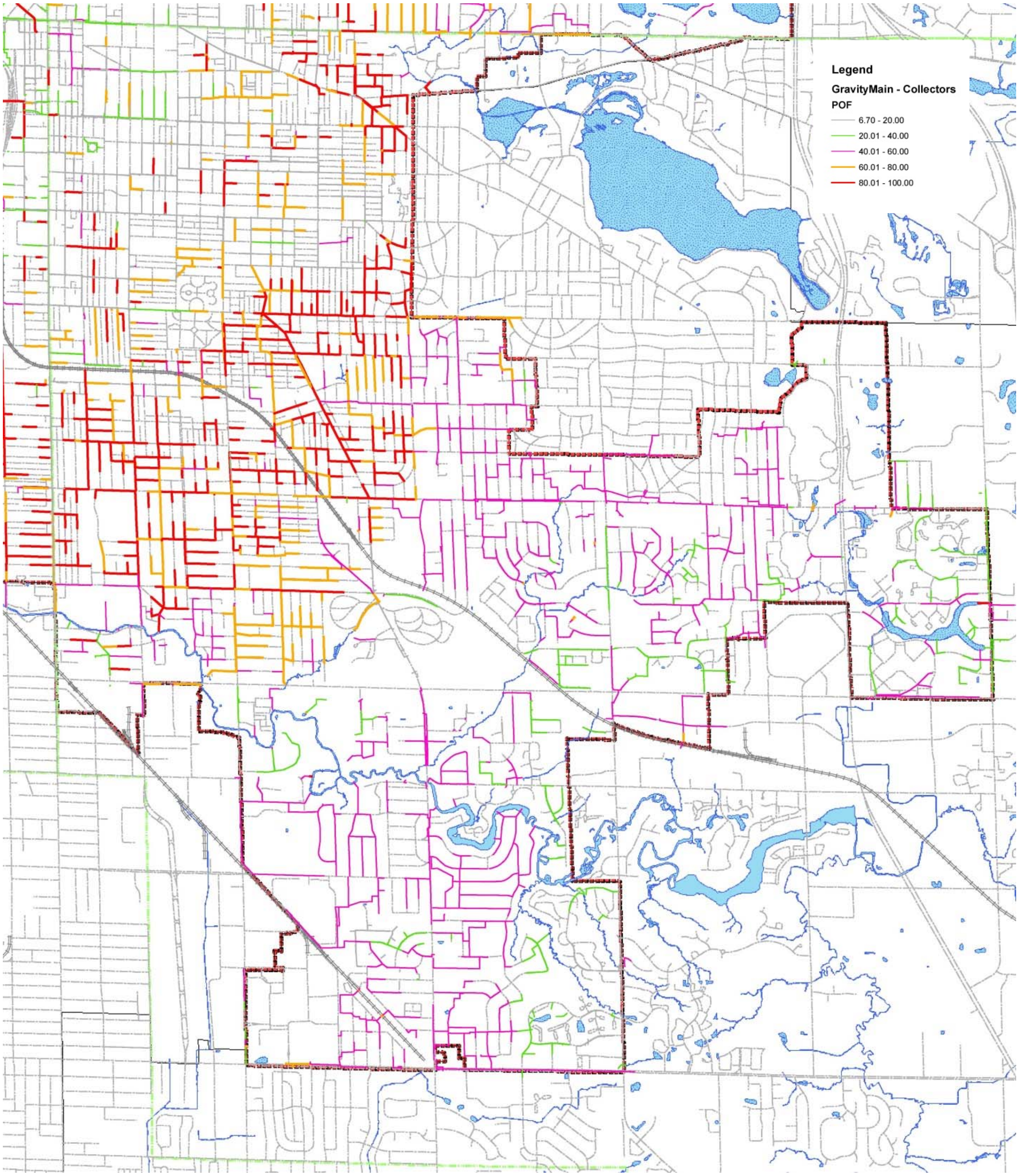


Figure A-4 Gravity Mains Probability of Failure SE



A2. CONSEQUENCE OF FAILURE MAPS

