20-Year Comprehensive Facility Plan

Critical Repair and Reinvestment Plan

Volume 3: Stormwater and Drainage

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June 2017

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Angela L. Akridge, PE, Chief Engineer
Louisville and Jefferson County Metropolitan Sewer District
700 West Liberty Street
Louisville, KY 40203

June 30, 2017

Subject: 20-Year Comprehensive Facility Plan—Critical Repair and Reinvestment Plan

Dear Ms. Akridge,

The attached 20-Year Comprehensive Facility Plan, also referred to as the Louisville and Jefferson County Metropolitan Sewer District (MSD) Critical Repair and Reinvestment Plan, represents MSD's most ambitious planning effort in a decade. The 2-year effort reviewed the challenges our community faces now and in the future, identified practical solutions, and developed a roadmap to protect the health, economic vitality, and environment of our city. The recommendations in this Facility Plan are the result of careful evaluation by the Facility Plan Team, which includes some of the most experienced engineers in Louisville Metro. We believe that the recommendations presented in this Facility Plan are essential to maintaining reliable facilities that will allow MSD to fulfill its responsibility for safe, clean waterways and help preserve and promote our competitiveness as a city.

One driver that led to Facility Plan development was a recognition that—for the past 10 years—MSD has focused much of its resources and investments on tackling the federally mandated undertaking to reduce sewer overflows. Major investments in other infrastructure rehabilitation, renewal, and replacement were limited by the community's desire to keep rates at or below industry averages, even as capital and operating spending ramped up to meet Consent Decree requirements. In the face of limited resources, MSD staff still continued its excellent record of regulatory compliance in areas not related to sewer overflow control by focusing on the day-to-day operation and maintenance of wastewater, stormwater, and flood protection facilities.

The result of deferred investment on infrastructure renewal and replacement is that Louisville's aging system of pipes, pumps, treatment plants, and flood control systems is now in urgent need of rehabilitation if it is to continue reliably protecting public health and safety. The Facility Plan recommends taking immediate action to begin implementing critical improvements to the wastewater, stormwater management, and flood protection systems.

Acting in accordance with the recommended schedule of improvements will require a significant investment from the community. Starting on these critical projects while still only halfway through the Consent Decree response will require a step-change increase in wastewater and drainage rates. If the community is unwilling to accept the rate increases necessary to fund the project schedules recommended, then many important projects will need to be deferred until the major Consent Decree spending is complete. The data indicate that *not* implementing necessary investments in a timely manner is almost certain to result in more infrastructure failures, an increase in the overall Facility Plan implementation cost, and an ever more rapidly increasing likelihood of a failure that could have serious consequences for the residents and business that make Louisville Metro their home.

Following the release of the December 2016 draft of the Facility Plan, MSD undertook a wide-reaching public outreach initiative, aimed at bringing many perspectives to the table for constructive dialogue about the needs and timing of implementing the Facility Plan recommendations. Community input confirms that Louisville supports restoring its vital wastewater, flood protection, and stormwater management facilities. Following are responses from those who engaged in the community conversation:

- Ninety percent of respondents understand and agree with the need for investing in the community's wastewater, stormwater, and flood protection systems to reduce risks to public health and safety rather than continuing to defer critical repairs and reinvestment.
- Eighty-nine percent of respondents believe beginning to address the public health and safety risks as quickly as possible is important.
- Seventy-one percent of respondents support increasing residential rates of up to $10 per month (with a proportional increase in industrial and commercial rates) to immediately begin funding critical wastewater, stormwater, and flood protection needs that address public health and safety risks.
- Seventy-eight percent of respondents support expanding MSD's existing Rate Relief Program to assist customers who meet federal criteria established for other utility rate assistance programs.

Working with MSD on this important planning assignment that addresses critical infrastructure issues impacting the future quality of life in our community has been an honor and privilege for the entire Facility Plan Team. The undersigned leaders of the Facility Plan Team, as representatives of our respective firms, proudly submit this final Facility Plan for your consideration.

Respectfully Submitted,

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20-YEAR COMPREHENSIVE FACILITY PLAN – PLAN OVERVIEW

PURPOSE

In January 2014, the Louisville and Jefferson County Metropolitan Sewer District (MSD) Board adopted a new Strategic Business Plan that defined a change agenda for MSD. The intent of the Strategic Business Plan is to dramatically improve customer care and service; make appropriate investments in technology, infrastructure, and employees; and improve the quality of life in Louisville and Jefferson County, while maintaining the financial viability of the utility. A key part of MSD's plan to implement the Strategic Business Plan is to develop this 20-Year Comprehensive Facility Plan—Critical Repair and Reinvestment Plan (Facility Plan). The purpose of this Facility Plan is to accomplish the following:

- Consolidate MSD's planning and prioritization for facility rehabilitation, renewal, replacement, upgrade, and expansion across all its service areas.
- Recommend and prioritize projects and programs to achieve the following objectives:
  - Protect the public health and safety of the community.
  - Protect our aquatic and terrestrial environment.
  - Meet customer expectations for a consistent level of service.
  - Comply with all federal and state laws, regulations, orders, and standards.

This Plan Overview presents a high-level summary of the Facility Plan and discusses the compelling need for implementing the recommendations presented herein.

BACKGROUND

From 1985 to 2003, MSD spent close to $1 billion on improvements to the wastewater collection and treatment system to address high-priority public health and safety issues. During this same period, a $134 million program for managing intermittent wet-weather sewer overflows was also underway to study the system behavior and subsequently design and construct several important sewer overflow abatement facilities. However, the investment made to tackle sewer overflows was not deemed sufficient to meet water quality goals within timeframes established by federal and state regulators, and in 2003, MSD received a request for information from the U.S. Environmental Protection Agency (EPA) in accordance with Section 308 of the Clean Water Act. This request for information was the first step in a process that eventually led to a notice of alleged Clean Water Act violations from EPA and the Kentucky Department for Environmental Protection (KDEP); this notice resulted in a negotiated settlement between these parties most commonly referred to as the Consent Decree.[1] One requirement of the

[1] The Commonwealth of Kentucky, Plaintiff, and the United States of American, Plaintiff-Intervener, v. Louisville and Jefferson County Metropolitan Sewer District, Defendant, in the United States District Court, Western District of Kentucky, Louisville Division. Amended Consent Decree, Case 3-08-cv-00608-CRS. Filed April 15, 2009. Available at http://www.msdprojectwin.org/Portals/0/Library/Consent%20Decree/Agreement/ Commonwealth%20of%20KY%20vs%20MSD%20%20Amended%20Consent%20Decree.pdf.

Consent Decree was for MSD to develop overflow abatement plans to address combined sewer overflows (CSOs), separate sewer overflows (SSOs), and unauthorized discharges. In response to this requirement, MSD consolidated the required overflow abatement plans into the Integrated Overflow Abatement Plan (IOAP), a long-term plan to control CSOs and eliminate SSOs and other unauthorized discharges in MSD's sewer system. Submitted December 2008 and approved by regulatory agencies in August, 2009, the IOAP identified $850 million in capital improvements, associated incremental operating costs, and a high-level financial plan that included cash-flow projections, projected borrowing schedules, and projected rate increases through the year 2024.

With the filing of the enforcement action, sewer overflows became the top priority, and MSD shifted resources and investments agency-wide to tackle this massive federally mandated undertaking. Spending in areas other than sewer overflow control was focused on the day-to-day operation and upkeep of wastewater, stormwater, and flood protection facilities. Major investments in infrastructure rehabilitation, renewal, and replacement were limited by a desire to keep rates at or below industry averages, even as capital and operating spending ramped up to meet the Consent Decree requirements. This shift was especially significant given that portions of the stormwater and flood protection system were already in decline due to exceeding their expected design life prior to MSD assuming responsibility for these facilities in 1987; and the initial funding source that had been established to address this deferred renewal and replacement was insufficient to address all the improvement needs identified.

The result of this deferred investment over the past 10 to 15 years is that Louisville's aging system of pipes, pumps, treatment plants, and flood gates are now in urgent need of rehabilitation so they can continue to reliably protect public health and community safety. While iconic landmarks and prominent structures garner more attention, Louisville is also home to a less visible system of facilities that serve a higher calling behind the scenes every day—facilities that keep Ohio River floodwaters at bay, prevent harmful bacteria from entering homes and local waterways through sewer overflows, and reduce the likelihood of disease outbreaks such as Zika virus spawned by poor drainage. When pipes fail and structures in the system collapse into sinkholes, and when inland flooding blocks roadways, access to emergency services and critical care is denied. A properly functioning sanitary sewer, stormwater, and drainage system is needed to support the community's economic engine, protect jobs, and sustain the local tax base.

Neglecting this essential system is no longer an option—serious failures are occurring at an increasingly rapid pace. The ability to successfully apply temporary repairs rather than permanent fixes diminishes significantly with each passing day. Rainfall totals that once could be managed by the system now overwhelm it. This risk is heightened by the increased frequency of extreme storm events. The back-to-back storm events experienced in 2015 flooded homes, leaving families without shelter. Cars were washed away, streets were impassable, schools and businesses shut down, and public safety was threatened in proportions not seen in decades. Citizens demanded that measures be taken to prevent similar occurrences from happening again.

Despite the public call to action, MSD recognized that there would likely be concern about the costs to complete the Consent Decree IOAP projects and meet the public expectation of improved levels of service provided by the wastewater and stormwater services. To help identify appropriate levels of investment and priorities, MSD developed this 20-year Comprehensive Facility Plan that consolidates

MSD's planning for facility rehabilitation, renewal, replacement, upgrade, and expansion across all its service areas. Projects listed in the Facility Plan were determined by the Facility Plan Team to address critical needs requiring correction over the next 20 years to protect the community health and safety, provide environmental protection, meet customer expectations for level of service, and move closer to the goal of our local waterways achieving federal and state water quality standards. This Facility Plan will also consider the long-term operating needs to accommodate operation and maintenance (O&M) of new facilities coming on line under the IOAP and other critical infrastructure investments.

Maintaining consistency in levels of service and protecting ratepayers across the entire Louisville community are also key objectives of this Facility Plan. The aim is to provide protection from drainage problems to a consistent 10-percent probability storm (also commonly referred to as a 10-year storm). Currently, the most recently constructed areas in the community are designed to protect against drainage problems due to the 10-percent probability storm as defined by MSD's current Design Manual (a 4.5-inch rainstorm occurring in 24 hours; MSD, 2015). Many older neighborhoods in the service area, constructed before MSD assumed responsibility for stormwater management, begin to experience localized drainage problems in a 3-inch rainstorm occurring in 24 hours. The implication is that MSD's current level of protection is not consistent across the service area.

Based on the analyses of this 20-Year Comprehensive Facility Plan, meeting the critical needs of the community is estimated to cost $4.3 billion over the next two decades. The reality is that the original Consent Decree resulted in large part from a similar pattern of deferred rehabilitation and reinvestment in critical wastewater infrastructure. The Facility Plan Team believes the community should not risk burdening our children and grandchildren with future federal mandates because of an unwillingness to dedicate adequate resources to the challenges of today.

MSD strongly believes that the Louisville community deserves to be informed on matters of public health and safety, and likewise, should have a voice in the conversation about the timing of necessary infrastructure investments. MSD committed to facilitating discussions with customers, business leaders, elected officials, and others. With this overall goal, after the draft report was submitted in December 2016, MSD undertook the wide-reaching "Community Conversation" initiative described in Volume 1 Section 2, aimed at bringing many perspectives to a constructive dialogue. This dialogue did not center around *if* the risks to the public health and safety of families and business owners will be addressed, but rather *how soon should the work begin*.

Community input confirms that Louisville supports restoring its vital wastewater, flood protection, and stormwater management facilities. Responses from those who engaged in the community conversation are as follows:

- Ninety percent of the respondents understand and agree with the need for investing in the community's wastewater, stormwater and flood protection systems to reduce risks to public health and safety rather than continuing to defer critical repairs and reinvestment.
- Eight-nine percent of the respondents believe it is important to begin addressing the public health and safety risks as quickly as possible.
- Seventy-one percent of the respondents support an increase in residential rates of up to $10 per month (with a proportional increase in industrial and commercial rates), to immediately begin to

fund critical wastewater, stormwater, and flood protection needs to address public health and safety risks.

- Seventy eight percent of the respondents support expanding MSD's Rate Relief Program, to assist customers who meet federal criteria established for other utility rate assistance programs.

This input echoes the priorities identified by local citizens at the 100 Resilient Cities Workshop hosted by Louisville Metro in early 2017, including the risks of severe or catastrophic weather, infrastructure vulnerability, and aging infrastructure.

SCOPE OF PLAN

As noted previously, the following are the purposes of this Facility Plan:

- Consolidate MSD's planning and prioritization for facility rehabilitation, renewal, replacement, upgrade, and expansion across all its service areas.
- Recommend and prioritize projects and programs to achieve the following objectives:
  - Protect the public health and safety of the community.
  - Protect our aquatic and terrestrial environment.
  - Meet customer expectations for a consistent level of service.
  - Comply with all federal and state laws, regulations, orders and standards.

This Facility Plan has identified overall financial needs for future facility rehabilitation, renewal, replacement, upgrade, and expansion. The projects are those recommended by the Facility Plan Team as needed to achieve MSD's mission, vision, and goals. All projects have been assigned recommended schedule dates and durations based on the Facility Plan Team's assessment of their relative priority and needs. The project schedules will be further refined by MSD staff as part of the annual budgeting process. In addition, this Facility Plan, like all long-term plans, should be revisited on a recommended 5-year cycle to make adjustments as changing conditions develop.

For projects directly affected by precipitation events, the Facility Plan includes projected rainfall intensity, duration, and frequency (IDF) curves for year 2035. These projections consider both statistical trends going back 60 years, along with state-of-the art global circulation models that project future precipitation conditions. These models reflect the observed increased frequency of extreme storm events that we have experienced, presumably related to the impacts of global climate change.

This Facility Plan recommends that MSD's current design criteria for facilities (based on published storm recurrence intervals) will apply to new facilities planned as appropriate, with revised precipitation projections applied to the recurrence intervals in the criteria. For example, stormwater culverts under secondary roadways will continue to be designed to the 10-percent probability storm (commonly known as the 10-year storm), but the 24-hour rainfall value used in the calculations reflects precipitation projections for the end of the 20-year planning period (2035). The Facility Plan recommends that MSD's design standards be modified to incorporate the projected 2035 precipitation projections in the requirements for new construction. For example, the 10-percent probability storm projected for 2035 is

5.2 inches of rain occurring in 24 hours, as compared with the current MSD Design Manual value (2015) of 4.5 inches of rain occurring in 24 hours.

This Facility Plan considers the operating costs, including staff increases, to accommodate O&M of new facilities coming online under the IOAP and this Facility Plan. In addition, shortfalls in current O&M budgets and staffing levels for facility maintenance have been evaluated, and a program to adjust both budgets and staffing over time has been recommended. The recommended budgets and staffing levels are intended to allow predictive and preventive maintenance to occur in accordance with current industry best practices for asset management.

A key part of the Facility Plan is a recommended 20-year capital improvement program (CIP). Projects in the recommended 20-year CIP were determined by the Facility Plan Team to address critical needs requiring correction over the next 20 years. Another key objective of the Facility Plan is consistent service for ratepayers across the entire Louisville community. The aim is to provide wastewater, drainage, and flood protection services to a 10-percent probability storm (10-year storm) for all customers within the MSD service area by the end of the 20-year planning period.

PROJECT DEVELOPMENT

The Facility Plan Team identified projects through a number of pathways. MSD's current CIP contains more than 100 projects related to wastewater systems. If these projects were already in design or construction, then these existing projects were included in the recommended 20-year CIP without change. If the projects were not in design or construction, then project needs were identified, project justification reviewed, and costs verified. These projects were then subject to prioritization along with all the other projects.

The IOAP has a number of very large projects still to construct. These projects are required to be completed on the schedule presented in the approved IOAP. No changes were made to the IOAP projects or their schedules.

MSD has a number of existing planning studies related to wastewater that have not been fully implemented, primarily because of funding limitations. The Facility Plan Team evaluated existing studies and found a number of worthwhile projects that have not been included in the CIP yet. These projects were evaluated and are included in the project mix for prioritization.

Finally, the Facility Plan Team looked for gaps in previous planning. This included reviewing population projections, assessing regulatory changes that might occur during the 20-year planning period, and conducting a facility condition assessment that included staff interviews, visual inspections, and in some cases diagnostic measurements. The projects resulting from regulatory changes will be mandatory to complete in the timeframe dictated by the adoption of new regulations. The anticipated timeframes for new regulations and new regulatory enforcement priorities have been identified by the Facility Plan Team, understanding that regulatory issues are not totally predictable and not within MSD's complete control. The facility condition assessment identified a number of projects that were critically needed to correct the past under-investment in asset renewal and replacement. A review of maintenance trends confirmed that the number of infrastructure failures (for example, sewer collapse, pump station capacity shortfalls) is directly related to the asset's age. This implies a system-wide deficiency in effective preventive maintenance, which impacts both the reliability and the overall cost of ownership of those assets.

PROJECT EVALUATION AND PRIORITIZATION

Project evaluation and prioritization requires a rigorous and transparent approach. The approach used to develop the IOAP was very successful in this regard and, to the extent possible, was replicated in developing this Facility Plan.

Given the variety of ways that projects were identified and developed, capital and operating cost-estimating used a variety of sources. The IOAP Cost Tool was used to develop project costs where applicable (new projects with standard components like sewers and pump stations). Where the standard cost tool could not be applied, the team used industry-standard cost references such as RS Means. When similar MSD projects were available, the estimating was conducted using unit prices from those projects.

Prioritizing projects followed the values-based benefit/cost evaluation used successfully in the development of the IOAP. The Wet Weather Team (WWT) Stakeholder Group was rechartered to continue to assist with IOAP implementation and also to serve a role in helping guide Facility Plan development. Many original members chose to continue serving on this team. Recognizing the broader scope of the Facility Plan, a number of new members representing different interest groups and demographics were added to the WWT Stakeholder Group.

A values-based benefit/cost evaluation assisted with developing scoring scales to grade projects on their effectiveness at protecting the community in the following values:

- Environmental Protection
- Public Health Protection
- Regulatory Compliance
- Sustainability
- Property Protection
- Economic Vitality

The values-based benefit scores were coupled with life-cycle cost information to develop a benefit/cost score used for the first round of project prioritization. This approach was then supplemented with an evaluation of the effectiveness of the project in mitigating risk. Risk mitigation effectiveness was valuated based on the change in either the probability of an event happening or the consequence of that event occurring. As Figure 1 indicates, the combination of a high probability and a serious consequence result in a risk that is considered to be “critical.” The anticipated change in risk resulting from implementing a project resulted in a risk reduction factor that was used in conjunction with the benefit/cost score to prioritize projects.

Consequence						
	5	Critical	Critical	Critical	High	Medium
	4	Critical	Critical	High	Medium	Low
	3	Critical	High	Medium	Low	Low
	2	High	Medium	Low	Low	Very Low
	1	Medium	Low	Low	Very Low	Very Low
		5	4	3	2	1
		Probability				

Figure 1. Risk Evaluation Matrix

RECOMMENDED 20-YEAR CAPITAL IMPROVEMENT PROGRAM

Table 1 summarizes the recommended 20-year CIP, broken down by service area and major program. Note that the values in the table have been escalated at 3 percent per year compounded to the projected mid-point of construction.

Table 1. Recommended 20-Year Capital Improvement Plan Summary

Service Area and Program	Capital Cost (in escalated dollars, millions)				Total FY17 through FY36
	FY17 through FY21	FY22 through FY26	FY27 through FY31	FY32 through FY36	
Wastewater	**$848.0**	**$392.3**	**$353.7**	**$262.6**	**$1,856.5**
Consent Decree (IOAP)	$564.6	$26.5	$0.4	$.0	$591.5
NMC	$116.2	$33.2	$35.1	$40.0	$224.5
CMOM	$144.2	$275.7	$184.4	$201.1	$805.4
Development	$23.0	$56.9	$133.8	$21.5	$235.2
Stormwater	**$348.8**	**$623.7**	**$636.2**	**$734.7**	**$2,343.4**
Drainage	$189.8	$403.0	$394.0	$529.7	$1,516.5
Floodplain Management	$19.8	$25.4	$29.4	$34.1	$108.6
Ohio River Flood Protection	$128.1	$175.6	$191.2	$145.9	$640.9
Stormwater Quality (MS4)	$11.2	$19.8	$21.5	$25.0	$77.5
Support Systems	**$43.5**	**$28.7**	**$24.9**	**$27.4**	**$124.5**
Capital Equipment	$11.3	$14.7	$16.7	$19.0	$61.8
Facilities	$27.7	$8.3	$3.2	$2.7	$41.9
IT	$3.1	$3.8	$3.1	$3.6	$13.6
LOJIC	$1.4	$1.9	$1.8	$2.1	$7.3
Total Escalated Costs	**$1,240.4**	**$1,044.7**	**$1,014.7**	**$1,024.7**	**$4,324.5**

FY fiscal year
IOAP Integrated Overflow Abatement Plan
IT information technology
LOJIC Louisville and Jefferson County Information Consortium
MS4 Municipal Separate Storm Sewer System

Table 2 summarizes the first 5 years of the recommended 20-year CIP, broken down by year, service area and major program. Note that the values in the table have been escalated at 3 percent per year compounded to the projected midpoint of construction. MSD's Fiscal Year (FY) 2017 approved CIP did not fully fund the Facility Plan recommendations for that fiscal year due to revenue limitations caused by a cap on the rate increases that the MSD Board can approve without receiving approval from Louisville Metro Council. MSD staff prioritized CIP spending based on the funding available, resulting from the FY2017 CIP budget that was approved by the MSD Board. The net effect is that the projects not funded in accordance with the Facility Plan recommendations will need to be reconsidered at a later date, and when sufficient funding becomes available.

Table 2. Recommended 5-Year CIP Summary

	Capital Cost (in escalated dollars, millions)					
Service Area and Program	**FY2017**	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**Total FY2017 through FY2021**
Wastewater	**$150.8**	**$188.1**	**$210.0**	**$161.1**	**$138.0**	**$848.0**
Consent Decree (IOAP)	$109.9	$139.5	$154.4	$89.7	$71.1	$564.6
NMC	$19.7	$21.3	$25.9	$26.7	$22.6	$116.2
CMOM	$18.6	$25.1	$24.1	$35.7	$40.7	$144.2
Development	$2.6	$2.2	$5.6	$9.0	$3.6	$23.0
Stormwater	**$19.1**	**$40.8**	**$63.7**	**$93.0**	**$132.3**	**$348.8**
Drainage	$4.2	$16.2	$31.8	$59.7	$77.9	$189.8
Floodplain Management	$1.6	$4.6	$4.4	$4.5	$4.6	$19.8
Ohio River Flood Protection	$11.4	$18.3	$25.6	$26.8	$46.0	$128.1
Stormwater Quality (MS4)	$1.9	$1.7	$1.9	$1.9	$3.7	$11.2
Support Systems	**$12.5**	**$5.5**	**$7.0**	**$7.4**	**$11.2**	**$43.5**
Capital Equipment	$.6	$1.4	$1.9	$2.4	$5.0	$11.3
Facilities	$10.2	$3.1	$4.7	$4.2	$5.7	$27.7
IT	$1.6	$.7	$.3	$.3	$.3	$3.1
LOJIC	$.1	$.4	$.1	$.5	$.3	$1.4
Total Escalated Costs	**$182.4**	**$234.5**	**$280.7**	**$261.4**	**$281.5**	**$1,240.4**

SIGNIFICANT SERVICE AREA PROJECTS AND PROGRAMS

The following sections will address each of the MSD service areas, along with support services, describing specific assumptions that drove project development.

WASTEWATER COLLECTION AND TREATMENT

For the past 10 years much of MSD's focus has been ensuring compliance with the Consent Decree requirements. Due to limited resources and a desire to maintain sewer and drainage rates at or below the national average, developing and implementing the IOAP has taken the focus off infrastructure renewal and repair for facilities not related to sewer overflow control. In addition, the weak economy from 2008 to 2012 also reduced the pressure to provide new wastewater service to developing areas. While IOAP implementation is only half finished, the consequences of deferred rehabilitation and reinvestment are beginning to show in increased numbers of sewer collapses, including multiple problems with the Broadway Interceptor and its connecting lines. With the local economy strengthening, MSD is seeing much more interest from the development community to provide sewer service to growth areas across the county. This Facility Plan addresses all these issues, as described in the following sections.

CONSENT DECREE AND INTEGRATED OVERFLOW ABATEMENT PLAN

The IOAP is a major part of MSD's Consent Decree compliance program. The IOAP is a long-term plan to control CSOs and eliminate SSOs and other unauthorized discharges from MSD's sewerage system. The IOAP is expected to improve water quality in both Beargrass Creek and the Ohio River through and downstream of Jefferson County. The expected water quality benefits of the IOAP include reductions in the peak levels of bacteria in the Ohio River and Beargrass Creek and in the amount of time that average bacteria levels exceed water quality standards. In addition, the IOAP program will enhance public health and safety by reducing the potential for the public to come in contact with untreated SSOs, in the basements of their homes or in the streets and ground surfaces where SSOs currently discharge.

Long-Term Control Plan Benefits

The suite of projects selected for the Final CSO Long-Term Control Plan (LTCP) part of the IOAP will result in approximately 98 percent capture and treatment of wet-weather combined sewage during an average year. This benefit represents an 89 percent reduction in CSO volume compared with conditions in 2008. As a point of reference, the presumptive approach for compliance with water quality standards in EPA's CSO Control Policy (EPA, 1994) is based on a minimum of 85 percent capture and treatment of wet-weather combined sewage.

Sanitary Sewer Discharge Plan Benefits

The suite of projects selected for the Final Sanitary Sewer Discharge Plan (SSDP) part of the IOAP will eliminate capacity-related SSOs up to the site-specific level of protection. The SSO projects are anticipated to eliminate an average of 145 SSO events per year (290 million gallons [MG] of overflow volume), based on 2005 to 2007 data normalized for rainfall. In terms of water quality, SSO projects will eliminate 100 tons of 5-day biochemical oxygen demand (BOD_5) and approximately 200 tons of total suspended solids (TSS) annually.

Sustainable Performance

MSD's IOAP is based on a "demonstration approach" to achieving compliance with the Consent Decree and the Clean Water Act requirements. While MSD is required to certify compliance with the CSO management requirements after completing the full suite of CSO projects in 2020, MSD's CSO management performance will continue to be monitored through the Morris Forman Water Quality Treatment Center (WQTC) Kentucky Pollutant Discharge Elimination System (KPDES) permit with performance standards consistent with the commitments of the IOAP. Similarly, the SSO elimination projects are required to be completed by the end of 2024. MSD's certification that the performance objectives have been met will mean that MSD's obligations under the Consent Decree have been discharged, but the requirements for continued operation of collection and treatment facilities in the system to avoid further SSOs will continue through the KPDES permits. The Consent Decree requirements do not go away with the completion of the IOAP projects—the enforcement mechanism for sewer overflow and control changes from the Consent Decree to the respective KPDES permits.

Integrated Overflow Abatement Plan Impacts on the Recommended Capital Improvement Program

Over the first 5 to 9 years of the planning period, the wastewater service area CIP is dominated by completing the remaining major IOAP projects. The major CSO storage basins are all scheduled to be completed by the end of FY2021, with the remainder of the SSO elimination projects scheduled to be completed by the end of FY2025. Completing the entire suite of CSO and SSO projects in accordance with the IOAP schedule is required by the Consent Decree. Any failure to complete a project on schedule could be considered a violation of the Consent Decree, with consequences including stipulated penalties that could total more than $1 million for a 1-year delay in completion.

The next section of the Plan Overview addresses the balance of the CIP. These projects address needs in wastewater, stormwater, flood protection and asset management infrastructure that have been deferred for the past 10 to 15 years as MSD's limited resources were focused on meeting Consent Decree requirements.

NINE MINIMUM CONTROLS

The EPA Nine Minimum Controls (NMC) were initially developed as part of the Clean Water Act CSO Policy to address combined sewer system (CSS) best management practices (BMPs) that do not require significant construction. In a continued focus on protection of public health and safety, the BMPs required by the NMCs will be integrated into MSD's KPDES permits to ensure protection of public health, safety, and the environment. Maximizing storage in the conveyance system, maintaining WQTC capacity, and ensuring effective public notification of sewer overflows are examples of the BMPs that will remain in place in perpetuity as conditions of the Morris Forman WQTC KPDES permit.

The recommended 20-year CIP includes funding for the formal NMC program that is reported quarterly as part of the Consent Decree requirements. Capital projects that help to sustain the intent of the NMC requirements are included in the preliminary CIP through the end of the planning period.

The most significant long-term NMC activities are the real-time control (RTC) system in the CSS and the Morris Forman WQTC improvements, which are also a major component of the IOAP. The 20-year CIP recommendation provides annual funding for ongoing RTC rehabilitation and renewal to ensure proper RTC system operation system. By using the storage capacity of MSD's large-diameter CSS, MSD can cost-effectively mitigate sewer overflows during smaller storms of concern in CSO control. The cost of providing storage in the pipes is typically a small fraction of the cost to provide that same storage in a stand-alone tank. The long-term operation of an effective RTC system is one of the cornerstones of the IOAP, which is necessary for long-term sustained compliance with the Clean Water Act CSO Policy, CSO Long-Term Control Plan, and NMC requirements.

