MONTGOMERY DRAIN
MAINTENANCE AND IMPROVEMENT PROJECT
PROJECT ALTERNATIVES ANALYSIS

Prepared By:
Patrick E. Lindemann
Ingham County Drain Commissioner

November 2018

Montgomery Drain Drainage Board Members:

To continue my practice of openness in all of my decisions as Ingham County Drain Commissioner, I have compiled this report. With the help of the Montgomery Drain project team, I have created a summary and short history of how we developed the final scope and design of this project. I would like to thank my project team for all of their creative energy and dedicated service. We have worked together for years on this drainage project to provide the best outcome for those served by the Montgomery Drain. I consider it an honor and a privilege to serve all of Ingham County's citizens, businesses, and municipalities.

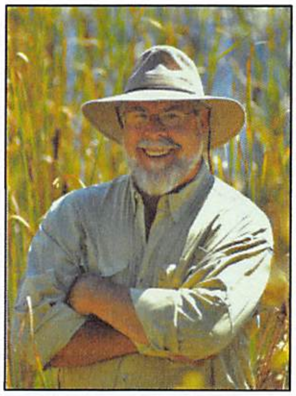
Shortly after becoming Drain Commissioner, while investigating a complaint of isolated flooding, I noticed the direct discharge of polluted stormwater entering the Red Cedar River from the Montgomery Drain. I began looking into the problems created by and associated with this aging and outdated drain infrastructure, which included poor structural condition, limited system capacity, and failure to treat contamination. Clearly, these problems were many years in the making and were not going to be solved easily or with a "quick fix" project.

Complicating the search for solutions, the Drain is at the juncture of three municipalities, two combined sewer systems, and four road entities. Furthermore, about half of the geographic area served by the Drain is in the 100-year floodplain of the Red Cedar River. To give perspective, Michigan Avenue would be under 6 feet of water during a 100-year flood of the Red Cedar River. It became apparent that the solution would lie in source control, in other words, holding and treating the polluted water as close to the source as practicable and feasible. Searching for open, available spaces that could be repurposed within an almost completely built out and 80% impervious service area brought with it many challenges.

Over the years, I brainstormed possible solutions with anyone willing to listen, including non-profit organizations, neighborhood associations, downtown development authorities, engineers, citizens, Michigan State University faculty, municipalities, and others. As a result of those meetings and conversations, an MSU professor and graduate student performed a survey and found that 91% of respondents were supportive of reconstructive efforts in the golf course or shopping center that would improve the water quality of the Red Cedar River.

I went full steam ahead to find workable solutions for the drainage issues facing this watershed and found that all open, available green space was owned by the City of Lansing, specifically Red Cedar Park and Ranney Park. Many concepts were developed, showing ways to repurpose the park properties for drainage. I went back to discuss these design concepts with the neighborhood groups, local property owners, and community service clubs. The response from constituents was overwhelmingly positive. In fact, 67% of voters in the City of Lansing approved a ballot measure to sell the Red Cedar Golf Course for redevelopment purposes.

A maintenance and improvement petition was filed in 2014 by the City of Lansing and the County of Ingham. As you are aware, the Drainage Board found the petition necessary and practicable, and authorized me to move forward with a project recommendation. The following alternatives analysis explains my recommendation for the scope and design of this project.



Patrick E. Lindemann
Ingham County Drain Commissioner

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

The City of Lansing and Ingham County filed a petition for maintenance and improvement of the Montgomery Drain ("Drain") due to concerns regarding public health, pollution, and flooding. The Montgomery Drain Drainage Board ("Drainage Board") determined that a project was necessary and authorized the Ingham County Drain Commissioner ("Drain Commissioner") to develop a recommended project to address these concerns. In doing so, the Drain Commissioner retained engineers to consider and analyze several different approaches to provide a recommendation. The Drain Commissioner identified three main goals of this Drain project: Improve Drain infrastructure condition, increase Drain capacity, and treat contamination that flows through the system.

As further discussed in Section VIII, the recommended project is **Alternative 5 – Targeted Low Impact Design**. This approach maximizes the use of existing infrastructure within the system while adding storage capacity where needed. A water quality "treatment train" would also be constructed, consisting of various facilities including media filters, engineered biofiltration, and constructed wetlands to significantly reduce the estimated 50,000-75,000 pounds of pollutants conveyed through the Montgomery Drain into the Red Cedar River on a yearly basis. Of the various alternatives discussed herein, the Drain Commissioner determined Alternative 5 to be the most cost effective and practical to attain the project goals.

II. INTRODUCTION

The Montgomery Drain is a county drain located in Ingham County and governed under Chapter 20 of the Michigan Drain Code, Public Act 40 of 1956, as amended. The Drain serves areas within the City of Lansing, the City of East Lansing, and Lansing Township ("Service Area"). The Drain is under the jurisdiction of the Drainage Board, consisting of the Drain Commissioner and two members of the Ingham County Board of Commissioners.