Figure A-5 Gravity Mains Consequence of Failure NW

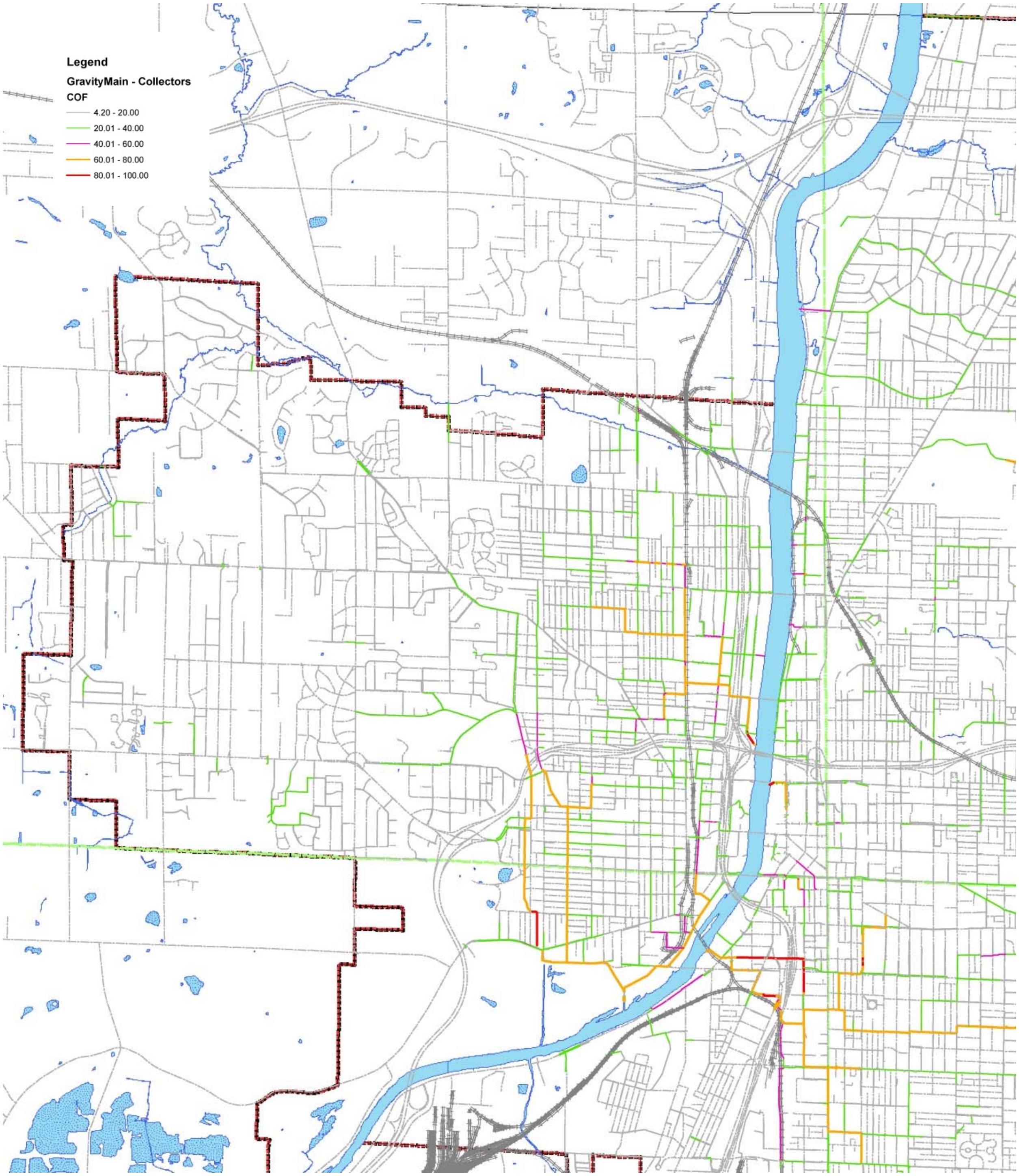


Figure A-6 Gravity Mains Consequence of Failure NE

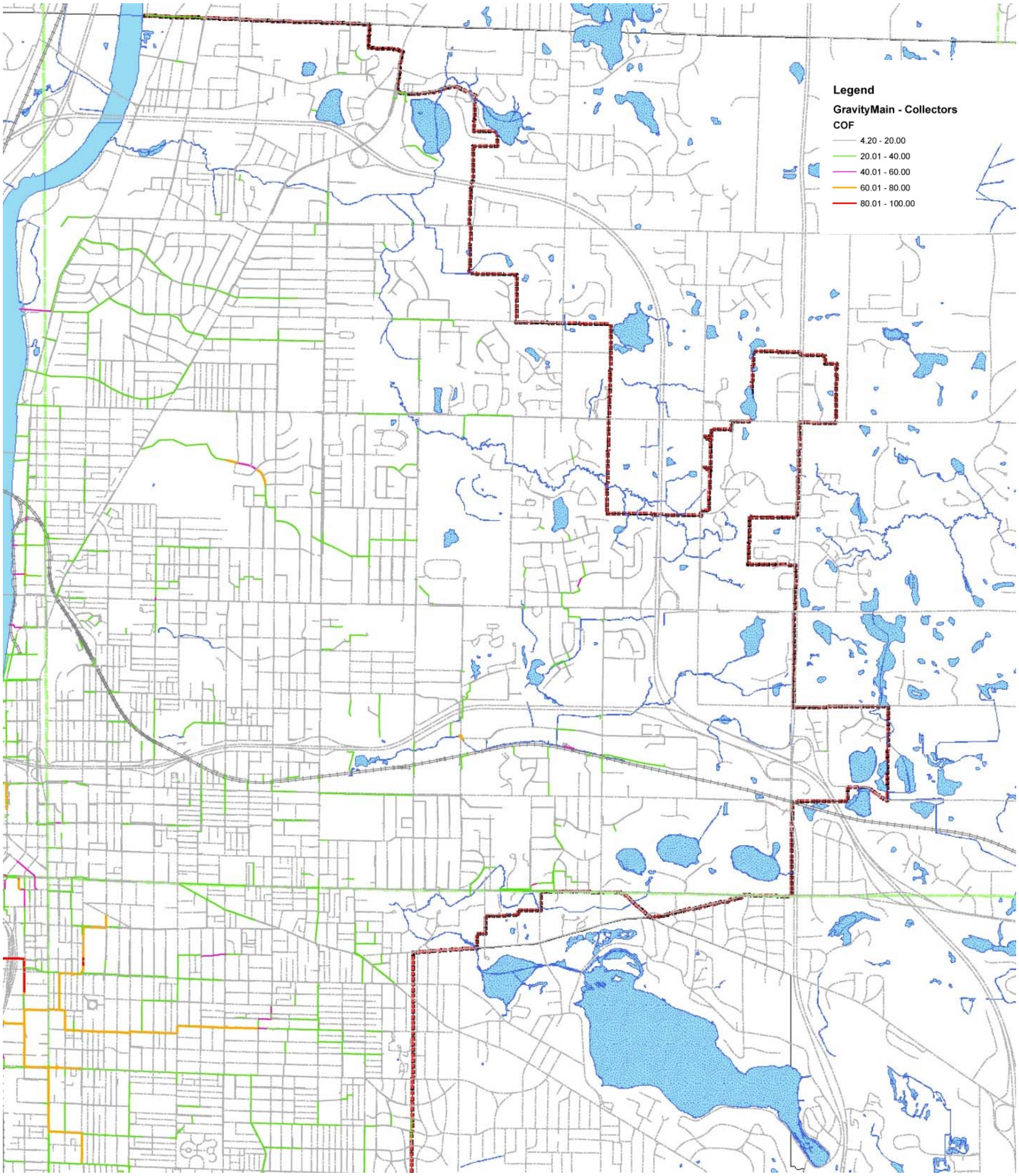