Sustaining reliable treatment capability and capacity at the Morris Forman WQTC is critical to ensure proper wastewater treatment for Ohio River water quality protection. This treatment is a significant endeavor that has been underfunded since the most recent overall plant rehabilitation was completed in the early 2000s. A detailed facility condition assessment has been prepared for the Morris Forman WQTC liquid process treatment facilities. Periodic equipment replacements and major plant renovations are scheduled in 5-year intervals for financial planning. Overall, the proposed 20-year CIP recommendations include almost $200 million in rehabilitation and renewal projects over the planning period. To protect public health, these rehabilitation and renewal projects are essential to maintaining reliable operation of the largest WQTC in MSD's system. Unfortunately, the 2015 failure of the Morris Forman WQTC high-voltage electrical distribution center provided a catastrophic view of the consequences of deferring facility renewal and replacement. As power was lost to the main electrical system for the WQTC, inadequate backup power resulted in flooding and extensive damage to the facility. Wastewater was discharged that had not been treated to the State of Kentucky's KPDES discharge standards, creating a potential public health risk to the community. Ironically, the capital project to provide backup power supply for the WQTC had been deferred and, therefore, was not in place to avoid the costly damage to the facility.

This Facility Plan assumes there will be no major changes in the Morris Forman WQTC discharge requirements during the planning period, and therefore, the existing plant will continue to operate as-is for the duration of the planning period, except for initial construction of facilities required for nutrient removal late in the planning period, described herein.

For many years, MSD has produced a high-quality soil conditioner called Louisville Green from the biosolids generated by the WQTC. The condition of the Louisville Green production equipment (primarily the biosolids dryers and pellet processing equipment) is rapidly degrading due to the severe duty conditions experienced in processing the highly abrasive dried biosolids product. MSD has, in the past, been able to sell all Louisville Green it could produce, thereby offsetting system operating costs. The current degraded condition of the equipment requires MSD to landfill dewatered biosolids when the drying system capacity is overwhelmed. MSD, under a separate initiative, is investigating short-term biosolids management solutions that may include increasing the amount of dewatered biosolids disposed of by landfill (by negotiating better prices in return for the commitment of guaranteed minimum amounts of dewatered biosolids being sent to the landfill), turning over management of the dewatered biosolids to a third-party vendor and/or replacing the drying system with an alternate technology approach. Recognizing that implementing a new biosolids management approach may take several years to implement, the recommended 20-year CIP includes short-term fixes for the dryer system, as well as expansion of the dewatered cake-handling system to allow increased landfilling as continued operation of the dryers becomes impractical. Other approaches to biosolids handling are currently under consideration, because a short-term solution may include designing and constructing a biosolids handling system by a third-party vendor, similar to how the high-purity oxygen generation system is currently being procured. If this procurement model is followed, then MSD will not directly incur capital cost, and the project will have more impact on the annual operating budget than the CIP.

A 50-year look at continued operations of the Morris Forman WQTC at the current site has concluded that there will not be any major changes in discharge standards, including adding nutrient removal or considering microconstituents such as residual antibiotics, hormones, or other pharmaceuticals and residual personal care products, within the current 20-year planning horizon. If major discharge standards changes occur, then they will likely require changes to both the liquid treatment and biosolids-handling approaches. Given the severe constraints of the existing site, locating new facilities on property not part of the current Morris Forman WQTC site will be necessary. The long-term plan has been developed, and a phasing roadmap for systematic facilities expansion is included. Some level of nutrient removal may be required toward the end of the 20-year planning period. The proposed 20-year CIP recommendation includes funds for purchasing land and starting facility construction to address nutrient removal during years 15 to 20 of the planning period. Treatment for microconstituents is not envisioned in the recommended 20-year CIP, but it will represent a significant capital expense when required by new regulations. If and when the discharge requirements change to include advanced nutrient removal and increased removal of BOD_5 and TSS from wet-weather flow, then the costs to expand and upgrade the Morris Forman WQTC could exceed $1.2 billion (2016 dollars).

CAPACITY, MANAGEMENT, OPERATIONS, AND MAINTENANCE

The next largest program within the wastewater service area is the Capacity, Management, Operations, and Maintenance (CMOM) program. EPA Region 4 developed the initial program that became CMOM, and MSD's Consent Decree specifically requires developing and implementing a CMOM program. The intent of the CMOM program is to ensure that BMPs are implemented across all aspects of the utility, thereby increasing the ability of the utility to meet its obligations under the Clean Water Act. CMOM activities represent BMPs for wastewater utilities and will be sustained for the entire 20-year planning period.

Major components of the CMOM program include projects for major renewal and replacement projects at the Hite Creek, Floyds Fork, Cedar Creek, and Derek R. Guthrie WQTCs. These renewal and replacement projects are scheduled at 5-year intervals for each center to ensure that MSD can maintain efficient and effective wastewater treatment, a critical aspect of public health protection. The budget established for each center is the result of an asset inventory and facility condition assessment of each WQTC. The actual scope of each project will be established during detailed design.

The CMOM program provides proactive asset management of pipes and pump stations that make up most of MSD's collection system. Clearwater intrusion of surface water and groundwater during rain events overloads the conveyance and treatment systems. This clearwater intrusion, referred to as infiltration and inflow (I/I), is a main cause of sewer overflows. Budgets are recommended to provide inventory of critical parts for pump stations, rehabilitate and replace sewers that are leaking or in danger of structural failure, and provide stand-by generators in more locations to improve reliability during power outages. Studies suggest that approximately 50 percent of the I/I entering MSD's sewer system during a rain event may be coming from private property sources outside of MSD's direct control. To achieve and sustain the required overflow abatement levels, a substantial portion of this I/I must be removed from the system. A project with "seed money" to initiate a private property I/I reduction program is also recommended in the CMOM budget. The private property I/I program is expected to become self-sustaining through new fees after initial start-up.

A significant addition to the CMOM program is the recommended expansion of the sewer rehabilitation and replacement activities to encompass major interceptors. In the past, MSD deferred major rehabilitation of these major interceptors due to the cost and difficulty in completing construction on these pipes. An increasing frequency of major interceptor failures indicates a critical need to proactively inspect and rehabilitate or replace these high-risk very old assets. When a major interceptor fails, a ripple effect is created across a much broader area due to road closures, traffic impacts, and other factors that directly impact the community. Since major interceptor rehabilitation projects have not been specifically identified at this time, an allowance has been recommended to begin the process of inspection, project development and early-action remediation of high-risk defects over the next five years. By the end of five years, the recommended allowance is increased to $10 million per year, totally focused on major interceptor rehabilitation and replacement. At this sustained funding level, MSD will be able to renew these critical assets on a prioritized basis. Preemptive rehabilitation is much less expensive than making emergency repairs, such as those MSD had to complete in response to a collapsed section of the Broadway Interceptor in 2015. This one repair interrupted businesses, severely impacted traffic flow on a main arterial roadway, and impeded access to a nearby hospital.

DEVELOPMENT

To assist in providing the proper level of sewer service for growing areas, the recommended 20-year CIP budget also includes treatment capacity expansions for the Hite Creek, Floyds Fork, and Cedar Creek WQTCs. The timing of these expansion projects has been based on population projections for each service area. Ensuring that capacity is available in advance of development supports growth and development for the community by avoiding moratoriums due to the rated capacity of the WQTCs being exceeded. This expansion is in accordance with KDEP regulations. The Derek R. Guthrie and Morris Forman WQTCs are not anticipated to need a growth-related capacity expansion within the 20-year planning period, however, they will require investment to continue operating properly.

In addition to WQTC capacity, the recommended 20-year CIP also addresses conveyance system capacity needs. Projects are recommended to address areas anticipated to have significant growth in the Floyds Fork WQTC and Cedar Creek WQTC service areas due in part to the development of the Parklands of Floyds Fork. Growth is also provided for in the Hite Creek WQTC and Derek R. Guthrie WQTC service areas. The Morris Forman WQTC service area is essentially built out, meaning growth will result from customers coming online through infill of existing developed areas. In addition to expansion of the sewer system, capacity issues with pump stations have also been identified and addressed. Several pump stations have been identified that do not have adequate capacity to meet projected peak flows due to future growth. To avoid creating new SSOs, these pump stations must be expanded in advance of the upstream collection system expansions that will bring them additional flow. The intent is to provide the needed reliable capacity in both the gravity and pumped portions of the collection system so that new connection moratoriums can be avoided.

REGULATIONS

The recommended CIP budget also includes future projects in anticipation of regulatory changes. Increased levels of treatment for nutrients (nitrogen and phosphorus) could be imposed before the end of the planning period, which would seriously impact MSD's WQTCs. Projects to begin addressing nutrient removal requirements at all WQTCs are included in the latter years of the planning period. The timing of nutrient removal regulations will govern when these projects are actually implemented.

Microconstituent removal has also been identified as a potential future regulatory requirement. While the imposition of standards requiring microconstituents removal is not anticipated with the 20-year planning window, preliminary concepts have been developed and placeholder budgets recommended to address this potential future need. These placeholder budgets are not in the recommended 20-year CIP. The timing of microconstituent removal regulations will govern when these projects are actually implemented.

STORMWATER MANAGEMENT

Stormwater management is a vital component of MSD's system, because it directly impacts the health and safety of all Louisville and Jefferson County residents. The recommended 20-year CIP includes a number of programs related to drainage and internal floodplain management. In 1987, MSD took over stormwater management and Ohio River flood protection through a Memorandum of Agreement with the City of Louisville (pre-merger with Jefferson County), and most of the small cities within Jefferson County. In 1988, MSD completed a *Stormwater Drainage Master Plan* (URS Corporation et al., 1988) that addressed the backlog of known drainage and flooding problems and planned for improvements in overall drainage and flood protection for the service area. MSD began implementing the recommendations of the *Stormwater Drainage Master Plan* on a prioritized basis, within the budget limitations imposed by the insufficient revenue generated through drainage fees. The flood of 1997 diverted the focus of stormwater management to deal with specific vulnerabilities exposed by that severe flooding event.

PROJECT DRAINAGE RESPONSE INITIATIVE

Drainage problems create health and safety impacts for citizens directly at their homes, schools, businesses, and transportation routes. Beginning in 2003, MSD initiated an aggressive program to address a wide variety of drainage issues that were pointed out by customers. This Drainage Response Initiative program, dubbed Project DRI, assigned experienced project managers, contractors, and inspectors to address drainage problems on a "grade-to-drain" basis. Efforts under this program address problems ranging from structural flooding to alleviating minor standing water problems. Since 2003, most funds available through drainage fees have been allocated to Project DRI, with more than $125 million in capital drainage improvements completed through this program. While MSD originally thought that Project DRI would be phased out as the backlog of customer drainage issues were resolved, customer drainage requests continue to be among the most common communication received by MSD's Customer Relations Department. These requests are likely due to drainage impacts of land use changes, the increase in the amount of impervious surfaces across Jefferson County, the increased frequency of extreme storm events, and the degradation of drainage facilities due to aging. MSD's experience has proven that having the ability to respond quickly to individual property owner's drainage concerns is a vital part of providing quality service and building customer satisfaction. Project DRI has proven to be a very valuable program for MSD's customers, and the recommended 20-year CIP includes an annual allocation of $2.8 million to $5 million per year to sustain it.

STORMWATER DRAINAGE MASTER PLAN

Given the public concern over the effects of the increased frequency of extreme storm events, the localized drainage solutions offered by Project DRI need to be supplemented with a program to address issues of stormwater management and flood protection on a countywide or watershed basis. To increase the public health and safety protection and provide a consistent level of protection for the entire service area, a significant increase in spending for drainage and flood protection is required.

Subsequent to the 1988 *Stormwater Drainage Master Plan,* the primary countywide stormwater planning completed by MSD has related to internal (that is, not related to the Ohio River) floodplain management. MSD and the Kentucky Division of Water have completed studies in most watersheds to update the Federal Emergency Management Agency (FEMA) Special Flood Hazard Areas and Local Regulatory Floodplains. These studies rely on rainfall IDF information that reflect historical observations. The Facility Plan Team has projected IDF information out to 2035 for long-range planning. Because the conditions projected for 2035 are not based on observed data, the updated floodplain information should not be used for regulatory purposes, but it can be used to inform potential property owners of the risks associated with potential future extreme storm events.

While MSD requires plans for new development to document no adverse impacts on downstream flooding, the cumulative effects of land use changes within the existing developed areas prior to MSD assuming responsibility for stormwater management may not have been subject to the same level of scrutiny. While the hydrologic and hydraulic models used for drainage planning have been updated to reflect recent land use changes, most have not been analyzed comprehensively for drainage issues outside of the Special Flood Hazard Areas or Local Floodplains to allow potential downstream impacts of new projects to be identified.

An update to the comprehensive countywide stormwater master plan is recommended to be initiated as one of the first recommendations from the stormwater portion of this Facility Plan. While current development standards require mitigating drainage impacts of land use changes, analysis of historical trends shows a significant reduction in natural green space and an increase in impervious surfaces within Jefferson County. In addition to addressing the potential impact of the increased frequency of extreme storms, the master plan should also consider a strategy to restore some of these surfaces to natural pervious conditions, which can have a significant impact on the amount of infrastructure that will be needed to address future needs. This plan should address floodplain management definition and non-floodplain related drainage problems in an integrated approach to deal with this highly visible MSD service.

EARLY ACTION PROJECTS

While the comprehensive stormwater master plan is being updated, MSD's customers expect immediate action to begin addressing stormwater issues. MSD and the Facility Plan Team have identified several areas across Jefferson County with a history of drainage problems primarily related to localized drainage, not directly related to floodplain management issues.

PROPOSED COMPREHENSIVE STORMWATER MASTER PLAN IMPLEMENTATION

Allowances have been established in the recommended 20-year CIP to provide for implementing the proposed stormwater master plan. The recommended budgeted amounts were identified through extrapolation of the Early Action Plan projects described previously to the entire county. The intent is to provide the entire county with updated and expanded stormwater management facilities to consistently meet the level of protection of a 10-year storm, using stormwater IDF targets projected for the end of the planning period. Based on an extrapolation of project costs developed for the Early Action Plan projects, the funding required for these projects is anticipated to exceed $600 million over the 20-year planning period. The Facility Plan Team deemed it critical to establish reasonable placeholder numbers in the long-range financial plan to be developed as part of this Facility Plan.

VIADUCT FLOODING

MSD is responsible for managing drainage from 32 viaducts that are subject to flooding during storm events. Some viaducts become completely impassable in relatively minor storms. Viaduct flooding disrupts transportation routes and creates potentially hazardous conditions when flooded roads are not barricaded in a timely manner or when drivers ignore the barricades and drive under the viaducts anyway. The Facility Plan Team has identified conceptual drainage solutions for each viaduct for which MSD is responsible. The projects were prioritized based on the team's understanding of traffic load and perceived risk to public health and safety. Note that viaducts are a shared responsibility with Louisville Metro Public Works and the Kentucky Transportation Cabinet. Before initiating a costly viaduct drainage solution, all parties should engage in determining the best approach to improving public safety at the viaduct locations.

STORMWATER QUALITY MUNICIPAL SEPARATE STORM SEWER SYSTEM

The Municipal Separate Storm Sewer System (MS4) Program is a drainage-related program to improve the quality of surface waters through controls on stormwater runoff quality in Jefferson County and to protect the public health, safety, and welfare by reducing the introduction of harmful materials into the MS4s that discharge into community streams. The MS4 Program permit outlines the regulatory requirements for discharging municipal stormwater into local water bodies. Major categories for program compliance include, but are not limited to, the following:

- Public education and outreach
- Management of industrial facilities
- Stormwater pollution prevention plan creation and oversight
- Administration of construction site management (erosion prevention and sediment control)
- Post-construction controls (green infrastructure)
- Maintenance and analysis of water quality monitoring equipment and data

The current 5-year MS4 Program permit cycle began on August 1, 2011, and it establishes the Maximum Extent Practicable (MEP) effort for MS4 programs to maintain MSD compliance with the Clean Water Act. MSD uses green infrastructure techniques—such as infiltration, rain gardens, and basin retrofits—to offset the need and costs on conventional facilities such as storage basins. Green infrastructure has proven to effectively reduce volume in the CSS, and for water quality improvements for treatment of runoff in MS4 areas. Requirements for new construction include these types of practices to control the 80th percentile event (0.6 inch of rain) in Louisville Metro. MSD funding is available for construction cost offsets in the CSS area and potential stormwater fee credits in the MS4 areas. Funding commitments for this program were defined in the IOAP and have been retained in the Facility Plan recommended CIP.

The Facility Plan identified several large stormwater retention basins with the potential for conversion of all or part of the basin to provide infiltration of stormwater. These projects are identified to be completed within the first 5 years of the CIP, providing very cost-effective green infrastructure solutions on a large scale.

FLOODPLAIN MANAGEMENT—FLOOD RESPONSE FUND

As of December 2016, MSD has purchased approximately 200 homes through federal grant programs since the 1997 flood and is currently working on 13 open grant projects to purchase additional homes located in flood prone areas. MSD also has 9 grant applications under review by FEMA. These grant applications include an additional 56 flood-prone properties that could be mitigated through acquisition.

Following a number of spring flooding events in 2015, the Mayor formed a multiagency Flood Mitigation Workgroup to address impacted residents who were unable, for a variety of reasons, to get back in their homes after the floodwaters receded. The Flood Mitigation Workgroup recommended several mitigation approaches, including establishment of a “quick-buy” program to allow property owners to sell flood-impacted property in a much shorter time than would typically be possible. The MSD Board approved allocation of $1.5 million from the FY2016 budget to fund this program. The Flood Mitigation Workgroup recommended an annual fund be established to provide timely relief to property owners impacted by future extreme storm events.

The resulting Flood Response Fund proved to be a vital part of the community’s recovery after the 2015 floods. The recommended 20-year CIP includes an annual allocation of $4 million per year to the Flood Response Fund for various flood mitigation and response activities, including continuing the quick-buy program where appropriate, implementing small-scale flood protection projects, and applying for, administering, and providing local-share funding for FEMA and other flood relief grant programs.

OHIO RIVER FLOOD PROTECTION SYSTEM

In 1987, as part of the Memorandum of Agreement with the City of Louisville related to drainage and flood protection services, MSD assumed responsibility for the Ohio River Flood Protection System (ORFPS). The ORFPS is critical to protecting Louisville and Jefferson County from the type of devastating flooding experienced in New Orleans following Hurricane Katrina and all along the Mississippi River when similar flood levee and pump station systems failed during the extreme high-water conditions experienced in the past decade. Louisville's ORFPS was evaluated in a Levee Safety Evaluation (LSE) by the U.S. Army Corps of Engineers (USACE) in 2015 and found to be compliant with the level of protection required by FEMA. The level of Ohio River flood protection required by FEMA incorporates a "coincident frequency analysis" that statistically determines the probability of a rain event happening at the same time as high Ohio River levels. The coincident frequency analysis found the MSD ORFPS is adequately sized to handle a 1-percent probability (100-year storm) event. MSD's local drainage design criteria calls for conveyance (pumps and pipes) to be sized for at least the 10-percent event. While meeting the FEMA 1-percent criteria in a coincident frequency analysis, several flood pumping stations would require significant expansion to achieve a capacity equivalent to a 10-percent probability event, should MSD decide to apply drainage criteria to the flood pumping stations. The LSE contained a wealth of information about minor deficiencies that need to be corrected. These items have been included in the recommended 20-year CIP.

Flood Pumping Stations

Much of the ORFPS was constructed in the 1950s. Design criteria that could be located from records of this era usually indicated the flood pumping stations were intended to pump the 10-percent probability storm (10-year storm), as defined by 1950 land use patterns and pre-1950 rainfall statistics. Some design documents recommended the capacity requirements be updated at 10-year intervals to account for land use changes, among other things. To our knowledge, prior to the LSE evaluation (USACE, 2015), the capacity of these flood pumping stations has never been reassessed through comprehensive hydraulic and hydrologic modeling. As previously described, capacity assessment completed as part of the LSE study identified several flood pumping stations that do not meet the 10-percent probability storm, although their capacity is adequate to provide protection for a 1-percent probability event under a coincident frequency analysis.

In addition to capacity concerns, many flood pumping stations have original 1950's vintage electrical and mechanical equipment. For the most part, the stations are manually operated using control systems that cannot be repaired with off-the-shelf components. To assure the reliability and adequacy of the flood pumping station system, all pump stations were subject to a facility condition assessment (in addition to the USACE LSE evaluation) and hydraulic and hydrologic modeling using storm IDFs projected for 2035. The recommended 20-year CIP includes rehabilitating and/or expanding 15 of the 16 flood pumping stations in MSD's system. Given the size of these facilities, the costs are substantial, but the risks being addressed are vital to Louisville's protection against catastrophic flooding.

Levee and Floodwall System

MSD maintains a proactive maintenance program to assure the integrity of the levee and floodwall system. In addition, the USACE biannually inspects the levee and floodwall, resulting in a report on any deficiencies noted. The recommended 20-year CIP includes continuing a proactive preventive maintenance program, in addition to the corrective actions recommended by the LSE study. These efforts are critical to protect the Louisville community from flooding.

SUPPORT SYSTEMS

MSD owns a large inventory of rolling stock, information technology (IT) systems, and above-ground facilities that support MSD's operation of wastewater, stormwater drainage, and ORFPS services.

CAPITAL EQUIPMENT

MSD owns more than 600 vehicles and portable equipment, ranging from passenger vehicles and pick-up trucks to large excavators and sewer-cleaning trucks. MSD has started leasing the commonly available passenger cars and pick-up trucks, which moves these costs from capital to operating budgets. The specialty equipment used in MSD's O&M activities are not available for lease, and MSD must continue to own them to be certain they are available any time they are required. This equipment is critical to MSD's ability to complete the preventive and corrective maintenance activities required to provide sustainable and reliable wastewater, stormwater, and flood protection services. For example, a comprehensive sewer inspection activity requires a sewer flush truck to clean the sewer, a vactor truck to capture the material flushed from the line to prevent it from moving downstream to cause problems elsewhere, and a closed-circuit television truck to closely inspect the condition of the pipe. After the condition is established, either heavy construction equipment like excavators and loaders or specialty equipment to install cured-in-place sewer lining is used to correct deficiencies. The specialized equipment is very expensive to purchase and maintain, given the severe service conditions that this equipment is operated under. The recommended 20-year CIP includes an annual allowance for equipment repair and replacement.

FACILITIES

The Facility Plan Team completed a facility condition assessment of more than 200 buildings and recommended corrective actions where deficiencies were noted. The main areas of deficiency were in roofs; MSD has above-ground buildings with roofs all over Jefferson County, ranging from the massive roof system at the Central Maintenance Facility to the little roof over a 10-foot-by-10-foot pump station building. Roofs appear to be one area that MSD allows to "run to failure." Roofs are seldom replaced until a leak is detected inside the building. The Facility Plan recommends an extensive program of roof replacement in the first 5 years, using standardized roofing systems for different applications. After that, regular inspection and replacement before failure occurs is recommended to provide the minimum cost of ownership for the buildings protected by these roofs.

The facility condition assessments also identified a number of deficiencies in areas related to heating, ventilation, and air conditioning (HVAC), building egress, signage and ancillary equipment, and indications of conditions that could eventually cause structural issues and even structural failure. The recommended 20-year CIP includes projects to address the specific recommendations identified by the Facility Plan Team, with future budgets recommended to complete periodic facility condition assessments following deficiency correction.

INFORMATION TECHNOLOGY SYSTEMS AND LOUISVILLE AND JEFFERSON COUNTY INFORMATION CONSORTIUM SUPPORT

MSD maintains an extensive inventory of IT hardware and software that is essential to overall agency operations; this includes the MSD intranet system that is the backbone of MSD electronic communication and digital data generation, communication and storage, and regulatory compliance reporting. This hardware and software system is also responsible for supplying the internet connection to MSD’s supervisory control and data acquisition (SCADA) system that controls more than 300 pump stations and control gates and serves as the platform for implementing the RTC system. This RTC system is used to optimize use of MSD’s conveyance facilities to cost-effectively maximize the use of existing facilities to reduce sewer overflows. Without adequate and updated IT systems, public health and safety could be at risk. This inventory is subject to periodic upgrade and replacement like all MSD’s other assets. In addition, MSD hosts the Louisville and Jefferson County Information Consortium (LOJIC) systems, which similarly require periodic upgrades and replacements to hardware and software. The recommended 20-year CIP includes annual allowances to account for these anticipated future costs.

FINANCE

To implement a $4.3 billion capital program and the associated costs to operate new facilities, MSD must have the funding to pay for it. Unlike the IOAP, which is required by the Consent Decree to be completed, most stormwater management and flood protection capacity projects developed in this Facility Plan are not specifically required by regulation. Providing for infrastructure renewal and replacement, and improving the consistent level of service in stormwater management and flood protection are local decisions driven by MSD’s mission to provide safe, clean waterways for the community. MSD will implement this Facility Plan to the extent funding is provided through the rate-setting process. If sufficient funding is not provided to complete the recommended projects in the 20-year planning period, then projects will be deferred to the future, when funding comes available.

REVENUE REQUIREMENTS AND RATES

The MSD Board approves rates, rentals, and charges on an annual basis. The MSD Board has the authority to raise rates up to 6.9 percent per year without Metro Council approval. Rate increases higher than 6.9 percent require Metro Council approval. The CIP recommended by the Facility Plan totals approximately $4.3 billion over 20 years. The recommended CIP for FY2017 through FY2021 exceeds $1 billion. The revenue generated by current rates, increased at 6.9 percent per year or less, will not generate enough revenue to support $1 billion in capital spending over the next 5 years. If current rates are increased by no more than 6.9 percent per year for the next 5 years ($3.60 per month for a typical customer in FY2018), then approximately $480 million in capital projects will need to be deferred. While 6.9 percent per year rate increases do provide enough revenue to implement the entire Facility Plan CIP over the 20-year planning period, the recommended schedule cannot be achieved, and completing critical public safety projects could be deferred by 3 to 5 years.

Completing the projects in the recommended CIP on the schedule recommended in the Facility Plan will require a 20-percent to 25-percent rate increase in FY2018 ($10.50 to $13.12 per month for a typical customer in FY2018), followed by rate increases up to 6.9 percent for the remaining years of the planning period. If a smaller rate increase is approved for FY2018, then the project schedule will need to be adjusted and recommended projects deferred to a later date based on MSD's resulting financial capabilities and project priorities identified by MSD staff. Projects directly related to the Consent Decree or other regulatory requirements, or those that address areas of high risk, will receive the highest immediate priority. Projects that do not address regulatory requirements or mitigation of high-risk issues will be deferred until the major IOAP projects have been completed and funds are available. The project prioritization system used to determine the recommended Facility Plan schedule is available for MSD staff to determine priorities based on information available at the time the budget revisions are made.

Table 3 presents the recommended project deferrals that could be anticipated for two alternative rate increase scenarios, based on the Facility Plan prioritization approach and information available at the time the Facility Plan was drafted. The alternative funding scenarios presented represent only two of the many rate approaches possible. Table 3 illustrates that if the funding scenario does not accommodate the recommended Facility Plan projects, the CIP implementation will be focused initially on completing the IOAP and other regulatory commitments. Even projects that deal with high-risk issues may be deferred due to funding shortfalls. Table 3 also illustrates the impact of deferred funding on the overall cost of Facility Plan implementation.

Under the most limited funding scenario presented (no rate increase over 6.9% per year) $480 million in capital projects must be deferred by 3 to 5 years. This has a ripple effect on the remainder of the 20-year cash flow, effectively pushing $480 million in projects to the end of the planning period. While Table 3 presents the Facility Plan recommendations for deferral, actual project deferrals will be established during the annual CIP budgeting process.