The Drain was constructed in 1906. Over the ensuing decades, the lands served by the Drain have been converted from primarily agricultural and open space to a more intense mix of commercial and residential use. The Drain was extended when Frandor Shopping Center opened in 1954. In the mid-1960s to early-1970s, major road development and improvement projects occurred in this area, including the construction of US-127 and the expansion of Saginaw Street and Grand River Avenue. The Drain was further extended in 1978 due to additional development.

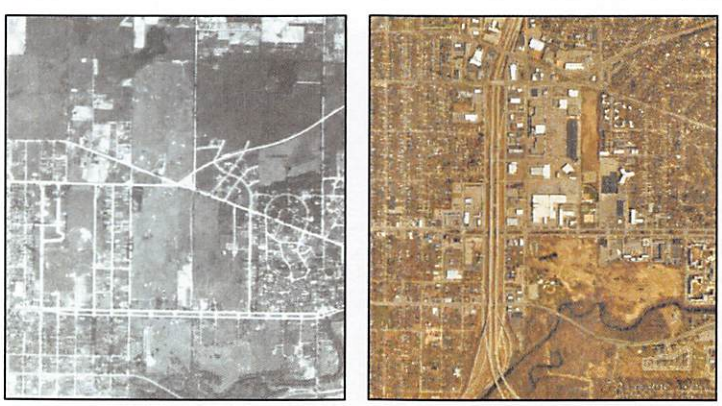
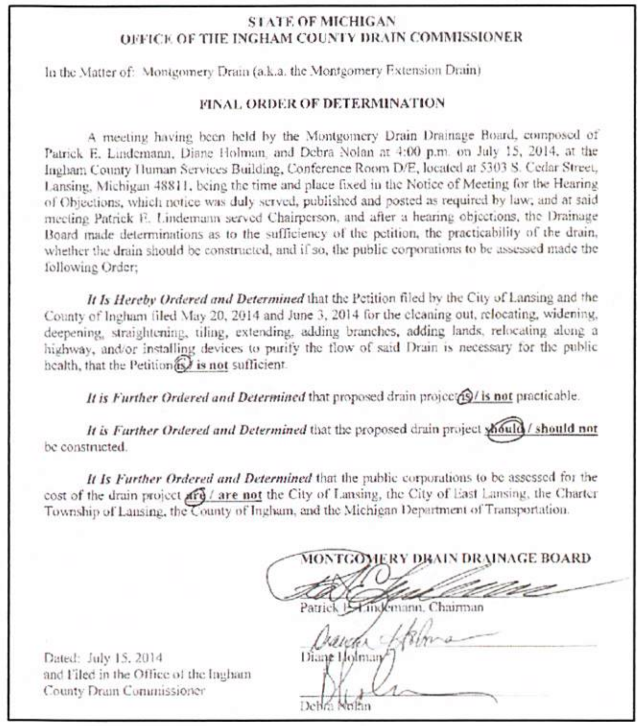


Figure 1. 1938 aerial image (left); 2015 aerial image (right).

Since the mid-1990s, there have been ongoing problems with flooding and contamination which have been reported to and investigated by the Drain Commissioner. In 2014, the City of Lansing and Ingham County petitioned for a drain maintenance and improvement project due to mounting problems and concerns with the Drain, including the poor structural condition of the pipes, insufficient capacity of the system, and contaminated stormwater runoff.

Upon receipt of the petition, the Drainage Board held the statutorily required public hearings and ultimately issued a Final Order of Determination finding that a drain maintenance and improvement project is practicable and necessary for the public health. The Drainage Board has authorized the Drain Commissioner to seek a recommended solution to address the identified problems. The Drain Commissioner engaged Spicer Group, Inc. and Eng., Inc. to assess the current condition of the Drain and to develop alternative project designs.


STATE OF MICHIGAN
OFFICE OF THE INGHAM COUNTY DRAIN COMMISSIONER

In the Matter of: Montgomery Drain (a.k.a. the Montgomery Extension Drain)

FINAL ORDER OF DETERMINATION

A meeting having been held by the Montgomery Drain Drainage Board, composed of Patrick E. Lindemann, Diane Holman, and Debra Nolan at 4:00 p.m. on July 15, 2014, at the Ingham County Human Services Building, Conference Room D/E, located at 5303 S. Cedar Street, Lansing, Michigan 48811, being the time and place fixed in the Notice of Meeting for the Hearing of Objections, which notice was duly served, published and posted as required by law; and at said meeting Patrick E. Lindemann served Chairperson, and after a hearing objections, the Drainage Board made determinations as to the sufficiency of the petition, the practicability of the drain, whether the drain should be constructed, and if so, the public corporations to be assessed made the following Order;

It Is Hereby Ordered and Determined that the Petition filed by the City of Lansing and the County of Ingham filed May 20, 2014 and June 3, 2014 for the cleaning out, relocating, widening, deepening, straightening, tiling, extending, adding branches, adding lands, relocating along a highway, and/or installing devices to purify the flow of said Drain is necessary for the public health, that the Petition **is / is not** sufficient.