Figure A-7 Gravity Mains Consequence of Failure SW

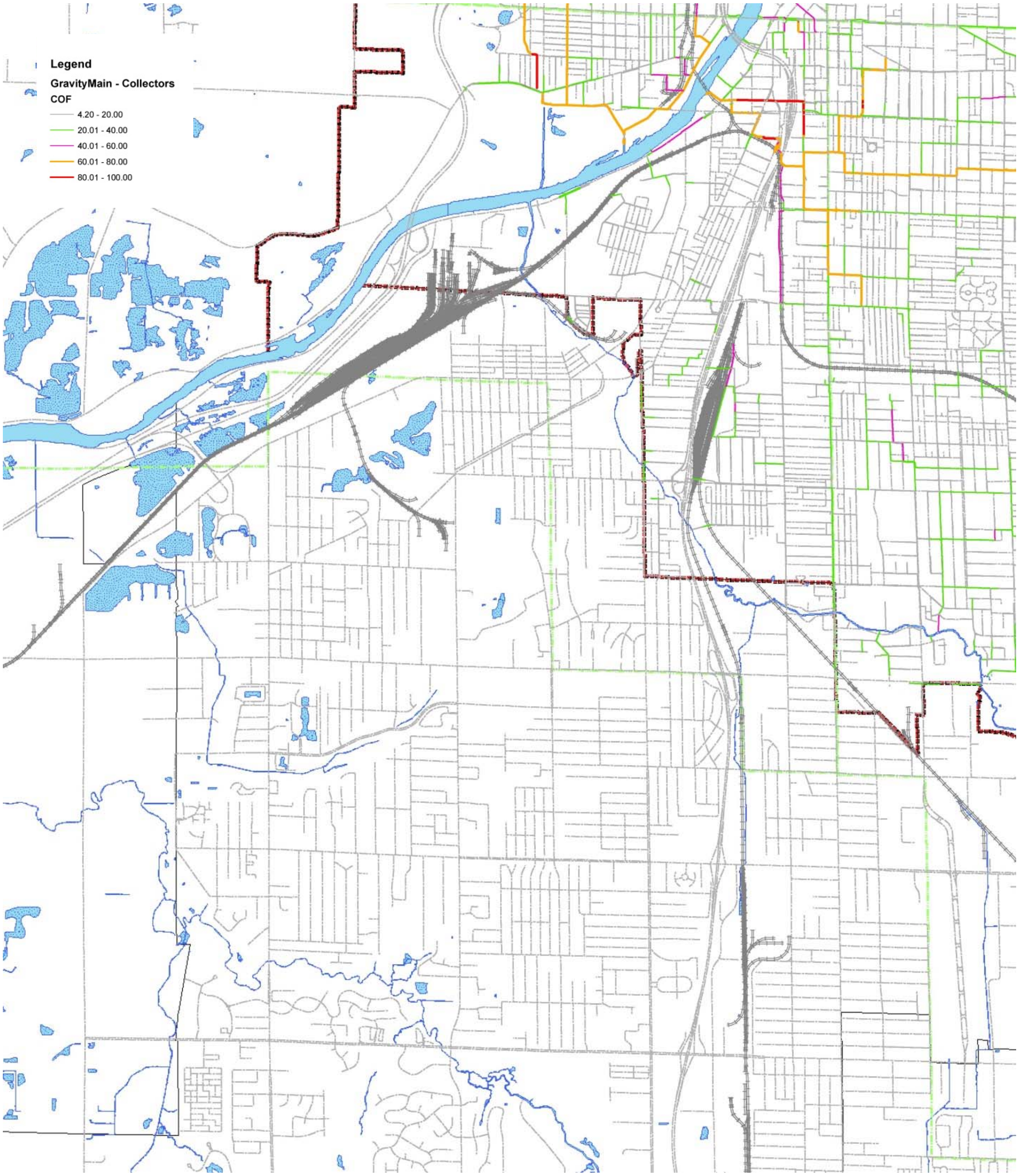
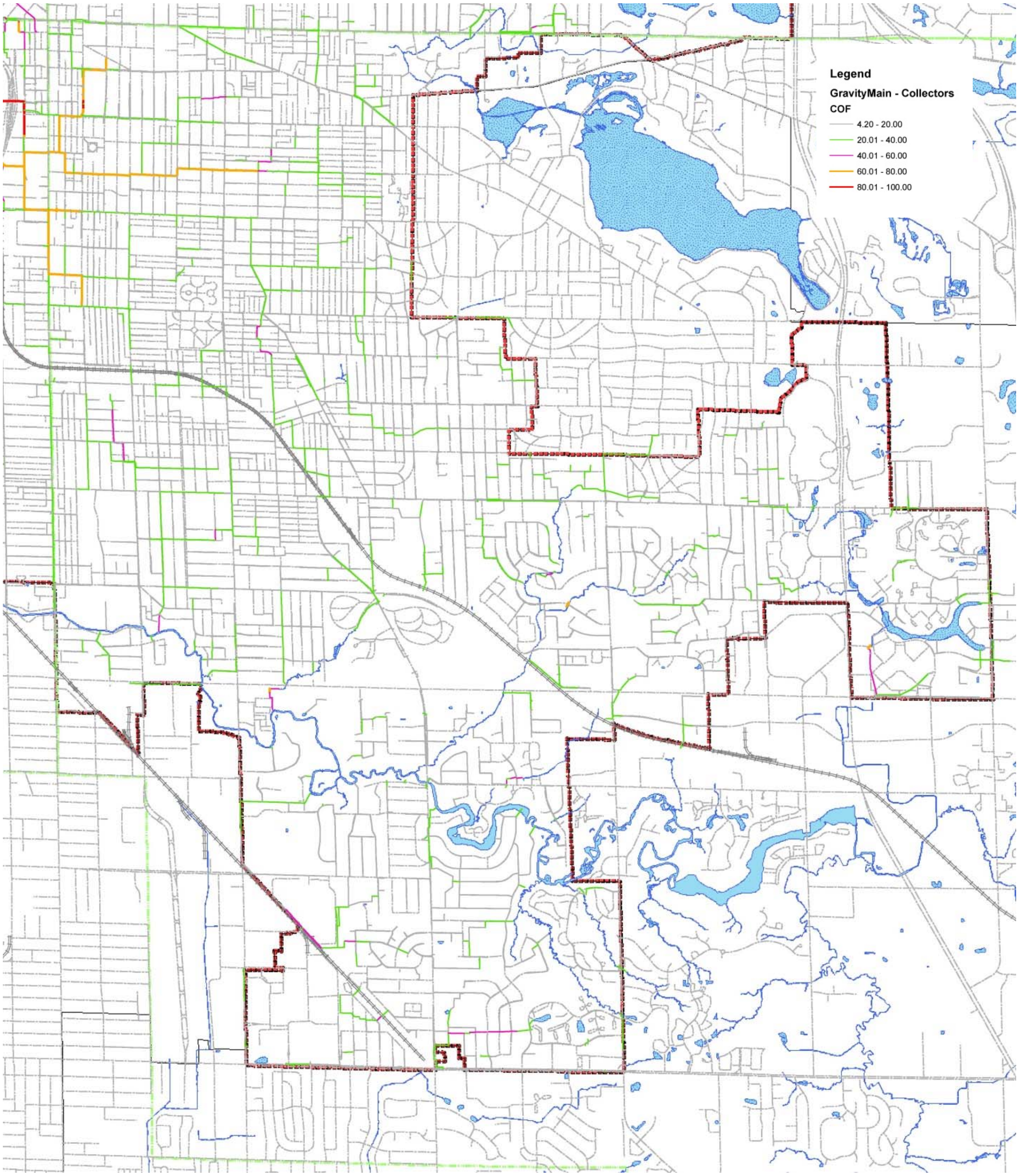