Table 3 – FY2018 – FY2020 CIP Project Deferrals Under Alternative FY2018 Rate Increases

Project Name	Baseline CIP Budget	Reduced CIP Budget ~$10/mo in FY18	Reduced CIP Budget ~$4/mo in FY18
Wastewater Projects			
CMOM			
Cedar Creek WQTC Asset Management Rehabilitation and Replace	$900,000	$900,000	$500,000
Cedar Creek WQTC Forcemain Extension	$177,000	$177,000	$0
Cedar Creek WQTC Sand Filter Replacement	$4,500,000	$4,500,000	$2,000,000

Project Name	Baseline CIP Budget	Reduced CIP Budget ~$10/mo in FY18	Reduced CIP Budget ~$4/mo in FY18
Cedar Creek WQTC Service Area Inventory for Critical Pump Station	$300,000	$300,000	$0
Collection System Spare Pump Inventory	$3,000,000	$3,000,000	$1,300,000
Derek R. Guthrie WQTC Service Area Inventory for Critical Pump Station	$300,000	$300,000	$0
Floyds Fork WQTC Service Area Inventory for Critical Pump Station	$300,000	$300,000	$0
FY18 PMP	$2,500,000	$2,500,000	$2,250,000
FY18-FY22 Operations Renewal and Replacement	$18,300,000	$18,300,000	$15,300,000
FY19 CMOM PM Assist	$225,000	$187,500	$187,500
FY19 PMP	$2,000,000	$2,000,000	$1,000,000
Hite Creek WQTC Solids Expansion	$6,800,000	$6,800,000	$1,500,000
Hite Creek WQTC Expansion	$19,553,703	$17,553,703	$3,623,703
Land Acquisition	$2,400,000	$2,400,000	$1,300,000
Lea Ann Way Pump Station Elimination	$8,000,000	$6,000,000	$0
Lea Ann Way West Rehab Quad 1	$400,000	$400,000	$500,000
Major Interceptor Rehabilitation	$5,500,000	$5,500,000	$3,000,000
Morris Forman Collection System Baffles	$624,000	$400,000	$0
Morris Forman WQTC Service Area Inventory for Critical Pump Stations	$900,000	$900,000	$0
Morris Forman WQTC Service Area MH and ARV Floodproofing for 100	$136,000	$136,000	$0
Morris Forman WQTC Service Area Pump Station Floodproof for 100-Year Storm	$328,000	$248,000	$0
Nightingale Rehab	$4,200,000	$4,200,000	$1,500,000
Slip Line JTWQTC	$1,398,000	$1,398,000	$0
Development			
Floyds Fork Zone B Sewers	$7,900,000	$7,900,000	$0
Floyds Fork Zone C Sewers	$4,000,000	$4,000,000	$0
KTC Greenwood Road Assessment	$525,000	$0	$0
NMC			
Morris Forman Central Business District CSO Cameras	$1,248,000	$1,248,000	$0
Morris Forman WQTC Draft Rehab and TWAS Piping Replacement	$1,500,000	$1,500,000	$0
Morris Forman WQTC Digester Lids and Mixers	$4,500,000	$4,500,000	$0

Project Name	Baseline CIP Budget	Reduced CIP Budget ~$10/mo in FY18	Reduced CIP Budget ~$4/mo in FY18
Morris Forman WQTC Equipment Renewal and Replacement in Year 5	$25,500,000	$15,000,000	$900,000
Morris Forman WQTC Sec Clarifiers and RAS/WAS Pumping	$6,500,000	$5,500,000	$0
Morris Forman WQTC Sedimentation Basin Rehabilitation	$12,500,000	$8,500,000	$500,000
Stormwater Projects			
Drainage			
Auburndale Early Action Project	$12,600,000	$4,200,000	$0
City of Hurstbourne Early Action Project	$6,000,000	$3,000,000	$0
Master Plan Implementation	$6,000,000	$5,000,000	$0
Newburg Early Action Project	$10,250,000	$3,000,000	$0
Pope Lick Early Action Project	$6,100,000	$1,220,000	$0
Prospect Early Action Project	$6,000,000	$1,500,000	$0
Seatonville Early Action Project	$3,400,000	$3,400,000	$0
Stormwater Master Plan	$4,000,000	$4,000,000	$0
Ten Broeck Early Action Project	$1,000,000	$1,000,000	$0
Valley Creek Early Action Project	$5,540,000	$3,000,000	$0
Via11 E Brandeis Ave and Brook Viaduct Flood Relief	$28,043,000	$2,000,000	$0
Via16 3rd and Eastern Pky Viaduct Flood Relief	$5,808,000	$0	$0
Whispering Hills Early Action Project	$2,560,000	$2,560,000	$0
Floodplain Management			
Flood Response-Buyouts Mitigation and Grants	$12,000,000	$10,000,000	$0
Ohio River Flood Protection			
10th Street Flood Pumping Station Reliability / Generator	$1,035,000	$0	$0
17th Street Flood Pumping Station Capacity / Reliability / Generator	$2,525,000	$2,525,000	$0
34th Street Flood Pumping Station to Los 5 - Improvements / Generator	$2,000,000	$0	$0
5th Street Flood Pumping Station to Los 5 - Improvements / Generator	$820,000	$0	$0
Allocation - Annual Flood Pumping Stations Equipment Renewal and Replacement	$3,000,000	$3,000,000	$2,500,000

Project Name	Baseline CIP Budget	Reduced CIP Budget ~$10/mo in FY18	Reduced CIP Budget ~$4/mo in FY18
Floodwall and Levee Risk Assessment	$750,000	$0	$0
Floodwall/Levee Repair and Toe Drains	$2,250,000	$2,250,000	$1,500,000
Levee and Floodwall Repair and Renewal Light	$1,875,000	$1,500,000	$750,000
Paddys Run Flood Pumping Station Reliability / Redundant Service	$31,575,000	$8,000,000	$0
Robert J. Starkey Flood Pumping Station Operational Improvements	$4,360,000	$2,180,000	$0
Western Parkway Flood Pumping Station –Capacity Improvements	$11,648,000	$4,648,000	$0
Western Parkway Flood Pumping Station - Reliability Improvements (Evaluation Repairs)	$3,334,000	$3,334,000	$0
Support Systems Projects			
Capital Equipment			
FY18 Vehicles & Equipment	$3,500,000	$3,500,000	$2,000,000
FY19 Vehicles & Equipment	$3,500,000	$3,500,000	$1,500,000
FY20 Vehicles & Equipment	$3,500,000	$3,500,000	$2,500,000
Systems Automation	$1,200,000	$750,000	$750,000
Facilities			
Admiral Pump Station Foundation Repairs	$246,936	$246,936	$246,936
Louisville Green Major Maintenance	$3,000,000	$3,000,000	$1,000,000
Morris Forman WQTC Elevator Repairs	$400,000	$400,000	$0
Miscellaneous Facility Repairs	$127,566	$127,566	$127,566
Roof Replacements	$3,230,458	$3,204,950	$3,200,000

RATE RELIEF

While increased spending on infrastructure is needed, the affordability of utility services is a serious concern for those in our community, especially those who are living at or near poverty levels. To avoid imposing additional stressors on the low-income population of our community, MSD is investigating the concept of meaningful rate relief for those in need. To provide the benefits of a significant wastewater rate reduction for low-income customers, a small incremental increase in costs (approximately $1.30 per month) would apply for a typical customer in 2018. These costs are passed on to customers who are better able to absorb it in their household budgets.

To implement this, MSD has partnered with the Metro Department of Community Services (Community Services). Community Services currently administers the Low-Income Home Energy Assistance Program

(LiHEAP). Community Services has agreed in principle to administer a rate relief program for MSD, based on the qualification standards used in the LiHEAP program. Subject to MSD Board approval, MSD is considering a rate relief subsidy proportional to annual rate increases, for customers who qualify. The current Low-Income Senior Citizens Discount Program is expected to be phased out, but seniors would be "grandfathered" into the new rate relief program regardless of LiHEAP qualification standards.

SUMMARY

The 20-year Comprehensive Facility Plan represents MSD's most ambitious planning effort in a decade. Working with the Wet Weather Team Stakeholder Group and MSD staff, the Facility Plan Team reviewed the challenges our community faces now and in the future and has developed a roadmap to protect the area's health, economic vitality, and environment. The recommendations in this plan are the result of well-vetted analyses from some of the most experienced engineers in Louisville Metro. The recommendations are essential to maintaining reliable and properly sized facilities that will allow MSD to fulfill its responsibility for safe, clean waterways and to help preserve and promote our competitiveness as a city.

Wastewater collection and treatment is MSD's largest service offering and was the original reason MSD was formed by state statute in 1946. Fully implementing the Facility Plan recommendations will accomplish the following wastewater service objectives:

- Fulfill the obligation of the Consent Decree, including completing all the projects contained in the IOAP on schedule
- Provide facilities that comply with the other environmental regulations MSD is governed by and provide a plan to remain in compliance with future regulations currently under development
- Renew and replace aging wastewater infrastructure to provide reliable service and the lowest overall cost using a best-practice asset management approach
- Position MSD to support the community's ability to grow responsibly as economic development opportunities become available

MSD assumed responsibility for stormwater management, including both drainage and interior floodplain management for most of Jefferson County in 1987. The drainage system at that time had a backlog of thousands of drainage complaints that MSD was expected to correct. While MSD has invested hundreds of millions of dollars in drainage infrastructure since 1987, drainage problems still are found across the entire county. In addition, the increased frequency of extreme storms that have been observed in Louisville Metro have raised customer concerns about the adequacy of our drainage and interior floodplain management systems. While current development standards require mitigation of the drainage impacts of land use changes, analysis of historical trends shows a significant reduction in natural green space and an increase in impervious services that do not allow stormwater to seep into the ground. Runoff from impervious surfaces also causes increased runoff volume and greatly increased runoff peak flows. Together, these factors exacerbate the observed deficiencies in the stormwater system that MSD now has responsibility for, impacting neighborhood drainage in addition to interior floodplain inundation. Implementing the Facility Plan recommendations will accomplish the following stormwater management objectives:

- Improve the level of protection against public health and property risks caused by inadequate stormwater drainage systems
- Continue support for the Project DRI neighborhood drainage solutions
- Expand the efforts of the MS4 program to reduce stormwater contamination of our waterways, primarily through BMPs and continued proactive support of green infrastructure solutions to both quantity and quality concerns
- Recognize and respond to the impact of changing weather patterns including the increased frequency of extreme storms

The ORFPS was developed in response to the flood of 1937. The system of levees, floodwalls, and flood pumping stations have protected Louisville since it became operational in the 1950s. While the system has an outstanding record of reliability, much of the system is more than 60 years old and includes antiquated equipment that cannot be repaired with standard parts available today. In addition, the same changing precipitation and land use patterns that affect drainage and inland floodplain management also impact the flood pumping stations and related appurtenances. Implementing the Facility Plan recommendations will accomplish the following ORFPS objectives:

- Maintain protection from Ohio River floods entering Louisville by proactive preventive and predictive maintenance activities related to the levee, floodwall, and all gates and other penetration closures that keep floodwaters at bay
- Modernize the flood pumping stations with current mechanical and electrical equipment that can provide continued reliability and a predictable cost because parts will be more readily available at a more reasonable cost
- Expand the capacity of those flood pumping stations to enhance community protection in response to changing precipitation and land use patterns

Implementing the recommendations for all three service areas in accordance with the schedule presented will require a significant investment from the community, which may mean a step-change increase in wastewater and drainage rates. If the community is unwilling to accept the rate increases necessary to fund the recommended project schedules presented, then many important projects will not be able to be implemented in the near term. The data indicate that not implementing necessary investments is almost certain to result in more infrastructure failures, an increase in the overall cost of implementing the Facility Plan, and an ever more rapidly increasing likelihood of a failure that could have serious consequences for the residents and businesses that make Louisville Metro their home.

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ACRONYMS AND ABBREVIATIONS

ARI	average recurrence interval
ASDSO	Association of State Dam Safety Officials
BMP	Best Management Practice
CFR	Code of Federal Regulations
cfs	cubic feet per second
CPI	Consumer Price Index
CRS	Community Rating System
CSO	combined sewer overflow
CSS	combined sewer system
CSSA	Combined Sewer System Area
cT	credit point
DRI	Drainage Response Initiative
EAP	emergency action plan
EPA	U.S. Environmental Protection Agency
Facility Plan	20-Year Comprehensive Facility Plan—Critical Repair and Reinvestment Plan
FEMA	Federal Emergency Management Agency
FFRMS	Federal Flood Risk Management Standard
FIRM	Flood Insurance Rate Maps
FIS	Flood Insurance Study
FY	Fiscal Year

GIS	geographic information system
HEC	Hydrologic Engineering Center
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center River Analysis System
hp	horsepower
I-265	Interstate 265
I-64	Interstate 64
ICM	integrated catchment model
ID	identification
IDF	intensity, duration, and frequency
in/hr	inches per hour
IOAP	Integrated Overflow Abatement Plan
ISO	International Organization for Standardization
KDOW	Kentucky Division of Water
KPDES	Kentucky Pollutant Discharge Elimination System
KY 841	Kentucky State Highway 841
KYTC	Kentucky Transportation Cabinet
LG&E	Louisville Gas & Electric
LIDAR	light detection and ranging
LOJIC	Louisville and Jefferson County Information Consortium
Louisville Metro	Louisville-Jefferson County Metro Government
LRCZ	Local Regulatory Conveyance Zone

LRF	Local Regulatory Floodplain
LTMN	long-term monitoring network
MCC	motor control center
MEP	Maximum Extent Possible
MS4	Municipal Separate Storm Sewer System
MSD	Louisville and Jefferson County Metropolitan Sewer District
NACWA	National Association of Clean Water Agencies
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
O&M	operations and maintenance
P.E.	Professional Engineer
POC	pollutant of concern
PVA	Property Valuation Administration
RCP	reinforced concrete pipe
SCADA	supervisory control and data acquisition
SFHA	special flood hazard area
SSO	sanitary sewer overflow
SWQMP	Stormwater Quality Management Plan

TMDL	total maximum daily load
TP	Technical Paper
TP-40	NOAA Technical Paper No. 40: *Rainfall Frequency Atlas of the United States*
TSS	total suspended solid
UofL	University of Louisville
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	United States Geological Survey
V	volt
WLA	wasteload allocation
WSEL	water surface elevation

VOLUME 3—STORMWATER AND DRAINAGE

EXECUTIVE SUMMARY

ES.1 HISTORY AND BACKGROUND

Louisville and Jefferson County Metropolitan Sewer District (MSD) assumed the responsibility for most of Jefferson County's public stormwater drainage system in 1987. Five suburban cities decided to manage and maintain their own drainage systems: Anchorage, Jeffersontown, St. Matthews, Shively, and Prospect (MSD took over drainage responsibilities for Prospect in 2004). MSD is not responsible for drainage in the right-of-way of most State-maintained roadways and some County through roads. MSD was not originally responsible for drainage in unincorporated areas or farmlands of the outer portions of Jefferson County. These areas became part of MSD's responsibilities following the City/County merger in 2003.

Before 1987, drainage services were the shared responsibility of MSD, the City of Louisville, the Jefferson County Department of Public Works, the Kentucky Transportation Cabinet (KYTC), the City of Jeffersontown, and numerous other agencies and groups. The Strategic Planning and Finance Committee, formed by MSD in 1984 and made up of citizens and elected officials charged with the role of evaluating long-standing environmental issues facing Louisville and Jefferson County, recommended in 1985 that MSD assume responsibility for county-wide drainage services. Having one agency in charge of drainage services allowed for regional planning, consolidated authority, and funding for adequate maintenance and correction of system deficiencies. Prior to the takeover, there was confusion regarding which agency was responsible for stormwater problems and inefficient response to emergencies, and the technical and funding coordination was not in place to resolve problems associated with multiagency responsibilities.

When MSD assumed drainage responsibility for most of the county, the agency also assumed responsibility for a large list of stormwater-related problems, some decades old. The new drainage program began in 1987, with about 1,500 historical requests for drainage improvements from Louisville, Jefferson County, and MSD's own files. As the program began, these requests began to multiply—to a total of more than 14,000 in the first 6 months and to more than 30,000 in the first 4 years. Most requests involved maintenance problems—clogged catch basins, cave-ins, pipes, and ditches—that could be resolved relatively quickly. However, a significant number of requests would require new construction.

To begin to address the major drainage problems of the community, priorities were set for 52 of the most-needed drainage projects, to be financed by a $25 million bond issue. These areas were identified from the *1988 Stormwater Drainage Master Plan* (URS Corporation et al., 1988). This study also served as the framework to put in place a new drainage user fee based on impervious area on a property. Court delays from challenges to the new drainage user fee delayed implementation of the capital program for more than 3 years. MSD completed nearly $2.5 million in small, neighborhood "mini" drainage projects in its first 4 years, but the large projects had to wait until additional funding could be secured. By performing these "mini" drainage projects, MSD resolved nearly 22,000 requests in the first 4 years, leaving approximately 8,000 of the most difficult requests to resolve.

By early 1991, MSD had identified more than 100 areas that needed major construction projects to deal with their drainage problems. The initial $25 million bond had been designed to cover only 52 capital projects. In reality, the $25 million bond was only enough to cover 40 of the original 52 projects. In January 1993, MSD approved a revised list of more than 200 drainage projects to be completed within the following 5 years, to be paid for with $48 million in bonds that were paid for with an increase in the drainage fee from $1.75 to $2.75 per residential unit. The need for the rate increase was explained at 40 community meetings and six public hearings. Most of the work for the 100 priority areas was completed despite the needs that arose from the 1997 flood taking a higher priority.

In January 2003, MSD launched a highly successful program called Project Drainage Response Initiative (DRI). This program was developed after the 2003 general election as MSD looked for a way to respond more quickly to citizen's drainage concerns. Project DRI prioritizes drainage request, meets with property owners at their home to discuss the problem, triages the problem, develops solutions, and prioritizes the remedial work necessary to address the request. To date, it has been a highly successful program in the view of the community. However, while this program handles minor drainage request very well, it does not tackle large-scale drainage problems that involve planning at a watershed level. Quite often, these types of problems only surface after infrequent, intense rain events.

Outside of Project DRI, MSD has completed several drainage capital projects, including both conveyance and basin projects in the last 15 years, including the recently completed Aluma Basin in the Pond Creek Watershed. However, the drainage and internal floodplain management capital program is not currently being driven by any watershed-based comprehensive master planning efforts.

Over the years, the U.S. Army Corps of Engineers (USACE) has conducted several studies of flooding in the community. In the mid-1970s, a special study of the Beargrass Creek watershed recommended a dry-bed reservoir on the South Fork near Houston Acres to relieve flooding downstream; the reservoir would hold water during heavy rains, then release it slowly afterward. Jefferson County built this reservoir as part of a major drainage program in the late 1970s. In 1989, a new study, the Pond Creek Feasibility Study of the Pond Creek watershed was authorized; MSD joined with the USACE in conducting it. In 1994, the study proposed $16.4 million in flood-control work, and in 1996, U.S. Congress appropriated the first $1.5 million to start detailed design of the Melco and Vulcan Basins. A feasibility study (USACE, 1997a and 1997b) of the South Fork of Beargrass Creek was started in 1994. The South Fork still had many problems during heavy rains, despite the improvements brought by the dry-bed reservoir. Eight additional basins in the South Fork were recommended as a result of this study. In 1994, a reconnaissance study of southwest Louisville was initiated. However, USACE ultimately determined from the resulting feasibility analysis and study that projects could not be justified, under the USACE benefit/cost requirements (USACE, 2012). This study did result in MSD enhancing the Plumbing Modification Program.

The aforementioned *Stormwater Drainage Master Plan* (URS Corporation et al., 1988) was updated in 2010. Because this update was basically a current snapshot of watershed existing conditions and ongoing projects, no comprehensive planning was performed by the 2010 update. In the years since the original master plan was written in 1988, land use patterns changed, impervious surface greatly increased, extreme storm events occurred with increased frequency, and some customers demanded a higher level of service. Recent heavy rains have highlighted the problem of flood-prone areas inside the floodwall.

In addition, drainage plans must consider water quality considerations as outlined in the Municipal Separate Storm Sewer System Program (MS4 Program) for the County. The mission of the MS4 Program is to enhance stormwater runoff quality and protect streams and riparian habitat to promote public health, safety, and welfare through a variety of program components. Since 1987, MSD has been held to requirements relating to public involvement and outreach, illicit discharges, industrial users, construction site runoff controls, post-construction runoff controls, pollution prevention and good housekeeping activities, and monitoring and reporting requirements. MSD, with several other co-permittees, is the lead agency performing these activities for Jefferson County.

The challenges still facing MSD with regards to stormwater are exacerbated by the County's geography. Some areas are previous swampland with little slope, while other areas are very hilly, which when combined with development, contributes to excessive streamflow and erosion if not properly controlled. Much of the area within the old Louisville city limits is in the combined sewer system (CSS), and when the system reaches capacity, many places in this highly developed and urban area flood despite not being next to an open stream. This occurs because the CSS took the place of the original streams and ditches. This practice started in the 1800s and was not uncommon in major cities at the time. Development quickly occurred in these areas. However, because the pipes are not sized to handle very large storm events, during intense rainfall events, the water can leave the CSS and travels overland where the creeks and ditches used to be. This has caused major damage to homes and businesses in these areas. More information on the history and background can be found in Chapter 1, Section 1.1.

ES.2 CRITICAL COMPONENTS ASSESSMENT

Major components in the stormwater system that are documented in the MSD Hansen Information System were reviewed, including storm pipes, catch basins, major detention basins, and main tributaries. Viaducts and Class C dams for which MSD has responsibility were also assessed. Other than inspection of the viaducts, field inspection to assess the condition of all MSD's stormwater assets was outside the scope of this report. MSD's Hansen Information System was used to extract infrastructure age and maintenance activities to track trends in work orders and costs. The viaducts were field examined to determine the number and condition of the inlets in the sag of the roadway. For the viaducts with pump stations, field investigations and interviews with MSD personnel are the basis for the condition assessment.

ES.2.1 Stormwater Collection and Conveyance Work Order Reviews

Storm pipes, catch basins, major detention basins, and main tributaries define this subset of assets. Analysis was conducted to determine whether the age of the asset had any correlation on the total number of work orders for that asset and, in addition, the amount of money being spent on the work orders per year. Data were normalized by dividing the total number of work orders by the number of assets, grouped in 5-year increments. Several assets do not have installation dates, and those assets are predominantly pre-1987, before MSD took over drainage responsibilities for most of the county. All inspection-type work orders were excluded from the analysis.

MSD took over most of the existing drainage infrastructure in 1987. Some parts of the system are now more than 100 years old. Examination of work order trends shows that the number of work orders increased with asset age for all stormwater assets studied. Figure ES-1 demonstrates that the number of work orders for every 100 catch basins, for example, is heavily influenced by the age of the asset. More information on the stormwater collection and conveyance work order reviews can be found in Chapter 2, Section 2.3.

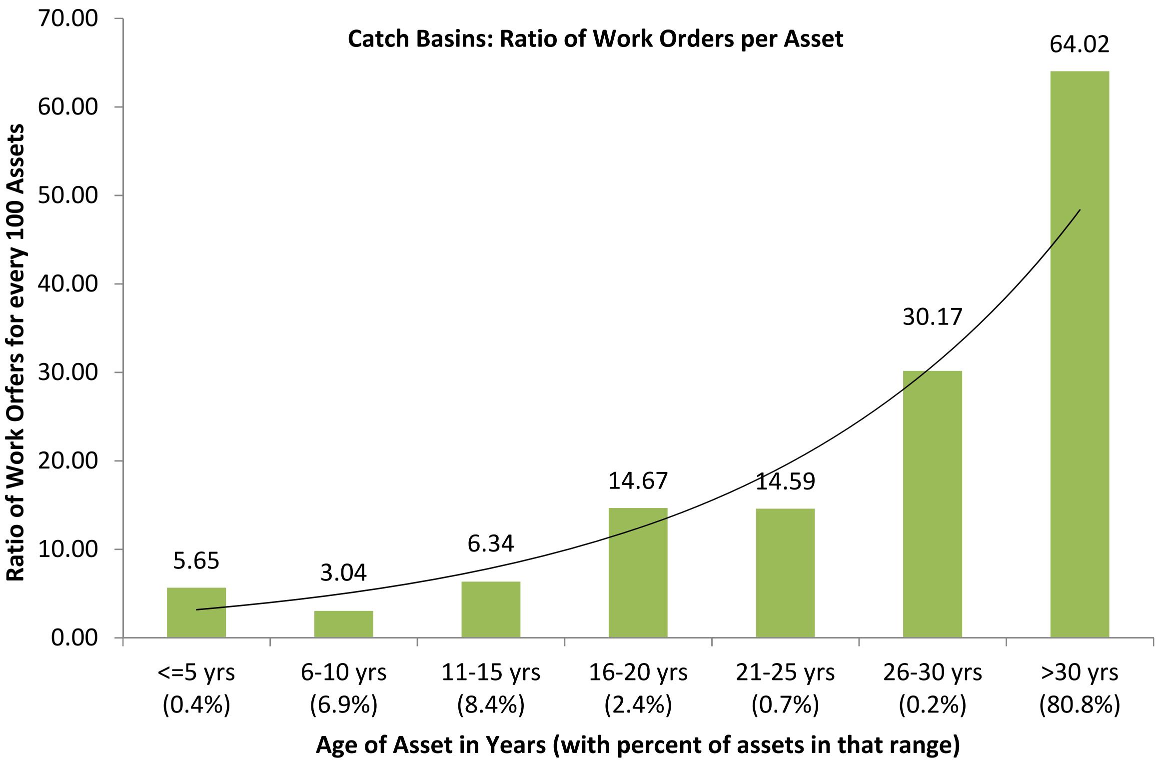

Figure ES-1. Catch Basins Age and the Effects on the Number of Work Orders

Despite the conclusion that maintenance needs are increasing with asset age, the money being spent on maintenance is trending downward, as shown in Figure ES-2; this is the case for all but natural channel work orders and catch basins. The cost breakdown extracted from work orders does not show increased attention to aging facilities. This suggests that deferred maintenance could result in reduced system performance and higher costs to repair and/or replace components in the future even after factoring in increase efficiency of crews and a shift away from the larger construction work orders. With the aging stormwater infrastructure, the need for additional maintenance will only continue to increase. Future operations and maintenance (O&M) budgets should consider this. More information on O&M budget considerations can be found in Volume 1, Chapter 7.

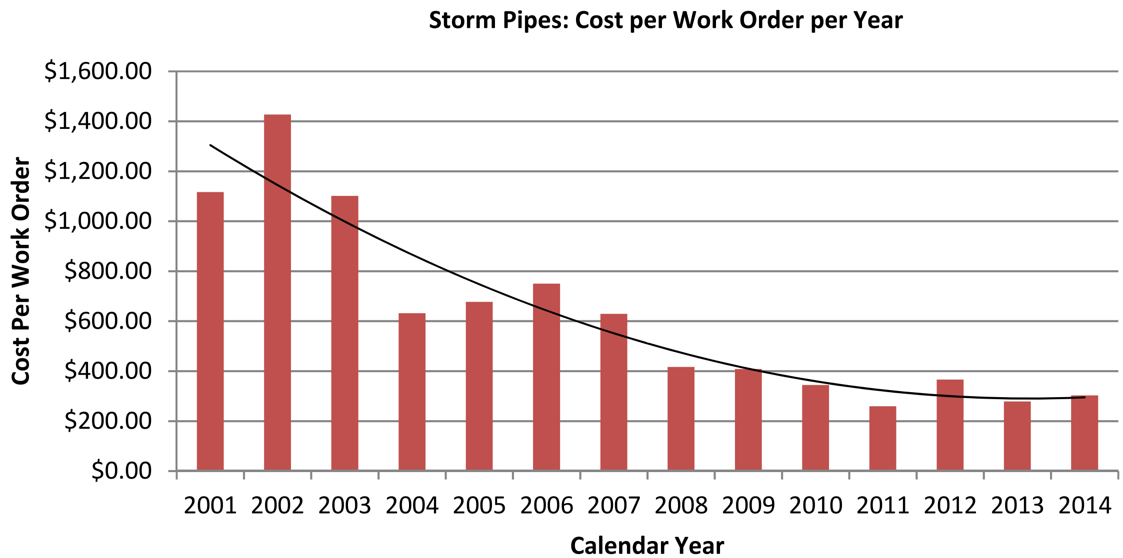

Figure ES-2. Storm Pipes Cost per Work Order per Year (Adjusted for Inflation)

ES.2.2 Viaducts Condition Assessment

Overall, the viaduct conditions are qualitatively ranked as marginal. Several improvements to the viaducts with pump stations, as shown in Figure ES-3, need to be made to extend the life and improve the resiliency of the current pump stations. However, the flood relief projects, identified in Volume 3, Chapter 3 (and summarized herein in Section ES.3.2), should be the priority and the concerns and needs identified in Figure ES-3 would be addressed with those projects. MSD must partner with Louisville Metro Public Works and the railroad companies to develop solutions to these complex transportation and drainage issues. More information on the viaduct condition assessment can be found Chapter 2, Section 2.4.

ES.2.3 Class C Dams—Potential Improvements for Consideration

Dams are assigned a structure classification using a risk-based approach considering the potential impact produced by a dam's failure. Class A structures are considered low-hazard structures for which failure would result in loss of the structure itself, but little or no additional damage to other property. Class B structures are considered a moderate-hazard structure for which failure would cause significant damage to property and project operation, but no loss of life. Class C dams are high-hazard structures, which indicates that a dam failure would result in one or more of the following consequences:

- Loss of life
- Extensive damage to residential buildings
- Damage to industrial or commercial buildings
- Damage to public utilities or

- Damage to main highways or railroads

Viaduct	Access Road	Main Pumps	Spare Pump	Sump Pump	Bar Screen	Grit	Control Room Flooding	MCC	SCADA	Control System	Transfer Switch	Generator Pad	Permanent Standby Generator	Control Room Heater w/ Thermostat	Ventalation	Exterior Painting	Guide Rail Systems	Excess Inflow	Inflow Pipes	Safety Concerns
16th & Algonquin	◆	◆	X	✓	◆	X	X	X	✓	N/I	X	X	X	✓	✓	✓	X	✓	✓	✓
4TH & Colorado	X	✓	X	N/I	X	X	✓	N/A	✓	✓	X	X	X	✓	✓	✓	X	✓	X	✓
3RD & Eastern Pkwy	X	✓	X	N/I	X	✓	✓	N/A	✓	PIP	✓	X	X	✓	◆	N/I	X	✓	✓	X
3RD & L&N	X	✓	X	N/I	X	✓	✓	N/A	✓	✓	✓	X	X	✓	◆	✓	X	✓	✓	X
Cardinal & Brandeis	✓	✓	✓	✓	◆	X	✓	N/A	✓	PIP	✓	◆	X	✓	✓	✓	X	X	✓	✓
Floyd & Hill	X	✓	X	N/I	◆	X	✓	N/A	✓	PIP	✓	X	X	✓	◆	X	X	X	✓	✓

Legend	
PIP	Project in Progress
X	Needs Attention
◆	Marginal
✓	Good Condition
N/A	Not Applicable
N/I	No Information

Figure ES-3. Status of Viaducts with Pump Stations

Table ES-1 lists MSD-owned Class C – high-hazard dams in Jefferson County. Table ES-2 lists Class C – high-hazard dams in Jefferson County that are owned by others. Tables ES-1 and ES-2 also identify the owner of each dam, the dam's impoundment volume, the dam's height, and the potential risks associated with the failure of each dam. Mitchell Hill Lake Dam and Norton Commons Dam do not meet the strict definition of a dam as defined by the Kentucky Division of Water (KDOW). However, because of the risks associated with the failure of either structure, the KDOW lists both structures as Class C – high-hazard dams. As identified in Tables ES-1 and ES-2, primary buildings include business and residential structures that are designed for human occupancy and include all homes, apartment buildings, and office buildings. Secondary buildings are not designed for human occupancy and include garages, sheds, and outbuildings. Critical structures include hospitals, schools, firehouses, and police stations.

MSD is nearing the end of its dam breach analysis project. This project has and will help MSD quantify both the risk to human life and the economic liability associated with a breach of each of MSD's Class C – high-hazard dams and should be included on each current and future Emergency Action Plan (EAP) documents.