It is Further Ordered and Determined that proposed drain project **is / is not** practicable.

It is Further Ordered and Determined that the proposed drain project **should / should not** be constructed.

It Is Further Ordered and Determined that the public corporations to be assessed for the cost of the drain project **are / are not** the City of Lansing, the City of East Lansing, the Charter Township of Lansing, the County of Ingham, and the Michigan Department of Transportation.

MONTGOMERY DRAIN DRAINAGE BOARD

Patrick E. Lindemann, Chairman

Diane Holman

Debra Nolan

Dated: July 15, 2014
and Filed in the Office of the Ingham County Drain Commissioner

Figure 2. Final Order of Determination.

III. CURRENT CONDITIONS OF THE MONTGOMERY DRAIN

1. Poor infrastructure condition. The Drain was inspected and inventoried using techniques such as surveying, pipe televising, manhole scanning, pipe defect assessment, manhole defect assessment, smoke testing, dye testing, illicit discharge research, flow metering, and automated sampling. The inspections revealed cracked and collapsed pipes, debris buildup, illicit connections, and parts of the system that had reached the end of their useful lives. Additionally, the inspections identified existing infrastructure that could be rehabilitated or repurposed as part of the project. These efforts found that 39% is in fair condition, and 57% is in poor condition. (See Map #1.)

Figure 3. Photos representative of Drain condition.

2. Insufficient capacity. The Drain lacks the capacity to adequately store and convey stormwater through the system. In its current condition, the Drain does not have stormwater storage and 52% of the pipes are now too small to convey the 10-year design event. (See Map #2.) Land use changes and increases in both the volume and intensity of precipitation events have also caused the Drain to no longer have enough capacity to operate efficiently. The insufficient capacity is evidenced by localized flooding, surcharged pipes, and increased stormwater velocities. Further, advancements in design standards and rainfall data collection support the conclusion that the Drain requires additional capacity to manage the stormwater in the Service Area.

Figure 4. Photos depicting Drain capacity issues. Left: Clippert and Grand River. Right: Clippert and Vine.

3. Contamination. Within the existing Service Area, 80% of the current land cover is impervious–meaning covered with pavement, concrete, rooftops, etc.–which leads to the direct runoff of stormwater into the Drain. This direct runoff causes an increase in non-point source pollution and introduces metals, salts, hydrocarbons, solids, bacteria, nutrients, and other contaminants into the stormwater, which ultimately discharges into the Red Cedar River. Studies performed by Triterra and Spicer Group, Inc. independently show that contamination exceeds mandated state and federal water quality criteria. The high level of contamination is a major contributor to the impairment of the Red Cedar River. Based on two years of sampling data, it is estimated that 50,000-75,000 pounds of contamination are conveyed through the Drain into the Red Cedar River annually.

Figure 5. Photos depicting Drain contamination.

IV. SUPPLEMENTAL CONSIDERATIONS AFFECTING PROJECT DESIGN

The Drain Commissioner has sought ways to reduce the cost of any selected Drain project, while providing the most beneficial public impact (i.e., "the biggest bang for the buck"). Below are some ways in which the Drain Commissioner has achieved this objective:

1. **Grant Funding.** The Drain Commissioner obtained a State of Michigan Stormwater, Asset Management and Wastewater ("SAW") Grant in the amount of $1,319,417.00 to inspect and inventory the infrastructure of the Drain. These funds were applied to offset the project costs expended on the necessary review of the existing infrastructure.

To further reduce project costs, the Drain Commissioner obtained a State of Michigan Department of Natural Resources Aquatic Habitat Grant in the amount of $427,178.00. These grant funds will be applied toward pollution remediation.

2. **MDOT Coordination.** The Drain Commissioner has been working with Michigan Department of Transportation ("MDOT") to eliminate both the siphon drain under US-127 and the Combined Sewer Overflow ("CSO") located in the area of Saginaw and Homer Streets by incorporating replacement facilities as part of the project. MDOT will be responsible for all costs associated with the elimination of the siphon drain and CSO.

3. **City of Lansing Coordination.** The Frandora Hills subdivision, constructed in the 1960s, is located north of Saginaw Street between US-127 and Coolidge Road. The City of Lansing currently maintains a storm sewer system and sanitary sewer lines within the streets of this subdivision. Both are in need of repair. The Drain Commissioner and City of Lansing officials are working together to improve the storm sewer system as part of the Drain project, while at the same time replacing the sanitary sewer lines to minimize further disruption to area residents and to reduce costs by coordinating construction. The City of Lansing will be responsible for all costs associated with the replacement of sanitary sewer lines and street reconstruction.