Figure A-8 Gravity Mains Consequence of Failure SE



A3. BUSINESS RISK EXPOSURE MAPS

Figure A-9 Gravity Mains Business Risk Exposure NW

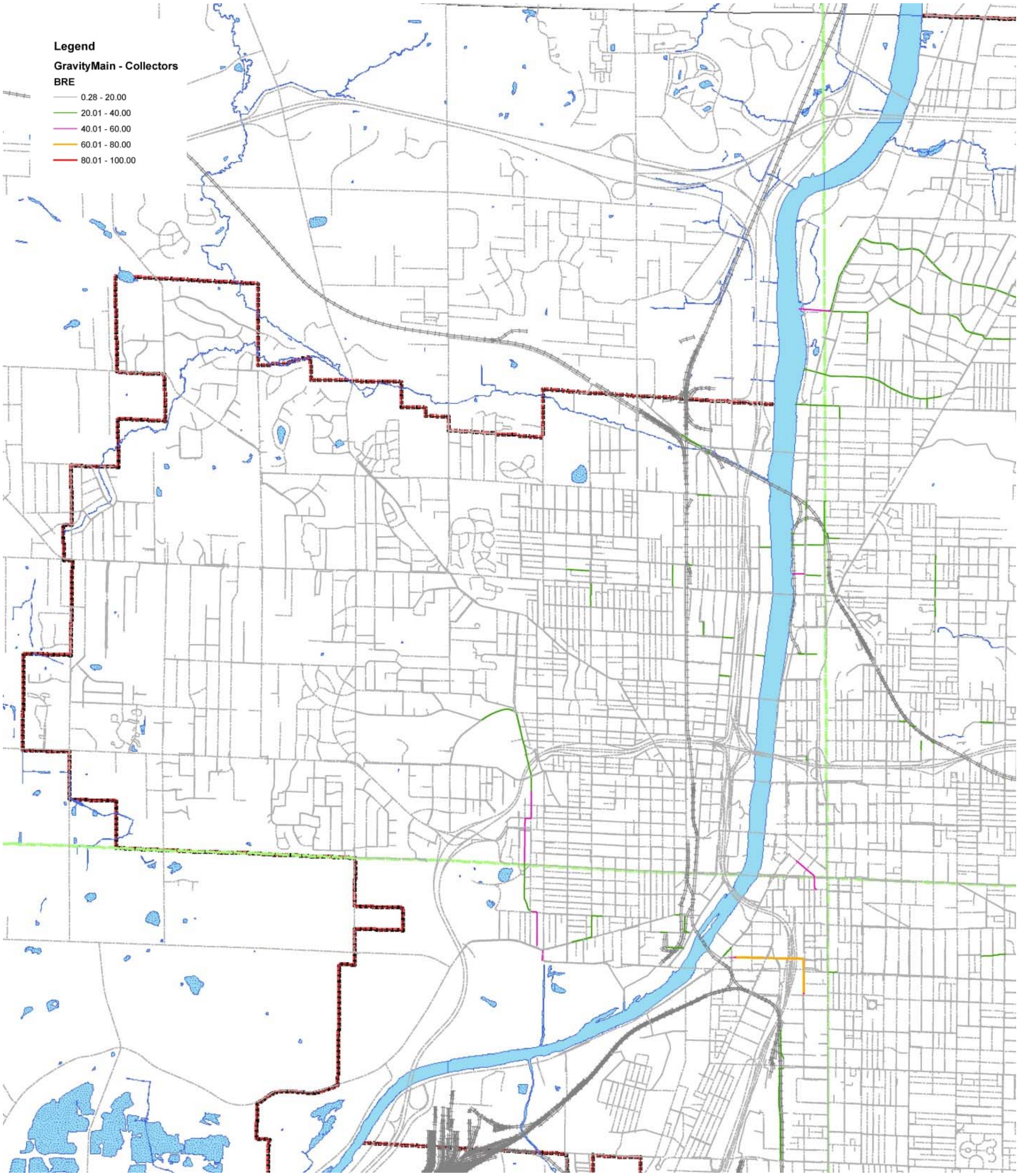


Figure A-10 Gravity Mains Business Risk Exposure NE

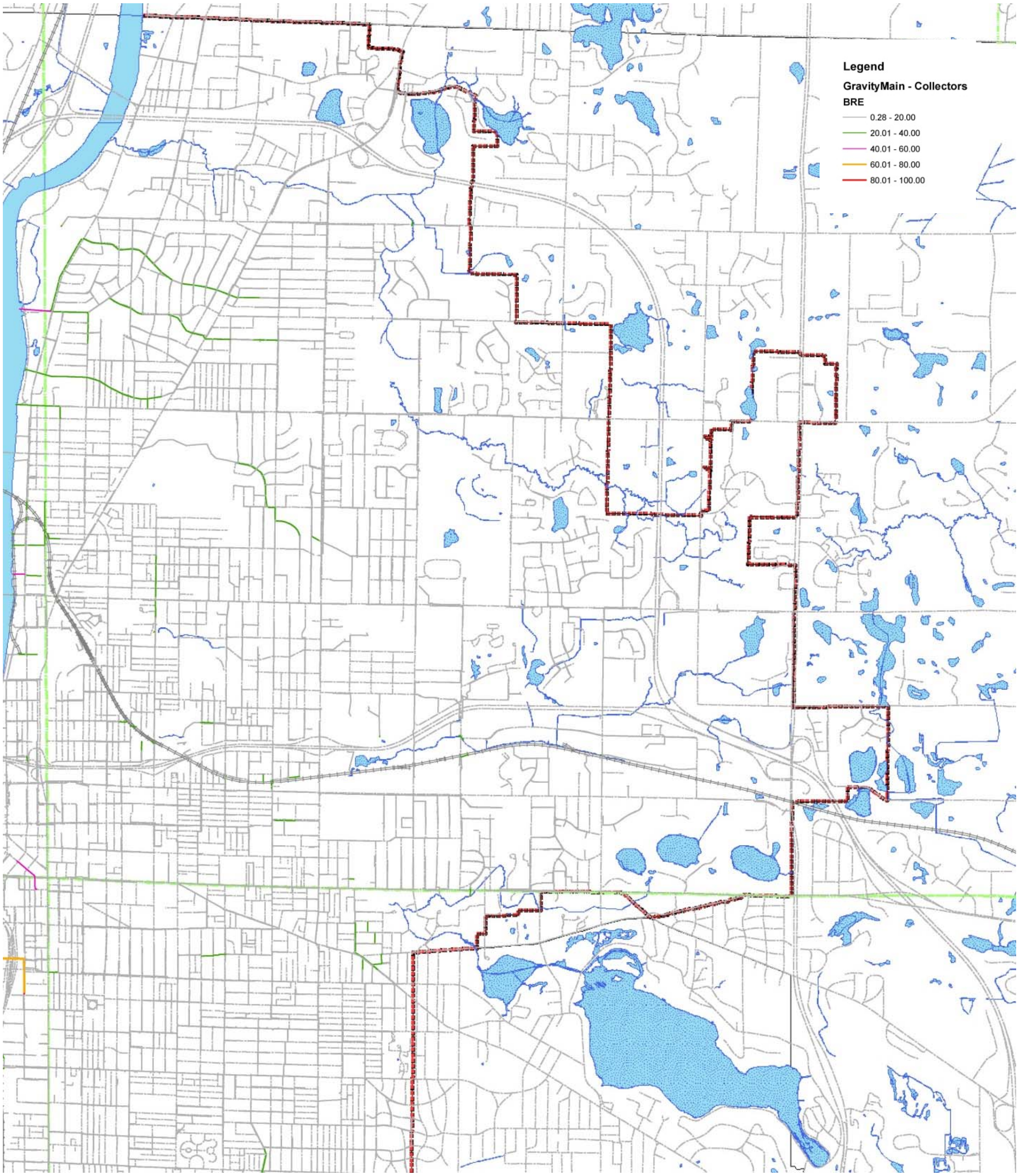