MSD owns and operates the three dams listed in Table ES-1. MSD's practices meet or exceed current industry standards in dam design, construction inspection, periodic in-service inspections, and EAPs. A licensed Professional Engineer supervises the development of MSD dam construction documents. In addition, MSD requires that regular inspections be completed during construction of a new or rehabilitated dam and that a final inspection be performed at the completion of dam construction activities. Industry standards for in-service inspections of Class C dams range from one inspection per year to one inspection every 2 years, and MSD requires that all MSD owned Class C dams receive four in-service inspections per year.

Although MSD's current practices with respect to dams and dam safety meet or exceed recognized industry standards, there are several activities that MSD could pursue on the dams they own and operate to further enhance the safety of the public. MSD is not responsible for maintaining or improving the dams owned by others (see Table ES-2). Table ES-3 summarizes the list of Class C potential improvements. More information on the Class C – high-hazard dams can be found in Chapter 2, Section 2.5.

Table ES-1. Class C – High-Hazard Dams in Jefferson County Owned by MSD

Name of Dam	Owner	Dam Impoundment (acre-feet)	Dam Height (feet)	At Risk from Dam Failure
South Fork Beargrass Creek Dry Bed Dam	Louisville MSD	488	56	2,176 primary buildings, 1,340 secondary buildings, 19 critical facilities, and 153 local roads
Roberson Run-Dry Impoundment	Louisville MSD	74.1	18	207 primary buildings, 181 secondary buildings, 1 critical facility: Okolona Fire Department 1, and 16 local roads
Whipps Mill Road Dry Dam	Louisville MSD	343.7	19	77 primary buildings, 50 secondary buildings, 2 critical facilities: Kinder Care Learning Center and Magnolia Springs Senior Living Center, and 20 local roads

Table ES-2. Class C – High-Hazard Dams in Jefferson County Owned by Others

Name of Dam	Owner	Dam Impoundment (acre-feet)	Dam Height (feet)	At Risk from Dam Failure
Tom Wallace Lake Dam	Louisville Metro Parks	98.2	25	190 primary buildings, 133 secondary buildings, 1 critical facility: Fairdale Elementary School, and 14 local roads
Pine Hill Lake No. 1	Windsor Lake Home Owners Association	37.3	27	See Windsor Forest Dam [a]
Windsor Forest Dam	Windsor Forest Home Owners Association	63.1	23	89 primary buildings, 49 secondary buildings, 1 critical facility: Britthaven of South Louisville, and 11 local roads [a]
Mitchell Hill Lake Dam	Louisville Metro Parks	25.7	20	104 primary buildings, 81 secondary buildings, no critical facilities, and 10 local roads
LG&E Wastewater Dam	LG&E	Pond has been filled in	12	Risk has been removed; LG&E is currently removing the dam from KDOW registry.
LG&E Ash Pond at Mill Creek Station	LG&E	4,135	77	LG&E has indicated that this pond will likely be filled in 2018.

Table ES-2. Class C – High-Hazard Dams in Jefferson County Owned by Others

Name of Dam	Owner	Dam Impoundment (acre-feet)	Dam Height (feet)	At Risk from Dam Failure
Norton Commons Dam	Norton Commons, LLC	31.5	13	6 primary buildings, 2 secondary buildings, no critical facilities, and 5 local roads

[a] Pine Hill Lake No. 1 is upstream and in series with Windsor Forest Dam. Risks shown are based on Pine Hill Lake No. 1 failing with subsequent failure of Windsor Forest Dam.
LG&E Louisville Gas and Electric Company

Table ES-3. Class C – High-Hazard Dams Potential Improvements

Potential Improvement	Notes
Dam monitoring systems	Construct a system to monitor MSD's dams 24/7. This system should be placed in real-time communication with public warning systems
EAP updates	Update all dam failure warning and response plans. This update should include these requirements and elements: • Conduct annual outreach to all properties affected by dams. • Coordinate with critical facility operators. • Develop response plan for any critical facilities that would be affected by dam failures.

ES.2.4 Critical Components Condition Assessment—Conclusions and Recommendations

MSD took over most of the existing drainage infrastructure in 1987, with some system components now more than 100 years old. Examination of work order trends shows that the number of work orders increased with asset age for all assets studied (as demonstrated in Figure ES-1). Future O&M budgets should take this into account. For more information on O&M budget considerations, please see Volume 1, Chapter 7.

Overall, the viaduct conditions are qualitatively ranked as marginal. Several improvements to the viaducts with pump stations, as shown in Figure ES-3, need to be made to extend the life and improve the resiliency of the current pump stations. However, the flood relief projects identified in Volume 3, Chapter 3 (and summarized herein in Section ES.3.2) should be the priority, and the concerns and needs identified in Figure ES-3 would be addressed with those projects. MSD must partner with Louisville Metro Public Works and the railroad companies to develop solutions to these complex transportation and drainage issues

MSD is nearing the completion of their dam breach analysis project. This project has and will help MSD quantify both the risk to human life and the economic liability associated with a breach of each of MSD's Class C – high-hazard dams, and should be included on each current and future EAP documents.

Installing a 24/7 dam monitoring system at each of MSD's Class C dams would provide MSD with the capability to provide real time notification to downstream residents. In addition to the dam monitoring systems, MSD should consider installing a public warning system at each dam location. The public warning system would be capable of notifying residents, businesses, and critical facilities that would be potentially inundated or isolated by a dam breach failure. MSD should also consider updating the Class C dam EAPs on a regular basis, such as once a year. Industry standards vary on updating EAPs, from 1 to 5 years between updates.

The Class C dam recommendations, summarized herein and in more detail in Chapter 2, Section 2.5.3, would help prepare the community in case of an emergency and reduce the likelihood of loss of life due to a catastrophic event at a dam. More information on the critical components condition assessment conclusions and recommendations can be found in Chapter 2, Section 2.6.

ES.3 GAP ANALYSIS

This analysis documents the gaps in stormwater planning as determined by the Facility Plan Team. Three main areas are discussed in this herein: 1) the need for comprehensive stormwater master planning, 2) the need to address viaduct flooding, and 3) a path to increasing the community rating system (CRS) ranking.

ES.3.1 Comprehensive Stormwater Master Planning

Since MSD took over drainage for most of the county in 1987, only one major stormwater master planning effort has occurred for the MSD service area. The list of projects it generated was updated in 1991 and again in 1993. The main document itself was partially updated in 2010 (MSD, 2010). The 2010 updates included updated watershed information and existing projects, but did not identify any needed projects for the future.

The 1988 master plan was very comprehensive, setting goals, policies and financial, institutional, and technical plans. It also helped to set the framework for a drainage utility and associated drainage fees. It identified 52 capital projects that would begin to address major neighborhood drainage problems, to be financed by a $25 million bond issue. Court delays from challenges to the new drainage user fee delayed implementation of capital program drainage projects for more than 3 years. However, MSD completed nearly $2.5 million in small, neighborhood "mini" drainage projects in its first 4 years, resolving nearly 22,000 requests. Approximately 8,000 of the more difficult larger projects had to wait until additional funding could be secured.

By early 1991, MSD had identified more than 100 areas that needed major construction projects to deal with their drainage problems. The initial $25 million bond had been designed to cover only 52 capital projects. In reality, the bond was only enough to cover 40 of the original 52 projects.

In January of 1993, MSD approved a revised list of more than 200 drainage projects, including the projects not constructed in the original 52, to be completed within the following 5 years and to be financed with $48 million in bonds that were paid for with an increase in the drainage fee from $1.75 to $2.75 per residential unit. The need for the rate increase was explained at 40 community meetings and six public hearings.

In 2003, Project DRI refocused much of the drainage program to deal with customer requests, many of which focus on standing water and simple, localized solutions. This program has been highly successful for handling minor drainage requests, but it does not resolve large-scale problems that require planning at a watershed level.

In the last 15 years, MSD has completed several capital projects, including both conveyance and basin projects, including the recently completed Aluma Basin in the Pond Creek watershed. However, the capital program is not currently being driven by any previous comprehensive master planning efforts, including the 2010 update to the 1988 master plan document. The 2010 effort focused on floodplain delineation efforts for CRS compliance, as well as documenting existing watershed conditions and ongoing projects. No comprehensive planning was performed by the 2010 update; therefore, no future capital projects were identified. In the years since the original master plan was written in 1988, land use patterns changed, impervious surface greatly increased, extreme storm events occurred with increased frequency, and customers demanded a higher level of service. Recent heavy rains have highlighted the problem of flood-prone areas inside the floodwall.

The probability that the existing stormwater infrastructure cannot provide protection from the 10-percent chance storm has increased in the past 15 years due to the lack of major stormwater capital planning and the increased frequency of extreme events (see Section ES.5). The recommended master planning effort will help bridge that gap. Stormwater should be managed on a watershed-by-watershed basis. This can be achieved through development of individual stormwater watershed master plans. These plans document the area's hydrological, physiographical, and drainage characteristics, as well as planning tools pertinent to managing stormwater in each of the watersheds. Most of this information is in the updated 2010 master plan. However, it should be reviewed and updated, if necessary, for today's conditions.

Using documented information within the context of various policies, goals, and objectives established for the stormwater master plan, specific action plans are recommended to be developed for each watershed. These action plans would then set forth recommended regional projects, special regulations for development, and the requirements for further updating and upgrading the planning data models. The recommended goals and objectives of the proposed comprehensive stormwater master plan are as follow:

- Establish minimum levels of protection for MSD's drainage service area, based on rainfall intensity, duration, and frequency projections anticipated to occur at the end of the planning period.
- Maintain an up-to-date inventory of the stormwater infrastructure, including identified deficiencies.
- Prepare a process to develop annual ratings of stormwater facilities by comparing present conditions with established standards and desired levels of service.

- Establish a methodology to review technical standards and design criteria for stormwater facilities within the MSD drainage service area, at least once every 5 years.
- Identify projects to design and construct stormwater facilities to conform to adopted design criteria and standards.
- Update rainfall and discharge data for watersheds and sub-basins to enhance knowledge of the existing drainage system through calibrated hydrological and hydraulic simulation models.
- Look for opportunities to integrate green infrastructure into the planning of all MSD drainage projects to help support and enhance the objectives of the MS4 Program. Simple water quality retrofits where appropriate in sensitive watersheds should always be looked into.
- Ensure content is consistent with elements identified in the U.S. Environmental Protection Agency's (EPA's) *Community Solutions for Stormwater Management: A Guide for Voluntary Long-Term Planning* (EPA, 2016a)

More information on the comprehensive stormwater master planning can be found in Chapter 3, Section 3.1.

ES.3.2 Viaduct Flooding Mitigation Projects

MSD is responsible for managing drainage from 32 viaducts that are subject to flooding during storm events. Some viaducts become completely impassable in relatively minor storms. Viaduct flooding disrupts transportation routes and creates potential hazardous conditions if flooded roads are not barricaded in a timely manner, or if drivers ignore the barricades and drive under the viaducts anyway. Nearly all the viaducts are connected to the combined sewer system, thereby adding to the complexity of the solutions. The Facility Plan team has identified conceptual drainage solutions for each viaduct for which MSD manages stormwater. The projects were prioritized based on the team's understanding of traffic load and perceived risk to public health and safety. Because the viaducts are a shared responsibility with Louisville Metro Public Works and KYTC, before initiating a costly viaduct drainage solution, all parties should work together to determine the best approach to improving public safety. Reducing the flooding potential at these viaducts will not be a simple task and will require a holistic approach. Most viaducts will require relatively complex solutions, potentially including large off-site storage basins (with associated land acquisitions), pumps, and/or revised transportation alignments to address the issues. More information on the viaduct flooding mitigation projects can be found in Chapter 3, Section 3.2.

ES.3.3 Community Rating System

In 2012, Louisville MSD's National Flood Insurance Program (NFIP) CRS status improved from Class 5 to Class 4. The community's Class 4 CRS rating qualified it for a 30-percent discount on flood insurance premiums for NFIP policies issued or renewed in Special Flood Hazard Areas (SFHA). The rate applied to all new policies and policies renewed on or after May 1, 2012, but only to properties located in an SFHA. To obtain the improved classification, MSD documented improved floodplain management practices to increase its CRS credit points from 3,017 to 3,316, as well as met the criteria required for a Class 4 community.

Since then, MSD's CRS classification has again improved. On June 12, 2015, the Insurance Services Office issued a much anticipated letter to MSD, indicating MSD had acquired the 3,503 credit points needed to move up to a CRS Class 3 community. This reclassification provides a 35 percent discount on flood insurance premiums for Louisville and Jefferson County residents located in SFHAs. The effective date for this discount was October 1, 2015. MSD earned the Class 3 rating through their comprehensive floodplain management program, which includes outreach, flood protection assistance, hazard disclosure, enhanced mapping, flood mitigation, drainage maintenance, and flood warning program. These programs and activities go beyond the minimum requirements to provide service to the community. In this respect, MSD is among the top communities in the country for the CRS program.

As MSD moves forward, the potential for moving to a higher CRS classification should again be evaluated. A Class 2 CRS community rating would entitle MSD's customers located in SFHAs to an additional 5 percent discount on their flood insurance premiums. This new discount rate of 40 percent would reduce the annual premium paid by each individual flood insurance policyholder located in an SFHA by $71 per year, as compared to the 35 percent discount rate. This reduction in premium would result in an additional combined annual savings of $277,965 for the 3,915 SFHA flood insurance policyholders.

MSD has indicated the desire to continue to stand out as a model CRS community. To reach this goal, MSD would need to obtain the highest practical CRS rating. Based on requirements, both practical and economical, the highest CRS community rating MSD can obtain is Class 2. To obtain a Class 2 CRS rating, MSD would be required to earn a total of 4,000 CRS credit points, which is an increase of about 500 points. Louisville Metro also must maintain a Building Code Effectiveness Grading Schedule of 4/4 or better for MSD to be eligible for Class 2.

The highest CRS community rating is Class 1. This classification would reduce the flood insurance premiums paid by all policyholders located in an SFHA by a final additional 5 percent, to the maximum allowable reduction of 45 percent. Communication with MSD personnel indicates that moving from a Class 2 to a Class 1 community would not be a cost-effective option for the community. The *National Flood Insurance Program Community Rating System Coordinator's Manual* (Federal Emergency Management Agency [FEMA], 2014) has specific prerequisites that a community must meet before obtaining Class 1 status. These prerequisites include the following:

- Meet all of the Class 4 prerequisites.
- Meet the minimum standards of the NFIP, as determined by a community assistance visit conducted by FEMA within the previous 12 months.
- Promote flood insurance as a vital way to protect residents and business from the financial impact of a flood. This is demonstrated by obtaining at least 50 percent of the maximum points under Activity 370.
- Demonstrate that the community has a "no adverse impact" approach to floodplain management.
- Mitigate repetitive loss problems and problems caused by other natural hazards.
- Protect natural floodplain functions.

- Develop a program that addresses the threat to life that flooding poses to the residents of the community.

MSD has completed the requirements defined by the first three prerequisites. As previously mentioned, MSD has indicated that the costs associated with pursuing the Class 1 community status are considerably higher than the 5-percent premium savings provided by the Class 1 rating. Item 5 requires that MSD demonstrate that at least 25 percent of its repetitive loss properties have been protected from flood damage. This mitigation can be accomplished by acquisition, retrofitting, or structural flood control projects. MSD has removed approximately 46 repetitive loss properties to date through acquisition. To date, MSD has mitigated approximately 11 percent of the flood loss properties. With each new flood, the number of repetitive loss properties continues to increase within the community. The cost associated with mitigating these properties with MSD funds is far more than the premium savings benefit derived from a Class 1 status. More information on the CRS can be found in Chapter 3, Section 3.3.

ES.4 MUNICIPAL SEPARATE STORM SEWER SYSTEM PROGRAM

An MS4 is a conveyance or system of conveyances that meets the following criteria:

- Owned by a state, city, town, village, or other public entity that discharges to waters of the U.S.
- Designed or used to collect or convey stormwater (for example, storm drains, pipes, ditches)
- Not a combined sewer
- Not part of a sewage treatment plant or publicly owned treatment works.

MSD began comprehensive water quality monitoring of local streams in collaboration with the U.S. Geological Survey in 1988. When the MS4 Kentucky Pollutant Discharge Elimination System permitting program began in the early 1990s, Louisville was the first Phase 1 MS4 permit issued in the Commonwealth of Kentucky. The mission of MSD's MS4 program is to enhance stormwater runoff quality and protect streams and riparian habitat to promote public health, safety, and welfare in compliance with state and federal requirements.

MSD, along with co-permittees Louisville Metro and the cities of Anchorage, Jeffersontown, St. Matthews, and Shively, is the lead agency performing these activities for Jefferson County. The requirements of the MS4 Program relate to public involvement and outreach, illicit discharges, industrial users, construction site runoff controls, post-construction runoff controls, pollution prevention and good housekeeping activities and monitoring and reporting requirements. Some MS4 Program activities are performed independently by the permittees, and others are performed cooperatively. The required components of the program continue to be integrated into the various aspects of MSD's work in the community, as well as into many aspects of the co-permittee operations including provisions for stormwater runoff pollution prevention, stream protection and restoration, and additional water quality or "green infrastructure" techniques to enhance stream corridors and reduce runoff volume and pollutants of concern.

Along with MSD, each co-permittee continually work to improve the water quality of local streams. Throughout each 5-year permit cycle, MSD and the co-permittees enhance and improve the MS4

Program planning and activities, regulatory authority, and environmental education programs to comply with the changing requirements of the permit.

ES.4.1 Impact of Future Regulations

In recent years, the EPA has been evaluating the potential to promulgate updated stormwater management regulations. According to the EPA website,[1] starting in December 2009, EPA began soliciting stakeholder input on the key issues that would be considered in a new rulemaking process, including the following:

- Expanding the universe of regulated discharges beyond the urbanized area
- Establishing substantive post-construction requirements for new development and redevelopment
- Developing a single set of requirements for Phase I and Phase II communities
- Addressing stormwater discharges from existing development through retrofitting

Two of these issues, the post-construction and retrofitting (that is, enhancing existing impervious surfaces and/or stormwater controls) requirements, could pose significant challenges for MSD. For example, one approach proposed by EPA was a new post-construction discharge standard that requires the matching of pre- and post-development hydrology (that is, peak flow and volume) for smaller storm events. Current MSD regulations require treating and storing the water quality event (0.6 inch in the MS4 Program area) and storing the 50-percent chance (2-year) storm (3.2 inches), but nothing in-between. A requirement to retain any additional post-development runoff volume on site represents a difficult and, in many instances, unachievable standard to attain, particularly for areas with poor draining soils. This requirement could impact the local economy by increasing the costs and feasibility to develop land. Location of developments could be impacted because it would be easier to meet the requirement in areas of the community with well-draining soils.

Additionally, EPA's proposal to consider a requirement to retrofit existing urbanized areas using stormwater can be very expensive depending on the level of retrofitting and pollutant reduction that is required.

Example permit regulations in the Chesapeake Bay area, Washington, D.C. area, and Massachusetts were evaluated, and the results are summarized in Chapter 4. These regulations and available cost information represent the upper threshold of what the permit could eventually lead to in Jefferson County. However, for the next 20 years, the Facility Plan Team believes that Nashville, Tennessee, and Indianapolis, Indiana, represent more realistic cost models to follow for budgeting purposes. The average annual total future escalated cost based on the Nashville and Indianapolis projections is $2 million for each of the next 5 years and $6.5 million annually for the following 15 years.

Key issues included in these permits cover retrofit requirements with specific implementation levels, maximum extent practicable (MEP) versus water quality based effluent limits, and other provisions that appear to stray from what is actually required in the federal rule. MSD is fortunate in that their current

[1] https://www3.epa.gov/npdes/outreach_files/webcast/feb020310/187267/final_sw_rulemaking.pdf

permit, in reference to the Stormwater Quality Management Program states: "The tables and requirements included in this part of the permit represent MEP." If MSD continues to implement their Stormwater Quality Management Program as outlined in the permit, and if they work with KDOW to ensure this language remains in subsequent permits, then the program will be well structured from an MEP perspective. However, as more receiving streams receive total maximum daily loads (TMDLs), the required activities could become more costly and the extent of controls required may be a significant item in future permit negotiations and/or implementation. Ensuring TMDLs are based on sound science and are not structured in a way that places an undue burden on MSD, as the MS4 permittee, with an unachievable endpoint is important. Additionally, antidegradation requirements will need to be defined with regulators to effectively implement future permits while balancing a community's economic and social considerations. However, while the current trend toward more stringent requirements on MS4 Program discharges is noteworthy, EPA is also discussing and/or promoting concepts such as water quality trading, integrated planning, and watershed permitting as strategies and mechanisms to potentially achieve water quality objectives more cost effectively than traditional end-of-pipe point source focused approaches.

ES.4.2 Municipal Separate Storm Sewer System Next Steps

Maps and tables compile relevant watershed information including water quality, floodplain, combined sewer overflows, and planned and completed stormwater-related projects within each of MSD's 11 watersheds. However, other endeavors are potentially being implemented by MSD, other City or County agencies, community groups, and private organizations that impact the quality and quantity of stormwater runoff or that target overall improvement to local water quality. MSD is recommended to continue to track and document these efforts within each watershed. Additionally, as stormwater projects are planned and implemented, coordinating and leveraging other stakeholder projects to enhance the overall water quality benefit and potentially reduce costs for MSD and its ratepayers.

In addition to coordinating efforts within MSD's watersheds to enhance the overall water quality impact, it is recommended that MSD continue to monitor the status of any future EPA rulemaking and take steps to engage in the dialogue on proposed revisions to the current rule. As a large MS4 Program, MSD's voice can help ensure future permit requirements are reasonable and achievable. Potential cost implications have been projected for anticipated regulatory changes in this area but the timing of those changes is uncertain. It is recommended to plan for a smaller cost for now and adjust future budgets as the regulatory schedule becomes more certain.

Involvement includes participating early on in the development of future TMDLs to ensure that these evaluations are technically sound, based on adequate and representative data and generate practical and achievable allocations. As part of the next step for this effort, MSD is recommended to perform a conceptual-level evaluation to determine the technical feasibility and costs of achieving the wasteload allocation identified in the approved TMDL for fecal coliform for the South Fork Beargrass Creek. The effort would include a theoretical desktop analysis of best management practices implementation with the goal of determining the distribution and types of projects best suited to meet the wasteload allocation reduction based on land use, the TMDL parameters, and other existing watershed conditions. The outcome of this analysis will provide MSD with a better understanding of the feasibility of implementing a program to meet current and future TMDL requirements.

Additionally, the KDOW is currently initiating a nutrient rulemaking process. If MSD joins in this dialogue, then it can represent MS4 Program interests in the deliberations. Although there has been and continues to be a national discussion regarding the impact of nutrient criteria on the wastewater industry, MS4 Program permittees are bearing a considerable amount of the financial burden associated with proposed nutrient reduction requirements. More information on the municipal separate storm sewer system next steps can be found in Chapter 4, Section 4.2.3.

ES.5 INCREASED FREQUENCY OF EXTREME EVENTS

This analysis focuses on the impacts of the increased frequency of extreme events and how MSD should prepare for these conditions over the next 20 years. It documents the impacts on the rainfall rates and depths used by designers that define the level of service of current MSD practices. The level of service provided to MSD's customers is defined by return intervals of rainfall, both in frequency and depth. A significant and long-term change in precipitation intensity, duration, and frequency could affect current stormwater and drainage infrastructure. This analysis also documents the effects on the mapped floodplains.

ES.5.1 Level of Service Summary

Rainfall amounts and rates are different today than 50 years ago, and they are trending upward. The rainfall used to define the return interval used by MSD to provide a level of service to its ratepayers needs to be reviewed and updated periodically, every decade or so. The Louisville area has seen a significant increase in both depth and intensity of rainfall events from years 2000 through 2014. Figure ES-4 supports this statement. Currently MSD standard is to us TP-40 rainfall amounts from 1961.

Over time, there is a clear trend for rainfall depth to increase for storms with longer recurrence intervals as more data, and more accurate data, are collected and analyzed. The net result of this effect is a diminished level of protection against flood events. Infrastructure sized to provide a certain level of protection based on information in the National Oceanic and Atmospheric Administration (NOAA) Technical Paper 40 (TP-40; NOAA, 1961) would not be able to perform as expected when updated storm information is applied. For example, infrastructure sized to manage a 1-percent annual chance (100-year), 24-hour storm as defined by TP-40 would only be able to manage a 4-percent annual chance (25-year) to 2-percent annual chance (50-year), 24-hour storm as defined by the updated Atlas 14; thus, the actual level of protection infrastructure can provide would be less than what had been planned.

Rainfall depths and intensity define return intervals that MSD uses to provide a level of service to the ratepayer. When rainfall amounts and intensities increase, the frequency of the same event happening also increases, and thus, the level of service decreases for existing facilities. Even new facilities that are being constructed and rehabilitation projects to existing facilities are immediately underperforming the expected level of service because of use of rainfall amounts published in 1961 (TP-40).

Although rainfall depth for the 10-percent annual chance (10-year) storm did not increase significantly, the rainfall intensity did. This leads to the under-sizing of the small-scale (neighborhood-level) conveyance systems and could lead to problems ranging from nuisance flooding to road flooding to structural flooding, depending on the circumstances. The larger storms (1 percent annual chance storm, commonly referred to as the 100-year storm) increased significantly, both in depth and intensity. Rainfall depths are used primarily for storage modeling and floodplain modeling. Therefore, the 1 percent annual chance (100-year) storm depth has a huge impact on how storage basins perform and how floodplains are defined. More information on the level of service can be found in Chapter 5, Section 5.2.

ES.5.2 Level of Service Recommendations

MSD should revise the rainfall amounts that define the return intervals used for the design of stormwater conveyance and storage systems and for floodplain definitions. The recommended minimum would be the 2035 projections, which provide for a 20-year planning window. Even using these numbers, design criteria should be tightened by using larger freeboard levels to account for the expected increases for the following 30 years (2065 rainfall projections). For example, given today's standards, storm sewers are designed for 100 percent full flow during the 10-year storm event. This should be revised to 80 percent full flow to allow for some freeboard and to address the increasing rainfall amounts. This freeboard will not account for all expected 2065 forecast rainfall amounts, but it is a start in the right direction. Also, as previously stated, rainfall statistics should be revisited on a periodic basis because of the dynamic nature of the current climate conditions.

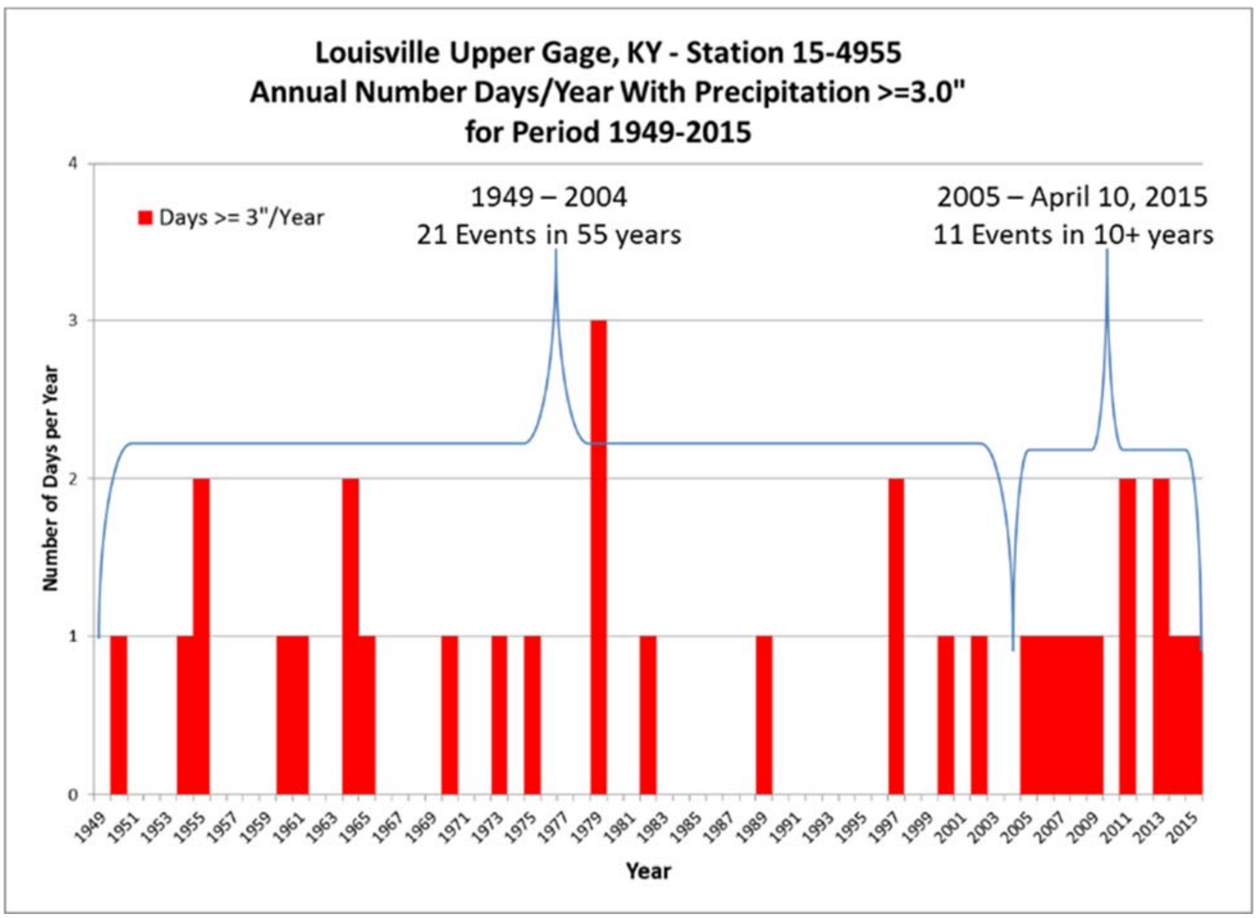

Figure ES-4. Rainfall Trends 1949 to 2015

While changing design standards for new facilities and projects is relatively easy, it is more difficult to retrofit existing infrastructure to meet the level of service for which it was intended to be designed. For these areas, which encompasses nearly all of MSD's service area, projects should be planned to address problem areas where the runoff from large events overwhelms the existing conveyance systems and runs unabated through neighborhoods and commercial areas. Although it is cost-prohibitive to dig up and replace every pipe and ditch in the MSD service area, the focus should be on conveyance of the large (1-percent chance) storm events—it should have a safe path to travel without endangering lives or causing structural flooding. These will likely be the retrofit projects of the future—making sure runoff from the larger storms has a defined place to go without causing loss of life or significant damage.