Through communications with the City of Lansing, the Drain Commissioner has also obtained easements over Ranney Park and Red Cedar Park at no cost. These easements are to be used for the Drain project, under the condition that the parks will continue to be used as recreational lands. These parks are an essential component of the project design.

4. **Coordination with Local Economic Development.** The Drain Commissioner is proactively working toward responsible regional growth by ensuring that developers treat stormwater at its source. Additionally, several area business owners have voluntarily provided easements to benefit the Drain project.

V. PROJECT ALTERNATIVES

The Drain Commissioner has met and consulted with area landowners, local government officials, environmental regulators at Michigan Department of Environmental Quality, engineers, environmental experts, and members of the general public throughout this process. Priorities and concerns were gathered and considered. Based on the feedback and the results of various research efforts, the Drain Commissioner determined that the following levels of service must be accomplished by the chosen project:

- Repair failing pipes and other parts of the system that are in poor condition;
- Increase capacity to handle a 10-year Storm;[1] and
- Reduce contamination by providing stormwater treatment for 96% of storm events.[2]

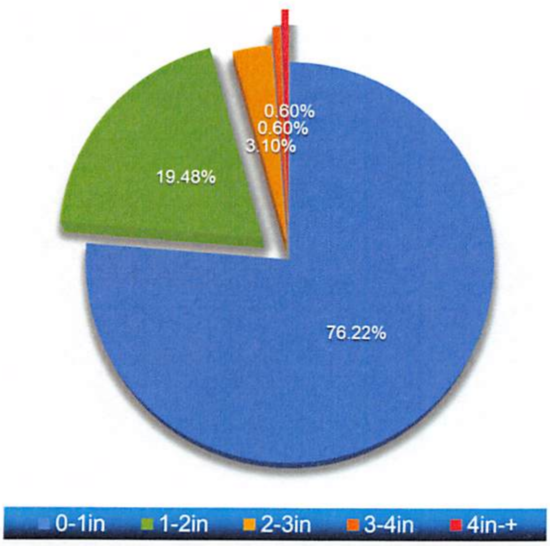


Figure 6. Based on daily rainfall records from 1910 to 2015, approximately 96% of storms have had total rainfall of 2" or less.

The Drain cannot prevent the flooding of the Red Cedar River because the River's watershed and its floodplain encompass an area vastly larger than the Drain's Service Area. However, with proper design and planning, localized flooding can be managed by the Drain while significantly decreasing the pollution that is introduced into the Red Cedar River from the Service Area.

In considering the alternatives, the Drain Commissioner remained committed to implementing the primary objective of the Clean Water Act, which is to restore and maintain the integrity of the nation's waters. This objective translates into two fundamental goals: to eliminate the discharge of pollutants and to achieve water quality levels that are fishable and swimmable.

Regulations implemented under the Clean Water Act, referred to as "Phase II," require storm water drainage systems in urbanized areas, such as the Montgomery Drain, to meet the following six minimum control measures:

1. *Public Education and Outreach;*
2. *Public Involvement and Participation;*
3. *Illicit Discharge Detection and Elimination;*
4. *Construction Site Stormwater Runoff Control;*
5. *Post Construction Stormwater Management (BMPs); and*
6. *Stormwater Pollution Prevention and Good Housekeeping.*

Among the multitude of alternatives considered, the following are the best representative options of the different approaches:

[1] 10-year storm is defined as a storm that has a 1 in 10 chance of occurring within a given year.

[2] 96% of storms have total rainfall of 2" or less, based on rainfall records from 1910 to 2015.

Alternative 1 – Stormwater Treatment Plant

This alternative would involve the construction and operation of a stormwater treatment plant ("SWTP")[3] near the Red Cedar River. The SWTP would provide end-of-pipe treatment and storage of stormwater prior to discharge into the Red Cedar River. The SWTP cannot be constructed within the floodway, and any construction within the boundaries of the floodplain would have to be built above the 100-year flood stage of the Red Cedar River. Protection for a 500-year flood stage is required by law.[4] An appropriately sized SWTP for the Drain's Service Area would require substantial land acquisition. Operation and maintenance associated with a SWTP would require 24-hour specialized staffing. In addition to the SWTP, broken and undersized pipes would be replaced or repaired to extend the useful life of the existing system.

The SWTP alternative would meet project goals and is estimated to cost $60.0 million.

Alternative 2 – Replace Existing Drain System

This alternative would involve the replacement of all existing infrastructure with the modern equivalent, thereby extending the life of the current system. This alternative was considered because it is a common approach to drain improvement projects. Typical operation and maintenance expenses would be expected.

Alternative 2, however, would not meet the project goals of increasing the Drain's capacity or treating contamination. The estimated cost for Alternative 2 is $77.3 million.