Figure A-11 Gravity Mains Business Risk Exposure SW

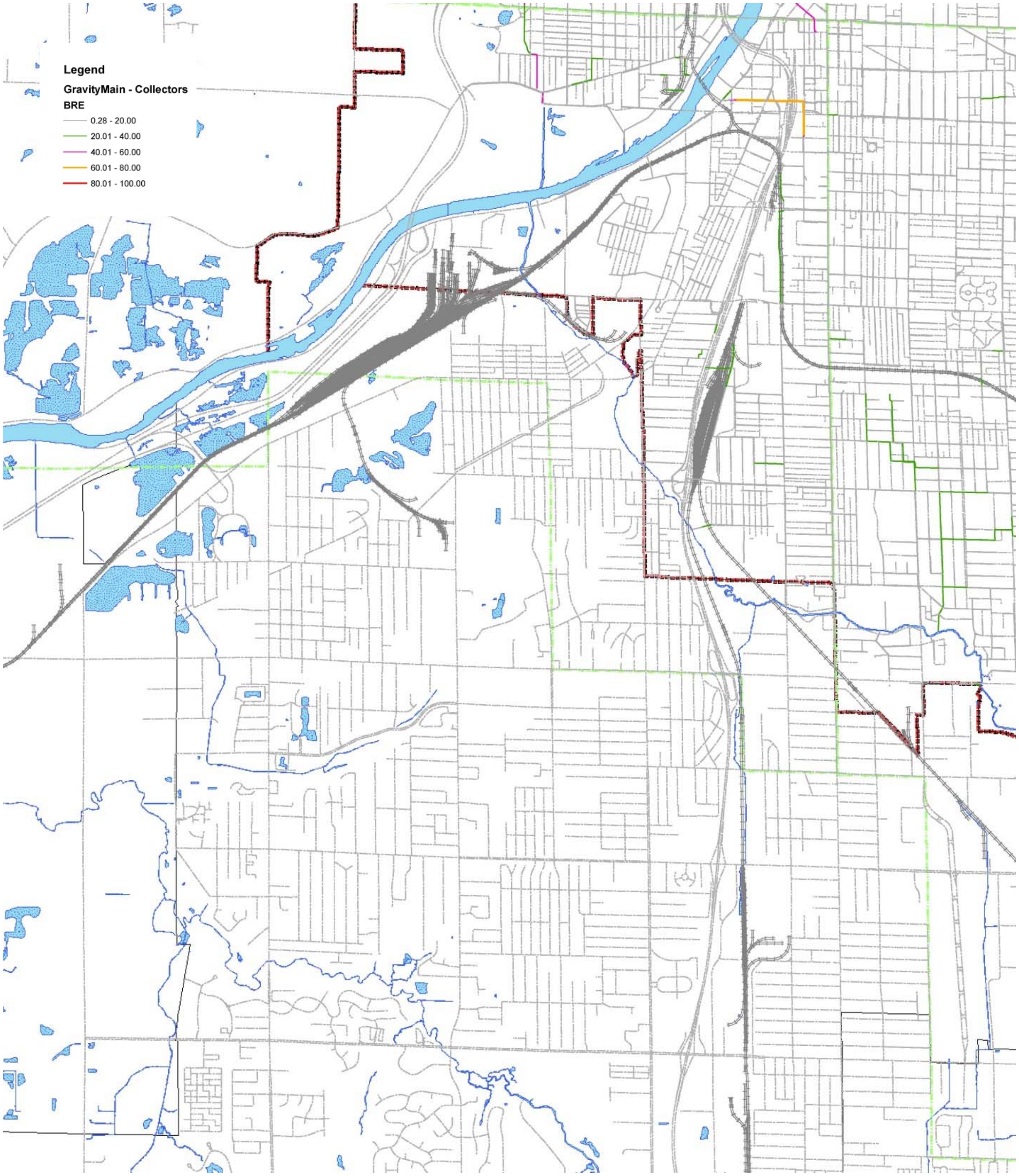
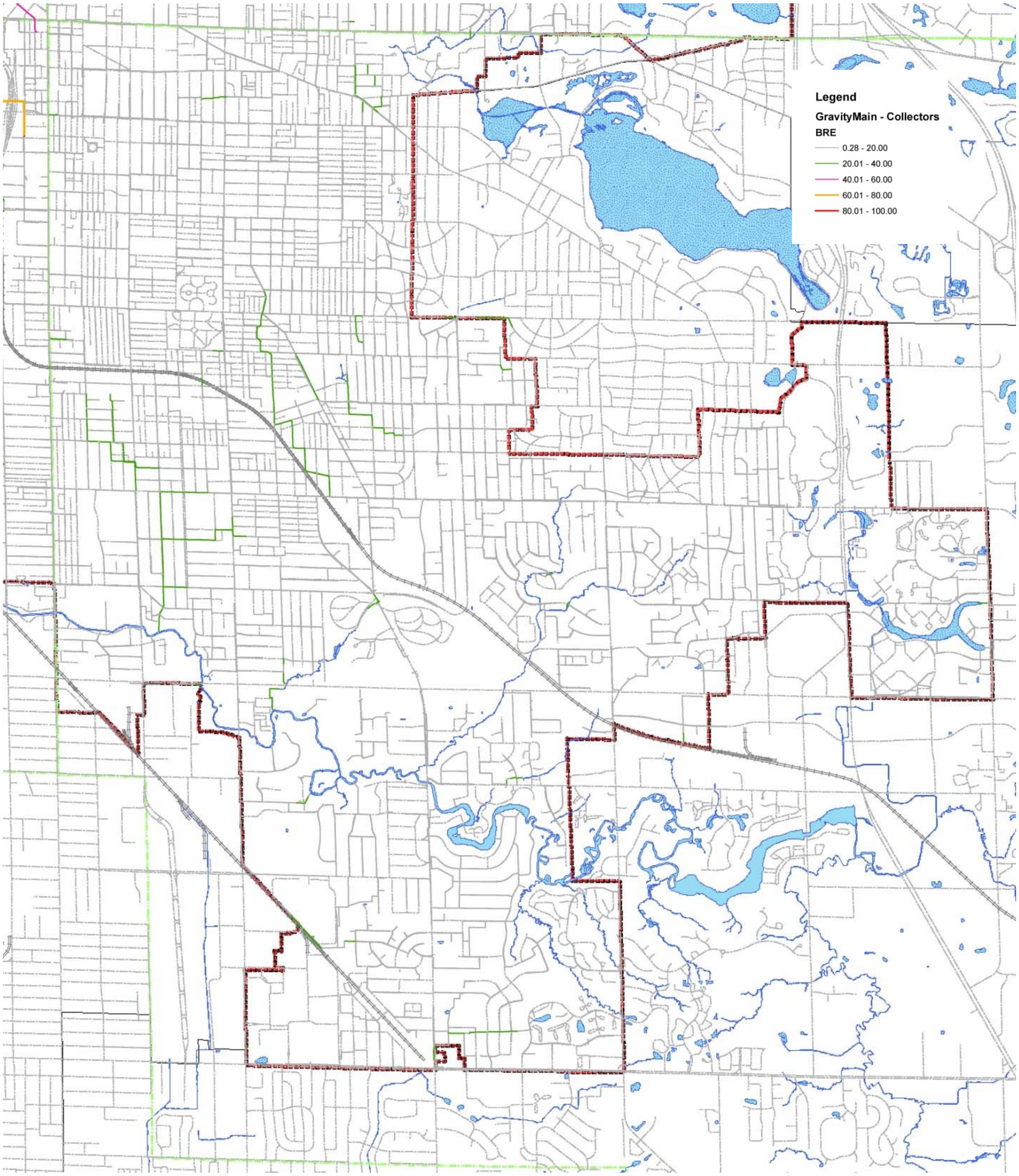