In summary, the recommended changes are as follows:

1. Keep the return intervals used for designing new and rehabilitation projects as they are. This represents the common practice in the industry and should be adequate, assuming the intervals are defined with accurate and up-to-date rainfall statistical analysis.
2. Update the rainfall depths and intensities used to define the return intervals,using the 2035 rainfall projections.
3. Increase freeboard requirements to account for the upward trend in rainfall amounts. Large storm events (1-percent chance to 0.2-percent chance storm [100- to 500-year return intervals]) should be checked to ensure the overflow has a safe route in which to be conveyed that does not lead to structure flooding or increased potential for loss of life.
4. Review rainfall statistics at least every 10 years and update accordingly.
5. Increase the width of new easements to ensure the projected 2035 1-percent chance (100-year) storm stays within the easement limits.
6. Look for ways to retrofit existing neighborhoods without replacing entire systems so that the larger storms have a safe path to travel.

More information on the level of service summary, conclusions, and recommendations can be found in Chapter 5, Section 5.2.4.

ES.5.3 Floodplain Impacts Summary

If the current flood maps are not adjusted for the updated rainfall amounts, then property owners may not be fully aware of current and future risks they face about structure flooding. As shown in this volume, Chapter 5, Tables 3.5-15 and 3.5-16, buyouts or the projects they represent would require perhaps prohibitive investments of dollars over significant periods of time. However, by continuing to enforce the existing local regulatory Floodplain Management Ordinance when new development is proposed in or near existing floodplains, MSD has reduced the potential for future damages. In the existing Ordinance, buildings must be elevated to a point 1 foot above the local regulatory floodplain. This floodplain, while still based on 6.2 inches (TP-40, 1961 data) of rain over a 24-hour period, is calculated based on a fully developed watershed condition, so the projected surface elevations are somewhat conservative. In summary, the recommended changes are:

- To convey to the public the possible risk of future floods because of increased rainfall, the local regulatory floodplain should be calculated to the projected 2035 year level (from the current

6.2 inches to 8.4 inches in 2035) in each watershed. This calculation would show property owners the risk of flooding outside the already mapped SFHA floodplains so they can decide whether or not to purchase flood insurance. The purchase of this flood insurance in these areas would not be mandatory. This also would communicate the risk to the public with respect to real estate transactions. It should also be noted that the Local Regulatory Floodplain (LRF) has implications on the repetitive loss definition as in the Jefferson County Floodplain Management Ordinance.

- MSD should calculate new conveyance zones based on the projected 2035 floodplain and strictly enforce the "no development rule" inside of these conveyance zones.
- MSD should consider requesting a first right to purchase from people selling their home in the LRF. This purchase would be contingent upon the degree and severity of flooding. Because it is not feasible to buyout all floodplain structures in Jefferson County at one time, a Flood Mitigation Response Fund should be established and funded annually at $4 million per year. This funding will go toward floodplain buyouts, future maintenance of the purchased property, local matches for grants after a major flooding event occurs, and annual grant programs that support purchasing and removing homes from the floodplain.
- Rainfall data and floodplain mapping should be reviewed at least every 10 years to ensure that the current flood maps accurately portray the real risk to the community. This new policy should be written in such a way as to make the review mandatory.
- Review floodplain definitions in context of the new Executive Order 13690.

More information on floodplain impacts can be found in Chapter 5, Section 5.3.

ES.6 RECOMMENDED PROJECTS

The basis for the recommended capital projects and other noncapital recommendations is provided in the condition assessment in Chapter 2, the gap analysis presented in Chapter 3, the MS4 analysis presented in Chapter 4, the analysis for the increased frequency of extreme events presented in Chapter 5, and the project development in Chapter 6. The recommendations are divided between capital projects and design/policy recommendations (noncapital recommendations).

ES.6.1 Noncapital Recommendations

Table ES-4 lists all the noncapital recommendations made throughout Volume 3.

ES.6.2 Capital Recommendations

The capital projects include annual budgetary considerations for various programs and traditional capital engineering projects in specific locations.

ES.6.2.1 Annual Budgetary Line Item Recommendations

Following are line items in the capital improvement program that are nontraditional engineering projects. These are not stand-alone design-bid-build construction projects, but rather they represent items that should be funded on an annual basis; more information on these items can be found in Chapter 6, Section 6.7:

- Floodprone Area Buyouts ("Flood Response Fund")
- Stormwater Master Plan
- Drainage Response Initiative Budgeting
- MS4 Program

Table ES-4. Noncapital Stormwater and Drainage Recommendations

Recommendation Number	Description	Volume Location
3.1	Have future O&M budgets consider that parts of the existing stormwater system are more than 100 years old, and examination of work order trends shows that the number of work orders increase with asset age for all assets studied. Reference Volume 1, Chapter 7 for more information on recommended O&M cost.	Chapter 2, Section 2.6
3.2	Enhance the high-hazard dams with continuation of the dam breach analysis project, continue to update EAPs, and consider installing dam monitoring and public warning systems.	Chapter 2, Section 2.5.3
3.3	Continue to support activities that maintain and possibly increase the CRS rating.	Chapter 3, Section 3.2
3.4	Continue to track and document relevant watershed information including water quality, floodplain, combined sewer overflows), and planned and completed stormwater-related projects within each of MSD's 11 watersheds.	Chapter 4, Section 4.2.3
3.5	Continue to monitor the status of any future EPA rulemaking, and take steps to engage in the dialogue on proposed revisions to the current rule.	Chapter 4, Section 4.2.3
3.6	Perform a conceptual-level evaluation to determine the technical feasibility and costs of achieving the wasteload allocation identified in the approved TMDL for fecal coliform for the South Fork Beargrass Creek. The effort would include a theoretical desktop analysis of best management practices implementation with the goal of determining the distribution and types of projects best suited to meet the wasteload allocation reduction based on land use, the TMDL parameters, and other existing watershed conditions.	Chapter 4, Section 4.2.3
3.7	Join KDOW with their current effort to initiate a nutrient rulemaking process so the process can represent MS4 Program interests in the deliberations.	Chapter 4, Section 4.2.3
3.8	Keep the return intervals used for designing new and rehabilitation projects as they are. This represents the common practice in the industry and should be adequate, assuming the intervals are defined with accurate and up-to-date rainfall statistical analysis.	Chapter 5, Section 5.2.4.2

Table ES-4. Noncapital Stormwater and Drainage Recommendations

Recommendation Number	Description	Volume Location
3.9	Update the rainfall depths and intensities used to define the return intervals by using the 2035 rainfall projections.	Chapter 5, Section 5.2.4.2
3.10	Increase freeboard requirements to account for the upward trend in rainfall amounts. Large storm events (100- to 500-year return intervals) should be checked to ensure the overflow has a safe route in which to be conveyed that does not lead to structure flooding or increased potential for loss of life.	Chapter 5, Section 5.2.4.2
3.11	Design new storm sewers for a maximum 80-percent full flow, instead of the current 100-percent full flow, leaving some freeboard for future capacity.	Chapter 5, Section 5.2.4.2
3.12	Review rainfall statistics at least every 10 years and update accordingly.	Chapter 5, Section 5.2.4.2
3.13	Increase the width of new easements to ensure the projected 2035 1-percent chance (100-year) storm stays within the easement limits.	Chapter 5, Section 5.2.4.2
3.14	To convey to the public the possible risk of future floods because of the increased rainfall, calculate the local regulatory floodplain to the projected 2035-year level (from the current 6.2 inches to 8.4 inches in 2035) in each watershed. These new flood maps would show property owners the risk of flooding outside the already mapped SFHA floodplains so they can decide whether to purchase flood insurance. Purchasing this flood insurance in these areas would not be mandatory. This also would communicate the risk to the public with respect to real estate transactions.	Chapter 5, Section 5.3.8
3.15	Calculate new conveyance zones based on the projected 2035 floodplain and strictly enforce the “no development rule” inside these conveyance zones.	Chapter 5, Section 5.3.8
3.16	Consider a first right to purchase from people selling their home in the LRF. This purchase would be contingent upon the degree and severity of flooding.	Chapter 5, Section 5.3.8
3.17	Review floodplain mapping at least every 10 years to ensure the current flood maps portray the real risk to the community. This new policy should be written in such a way as to make it the review mandatory.	Chapter 5, Section 5.3.8
3.18	Review floodplain definitions in context of the new Executive Order 13690.	Chapter 5, Section 5.3.8

ES.6.2.2 Early Action Projects

As documented in Volume 3, Chapter 3, a comprehensive stormwater master plan needs to be completed to identify and prioritize areas that need stormwater infrastructure upgrades and improvements. This plan will take some time to put together. However, in the interim, ten early action project areas have been identified that some improvements may be designed and constructed while the master planning is being performed if funding is available. Planning-level cost have been calculated to achieve a 10-percent annual chance (10-year) level of service in these ten areas; four of these areas were included due to extreme storm events that hit neighborhoods during spring and summer 2015. These four areas, along with the other six areas that were carefully screened as poor drainage areas, will make up an early action project that MSD could implement while the comprehensive stormwater master plan is being crafted. The four areas that were included due to the 2015 extreme storm events were studied and determined to contain worthwhile drainage improvement projects. At least one of these areas previously rejected a solution and proposed improvements may not be acceptable. These studies and associated cost estimates were developed outside of the Facility Plan Team. However, as described herein, the projects are a part of the stormwater early action project and the overall 20-year facility plan recommendations. The early action projects may only include the first phase of a larger improvements program.

The other six areas will be referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These sample areas do not represent the worst drainage areas in the County, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains, since floodplain issues are their own complex problem in and of themselves, and were examined separately in the *Project Summary Report: Countywide Flooding Prioritization* (PRIME AE Group. 2016b). The following is a list the 10 study areas included in the early action projects. These projects and their associated cost are shown in Table ES-5.

- Pope Lick—Pilot Area
- Seatonville—Pilot Area
- Whispering Hills—Pilot Area
- Newburg—Pilot Area
- Auburndale—Pilot Area
- Valley Creek—Pilot Area
- City of Prospect—Extreme Storm Event Area
- City of Hurstbourne—Extreme Storm Event Area
- Ten Broeck—Extreme Storm Event Area
- Richland—Extreme Storm Event Area

More information on the early action projects can be found in Chapter 6, Section 6.2.

ES.6.2.3 Viaduct Flood Relief Projects

Table ES-5 includes the individual viaduct flood relief projects identified from Chapter 3, Section 3.2, which should be referenced for a complete description of how these projects were planned. Note that the cost associated with these projects are planning-level numbers; detailed preliminary engineering would need to be performed to get a more accurate cost for each site.

ES.6.2.4 Basin Retrofit Projects

The purpose of the basin retrofit projects is to modify the outlet structures and the materials in the bottom of the basins so that it will promote infiltration of at least the first flush of stormwater runoff. These projects are listed below and also more completely in Table ES-5; More information on the basin retrofit projects can be found in Chapter 6, Section 6.7.4.

- Gerald Court Basin Retrofit
- Downing Way Basin Retrofit
- Woodlawn Park Basin Retrofit
- Hikes Lane Basin Retrofit
- Richland Ave Basin Retrofit
- Breckenridge Lane Basin Retrofit
- Fountain Square Basin Retrofit
- Old Shepherdsville Rd Basin Retrofit

Table ES-5. Recommended Projects

Project	Project Start Year	FY17 to FY21	FY22 to FY26	FY27 to FY31	FY32 to FY36	20-Year Total	Budget ID
MS4 Program	2017	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$40,000,000	X_0067 and Various
DRI	2017	$20,000,000	$25,000,000	$25,000,000	$25,000,000	$95,000,000	X_0316
Flood Response (Buy-outs, Mitigation and Grants)	2017	$17,500,000	$20,000,000	$20,000,000	$20,000,000	$77,500,000	X_0024
Stormwater Master Plan	2017	$4,000,000	$0	$0	$0	$4,000,000	X_0027
Richlawn Early Action Project	2017	$350,000	$0	$0	$0	$350,000	X_0105
Whispering Hills Early Action Project	2018	$3,200,000	$0	$0	$0	$3,200,000	X_0101
Seatonville Road Early Action Project	2018	$3,400,000	$0	$0	$0	$3,400,000	X_0099
VIA11 East Brandeis Avenue and Brook Street Viaduct Flood Relief	2018	$28,040,000	$0	$0	$0	$28,040,000	X_0144
Master Plan Implementation (Projects to be Defined)	2019	$16,000,000	$184,000,000	$200,000,000	$200,000,000	$600,000,000	X_0028
Ten Broeck Way Early Action Project	2019	$4,000,000	$0	$0	$0	$4,000,000	X_0102
Pope Lick Early Action Project	2019	$6,100,000	$0	$0	$0	$6,100,000	X_0096
Prospect Early Action Project	2019	$7,000,000	$0	$0	$0	$7,000,000	X_0103
City of Hurstbourne Early Action Project	2019	$11,000,000	$0	$0	$0	$11,000,000	X_0104
Valley Creek Early Action Project	2020	$9,700,000	$0	$0	$0	$9,700,000	X_0100

Table ES-5. Recommended Projects

Project	Project Start Year	FY17 to FY21	FY22 to FY26	FY27 to FY31	FY32 to FY36	20-Year Total	Budget ID
Auburndale Early Action Project	2020	$12,600,000	$0	$0	$0	$12,600,000	X_0098
VIA16 3rd Street and Eastern Parkway Viaduct Flood Relief	2020	$15,000,000	$14,910,000	$0	$0	$29,910,000	X_0145
Newburg Road Early Action Project	2021	$20,500,000	$0	$0	$0	$20,500,000	X_0097
VIA10 Floyd Street and Hill Street Viaduct Flood Relief	2021	$5,610,000	$22,430,000	$0	$0	$28,040,000	X_0143
VIA17 4th Street and Industry Road Viaduct Flood Relief	2021	$500,000	$29,410,000	$0	$0	$29,910,000	X_0146
Gerald Court Basin Retrofit	2022	$0	$70,000	$0	$0	$70,000	X_0106
Downing Way Basin Retrofit	2022	$0	$120,000	$0	$0	$120,000	X_0107
Woodlawn Park Basin Retrofit	2022	$0	$150,000	$0	$0	$150,000	X_0108
Breckenridge Lane Basin Retrofit	2022	$0	$230,000	$0	$0	$230,000	X_0111
Richland Avenue Basin Retrofit	2022	$0	$220,000	$0	$0	$220,000	X_0110
Hikes Lane Basin Retrofit	2022	$0	$210,000	$0	$0	$210,000	X_0109
Fountain Square Basin Retrofit	2022	$0	$230,000	$0	$0	$230,000	X_0112
Old Shepherdsville Road Basin Retrofit	2022	$0	$260,000	$0	$0	$260,000	X_0113
VIA28 South 15h Street and West Broadway Viaduct Flood Relief	2022	$0	$3,870,000	$0	$0	$3,870,000	X_0119

Table ES-5. Recommended Projects

Project	Project Start Year	FY17 to FY21	FY22 to FY26	FY27 to FY31	FY32 to FY36	20-Year Total	Budget ID
VIA09 6th Street and Hill Street Viaduct Flood Relief	2022	$0	$3,980,000	$0	$0	$3,980,000	X_0121
VIA22 22nd Street and Standard Avenue Viaduct Flood Relief	2022	$0	$3,800,000	$0	$0	$3,800,000	X_0117
VIA32 3rd Street and Winkler Avenue Viaduct Flood Relief	2022	$0	$29,910,000	$0	$0	$29,910,000	X_0147
VIA27 South 15th Street and West Chestnut Street Viaduct Flood Relief	2027	$0	$0	$3,860,000	$0	$3,860,000	X_0118
VIA12 South 8th Street and West Oak Street Viaduct Flood Relief	2027	$0	$0	$3,990,000	$0	$3,990,000	X_0122
VIA13 South 13th Street and West Hill Street Viaduct Flood Relief	2027	$0	$0	$4,090,000	$0	$4,090,000	X_0126
VIA14 South 31st Street and West Broadway Viaduct Flood Relief	2027	$0	$0	$4,600,000	$0	$4,600,000	X_0130
VIA29 13th Street and Maple Street Viaduct Flood Relief	2027	$0	$0	$3,760,000	$0	$3,760,000	X_0114
VIA30 12th Street and Maple Street Viaduct Flood Relief	2027	$0	$0	$3,800,000	$0	$3,800,000	X_0115
VIA21 30th Street and Del Park Terrace Viaduct Flood Relief	2027	$0	$0	$4,000,000	$0	$4,000,000	X_0123

Table ES-5. Recommended Projects

Project	Project Start Year	FY17 to FY21	FY22 to FY26	FY27 to FY31	FY32 to FY36	20-Year Total	Budget ID
VIA06 30th Street and Bank Street Viaduct Flood Relief	2027	$0	$0	$4,260,000	$0	$4,260,000	X_0127
VIA20 31st Street and Vermont Avenue Viaduct Flood Relief	2027	$0	$0	$4,020,000	$0	$4,020,000	X_0124
VIA19 32nd Street and Muhammad Ali Boulevard Viaduct Flood Relief	2027	$0	$0	$6,720,000	$0	$6,720,000	X_0141
VIA33 Taylorsville Road and Merioneth Drive Viaduct Flood Relief	2032	$0	$0	$0	$4,390,000	$4,390,000	X_0129
VIA15 South 7th Street and West Magnolia Avenue Viaduct Flood Relief	2032	$0	$0	$0	$4,050,000	$4,050,000	X_0125
VIA26 7th Street and Davies Avenue Viaduct Flood Relief	2032	$0	$0	$0	$5,330,000	$5,330,000	X_0135
VIA23 Dixie Highway and Standard Avenue Viaduct Flood Relief	2032	$0	$0	$0	$5,350,000	$5,350,000	X_0136
VIA05 North 30th Street and Portland Avenue	2032	$0	$0	$0	$4,350,000	$4,350,000	X_0128
VIA01 13th Street and Market Street Viaduct Flood Relief	2032	$0	$0	$0	$5,020,000	$5,020,000	X_0131
VIA07 South 13th Street and West Jefferson Street Viaduct Flood Relief	2032	$0	$0	$0	$5,020,000	$5,020,000	X_0132

Table ES-5. Recommended Projects

Project	Project Start Year	FY17 to FY21	FY22 to FY26	FY27 to FY31	FY32 to FY36	20-Year Total	Budget ID
VIA24 South 15th Street and West Oak Street Viaduct Flood Relief	2032	$0	$0	$0	$5,290,000	$5,290,000	X_0133
VIA25 10th Street and West Hill Street Viaduct Flood Relief	2032	$0	$0	$0	$5,330,000	$5,330,000	X_0134
VIA03 13th Street and Main Street Viaduct Flood Relief	2032	$0	$0	$0	$5,370,000	$5,370,000	X_0137
VIA18 Eastern Parkway and Hahn Street Viaduct Flood Relief	2032	$0	$0	$0	$6,500,000	$6,500,000	X_0139
VIA04 13th and Muhammad Ali Boulevard Viaduct Flood Relief	2032	$0	$0	$0	$5,820,000	$5,820,000	X_0138
VIA02 32nd Street and Market Street Viaduct Flood Relief	2032	$0	$0	$0	$6,720,000	$6,720,000	X_0140
VIA08 16TH Street and Algonquin Parkway Viaduct Flood Relief	2032	$0	$0	$0	$16,825,536	$16,825,536	X_0142

FY Fiscal Year

VOLUME 3—STORMWATER AND DRAINAGE

CHAPTER 1 INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

The purpose of the 20-Year Comprehensive Facility Plan—Critical Repair and Reinvestment Plan (Facility Plan) is to consolidate and update the plans that Louisville and Jefferson County Metropolitan Sewer District (MSD) has prepared in the past, relative to wastewater, stormwater, and flood protection services. This volume of the report focuses on the interior stormwater and drainage. It does not include any discussions or analysis associated with protection of flooding because of the Ohio River. For information on Ohio River flooding and the associated infrastructure, refer to Volume 4.

1.1.1 History

MSD assumed the responsibility for most of Jefferson County's public stormwater drainage system in 1987. Five suburban cities decided to keep their own drainage programs: Anchorage, Jeffersontown, St. Matthews, Shively and Prospect. (MSD took over drainage responsibilities for Prospect in 2004.) MSD is not responsible for drainage in the right-of-way of most State-maintained roadways and some County through roads. MSD was not originally responsible for drainage in unincorporated areas, or farmlands, of the outer portions of the Jefferson County. These areas became part of MSD's responsibilities following the City/County merger in 2003.

Before 1987, drainage services were the shared responsibility of MSD, City of Louisville, Jefferson County Department of Public Works, Kentucky Transportation Cabinet (KYTC), the City of Jeffersontown, and numerous other agencies and groups. The Strategic Planning and Finance Committee, formed by MSD in 1984 and made up of citizens and elected officials charged with the role of evaluating long-standing environmental issues facing Louisville and Jefferson County, recommended in 1985 that MSD assume responsibility for county-wide drainage services. Having one agency in charge of drainage services allowed for regional planning, consolidated authority, and funding for adequate maintenance and correction of system deficiencies. Prior to the takeover, there was confusion regarding which agency was responsible for stormwater problems and inefficient response to emergencies, and the technical and funding coordination was not in place to resolve problems associated with multiagency responsibilities.

When MSD assumed drainage responsibility for most of the county, the agency also assumed responsibility for a large list of stormwater-related problems, some dating back to 1778 when the City was first established. The new drainage program began in 1987, with about 1,500 historical requests for drainage improvements from Louisville, Jefferson County, and MSD's own files. As the program began, these requests began to multiply—to a total of more than 14,000 in the first 6 months and to more than 30,000 in the first 4 years. Most requests involved maintenance problems—clogged catch basins, cave-ins, pipes, and ditches—that could be resolved relatively quickly. However, a significant number of requests would require new construction.

To begin to address the major drainage problems of the community, priorities were set for 52 of the most-needed drainage projects, to be financed by a $25 million bond issue. These areas were identified from the *1988 Stormwater Drainage Master Plan* (URS Corporation et al., 1988). This study also served as the framework to put in place a new drainage user fee based on impervious area on a property. Court delays from challenges to the new drainage user fee delayed implementation of the capital program for more than 3 years. MSD completed nearly $2.5 million in small, neighborhood "mini" drainage projects in its first 4 years, but the large projects had to wait until additional funding could be secured. By performing these "mini" drainage projects, MSD resolved nearly 22,000 requests in the first 4 years, leaving approximately 8,000 of the most difficult request to resolve.

By early 1991, MSD had identified more than 100 areas that needed major construction projects to deal with their drainage problems. The initial $25 million bond had been designed to cover only 52 capital projects. In reality, the $25 million bond was only enough to cover 40 of the original 52 projects. In January 1993, MSD approved a revised list of more than 200 drainage projects to be completed within the following 5 years, to be paid for with $48 million in bonds that were paid for with an increase in the drainage fee from $1.75 to $2.75 per residential unit. The need for the rate increase was explained at 40 community meetings and six public hearings. Most of the work for 100 priority areas was completed with needs that arose from the 1997 flood taking a higher priority.

In January 2003, MSD launched a highly successful program called Project Drainage Response Initiative (DRI). This program was developed after the 2003 general election as Mayor Jerry Abramson and Louisville Metro Council representatives looked for a way to respond more quickly to citizen's drainage concerns. Project DRI prioritizes drainage request, meets with property owners at their home to discuss the problem, triages the problem, develops solutions, and prioritizes the remedial work necessary to address the request. To date, it has been a highly successful program in the view of the community. However, while this program handles minor drainage request very well, it does not tackle large-scale drainage problems that involve planning at a watershed level. Quite often, these types of problems only surface after infrequent, intense rain events.

Outside of Project DRI, MSD has completed several drainage capital projects, including both conveyance and basin projects in the last 15 years, including the recently completed Aluma Basin in the Pond Creek Watershed. However, the drainage and internal floodplain management capital program is not currently being driven by any watershed-based comprehensive master planning efforts.

Over the years, the U.S. Army Corps of Engineers (USACE) has conducted several studies of flooding in the community. In the mid-1970s, a special study of the Beargrass Creek basin recommended a dry-bed reservoir on the South Fork near Houston Acres to relieve flooding downstream; the reservoir would hold water during heavy rains, then release it slowly afterward. Jefferson County built this reservoir as part of a major drainage program in the late 1970s. In 1989, a new study of the Pond Creek watershed (Pond Creek Feasibility Study) was authorized; MSD joined with the USACE in conducting it. In 1994, the study proposed $16.4 million in flood-control work, and in 1996, U.S. Congress appropriated the first $1.5 million to start detailed design. A feasibility study (USACE, 1997a and 1997b) of the South Fork of Beargrass Creek was started in 1994. The South Fork still had many problems during heavy rains, despite the improvements brought by the dry-bed reservoir. The South Fork Beargrass Creek Flood Protection project was initiated in 2001.

The project was a joint project between the USACE and MSD and included the construction of eight regional basins, ranging in size from 9 acre-feet to 160 acre-feet of storage, throughout the South Fork Watershed. The project also included 2,000 feet of channel improvement, 1,900 feet of floodwall around an apartment complex, and environmental features, such as construction of pools and riffles in the channels and planting 9 acres of bottomland hardwoods. This project intended to help relieve flooding in the South Fork Watershed. The basins are located near Bashford Manor, Breckenridge Lane, Downing Way, Fountain Square, Hikes Lane, Gerald Court, Richland Ave, and Old Shepherdsville Road.

In 1994, a reconnaissance study of southwest Louisville was initiated. However, USACE ultimately determined from the resulting feasibility analysis and study that projects could not be justified, under the USACE benefit/cost requirements (USACE, 2012).

The aforementioned *1988 Stormwater Drainage Master Plan* (URS Corporation et al., 1988) was updated in 2010. Because the update was basically a current snapshot of watershed existing conditions and ongoing projects, no comprehensive planning was performed by the 2010 update. In the years since the original master plan was written in 1988, land use patterns changed, impervious surface greatly increased, extreme storm events occurred with increased frequency, and customers demanded a higher level of service. Recent heavy rains have highlighted the problem of flood-prone areas inside the floodwall. In addition, drainage plans must consider water quality considerations as outlined in the Municipal Separate Storm Sewer System (MS4) Program for the County.

The mission of the MS4 Program is to enhance stormwater runoff quality and protect streams and riparian habitat to promote public health, safety, and welfare through a variety of program components. Since 1987, MSD has been held to requirements relating to public involvement and outreach, illicit discharges, industrial users, construction site runoff controls, post-construction runoff controls, pollution prevention and good housekeeping activities, and monitoring and reporting requirements. MSD, with several other co-permittees, is the lead agency performing these activities for Jefferson County.

The challenges still facing MSD with regards to stormwater are exacerbated by the County's geography. Some areas are previous swampland with little slope, while other areas are very hilly, which when combined with development, contributes to excessive streamflow and erosion. Much of the area within the old Louisville city limits is in the combined sewer system (CSS), and when the system reaches capacity, many places in this highly developed and urban area flood despite not being next to an open stream. This occurs because the CSS took the place of the original streams and ditches. This practice started in the 1800s and was not uncommon in major cities at the time. Development quickly occurred in these areas. However, because the pipes are not sized to handle large storm events, during intense rainfall events, the water leaves the CSS and travels overland where the creeks and ditches used to be. This causes major damage to homes and businesses in these areas.

1.1.2 20-Year Stormwater and Drainage Facility Planning Goals

This 20-Year Comprehensive Facility Plan reviews, consolidates, updates, and prioritizes the plans that MSD has prepared in the past relative to stormwater and drainage and determines whether additional projects are needed to meet the established goals. The rest of this volume inventories the previously planned projects, looks for gaps in that planning, adjusts the previously planned projects to deal with future requirements and rainfall, looks for any new projects or opportunities, and prioritizes the projects along with all other projects that will be coming out of the other service areas.

These activities will focus on stormwater quantity as well as stormwater quality. Regarding the current MS4 Program, the Facility Plan Team has looked towards the future and used their best engineering judgment, combined with examples from similar cities, to determine what is likely to represent what regulators may be looking for in future MS4 Program permitting.