Alternative 3 – Total Low Impact Design

This alternative would require the installation of low impact design ("LID") infrastructure such as rain gardens, infiltration basins, green roofs, permeable pavement, and other methods on every parcel in the Drain's Service Area. The LID infrastructure would capture and treat pollutants at the source, reducing the amount of contaminants conveyed through the Drain and ultimately into the Red Cedar River. To implement this alternative, an estimated 20% of each parcel would be dedicated for LID infrastructure. Broken and undersized pipes would be replaced or repaired to extend the useful life of the existing system. Necessary maintenance would be required to ensure that the LID infrastructure operates efficiently, which would require permanent access to every parcel within the Service Area.

This alternative would meet all project goals. The estimated cost for Alternative 3 is $139.4 million.

Alternative 4 – Stormwater Treatment Under Impervious Surfaces

This alternative would involve making underground improvements to the Drain infrastructure and storage capacity. Water quality treatment facilities–such as hydrodynamic separators, baffle boxes, oil/water separators, and grit chambers–would be constructed in pipes or concrete vaults. Treatment and storage facilities would be located under impervious surfaces (roadways, parking lots, etc.) in existing rights of way. Broken and undersized pipes would be replaced or repaired to extend the useful life of the existing system. Necessary maintenance, most of which would have

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[3] The stormwater treatment plant would be regulated under the same conditions as a wastewater treatment plant.

[4] Michigan Administrative Code §R 408.30451c (Michigan Building Code).

to be performed underground, would be required to ensure that the infrastructure operates efficiently.

This alternative would meet all project goals. The estimated cost for Alternative 4 is $41.7 million.

Alternative 5 – Targeted Low Impact Design

This alternative would involve making improvements to the Drain infrastructure, adding storage capacity, and placing water quality features at key locations. Broken and undersized pipes would be replaced or repaired to extend the useful life of the existing system. The construction of ponds and underground storage would increase the capacity of the system. This additional storage would be part of an overall "treatment train" of media filters, engineered biofiltration, and constructed wetlands to improve water quality. Necessary maintenance to above ground LID elements and underground infrastructure would be required to ensure that the system operates efficiently.

This alternative would meet all project goals. The estimated cost for Alternative 5 is $34.9 million.

Alternative 6 – "Band-Aid®" the Drain

This alternative would only address major structural defects by replacing or repairing those pipes that are failing or in poor condition. This alternative would prolong the useful life of portions of the system. Necessary maintenance would be required to ensure that the system remains operational and would continue to increase in frequency and expense over time.

This alternative would improve the Drain infrastructure condition, but would not address the Drain capacity or water quality goals. The estimated cost for Alternative 6 is $23.9 million.

Alternative 7 – Do Nothing

This alternative would halt design work and eventually abandon the petition. No improvements to the system would be made. System maintenance requirements would continue to increase over time, and the Drain would be more susceptible to catastrophic failure. Moreover, pollution of the Red Cedar River would continue unabated.

This alternative would not meet any of the project goals. The estimated cost of Alternative 7 is $10.9 million, as a result of responding to the petition.

VI. ALTERNATIVES NOT MEETING PROJECT GOALS

Alternatives 2, 6, and 7 were rejected by the Drain Commissioner because they do not fully meet the project goals. The following summarizes important considerations, analysis and reasoning of these alternatives:

Alternative 2 – Replace Existing Drain System. This alternative was rejected by the Drain Commissioner because 1) the project would be excessively disruptive to the flow of traffic on local streets and around local businesses; 2) the project would not improve the Drain's water quality; 3) the project would not increase the Drain's capacity.

Alternative 6 – "Band-Aid®" the Drain. This alternative was rejected by the Drain Commissioner because 1) the system would continue to fail and require more substantial and costly repairs over time; 2) the project would not improve the Drain's water quality; and 3) the project would not increase the Drain's capacity.

Alternative 7 – Do Nothing. This alternative was rejected by the Drain Commissioner because 1) the system would continue to fail and require more substantial and costly repairs over time; 2) the project would not improve the Drain's water quality; 3) the project would not increase the Drain's capacity; 4) doing nothing would waste funds that have already been expended to address the concerns of the petition; and 5) doing nothing would likely increase future legal liability.

VII. ALTERNATIVES MEETING PROJECT GOALS

The remaining four project alternatives meet the Drain Commissioner's goals:

Alternative 1 – Stormwater Treatment Plant

Alternative 3 – Total Low Impact Design

Alternative 4 – Stormwater Treatment Under Impervious Surfaces

Alternative 5 – Targeted Low Impact Design

Of these four that meet the project goals, Alternative 5 is the recommended alternative. It is the most cost-effective option, both from a capital and lifecycle cost standpoint.