Figure A-12 Gravity Mains Business Risk Exposure SE



APPENDIX B. ASSESSMENT STRATEGY LOS B

Figure B-1 Assessment Strategy NE

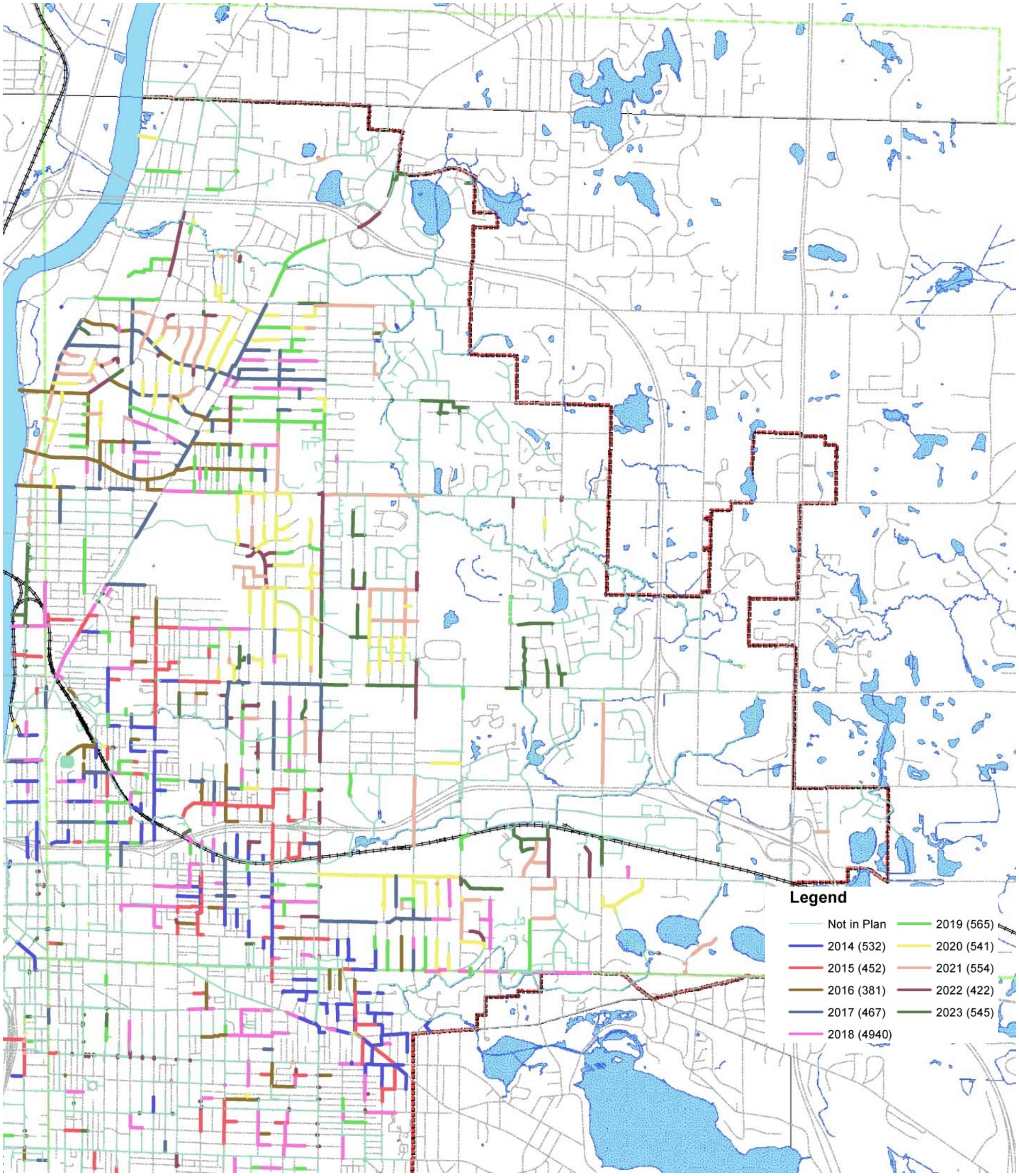