1.2 STORMWATER AND DRAINAGE DOCUMENTS REVIEWED

The Facility Plan Team reviewed the following documents dated December 2015 or earlier for all pertinent information relevant to the stormwater and drainage service area:

- *MS4 Program Audit* (U.S. Environmental Protection Agency [EPA] and KDOW, 2013)
- National Flood Insurance Program (NFIP) Community Rating System Coordinator's Manual (Federal Emergency Management Agency [FEMA], 2014)
- Kentucky Pollutant Discharge Elimination System (KPDES) MS4 Program Permit KYS000001 (Kentucky Division of Water [KDOW], 2011)
- Louisville Metro Floodplain Management Ordinance (Louisville Metro, 2006)
- *Louisville Metro Multi-Hazard Mitigation Five-Year Action Plan* (Louisville-Jefferson County Metro Government [Louisville Metro], 2011)
- *Louisville Metro Hazard Mitigation Plan 2016 Update (*Louisville Metro et al., 2016)
- *Louisville and Jefferson County Floodplain Management Plan (*MSD, 2001)
- *Erosion Prevention and Sedimentation Control Ordinance* (MSD, 2007)
- *Integrated Overflow Abatement Plan* (IOAP) Volume 2, Chapter 5: History and Philosophy of Green Program (MSD, 2009)
- *Stormwater Management Master Plan* (MSD, 2010)
- *Green Infrastructure Incentives and Savings for Commercial, Industrial, and Institutional Property Owners* (MSD, 2011a)
- *State of the Streams: Water Quality Synthesis Report* (MSD, 2011b)
- *Stormwater Quality Management Plan* (MSD, 2011c)
- *Industrial Standard Operating Procedures* (MSD, 2012a)
- *Stormwater Procedures* (MSD, 2012b)
- *Stormwater Quality Management Plan* (MSD, 2012c)
- *MSD Wastewater/Stormwater Discharge Regulations* (MSD, 2013a)
- *Stormwater Quality Management Plan* (MSD, 2013b)
- *MSD Strategic Business Plan 2014-18* (MSD, 2014)
- *Design Manual* (MSD, 2015a)

- *MS4 Program Annual Report* (MSD, 2015b)
- *Project Waterway Improvements Now* (WIN; MSD, 2016)
- *2016 Countywide Flooding Mitigation Prioritization for Louisville and Jefferson County, Kentucky* (Prime AE Group, Inc., 2016)
- *Stormwater Drainage Master Plan* (URS Corporation et al., 1988)
- *Green Infrastructure Design Manual—Green Management Practices and Design Strategies to Manage Stormwater in our Community* (URS Corporation, 2013)
- *Interim Feasibility Study Termination Report* (USACE, 2012)

The reports and documents were reviewed primarily to see if they contained any information on outstanding projects that could be used in the project evaluation and prioritization stage of the 20-year facility plan. In general, most documents were not planning documents that included projects. Some were manuals or similar documents that spoke to procedures and policies, rather than actual projects. A summary of any relevant findings with respect to the Facility Plan are provided in the remainder of this section.

1.2.1 1988 Stormwater Drainage Master Plan

The *1988 Stormwater Drainage Master Plan* (URS Corporation et al., 1988) identified 52 major capital projects to be constructed. Construction of the projects was delayed for more than 3 years due to court battles over the drainage fee that was recently established. The initial $25 million bond set up to cover the construction of the 52 projects was actually only able to cover the construction of 40 projects. By early 1991, MSD had identified more than 100 areas that needed major construction projects to deal with their drainage problems. In January 1993, MSD approved a revised list of more than 200 drainage projects, including projects not constructed as part of the original 52, to be paid for with $48 million in bonds that were paid for with an increase in the drainage fee from $1.75 to $2.75 per residential unit. Most of this work is thought to have been completed; however, competing priorities resulting from the 1997 flood constrained completion of the plan. No documentation exists to say what major projects did not get completed. To help identify current needs, the current drainage-request system will be used to capture a “snapshot” of current request and/or identified projects within the DRI program.

1.2.2 2010 Stormwater Management Master Plan

The aforementioned *1988 Stormwater Drainage Master Plan* was updated in 2010 (MSD, 2010). However, the update was essentially a current snapshot of watershed existing conditions and ongoing projects. No comprehensive planning was performed by the 2010 update. In the years since the original master plan was written in 1988, land use patterns changed, impervious surface greatly increased, extreme storm events occurred with increased frequency, and customers demanded a higher level of service. Recent heavy rains have highlighted the problem of flood-prone areas inside the floodwall.

The report was broken down into all the major watersheds of Jefferson County. In each watershed, any major capital projects were mentioned, along with DRI projects, green demonstration projects, and “gray” sanitary sewer overflow abatement projects.

Only one watershed, Pond Creek, listed a future major capital project, the Aluma Basin, of which construction is now complete. The study also mentions a USACE study in the Mill Creek area. This study was terminated by USACE and MSD in 2012, because the studied projects did not meet federal criteria for the benefit/cost ratios.

For the DRI projects mentioned, the report listed all DRI projects for phases I through III, which were completed by or scheduled to be completed by 2010. The report mentions that phase IV was going to be initiated during 2010; however, projects listed in phase IV were still under development at the time, and a list of projects was not provided.

The 15 green infrastructure projects in the Ohio River watershed listed in the plan have been completed, and the lessons learned from those projects will be discussed in more detail in Volume 3, Chapter 4, MS4 Program, of this Facility Plan. A total of 23 gray projects are included in this report; however, these types of projects will be handled in the wastewater service area.

1.2.3 Metropolitan Sewer District Design Manual, Standard Drawings, and AutoCAD Sample Drawings

The MSD Design Manual (2015a) is a guide for planning and designing stormwater systems, flood protection works, sanitary sewers, erosion control structures, green infrastructure, small sanitary pump stations, small wastewater treatment plants, and associated activities for MSD. The MSD Design Manual will be used going forward during the level-of-service discussions. Figures 3.1-1 through 3.1-3 shows the current return interval used when designing various facilities. These return intervals are not expected to change; however, the current and likely future rainfall amounts associated with these return intervals will be studied to the possible effects it may have on stormwater and drainage facilities. The actual data to be reviewed from a rainfall standpoint are the intensity-duration-frequency curves and the rainfall depth chart, as shown below in Figures 3.1-2 and 3.1-3.

Design Storm Return Interval								
Situation		Return Interval (years)						
Type of Analysis	Limiting Values	2	5	10	25	50	100	500
Bridge	ADT< 400			•			•	
	400<ADT<1,500				•		•	
	ADT>1,500					•	•	
Culvert Capacity	ADT< 400			•			•	
	400<ADT<1,500				•		•	
	ADT>1,500				•		•	
Bridge Scour Analysis							•	•
Storm Sewer				•			•	
Channel Change		•		•			•	
Roadway Ditch				•			•	
Drop Inlets				•			•	
Detention or Retention Basin		•		•			•	
Note: ADT=Average Daily Traffic								

Figure 3.1-1. MSD Design Manual, Section 10.2.2.1.

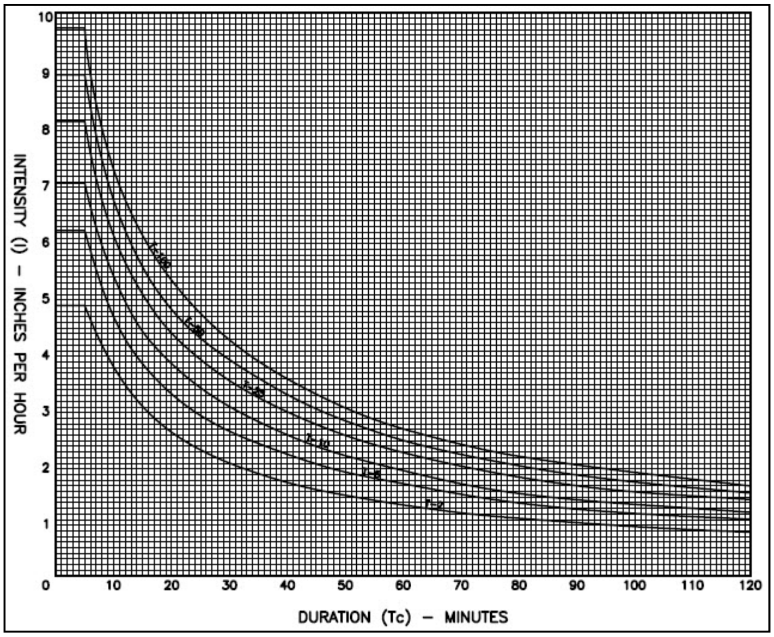

Figure 3.1-2. IDF Curves Used in the Design of Small-Scale Conveyance Systems (Source: MSD Design Manual, Chapter 10, Exhibit 10-2, Rainfall Intensity-Duration Curves)

FREQUENCY (YEARS)

DURATION	1	2	5	10	25	50	100	PMP
30 min.	1.0	1.1	1.4	1.6	1.9	2.0	2.3	
1 hour	1.2	1.4	1.8	2.0	2.3	2.6	2.8	
2 hour	1.5	1.7	2.2	2.5	2.8	3.2	3.5	
3 hour	1.6	1.9	2.4	2.7	3.2	3.4	3.8	
6 hour	2.0	2.3	2.8	3.3	3.7	4.2	4.5	28.0
12 hour	2.4	2.8	3.4	3.9	4.4	4.9	5.4	33.0
24 hour	2.7	3.2	4.0	4.5	5.2	5.7	6.2 **	35.0
2 day	0.0	3.6	4.4	5.1	6.1	6.4	7.3	38.5
4 day		4.3	5.3	6.0	6.9	7.6	8.4	
7 day		5.0	6.1	6.8	8.0	8.8	9.6	

* SOURCE:
DIVISION OF WATER RESOURCES
DEPARTMENT FOR NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION
ENGINEERING MEMORANDUM NO. 2 (4–30–71), REVISED (6–1–79)

** NOTE:
RAINFALL RANGED FROM 7.5 TO 12.5 INCHES DURING THE FEBRUARY 28/ MARCH 1, 1997 EVENT.

Figure 3.1-3. Stormwater Depths Used in Large-Scale Drainage Studies (Source: MSD Design Manual, Exhibit 10-3)

1.2.4 Countywide Flooding Mitigation Prioritization

This goal was brought about by a flooding event during October 2013 and reinforced by more severe flooding in 2015, when dozens of homes were restricted from rebuilding due to the substantial damage language in the City's Floodplain Ordinance. This report (PRIME AE Group, 2016a) developed a proactive approach to flood mitigation rather than reacting to each rain event.

The report identified and evaluated various mitigation alternatives to reduce flooding. This process included creating an inventory of flood-prone structures, classifying the level of risk for each structure, grouping the structures in hydrologically connected and heterogeneous project areas, evaluating the potential economic damages, developing potential mitigation measures, estimating their construction costs, and evaluating the economic viability of each of the selected alternatives. Structural mitigation measures included detention basins, berms, floodwalls, rechannelization, and replacement of undersized culverts and bridges. Nonstructural measures included acquisition, elevation, and floodproofing.

The study focused on the top 50 project areas for riparian flooding and 18 project areas in the CSS service area where 100-year flooding was above the first floor. Only pertinent forms of mitigation were considered for each project area. For example, structural alternatives were not considered along the Ohio River because construction costs would far outweigh the value of the structures, and dry floodproofing was not considered in areas not adjacent to the Ohio River because of the required notification time to implement during an impending flood.

The results indicated that no structural alternatives were economically viable using the available hydrologic and hydraulic models when using the depth-damage curves approved by FEMA. Those project areas with the highest benefit-to-cost ratios are along the Ohio River where the flood depths are highest. As expected, some homes in these project areas show positive net benefits for acquisition and elevation. In general, the interior streams exhibited more shallow flooding on a less frequent basis and therefore did not have high enough probable damages to economically justify structural nor nonstructural solutions.

1.2.5 Louisville Metro Hazard Mitigation Plan 2016 Update

The *Louisville Metro Hazard Mitigation Plan 2016 Update* (Louisville Metro et al., 2016) sets a strategy for building a more resilient community that will mitigate damages and losses caused by hazard events. The plan is the result of a systematic evaluation of the nature and extent of the vulnerability posed by the effects of hazards (risk assessment) and includes a 5-year action plan to minimize future vulnerability (mitigation strategy), accompanied by a schedule that outlines a method for monitoring and evaluating plan progress (plan maintenance).

The projects identified in the plan under the flood hazard category include two neighborhood detention basins—Tin Dor Way and LaClede Basin. These projects are conceptual in nature and need preliminary engineering to determine cost and feasibility. Other projects in the report include possible elevation projects for homes along the Ohio River, signage along flood-prone roads, public outreach, and building mitigation assessments. The report also lists several ongoing dam and levee projects that consist of developing emergency action plans (EAPs), risk assessments, and better dam construction, permitting, and inspection criteria.

1.2.6 Municipal Separate Storm Sewer System and Green Infrastructure

In general, the Facility Plan Team reviewed available documents that discuss general philosophies, existing water quality conditions, and local and state regulations, requirements, and policies related to the MS4 Program and green infrastructure. This information will be helpful as the Facility Plan Team begins to identify future projects to address local issues and regulatory obligations.

1.2.6.1 Municipal Separate Storm Sewer System Permit

When the MS4 KPDES permitting program began in the early 1990s, Louisville received the first, phase I MS4 permit issued in the Commonwealth of Kentucky. The mission of the MS4 Program is to enhance stormwater runoff quality and protect streams and riparian habitat to promote public health, safety, and welfare. Louisville MSD's current permit, KPDES No. KYS000001, was issued during June 2011. For Louisville's MS4 Program permit, MSD serves as the administrative lead and is joined by several city governments as copermittees. MSD's copermittees include Louisville Metro and the Cities of Anchorage, Jeffersontown, St. Matthews, and Shively. Some MS4 Program permit activities are performed independently, while others are performed cooperatively among MSD and the copermittees.

Based on the Facility Plan Team's review of the MS4 Program permit, potential future projects per part II of the MS4 permit state the following:

> *The permittee shall continue, in cooperation with Louisville Metro Mayor's administration, University of Louisville and other local agencies, to pursue development of stormwater quality and green infrastructure interpretive center(s) at strategic location(s) around Jefferson County with the intent of providing a positive highly visible platform to promote the viability and desirability of green infrastructure BMPs* [Best Management Plans]*. Where feasible explore the opportunity for BMP evaluation and pre-/post-monitoring.*
>
> *The permittee shall continue to collaborate with the U.S. Army Corps of Engineers in their efforts to develop a trail system integrating community assets and environmental resources.*

Additionally, there are requirements in the MS4 Program permit that may need to be revisited as part of the gap analysis. Based on information compiled to date, it appears that there may be a need for MSD to collect and track some additional information. For example, part II.B.5.f of the MS4 Program permit states the following:

> *The permittee shall maintain an inventory and map of post-construction stormwater controls, including retention ponds, detention basins, and stormwater quality treatment facilities. The inventory should be updated annually.*

Based on the Facility Plan Team's review of available information, MSD has an existing inventory and mapping available for wet and dry basins and water quality projects. However, whether this is a comprehensive representation of the total number of water quality-related projects that have been implemented throughout the County and how often this list is updated or maintained are unknown.

1.2.6.2 Water Quality Synthesis Report

The Water Quality Synthesis Report (MSD, 2011b) provide valuable information on the conditions of streams in Jefferson County, including habitat, flow, and insects. The data presented in the reports are a product of the efforts between MSD and United States Geological Survey (USGS) to operate and maintain the long-term monitoring network (LTMN). As part of this effort, MSD collects information on water quality, and USGS collects stream flow data.

While no specific planned projects are summarized in these reports, the reports provide tremendous data that will help inform the locations and types of water quality-based projects needed in the future. Overall findings list stream bank erosion as one of the main issues in Jefferson County; this will be an important consideration in the design of future projects.

1.2.6.3 Metropolitan Sewer District Requirements for Green Infrastructure

MSD's current post-construction design regulations will require future projects to implement water quality-based controls. Based on the Facility Plan Team's review of available documents this requirement is governed by Article 6, Post-Construction Best Management Practices, in *MSD Wastewater/Stormwater Discharge Regulations* (MSD, 2013a). Section 6.01 states that *"users must meet the Stormwater Quality Event, as defined in the MSD Design Manual Chapter 18…"*

Chapter 18 of *Green Infrastructure Design Manual – Green Management Practices and Design Strategies to Manage Stormwater in our Community* (URS, 2013), states the following:

> *There are two REWQV* [Required Water Quality Rain Events] *to consider, the 92nd percentile storm and the 80th percentile storm. The selection of the REWQV is dependent upon the location of the project site. If the site is in the MS4 area, then the 80th percentile storm is used. If the site is located in the combined sewers system area, then the 92nd percentile storm is used to calculate the required WQv* [water quality volume].

This requirement applies to all development projects that disturb greater than 1 acre or that are part of a larger common development plan. Therefore, with each development project, additional green infrastructure or water quality-based controls will be implemented throughout Jefferson County.

VOLUME 3—STORMWATER AND DRAINAGE

CHAPTER 2 CRITICAL COMPONENTS AND DAM ASSESSMENT

2.1 INTRODUCTION AND BACKGROUND

This analysis reports the results of the condition assessment of stormwater and drainage infrastructure. The assets included in this study are storm sewer pipes (all sizes), catch basins, storm channels, detention basins, viaducts, and Class C dams. This analysis does not include the flood wall and levee system or any of the major flood control pumping stations along the Ohio River, which are addressed in Volume 4.

MSD assumed the responsibility for most of Jefferson County's public stormwater drainage system in 1987. Five suburban cities decided to keep their own drainage programs: Anchorage, Jeffersontown, St. Matthews, Shively, and Prospect. (MSD took over drainage responsibilities for Prospect in 2004.) MSD is not responsible for drainage in the right-of-way of most State-maintained roadways and some County through roads. MSD was not originally responsible for drainage in unincorporated areas, or farmlands, of the outer portions of the County. These areas became part of MSD's responsibilities following the city/county merger in 2003.

MSD is responsible for maintaining approximately 5,290 miles of drainage system. Work orders for maintenance items are logged and tracked in MSD's Hansen Information System, which is the basis for most of the condition assessments found in this chapter.

Dams and public warning systems are also reviewed in this chapter, with respect to current policies, procedures, and activities and recommendations for possible improvements.

2.2 OVERVIEW OF CRITICAL COMPONENT ASSETS REVIEWED

Major components in the stormwater system that are documented in the MSD Hansen Information System were reviewed, including all storm pipes, catch basins, major detention basins, and main tributaries. Viaducts and Class C dams for which MSD has responsibility were also assessed.

Other than inspection of the viaducts, no field inspection took place to assess the condition of the associated stormwater assets. MSD's Hansen Information System was used to extract infrastructure age and maintenance activities to track trends in work orders and costs.

The viaducts were field examined to determine the number and condition of the inlets in the sag of the roadway. For the viaducts with pump stations, field investigations, and interviews with MSD personnel are the basis for the condition assessment.

2.3 STORMWATER COLLECTION AND CONVEYANCE ASSETS—ANALYSIS OF WORK ORDERS

The following lists are the work order codes that were reviewed for each of the asset types:

- Storm Drains:
  - CAVIN – Cave In

- DINSP – Drainage Inspection (not included in analysis)
- OBS – Obstruction Removal
- STLR – Storm Line Repair

- Catch Basins:
  - CAVIN – Cave In
  - CBC – Catch Basin Cleaning (programmed maintenance) (not included in analysis)
  - CBCL – Catch Basin Cleaning (not included in analysis due to irregular entry/use of code)
  - CBLEAD – Catch Basin Lead Inspection (programmed maintenance) (not included in analysis)
  - CBLR – Catch Basin Lead Repair
  - CBR – Catch Basin Repair
  - CIR – Curb Iron Repair
  - DINSP – Drainage Inspection (not included in analysis)
  - GRATE – Catch Basin Grate/Repair or Replace
  - INSPEC – MSD Inspection Activities (not included in analysis)
  - OBS – Obstruction Removal
  - V – Vactor
- Detention Basins:
  - CINSP – Inspection of Credited Basins (not included in analysis)
  - DINSP – Drainage Inspection (not included in analysis)
  - DITCHC – Ditch Cleaning
  - DITCHR – Ditch Regrading
  - ERORPR – Erosion Repair
  - FBINSP – Flood Basin Inspection (not included in analysis)
  - INSPEC – MSD Inspection Activities (not included in analysis)
  - OBS – Obstruction Removal
- Storm Channels (Channelized and Natural):
  - DINSP – Drainage Inspection (not included in analysis)
  - DITCHC – Ditch Cleaning
  - DITCHR – Ditch Regrading
  - ERORPR – Erosion Repair
  - OBS – Obstruction Removal

For each asset evaluated, the first analysis was to determine whether the age of the asset had a correlation on the total number of work orders for that asset. Data were normalized by dividing the total number of work orders by the number of assets, grouped in 5-year increments. Several assets do not have installation dates, and those assets are assumed to be pre-1987, before MSD took over drainage responsibilities for most of the county. The inspection-type work orders were excluded from the analysis.

The second analysis was performed by looking at both the total cost of the work orders per year and the cost per work order per year. The later analysis was conducted so that the data could be normalized. Costs for the last 15 years were generally reviewed. The dollar amounts were adjusted for inflation by using published consumer price index (CPI) numbers from the U.S. Bureau of Labor Statistics for each year. All inspection-type work orders were excluded from the analysis.

2.3.1 Storm Pipe (All Sizes)

This asset group include pipes in the Hansen Information System that are tagged as stormwater pipes, including roadway and driveway culverts and storm sewers. All pipe sizes were included. A total of 81,232 pipes were identified in the Hansen Information System. The results of the age and cost analysis are shown on Figures 3.2-1, 3.2-2, and 3.2-3. For the age analysis, a trend line was plotted, and there is a clear correlation between the number of work orders issued and the age of the storm pipe system. Inspection work orders were not included, and assets without an identified install date were assumed to be older than 30 years. More than two-thirds of the storm pipes in the system do not have an installation date associated with them. The cost analysis was completed by examining the cost of all work orders for each year. The data were normalized by dividing the cost numbers by the number of assets that the work orders were performed on. The cost was also adjusted by using the U.S. Bureau of Labor Statistics CPI values. Figure 3.2-2 shows the relationship of cost per work order per year. Inspection work orders were not included in the analysis.

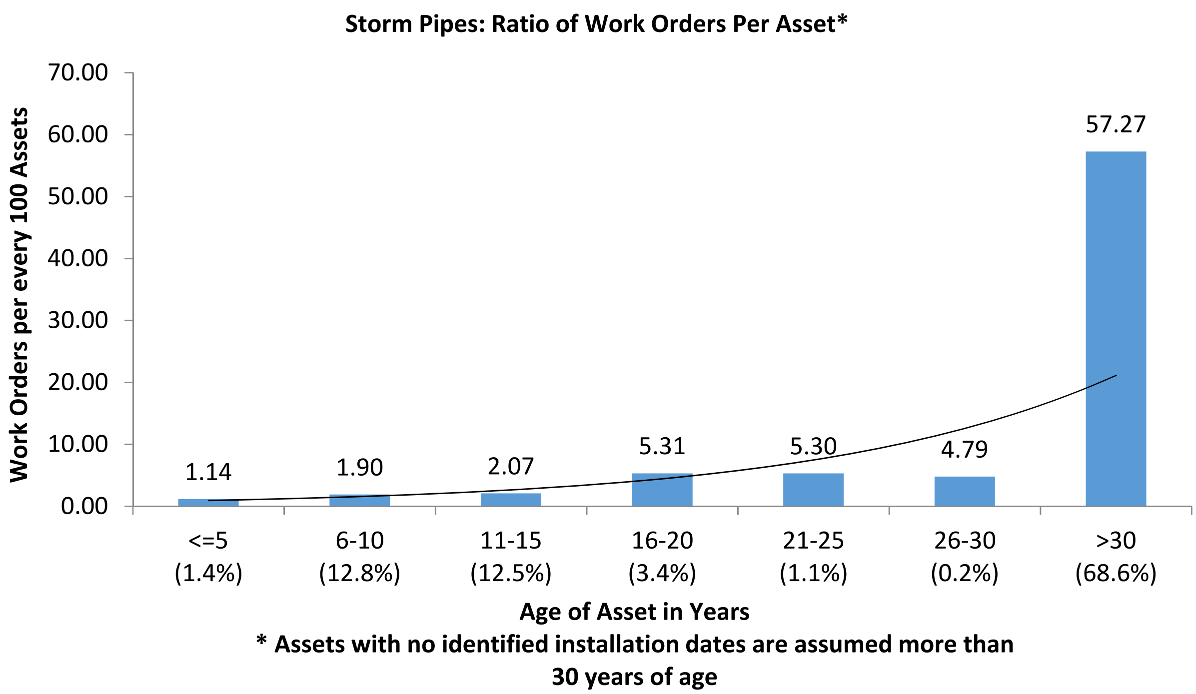

Figure 3.2-1. Storm Pipe Age and the Effects on the Number of Work Orders

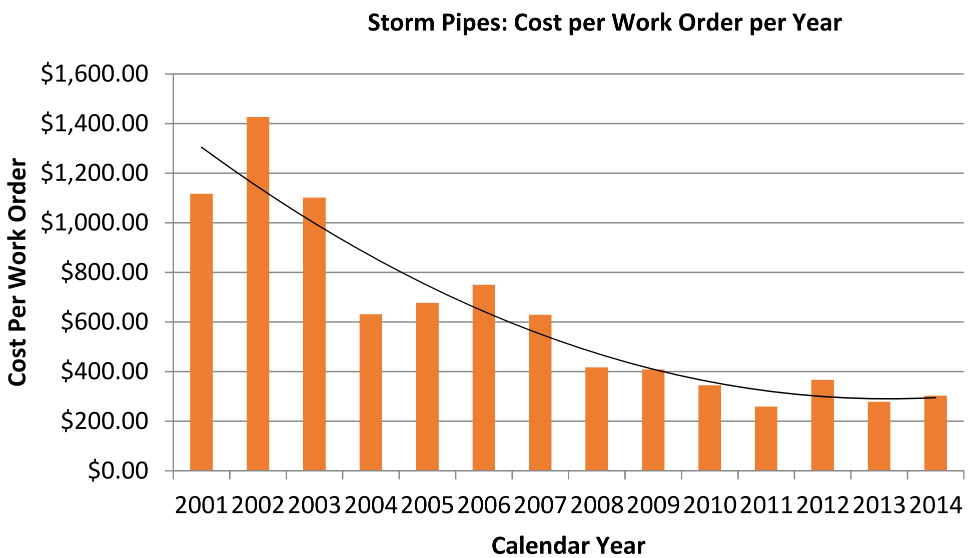

Figure 3.2-2. Storm Pipes (All Sizes): Cost per Work Order per Year (Adjusted for Inflation)

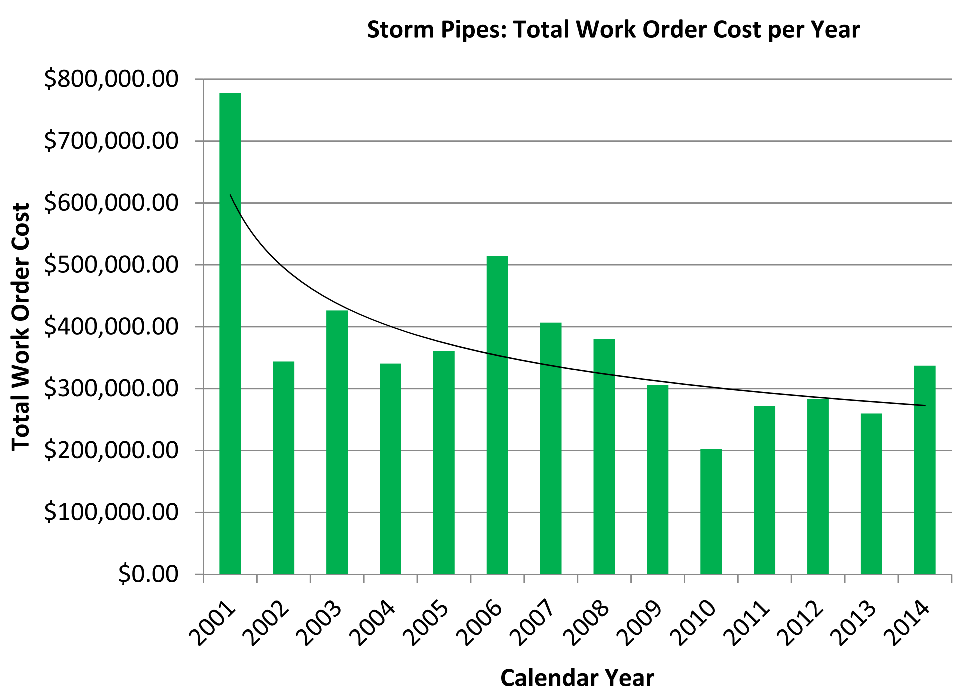

Figure 3.2-3. Storm Pipes (All Sizes): Total Work Order Cost per Year (Adjusted for Inflation)

The cost numbers displayed on Figures 3.2-2 and 3.2-3 indicate that the amount of money being spent on storm pipes has decreased significantly since the first part of the previous decade. The cause for the decline in spending is not known; it could be due to inconsistent data entry in the Hansen Information System or due to increased efficiency. However, as noted previously and shown on Figure 3.2-1, the number of work orders is expected to trend up over the next 20 years, as the system continues to age, indicating a possible need for increased spending for this asset.

2.3.2 Catch Basins

This asset group include catch basins in the Hansen Information System; 74,714 catch basins were identified in the Hansen Information System. The results of the age and cost analysis are shown on Figures 3.2-4, 3.2-5, and 3.2-6. For the age analysis, a trend line was plotted, and there is a clear correlation between the number of work orders issued and age of the catch basins. Note that a large majority of catch basins did not have an installation date; these are assumed to be assets installed before the MSD takeover in 1987.