Alternative 1 – Stormwater Treatment Plant. This alternative was rejected by the Drain Commissioner because 1) there is a shortage of available lands that are suitable for end-of-pipe SWTP construction; 2) the SWTP has the most extensive operational costs due to 24-hour specialized staffing and utility expenses; 3) there is a large energy consumption component associated with a SWTP; 4) treatment plants need to receive stormwater with consistent flow and quality characteristics; and 5) treatment plants create a sludge byproduct.

Alternative 3 – Total Low Impact Design. While favoring total low impact design and source control, this alternative was rejected by the Drain Commissioner because 1) retrofitting an existing developed commercial area with total LID would not be practicable; 2) a significant amount of additional, and potentially expensive rights of way would need to be obtained; 3) it may not be feasible to perform the necessary widespread relocation of utilities; and 4) it could be unreasonably burdensome to property owners.

Alternative 4 – Stormwater Treatment Under Impervious Surfaces. This alternative was rejected because 1) the amount of construction, operation, and maintenance in the roadway would be highly disruptive to the flow of traffic; 2) additional rights of way would be required; 3) it may not be feasible to perform the necessary widespread relocation of utilities; and 4) the extent of underground treatment facilities required to implement this alternative is considerably more expensive to construct and operate when compared to above-ground treatment facilities, due in part to the labor-intensive mechanical maintenance in confined spaces.

VIII. RECOMMENDED PROJECT ALTERNATIVE

Alternative 5 – Targeted Low Impact Design. This alternative was chosen by the Drain Commissioner because it 1) provides practicable source control with less burden to property owners; 2) avoids mandatory acquisition of additional rights of way by building treatment and storage facilities in existing public open spaces (Ranney Park and Red Cedar Park); 3) maximizes previous infrastructure investments by using existing pipes that would otherwise require upsizing; 4) reduces traffic disruption when compared to other alternatives; 5) treats contamination by conveying the stormwater through a "treatment train" which is considerably less expensive than other acceptable alternatives; and 6) meets all six of the Clean Water Act's Phase II minimum control measures.

There are also many indirect benefits provided by Alternative 5, including 1) enhancement of public space and wetlands; 2) improvement of habitat for native plants and animals; and 3) connection of drain access and maintenance paths with regional trail systems that can be used for outdoor recreation.

When considering all lifecycle costs, Alternative 5 has the lowest cost of the four acceptable alternatives. This targeted low impact design project is the most feasible, cost effective, and practical to construct and maintain.

Figure 7. Conceptual drawing of Ranney Park.

Figure 8. Conceptual drawing of Red Cedar Park.

GLOSSARY

10-year Storm
A 10-year storm is one that has a 1 in 10 chance of occurring within a given year.

Baffle Box
A baffle box is a concrete or fiberglass structure containing a series of sediment settling chambers separated by baffles. The primary function of a baffle box is to remove sediment, suspended particles, and associated pollutants from stormwater. It may also contain a trash screen or skimmer to capture larger materials, trash, and floatables.

Biofiltration
Biofiltration refers to a pollution control technique using an engineered device or system containing living material to capture and biologically degrade pollutants.

Combined Sewer Overflow
A combined sewer system mixes sanitary and storm water, and the overflow of the system will discharge untreated sewage to receiving water bodies.

Easement
An easement is a legal right to use property for a specific purpose.

Floodplain
A floodplain is an area of land adjoining a river or stream that will be inundated by a 100-year flood (a flood which has a 1 in 100 chance of occurring in any given year).

Flood Stage
A flood stage is the level at which the surface of a body of water has risen to a certain level to cause sufficient inundation of areas that are not normally covered by water, and causing an inconvenience or threat to life or property.

Floodway
A floodway is the channel of a river or stream and adjacent shore areas that will carry moving water during times of flood.

Green Roof
A green roof is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems.

Grit Chamber
A grit chamber is a tank or an enlargement of a collection line designed to slow the flow of stormwater for the purpose of separating solids.

Hydrodynamic Separator
A hydrodynamic separator is a flow-through structure with a settling or separation unit designed to capture oils, sediment, and other pollutants contained in runoff and to prevent these contaminants from entering the stormwater drainage system.

Impervious
Impervious means not allowing, or allowing only with great difficulty, the movement of water to pass through.

Infiltration Basin
An infiltration basin is a water impoundment over permeable soils which receives stormwater runoff and contains it until it infiltrates the soils. The basin removes fine sediment and the pollutants associated with them.

Lifecycle Cost
A lifecycle cost is the sum of all recurring and one-time costs over the full life span of a system. This includes material costs, installation cost, operating costs, maintenance and upgrade costs, and residual value at the end of useful life.

Low Impact Design ("LID")
Low Impact Design is a land planning and design technique to manage stormwater runoff as part of green infrastructure. LID emphasizes conservation and use of on-site natural features to protect water quality.

Media Filter
A media filter is a type of filter that uses some combination of sand, peat, turf, shredded tires, geo-textile fabric, or other material to protect water quality in streams, rivers, and lakes. A media filter can be effective at removing pollutants in stormwater such as suspended solids and phosphorus.