Figure B-2 Assessment Strategy NW

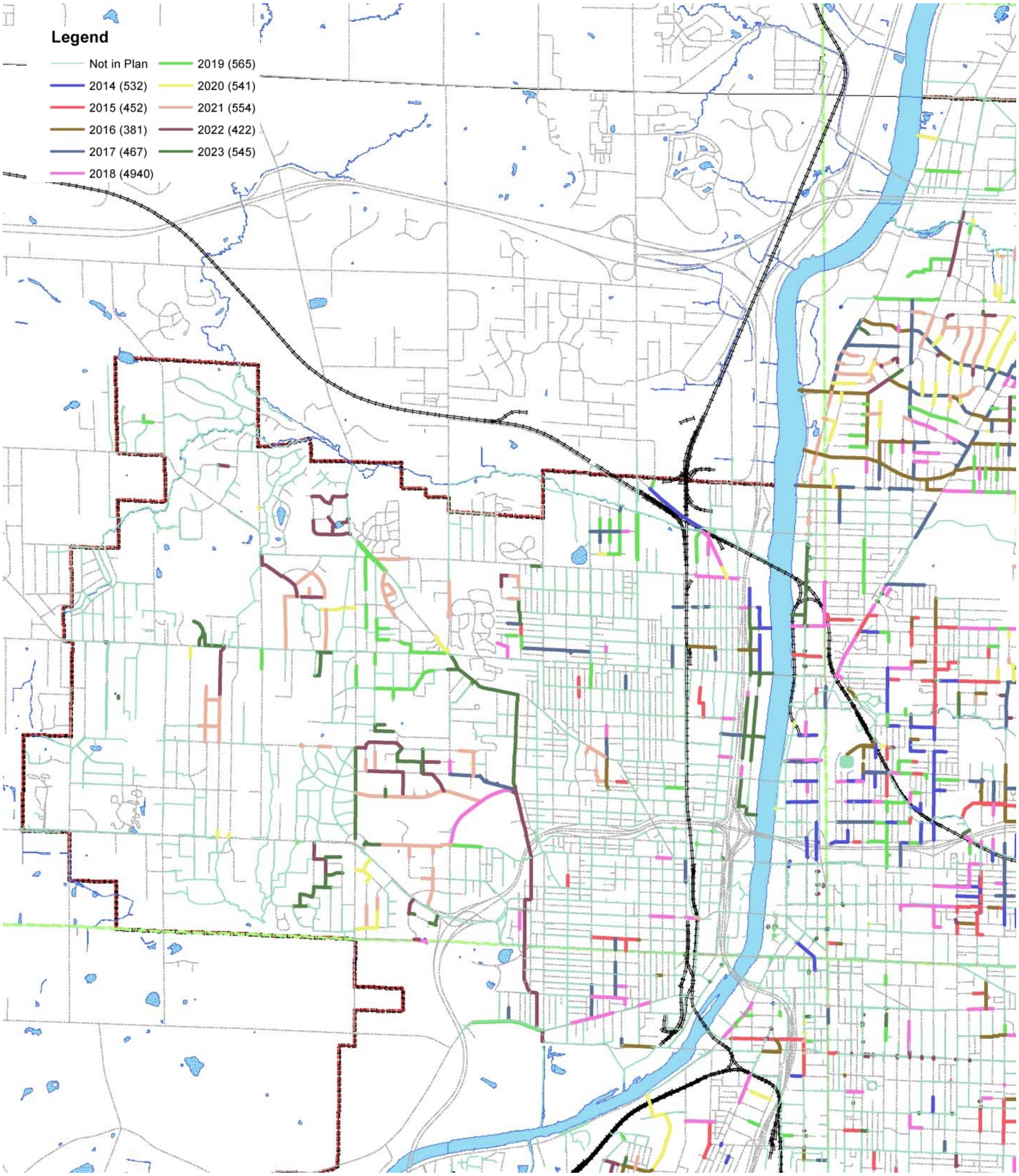


Figure B-3 Assessment Strategy SW

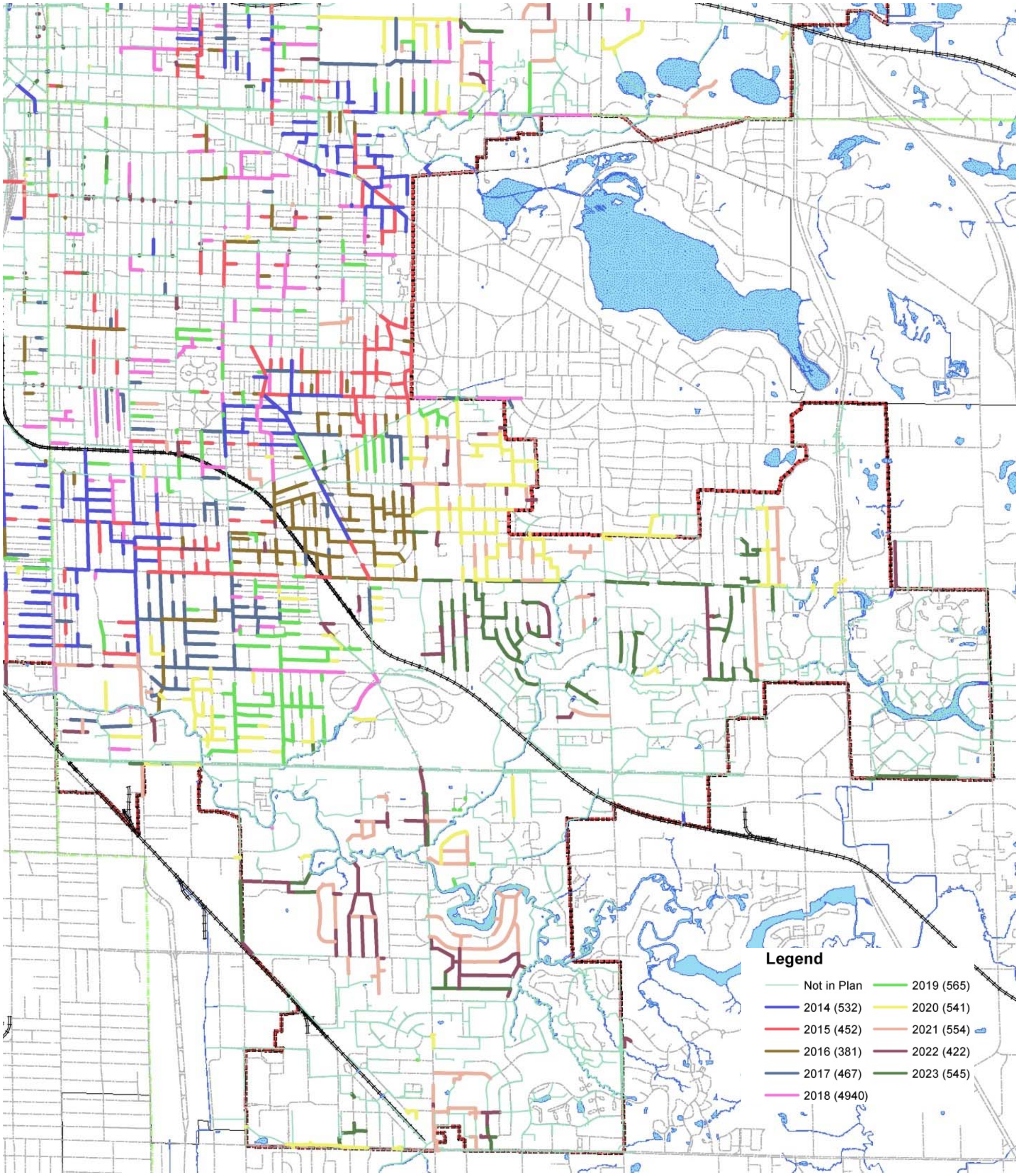


Figure B-4 Assessment Strategy NW