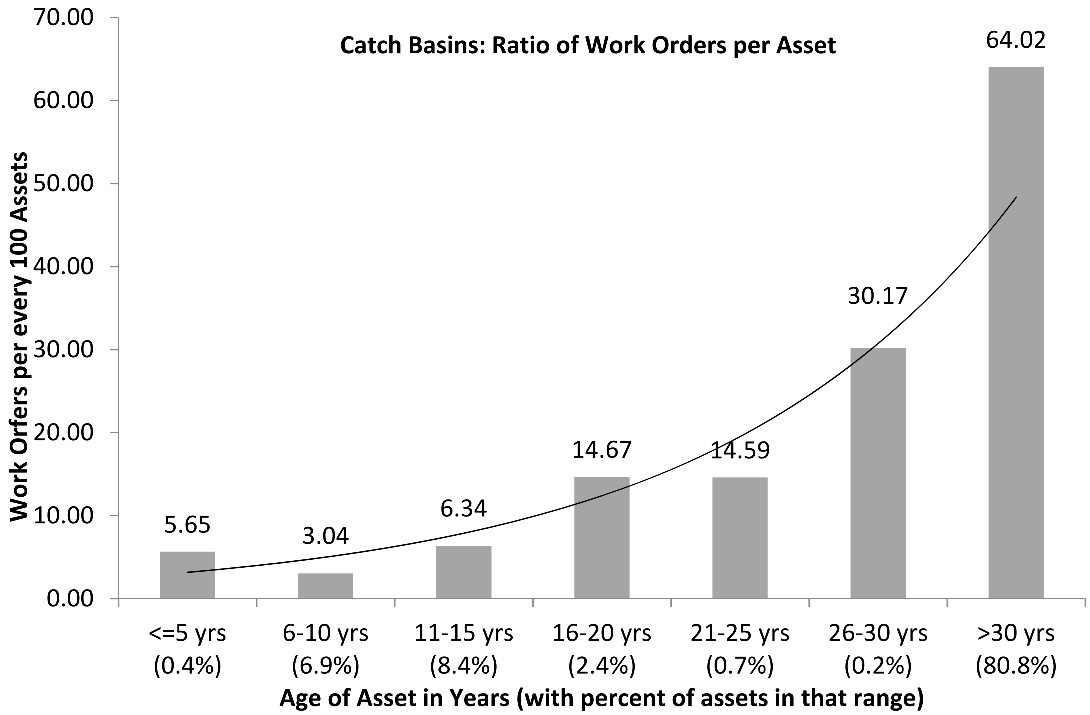

Figure 3.2-4. Effect of Age on the Number of Work Orders for Catch Basins

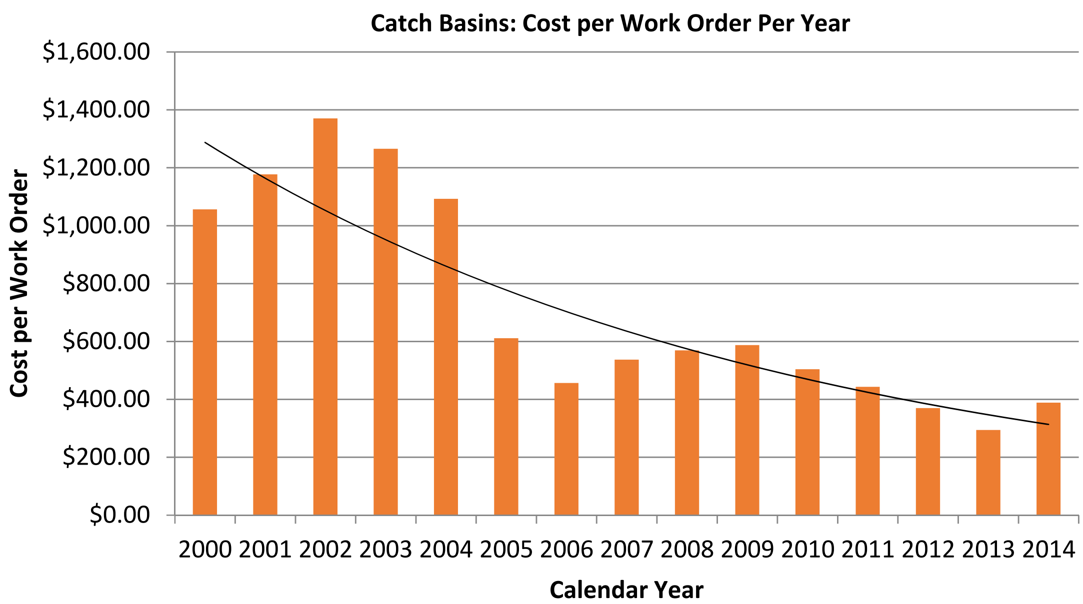

Figure 3.2-5. Cost per Work Order per Year for Catch Basins (Adjusted for Inflation)

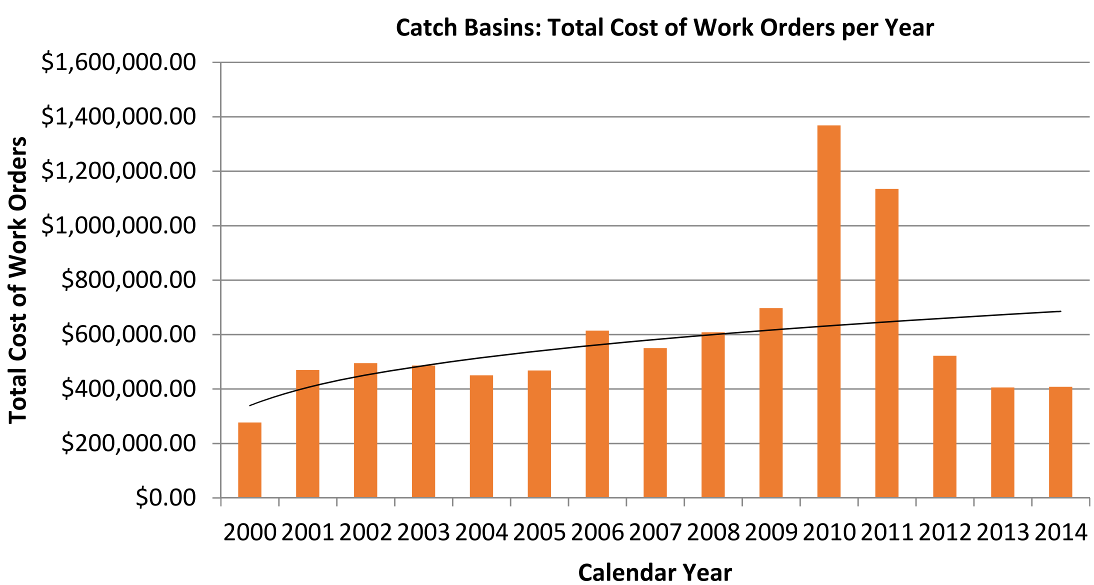

Figure 3.2-6. Total Cost of Catch Basin Work Orders per Year (Adjusted for Inflation)

The cost analysis was completed by examining the cost of work orders for each year. The data were normalized by dividing the cost numbers by the number of assets that the work orders were performed on. The cost was also adjusted by using the Bureau of Labor Statistics CPI values. Figure 3.2-5 shows the relationship of cost per work order per year. Inspection work orders were not included in the analysis.

The costs shown on Figures 3.2-5 and 3.2-6 indicate that the amount spent per work order has decreased, but the overall trend in total money spent since 2000 has a more upward trend. The anomaly of 2010 and 2011, however, tends to skew the trendline in that direction due to the catch basin lead program in response to the August 2009 flood event. Since 2010, total spending has been trending down. As noted previously, the number of work orders is expected to trend up over the next 20 years as the system continues to age, indicating the need for increased spending for this asset.

2.3.3 Stormwater Detention Basins

This asset group include detention basins in the Hansen Information System, including regional, credited, and noncredited basins for a total of 17 regional basins, 198 credited basins, and 726 noncredited basins. The results of the age and cost analysis are shown on Figures 3.2-7 and 3.2-8.

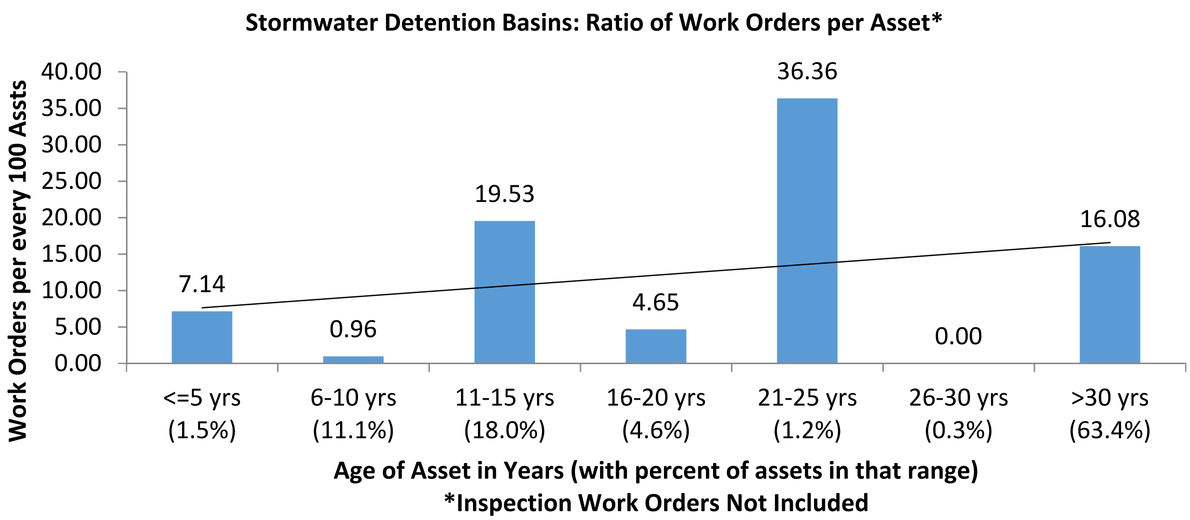

Figure 3.2-7. Effect of Age on the Number of Work Orders for Detention Basins

For the age analysis, a trend line was plotted, and there was a correlation between the number of work orders issued and age of the detention basins, although there is not as strong a correlation as the previous assets. Again, the number of work orders is expected to trend up over the next 20 years, as the assets continues to age, indicating the need for increased spending for this asset. Spending has decreased since 2009, as shown on Figure 3.2-8.

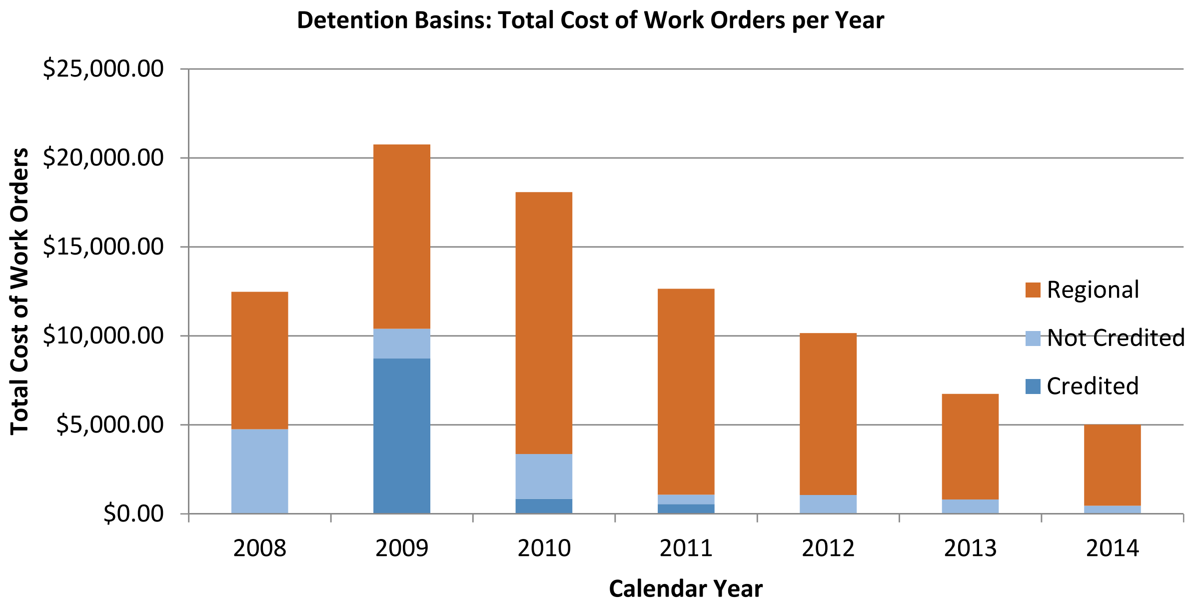

Figure 3.2-8. Total Cost of Work Orders per Year (2008-2014), Inspection Work Orders Not Included

2.3.4 Channelized Streams

This group includes all constructed channelized streams—for example, the concrete section of Beargrass Creek; 770 channelized streams were identified in the Hansen Information System. The results of the age and cost analysis are shown on Figures 3.2-9, 3.2-10, and 3.2-11. For the age analysis, a trend line was plotted and there appears to be correlation between the number of work orders issued and age of the channelized streams. Natural streams were not considered in the age analysis because they do not have an install date in the traditional sense. Stream restoration projects are fairly new and not enough data exist to track maintenance issues over a reasonable period of time; therefore, only channelized streams were included in the age analysis. Assets with no install date are assumed to be prior to 1987.

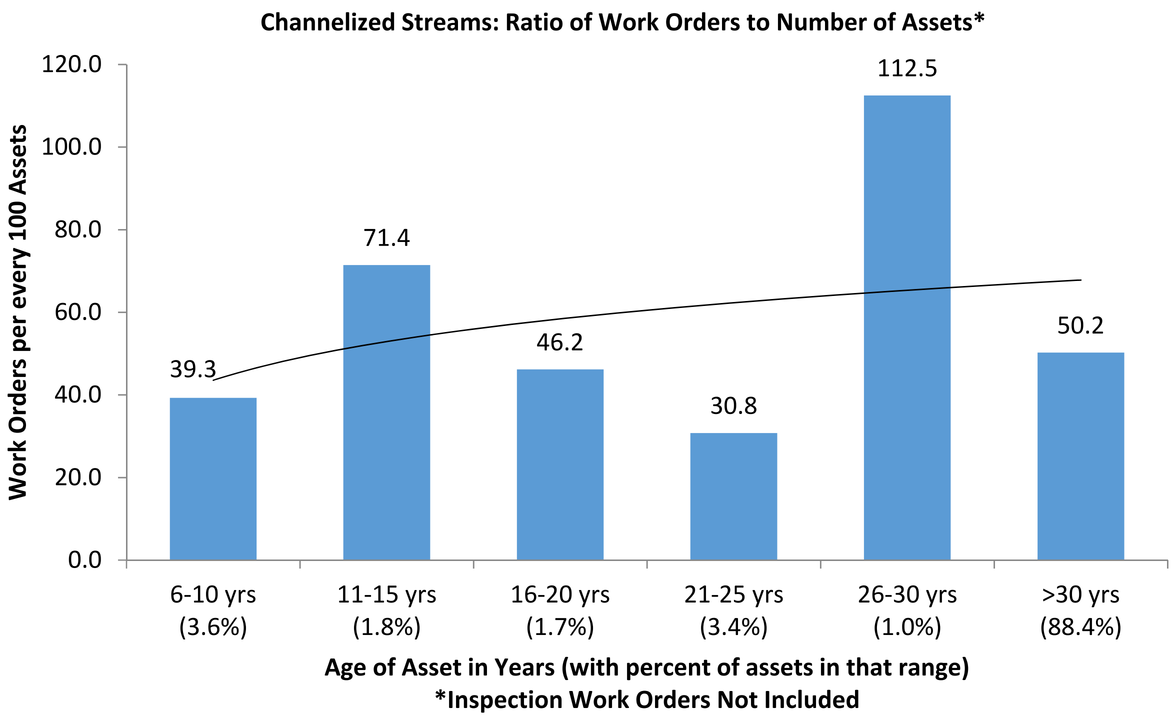

Figure 3.2-9. Effect of Age on the Number of Work Orders for Channelized Streams

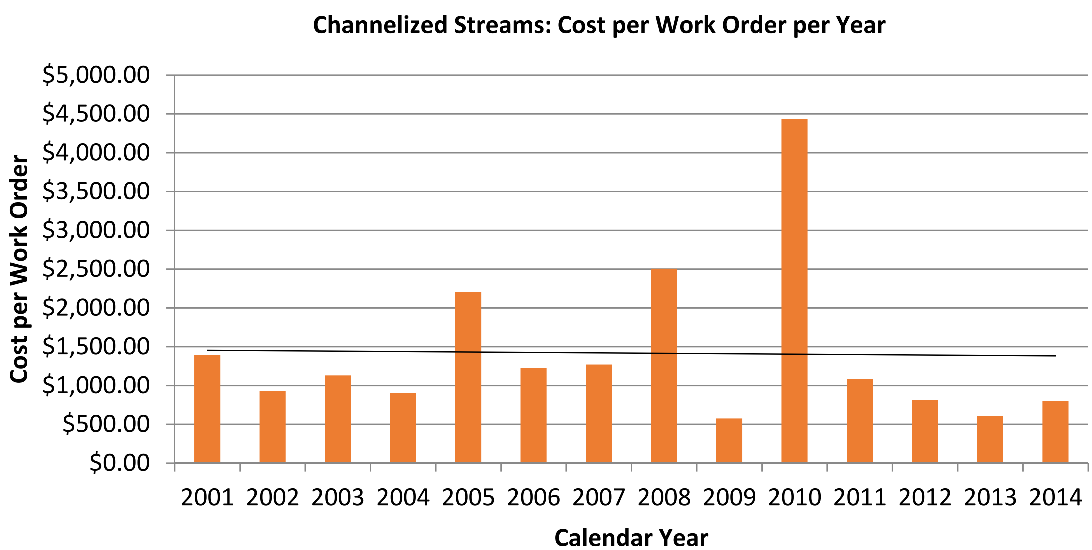

Figure 3.2-10. Cost per Work Order per Year for Channelized Streams

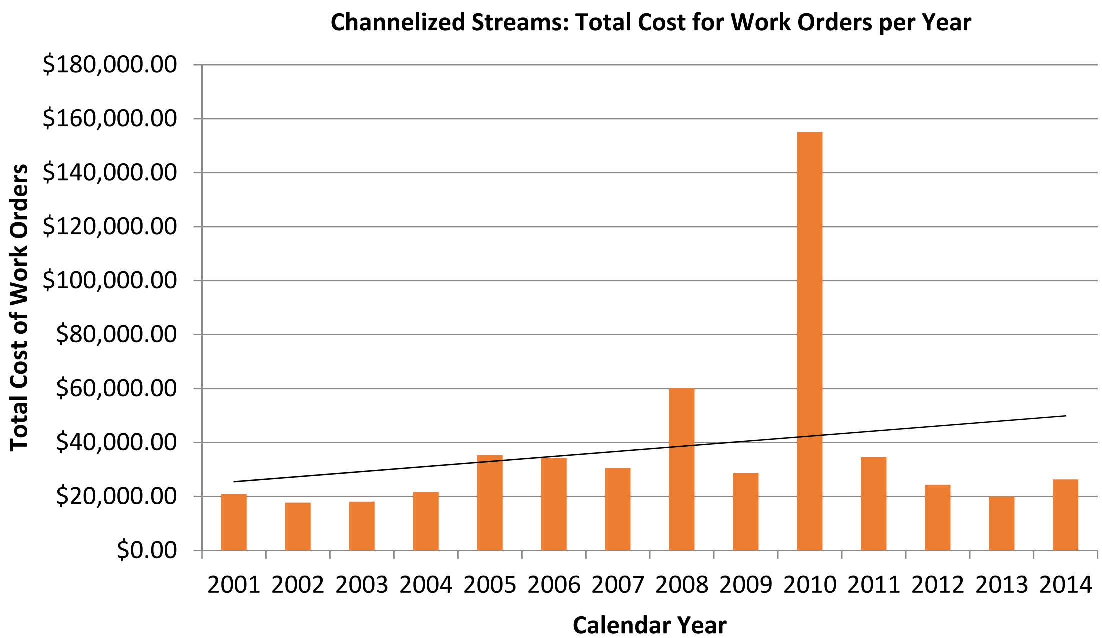

Figure 3.2-11. Total Cost for Work Orders for Channelized Streams

The cost figures indicate nearly flat cost per work order amounts and slight upward trend in total spending; however, without the 2010 anomaly, the spending line would be nearly flat. The 2010 anomaly was likely a direct result of the August 2009 flood event. The number of work orders is expected to trend up over the next 20 years, as assets continue to age, indicating a possible need for increased spending for this asset.

2.3.5 Natural Streams

Natural streams totaled 16,728 in the Hansen Information System. Figures 3.2-12 and 3.2-13 show asset's cost analysis. Again, natural streams were not considered in the age analysis because they do not have an installation date in the traditional sense. Stream restoration projects are new, and not enough data exist to track maintenance issues over a reasonable period. Trend line indicates an upward spending trajectory, but spending has been on a downward trend since 2010. Again, the 2010 anomaly is a direct result of the August 2009 flood event. As more stream restoration projects are completed, more O&M money must be used to maintain those projects in the future.

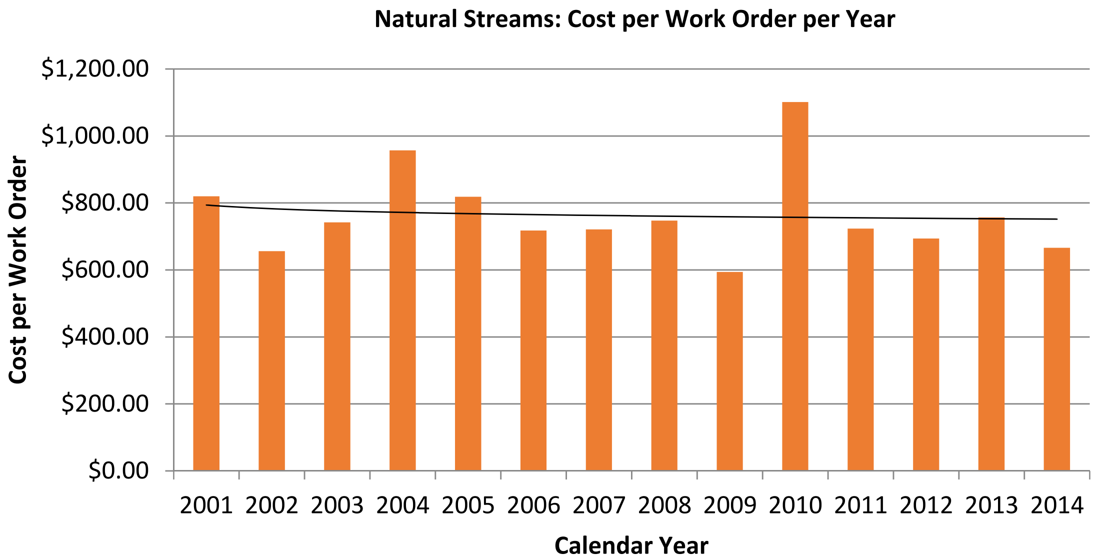

Figure 3.2-12 . Cost per Work Order Per Year for Natural Streams

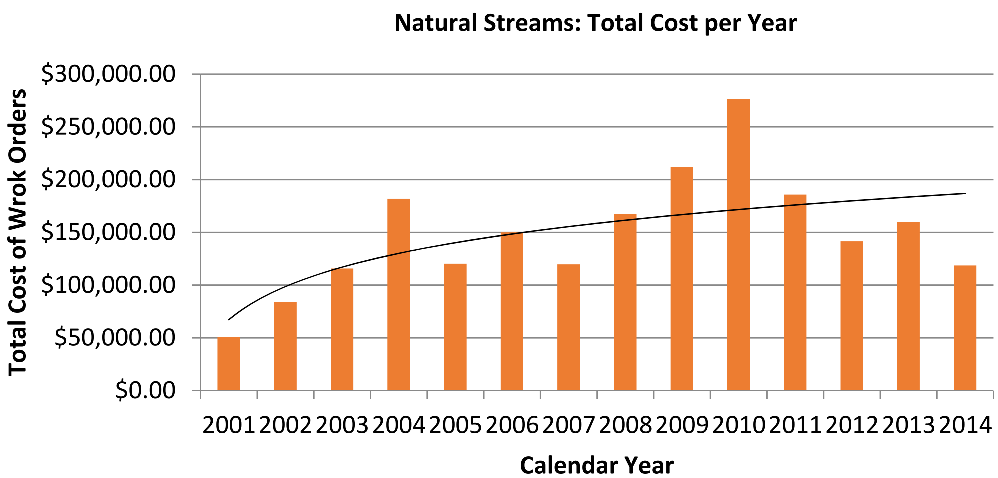

Figure 3.2-13 . Total Cost of Work Orders for Natural Streams Per Year

2.4 VIADUCT DRAINAGE SYSTEM CONDITION ASSESSMENT

MSD Drainage Department maintains the catch basin inlets at viaducts that MSD maintains and the MSD Flood Protection Division is responsible for the viaduct's pump stations. No detailed viaduct work order history from the Hansen Information System is available for analysis. Viaducts were field-inspected to review the condition and quantity of drainage structures. In addition, interviews were conducted with

MSD staff to gather the information needed. MSD must partner with Louisville Metro Public Works and the railroad companies to develop solutions to these complex transportation/ drainage issues. Figure 3.2-14 shows locations of Jefferson County viaducts.

2.4.1 Viaducts with Pumping Stations

The following viaducts with pump stations were field inspected with the assistance of the MSD Flood Protection Division staff:

- 16th and Algonquin Viaduct (MSD0063-PS)
- 4th and Colorado Viaduct (MSD0018-PS)
- 3rd and Eastern Parkway Viaduct (MSD0019-PS)
- 3rd and L&N Viaduct (MSD0020-PS)
- Brandeis Viaduct (MSD0036-LS)
- Floyd and Hill Viaduct (MSD0021-PS)

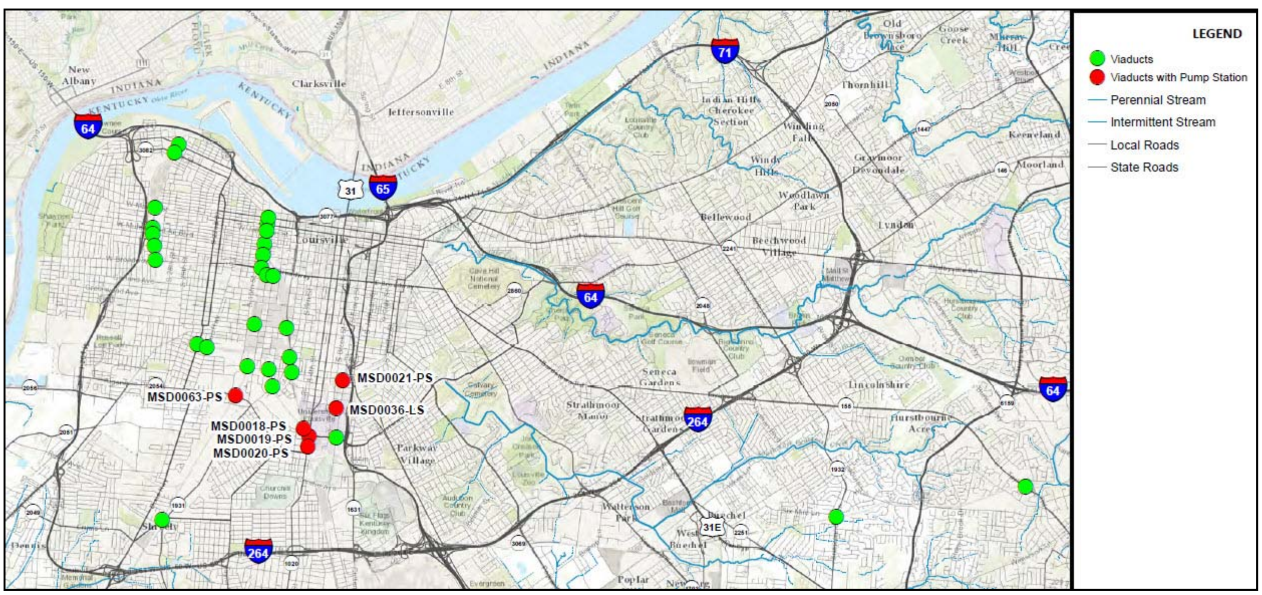

Figure 3.2-14. Viaduct Type and Location

These facilities are maintained and operated by MSD. The viaduct pump station at Breckenridge Lane and Six Mile Lane and the viaduct at 7th and Manslick are maintained by the KYTC, and MSD has no responsibility for inspecting, operating, or maintaining them.

2.4.2 General Comments (Viaducts with Pump Stations)

The MSD Flood Protection Division is responsible for the viaduct pump stations maintained by MSD. The following is a summary of general comments:

- MSD has upgraded supervisory control and data acquisition (SCADA) systems and added transfer switches to allow generators to be used to run them in the event of power loss.
- Drawdown tests to confirm pump capacity at each station were completed in late 2016. No records exist of prior drawdown tests being performed. Drawdown test confirm that some pump sizes are inadequate for large rain events.
- Viaduct pump stations are inspected weekly.
- Wet wells are vactored quarterly.
- Grit chambers (which are in the road) for both 3rd Street pump stations are vactored annually.
- Some viaduct pump stations discharge into a head box with cast-iron flap valves. A preventive maintenance program has been initiated for flap valves.
- MSD and the University of Louisville (UofL) have had previous discussions regarding painting the exteriors of the pump station buildings with UofL school emblems and colors for those viaducts on or near the UofL campus. The status of this is not known.
- Pump operation is automatically controlled by wet-well level. All pumps in a station can run simultaneously.
- In viaduct pump stations without forced air ventilation, the electrical equipment and components in the control rooms may not meet current code. (At the time of construction, stormwater was thought of as “clean” water.) National Fire Protection Association (NFPA) 820 (NFPA, 2016) would require Division 2 rating where openings to the wet well are only plated and not sealed.
- Viaduct pump stations typically do not generate odor complaints.
- O&M manuals, pump information, and records of previous modifications, particularly to the electrical systems, are essentially nonexistent.
- Viaduct flooding is not necessarily because of the station pumping capacity. Flooding could result due to the limited capacity of the sewer to which the station is discharging. MSD has been considering the feasibility of pumping into offline storage basins that could then be drained at a slower rate after the wet weather event. Viaduct flooding in many cases is the direct result of storm events larger than the design standards at the time the viaducts were installed. Many viaducts were designed and constructed to minimize traffic delays on a daily basis, while allowing the roads to be closed during heavy rain events. While this is now an unacceptable practice, the ultimate solutions should include the ability to convey water and possible transportation realignments.

Figure 3.2-15 shows the status of each viaduct and areas where improvements are needed. Photographs of each station are also included as attachments at the end of this chapter. The following sections summarize each viaduct in more detail.