Nonpoint Source Pollution
Nonpoint source pollution is caused by rain and snowmelt carrying pollution from random and diverse sources over or through the ground, finally depositing it into lakes, streams, wetlands, and other water bodies.

Nutrients
Nutrients in stormwater refer primarily to phosphorus and nitrogen, which can induce excessive plant and algae growth when a body of water becomes overly enriched with them. This also can lead to reduced water clarity and to oxygen depletion of the water body, which causes harmful algal blooms, dead zones, and fish kills.

Oil/Water Separator
An oil/water separator is a specialized concrete vault integrated into a larger water treatment system to separate oil and petroleum products from stormwater and runoff.

Permeable Pavement
Permeable pavement is made of porous concrete, asphalt, or interlocking pavers, allowing stormwater to pass through the pavement to an outlet pipe below.

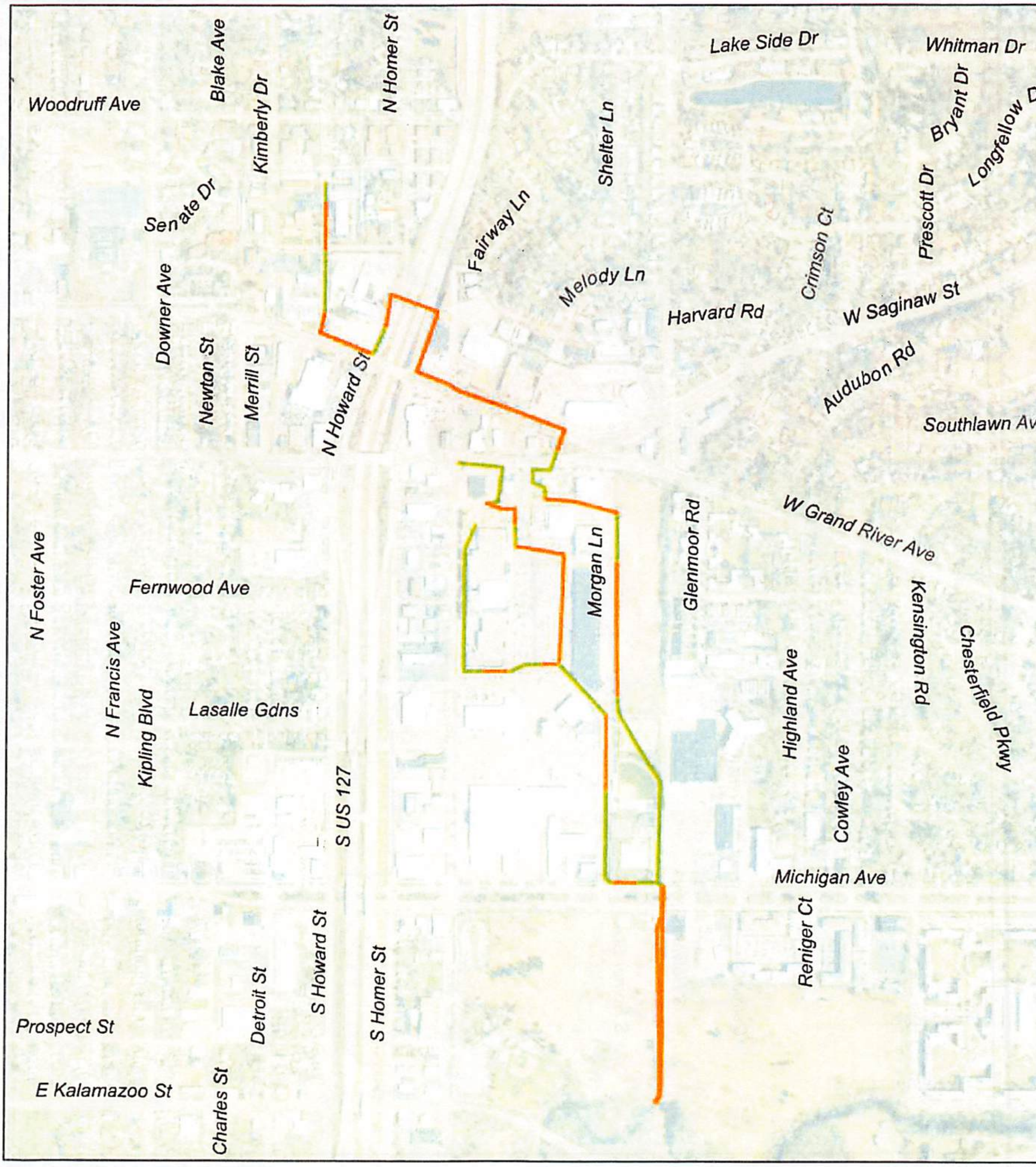
Rain Garden
A rain garden is a depressed area in the landscape that collects stormwater runoff, allowing it to soak through and be filtered by the plants and engineered soil medium to an outlet pipe below.

Runoff
Runoff is the excess portion of precipitation that does not infiltrate into the ground, but "runs off" and reaches a stream, water body, or storm sewer.

Treatment Train
A treatment train is a sequence of multiple stormwater treatment facilities designed to reduce pollution.

Storm Sewer Pipe Condition

Montgomery Drain



LEGEND

Pipe Condition

- Fair
- Poor

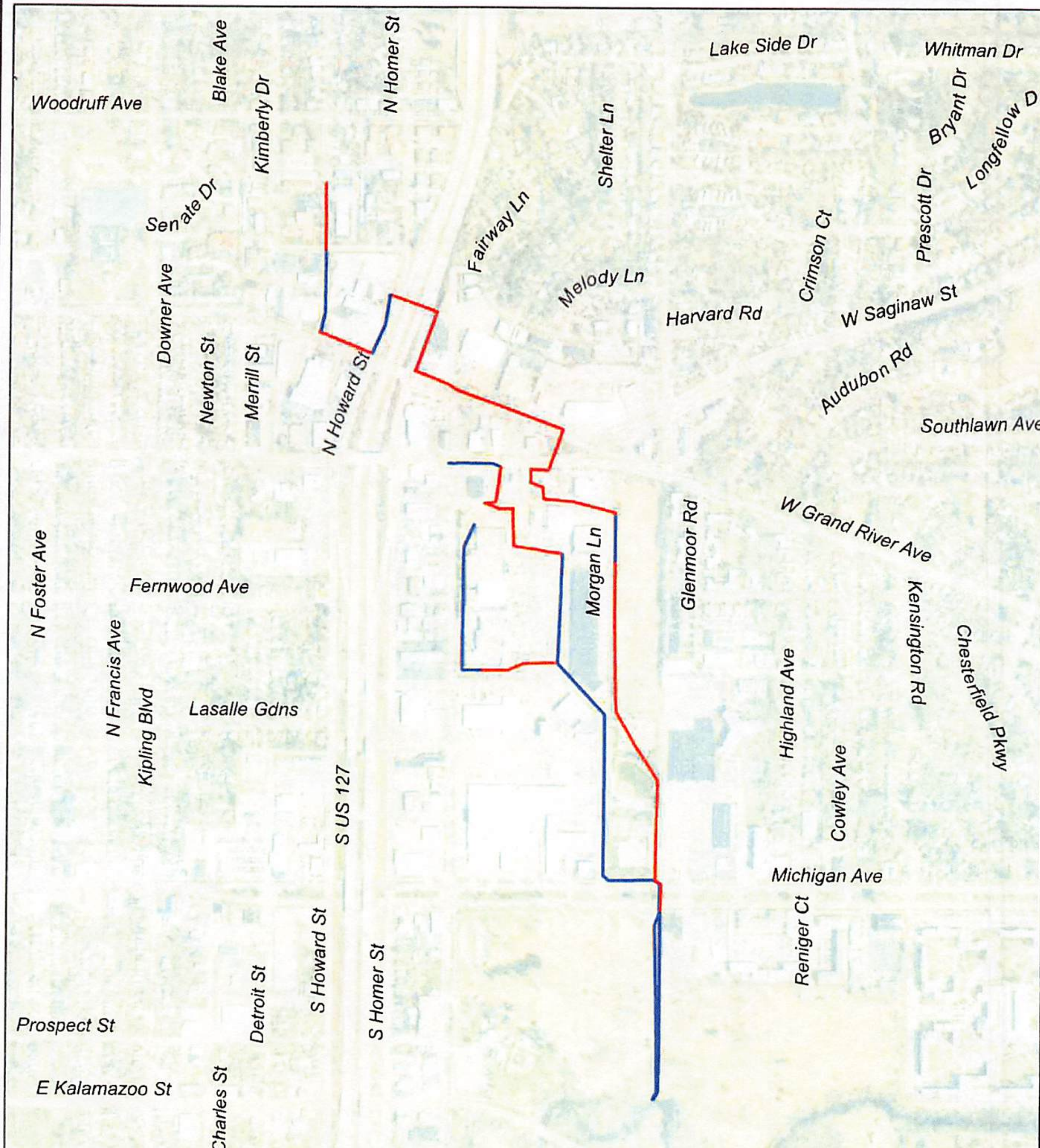
LANSING OFFICE
416 N Homer St, Suite 109
Lansing, MI 48912
Tel. 517-325-9977
www.SpicerGroup.com

FEET 0 430 860

MAP #1 DATE: NOVEMBER 2018

Storm Sewer Pipe Capacity

Montgomery Drain



LEGEND

Pipe Capacity

- *Sufficient Capacity* (blue)
- *Insufficient Capacity* (red)

Spicer group

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MAP #2

DATE: NOVEMBER 2018