Viaduct	Access Road	Main Pumps	Spare Pump	Sump Pump	Bar Screen	Grit	Control Room Flooding	MCC	SCADA	Control System	Transfer Switch	Generator Pad	Permanent Standby Generator	Control Room Heater w/ Thermostat	Ventalation	Exterior Painting	Guide Rail Systems	Excess Inflow	Inflow Pipes	Safety Concerns
16th & Algonquin	◆	◆	X	✓	◆	X	X	X	✓	N/I	X	X	X	✓	✓	✓	X	✓	✓	✓
4TH & Colorado	X	✓	X	N/I	X	X	✓	N/A	✓	✓	X	X	X	✓	✓	✓	X	✓	X	✓
3RD & Eastern Pkwy	X	✓	X	N/I	X	✓	✓	N/A	✓	PIP	✓	X	X	✓	◆	N/I	X	✓	✓	X
3RD & L&N	X	✓	X	N/I	X	✓	✓	N/A	✓	✓	✓	X	X	✓	◆	✓	X	✓	✓	X
Cardinal & Brandeis	✓	✓	✓	✓	◆	X	✓	N/A	✓	PIP	✓	◆	X	✓	✓	✓	X	X	✓	✓
Floyd & Hill	X	✓	X	N/I	◆	X	✓	N/A	✓	PIP	✓	X	X	✓	◆	X	X	X	✓	✓

Legend	
PIP	Project in Progress
X	Needs Attention
◆	Marginal
✓	Good Condition
N/A	Not Applicable
N/I	No Information

Figure 3.2-15. Status of Viaducts with Pump Stations

2.4.3 16th and Algonquin Viaduct Pump Station

- Access is by gravel road through Dismas Charities property.
- There are five Simflo mixed-flow pumps: 40 horsepower (hp), 480 volts (V), 3-phase each.
- Pumps discharge to the head box with flap gates.
- Pump nos. 2, 4, and 5 have been rebuilt. All five vertical turbine pumps should be replaced. Pump no. 2 had a broken shaft for 2 to 3 years.
- Sump pump was replaced and working. There is also a spare sump pump.
- Bar screen was manually cleaned with access through the hatch in station’s top slab.
- There is no grit collection.
- Control room flooded during the August 4, 2009, flood event.
- Motor control center (MCC) needs to be replaced.
- Control system has been upgraded.
- SCADA system is satisfactory.
- Transfer switch for portable generator has not been installed.
- Control room has a thermostat-controlled unit heater.

- Control room lights and ventilation are automatically activated by a switch on the access hatch.
- Wet-well ventilation is controlled by manual switch on the top slab of structure.

2.4.4 4th and Colorado Viaduct Pump Station

- Access is by driving over the curb at entrance to UofL student housing complex then overland to the station. There is no access road. A curb-cut access road accessible during a flood event and generator pad are needed.
- There are three KSB submersible pumps with a cable guide system: 240-V, 3-phase each. Guide rails should be installed.
- There is no bar screen or grit collection.
- During a 2015 flood event, the viaduct flooded, but very little flow reached the pump station, indicating a plugging issue in the influent sewer. The problem area has not been found to date.
- Currently, there is one hydrostatic level sensor and tilt bulb backup. Upgrades have not been completed.
- SCADA upgrades were started but not completed.
- Building interior was recently painted.
- O&M manuals on pumps are available.
- Control room has a thermostat-controlled unit heater.
- Ventilation is activated when exterior building door is opened.

2.4.5 3rd and Eastern Parkway Viaduct Pump Station

- Access is by driving over the curb on 3rd Street, partially following asphalt walking path, then overland to the station. There is no true access road. A curb-cut access road accessible during a flood event and generator pad are needed. A dead tree next to the station needs to be removed.
- There are three Flygt-submersible pumps without guide rail systems: 240-V, 3-phase each. Guide rails should be installed.
- There is no bar screen. The grit chamber is located in 3rd Street.
- Control system currently is being upgraded.
- SCADA upgrades are in progress.
- Transfer switch for portable generator was installed.
- A hoist monorail for removing pumps would be helpful.
- Access to wet well is by fixed section of aluminum extension ladder; this is a safety concern.
- Plate covering access opening to wet well is loose and not hinged; this is a safety concern.

- Plates covering access openings to pumps are loose and not hinged; this is a safety concern.
- Exterior door needs to be replaced.
- Control has a thermostat-controlled unit heater.
- There is only gravity ventilation. Mechanical ventilation is needed.

2.4.6 3rd and L&N Viaduct Pump Station

- Access is through the parking lot for the UofL student housing complex then overland to station. Need an access road from the parking lot to station and generator pad.
- There are three Flygt-submersible pumps without guide rail systems: 240-V, 3-phase each. Guide rails should be installed.
- There is no bar screen. There is a grit chamber on 3rd Street.
- Control system upgrades are complete.
- SCADA upgrades are complete.
- The transfer switch for portable generator is installed.
- A hoist monorail for removing pumps would be helpful.
- Access to wet well is by fixed section of aluminum extension ladder; this is a safety concern.
- Plate covering access opening to wet well is loose and not hinged; this is a safety concern.
- Plates covering access openings to pumps are loose and not hinged; this is a safety concern.
- Control room has a thermostat-controlled unit heater.
- There is only gravity ventilation. Mechanical ventilation is needed.
- Interior of building was recently painted.
- A pipeline of unknown origin is apparently running north and south through the wet well over the tops of the pumps. This needs to be investigated.

2.4.7 Brandeis Viaduct

- Access is via a concrete access road that run from a driveway behind the commercial establishment.
- The deep station is located approximately 34 feet from control room floor to bottom of wet well.
- There are two mixed-flow pumps: 50-hp, 480-V, 3-phase each. These were replaced in 2013.
- MSD has a spare pump motor.
- Pumps discharge to head box with flap gates.
- Manually cleaned bar screen is accessed by a spiral staircase.

- There is no grit collection.
- The control system upgrades are in progress.
- SCADA upgrades are in progress.
- Transfer switch for portable generator is installed.
- MSD is planning to install a guide rail system for the sump pump.
- Control room has a thermostat-controlled unit heater.
- Control room lights and ventilation are automatically activated by switch on the access hatch.
- Station always has significant inflow that is pretty clear. It has tested negative for chlorides and fluorides.

2.4.8 Floyd and Hill Viaduct

- Access is by driving over curb along Hill Street then overland to the station. There is no access road. Need a curb cut, access road accessible during a flood event, and generator pad.
- There are three Flygt-submersible pumps without guide rail systems: 240-V, 3-phase each. Guide rails should be installed.
- Bar screen has been manually cleaned. It appeared to have the most trash of all stations.
- There is no grit collection.
- Control system upgrades are in progress.
- SCADA upgrades are in progress.
- A transfer switch for portable generator is installed.
- Control room has a thermostat-controlled unit heater.
- There is no forced-air ventilation.
- The station needs to be painted and coated with graffiti guard.
- The station always has significant inflow that is pretty clear. The station tested negative for chlorides and fluorides.
- There is a root problem in the influent sewer to the station.
- Limited inlets in roadway are prone to clogging.

2.4.9 Viaducts Without Pump Stations

For the viaducts without pump stations, field visits were made to document the number of inlets and conditions. Table 3.2-1 shows the status of each viaduct. Table 3.2-1 shows that some viaducts simply do not have enough capacity to intercept and move the water away from the viaduct sump areas. Also, not enough flanker inlets are installed. Flanker inlets act as a safety valve in case the sump inlet gets clogged, but can also help with additional inlet capacity once the depth of water reaches a certain height. By normal practice, flankers are designed to start intercepting water at 60 percent of the design spread (or depth) of the roadway. Generally, the inlets were in good shape physically, except a few that were clogged with debris. However, it is MSD's practice to clean debris from the inlets in the viaducts before a major storm event and during scheduled program maintenance cleanings.

2.5 CLASS C DAMS ASSESSMENT AND PUBLIC WARNING SYSTEMS

This section documents the existing conditions for Class C dams and public warning systems and makes recommendations for future projects and/or programs in this area moving forward.

2.5.1 Background

Kentucky uses two criteria to define dams. First, a dam is an impounding structure that is 25 feet or more in height. Dam height is measured from the downstream toe to the dam crest. Second, a dam is a structure that impounds, or has the capacity to impound, 50 acre feet at the top of the structure. Dams are assigned a structure classification that is based on the potential impact produced by a dam's failure. Class A structures are considered low-hazard structures for which failure would result in loss of the structure itself, but little or no additional damage to other property. Class B structures are considered a moderate hazard structure for which failure would cause significant damage to property and project operation, but loss of life is not envisioned. Class C dams are high hazard structures.

By definition, the Class C high-hazard dam classification indicates that a dam failure would result in one or more of the following consequences:

- Loss of life
- Extensive damage to residential buildings
- Damage to industrial or commercial buildings
- Damage to public utilities
- Damage to main highways or railroads

Table 3.2-2 lists MSD-owned Class C-high hazard dams located in Jefferson County, and Table 3.2-3 lists Class C-high hazard dams located in Jefferson County and owned by others. Tables 3.2-2 and 3.2-3 also identify each dam owner, impoundment volume, and height, as well as potential risks associated with dam failure. Mitchell Hill Lake Dam and Norton Commons Dam do not meet the strict definition of a dam as defined by the KDOW. However, because of the risks associated with the failure of either structure, KDOW lists both structures as Class C-high hazard dams. As identified in Tables 3.2-2 and 3.2-3, primary buildings include business and residential structures that are designed for human occupancy. By definition, primary buildings would include all homes, apartment buildings, and office buildings. Secondary buildings are not designed for human occupancy. These structures include garages, sheds, and outbuildings. Critical structures include hospitals, schools, firehouses, and police stations.

Table 3.2-1. Status of Viaducts

Viaduct ID	Location	Number of Sump Inlets (each)	Type of Sump Inlets	Flanker Inlets (within 1 inch vertically) (each)	General Condition of Inlets	Approximate Total Sag Inlet Capacity (assumes no tailwater) (cfs)
VIA01	13th and Market Streets	2	MSD double	0	OK	12.1
VIA02	32nd and Market Streets	2	MSD single	0	Silted/clogged	11.5
VIA03	13th and Main Streets	2	MSD double	0	OK	12.1
VIA04	13th Street and Muhammed Ali Boulevard	2	MSD single	0	OK	11.5
VIA05	30th Street and Portland Avenue	2	MSD double	3	OK	12.1
VIA06	North 30th and Bank Streets	8	MSD single	0	OK	46.1
VIA07	South 13th and West Jefferson Streets	4	MSD double	0	OK	24.1
VIA08	South 16th Street and Algonquin Parkway	2	CBI A	4	Cracked	Pump station
VIA09	South 6th and West Hill Streets	4	MSD double	0	OK	24.1
VIA10	South Floyd and East Hill Streets	2	MSD double	0	OK	Pump station
VIA11	East Brandeis Avenue and South Brook Street	2	MSD double	4	OK	Pump station
VIA12	8th and Oak Streets	2	MSD single	0	OK	11.5
VIA13	South 13th and West Hill Streets	2	MSD double	0	OK	12.1
VIA14	South 31st Street and West Broadway	2	MSD double	0	OK	12.1
VIA15	South 7th Street and West Magnolia Avenue	4	MSD single	-	OK	23.0
VIA16	3rd Street and Eastern Parkway	2	MSD double	0	OK	Pump station
VIA17	South 4th Street and Industry Road	4	MSD double	0	Clogged	Pump station

Table 3.2-1. Status of Viaducts

Viaduct ID	Location	Number of Sump Inlets (each)	Type of Sump Inlets	Flanker Inlets (within 1 inch vertically) (each)	General Condition of Inlets	Approximate Total Sag Inlet Capacity (assumes no tailwater) (cfs)
VIA18	Eastern Parkway and Hahn Street	2	MSD double	0	OK	12.1
VIA19	South 32nd Street and West Muhammad Ali Boulevard	4	MSD double	0	Partially clogged	24.1
VIA20	31st Street and Vermont Avenue	4	MSD double	0	OK	24.1
VIA21	30th Street and Del Park Terrace	2	MSD double	0	OK	12.1
VIA22	22nd Street and Standard Avenue	2	Single and double	0	OK	11.8
VIA23	Dixie Highway and Standard Avenue	2	MSD single	0	OK	11.5
VIA24	South 15th and West Oak Streets	9	MSD double	0	OK	54.3
VIA25	South 10th and West Hill Streets	2	MSD double	4	OK	12.1
VIA26	7th Street and Davies Avenue	2	MSD double	0	OK	12.1
VIA27	15th and Chestnut Streets	2	MSD double	0	OK	12.1
VIA28	South 15th Street and West Broadway	2	MSD double	0	OK	12.1
VIA29	13th and Maple Streets	4	MSD double	0	OK	24.1
VIA30	12th and Maple Streets	2	MSD double	0	OK	12.1
VIA31	Breckinridge and Six Mile Lanes	KYTC maintained				
VIA32	South 3rd Street and Winkler Avenue	4	MSD double	0	OK	Pump station
VIA33	Taylorsville Road and Merioneth Drive	4	MSD single	0	OK	23.0
VIA34	7th Street and Manslick Road	KYTC maintained				

cfs cubic feet per second

MSD owns and operates the three dams listed in Table 3.2-2. Based on available information, all three currently have EAPs in place. Kentucky law does not require that EAPs be implemented by dam owners; however, the National Dam Safety Review Board "strongly recommends" that dam owners prepare and maintain EAPs. Whether the other seven Class C dams located in Jefferson County have EAPs in place is unknown. MSD is not responsible for maintaining, improving, inspecting, or otherwise operating the other seven Class C dams located in Jefferson County.

Table 3.2-2. Class C-High Hazard Dams in Jefferson County Owned by MSD

Name of Dam	Dam Impoundment (acre-feet)	Dam Height (feet)	At Risk from Dam Failure
South Fork Beargrass Creek Dry Bed Dam	488	56	2,176 primary buildings, 1,340 secondary buildings, 19 critical facilities, and 153 local roads
Roberson Run-Dry Impoundment	74.1	18	207 primary buildings, 181 secondary buildings, 1 critical facility-Okolona Fire Department 1, and 16 local roads
Whipps Mill Road Dry Dam	343.7	19	77 primary buildings, 50 secondary buildings, 2 critical facilities (Kinder Care Learning Center and Magnolia Springs Senior Living Center), and 20 local roads

2.5.2 Current Inspection Practices

As previously stated, MSD owns, operates, and maintains three of the ten Class C dams located in Jefferson County. MSD inspects the three Class C dams on a quarterly basis. MSD's quarterly inspections address aspects of the dam facility including: access roads, rip rap and erosion protection, berm condition including potential sources of piping failure, concrete spillways, inlets and outlets, and control valves. Inspections are visual and any deficiencies identified by MSD inspectors are addressed by MSD maintenance crews. Table 3.2-4 compares MSD's current dam operation and maintenance practices to industry standard practices. Industry standards used for comparison include the KDOW, Natural Resources Conservation Service (NRCS), and the Association of State Dam Safety Officials (ASDSO).

MSD's practices meet or exceed current industry standards for the four major categories listed in Table 3.2-4. A licensed Professional Engineer (P.E.) supervises the development of MSD dam construction documents. In addition, MSD requires that regular inspections be completed during construction of a new or rehabilitated dam and that a final inspection be performed at the completion of dam construction activities. Industry standards for in-service inspections of Class C dams range from one inspection per year to one inspection every 2 years. MSD requires that all Class C dams receive four in-service inspections per year.

Table 3.2-3. Class C-High Hazard Dams in Jefferson County Owned by Others

Name of Dam	Owner	Dam Impoundment (acre-feet)	Dam Height (feet)	At Risk from Dam Failure
Tom Wallace Lake Dam	Louisville Metro Parks	98.2	25	190 primary buildings, 133 secondary buildings, 1 critical facility (Fairdale Elementary School), and 14 local roads
Pine Hill Lake No. 1	Windsor Lake Home Owners Association	37.3	27	See Windsor Forest Dam [a]
Windsor Forest Dam	Windsor Forest Home Owners Association	63.1	23	89 primary buildings, 49 secondary buildings, 1 critical facility (Britthaven of South Louisville), and 11 local roads [a]
Mitchell Hill Lake Dam	Louisville Metro Parks	25.7	20	104 primary buildings, 81 secondary buildings, no critical facilities, and 10 local roads
LG&E Wastewater Dam	LG&E	Pond has been filled in	12	Risk has been removed; LG&E is in the process of removing the dam from KDOW registry.
LG&E Ash Pond at Mill Creek Station	LG&E	4,135	77	LG&E has indicated that this pond will likely be filled in 2018
Norton Commons Dam	Norton Commons, LLC	31.5	13	6 primary buildings, 2 secondary buildings, no critical facilities, and 5 local roads

[a] Pine Hill Lake No. 1 is upstream and in series with Windsor Forest Dam. Risks shown are based on Pine Hill Lake No. 1 failing with subsequent failure of Windsor Forest Dam.

LG&E Louisville Gas and Electric

Table 3.2-4. Class C High-Hazard Dams Owned by MSD in Jefferson County—MSD Practice vs. Industry Standards

Practice	MSD	KDOW	NRCS	ASDSO
Dam design [a]	P.E.	P.E.	P.E.	P.E.
Construction inspection	Yes	Yes	Yes	Yes
Periodic in-service inspections	Quarterly	Biannually [b]	Yes, interval undefined	Annually/ biannually [b]
EAPs	Yes	Yes	Yes	Yes

[a] Dam design is prepared and stamped by a P.E.
[b] Once every 2 years

2.5.3 Potential Improvements for Consideration

Although MSD's current dam and dam safety practices meet or exceed recognized industry standards, there are several activities that MSD could consider pursuing to further enhance the safety of the public. Table 3.2-5 summarizes the list of potential improvements for MSD's Class C-high hazard dams. MSD is nearing the completion of their dam breach analysis project. This project has and will help MSD quantify both the risk to human life and the economic liability associated with a breach of MSD's Class C-high hazard dams, and should be included on current and future EAP documents. Installing a 24/7 dam monitoring system at each of MSD's Class C dams would provide MSD with the capability to provide real time notification to downstream residents. The monitoring systems would be capable of detecting both potential overtopping and internal "piping" failures. Piping failures are internal failures that can occur if water begins to move unchecked through the dam structure itself. The dam monitoring system could detect most indicators of a potential dam failure. Sensors would be placed to monitor water movement over the dam, water movement through the dam, and any relative movement of the dam itself.

In addition to the dam monitoring systems, MSD should consider installing a public warning system at each dam location. The public warning system would be capable of notifying residents, businesses, and critical facilities that would be potentially inundated and isolated by a dam breach failure. The public warning system should generate audible sirens and be connected to a local dispatching center. A reverse 911 call system should also be considered, as well as text and Twitter alerts. National Oceanic and Atmospheric Administration (NOAA) alert radios could be given out to the homes and businesses that are in the danger zone.

Table 3.2-5. Class C High-Hazard Dams Potential Improvements

Potential Improvement	Notes
High-Hazard Dam Breach Analysis Project	MSD has a current ongoing project—nearly complete—to accomplish this analysis.
Dam Monitoring Systems	A system to monitor MSD's dams 24/7 should be constructed. This system should be in real-time communication with public warning systems.
Update all EAPs	All dam failure warning and response plans should be updated to include these requirements and elements: • Conduct annual outreach to all properties affected by dams. • Coordinate with critical facility operators. • Develop response plan for critical facilities that would be affected by dam failures.

MSD should also consider updating the Class C dam EAPs on a regular basis. Industry standards vary on updating EAPs, from 1 to 5 years between updates. CH2M recommends reviewing each individual EAP annually and update each EAP as needed. As a minimum, the notification and communication element of the EAPs should be thoroughly examined and updated each year. The parties responsible for notification and communication change on an unpredictable and irregular basis. Downstream infrastructure is also subject to change; further necessitating the need to refresh EAPs at MSD-owned facilities on a regular schedule.

2.6 CRITICAL COMPONENTS CONDITION ASSESSMENT—CONCLUSIONS AND RECOMMENDATIONS

MSD took over most of the existing drainage infrastructure in 1987. Some parts of the system are now more than 100 years old. Examination of work order trends shows that the number of work orders increased with asset age for all assets studied. Future O&M budgets should take this into account. More information on O&M budget considerations can be found in Volume 1, Chapter 7.

However, despite this conclusion, for all but natural channel work orders and catch basins, the money being spent on maintenance is trending downward. The cost breakdown extracted from work orders does not show increased attention to aging facilities. This suggests deferred maintenance could result in reduced system performance and higher costs to repair and/or replace components in the future. With the aging stormwater infrastructure, the need for additional maintenance will only continue to increase. O&M budgets should not be cut and likely should be increased to meet the need of the aging stormwater infrastructure.

The viaduct assessment revealed several improvements to the viaducts with pump stations, as shown in Figure 3.2-15. These minor improvements should be made to extend the life and improve the resiliency of the current pump stations. However, the flood relief projects, identified in Volume 3, Chapter 3, should be the priority and the concerns and needs identified in this chapter would be addressed with those projects. The dam recommendations, described in Section 2.5.3, would help prepare the community in case of an emergency and reduce the likelihood of loss of life due to a catastrophic event at a dam.

VOLUME 3—STORMWATER AND DRAINAGE

CHAPTER 3 DEFICIENCIES AND LEVEL OF SERVICE GAPS IN MAJOR COMPONENTS

This analysis documents the gaps in stormwater planning as determined by the Facility Plan Team. Three main areas are discussed in this chapter: (1) need for comprehensive stormwater master planning, (2) need to address viaduct flooding, and (3) path to increasing the Community Rating System (CRS) ranking.

3.1 COMPREHENSIVE STORMWATER MASTER PLANNING

3.1.1 Background

MSD assumed the responsibility for most of Jefferson County's public stormwater drainage system in 1987. Five suburban cities decided to manage and maintain their own drainage systems: Anchorage, Jeffersontown, St. Matthews, Shively, and Prospect (MSD took over drainage responsibilities for Prospect in 2004). MSD is not responsible for drainage in the right-of-way of most State-maintained roadways and some County through roads. MSD was not originally responsible for drainage in unincorporated areas, or farmlands, of the outer portions of Jefferson County. These areas became part of MSD's responsibilities following the City/County merger in 2003.

When MSD assumed responsibility for countywide drainage responsibilities, it also assumed responsibility for a large list of stormwater-related problems, some dating back several decades. The new drainage program began in 1987 with about 1,500 historical requests for drainage improvements from Louisville, Jefferson County, and MSD's own files. As the program began, these requests began to multiply—to a total of more than 14,000 in the first 6 months and to more than 30,000 in the first 4 years. Most of the requests involved maintenance problems—clogged catch basins, cave-ins, pipes, and ditches—that could be resolved relatively quickly. However, a significant number would require new construction.

To address the major drainage problems of the community, priorities were set for 52 of the most-needed drainage projects, to be financed by a $25-million bond issue. These areas were identified from the *Stormwater Drainage Master Plan* (URS Corporation et al., 1988) and are shown on Figure 3.3-1. This plan also served as the framework to put in place a new drainage user fee based on impervious area on a property. Court delays from challenges to the new drainage user fee delayed implementation of the capital program drainage projects for more than 3 years. MSD completed nearly $2.5 million in small, neighborhood "mini" drainage projects in its first 4 years, but the large projects had to wait until additional funding could be secured. By performing these "mini" drainage projects, MSD resolved nearly 22,000 requests in the first 4 years, resolving nearly 22,000 requests. Approximately 8,000 of the more difficult larger projects had to wait until additional funding could be secured.

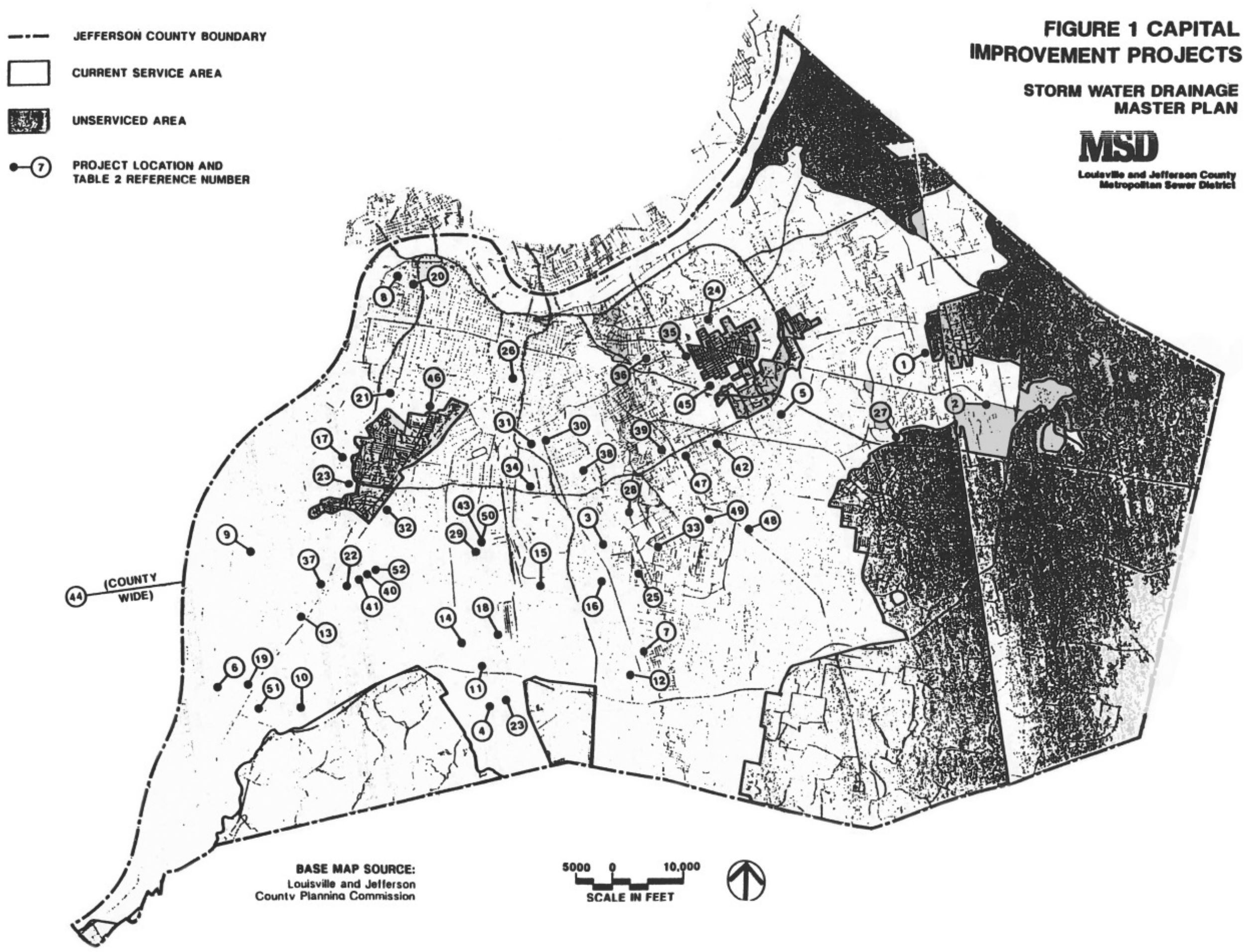

Figure 3.3-1. Capital Projects recommended in the 1988 Stormwater Drainage Master Plan (URS Corporation et al., 1988)

By early 1991, MSD had identified more than 100 areas that needed major construction projects to deal with their drainage problems. The initial $25-million bond had been designed to cover only 52 capital projects. In reality, it was only enough to cover 40 of the original 52 projects. In January 1993, MSD approved a revised list of more than 200 drainage projects to be completed within the following 5 years; to be paid for with $48 million in bonds that were paid for with an increase in the drainage fee from $1.75 to $2.75 per residential unit. The need for the rate increase was explained at 40 community meetings and six public hearings. Most work for the 100 priority areas was completed despite the needs that arose from the 1997 flood taking a higher priority.

In January 2003, MSD launched a highly successful program called Project DRI that was developed after the 2003 general election, as MSD looked for a way to respond more quickly to citizen's drainage concerns. Project DRI prioritizes drainage request, meets property owners at their home to discuss the problem, triages the problem, develops solutions, and prioritizes the remedial work necessary to address the request. To date, it has been a highly successful program in the view of the community. However, while this program handles minor drainage request very well, it does not tackle large-scale drainage problems that involve planning at a watershed level. Quite often, these types of problems only surface after infrequent, intense rain events.

Over the years, the USACE has conducted several studies of flooding in the community. In the mid-1970s, a special study of the Beargrass Creek watershed recommended a dry-bed reservoir on the South Fork near Houston Acres to relieve flooding downstream; the reservoir would hold water during heavy rains, then release it slowly afterward. Jefferson County built this reservoir as part of a major drainage program in the late 1970s. In 1989, a new study, the Pond Creek Feasibility Study of the Pond Creek watershed was authorized (USACE, 1989); MSD joined with the USACE in conducting it. In 1994, the study proposed $16.4 million in flood-control work, and in 1996, U.S. Congress appropriated the first $1.5 million to start detailed design of the Melco and Vulcan Basins. A feasibility study (USACE, 1997a and 1997b) of the South Fork of Beargrass Creek was started in 1994. The South Fork still had many problems during heavy rains, despite improvements brought by the dry-bed reservoir. Eight additional basins in the South Fork were recommended as a result of this study. In 1994, a reconnaissance study (USACE, 1994) of southwest Louisville was initiated. However, USACE ultimately determined from the resulting feasibility analysis and study that projects could not be justified, under the USACE benefit/cost requirements (USACE, 2012). This study did result in MSD enhancing the Plumbing Modification Program.

The aforementioned *Stormwater Drainage Master Plan* was updated in 2010 (MSD, 2010) to include information on existing watershed conditions and ongoing projects. The long-term planning of the 1988 version was not modified, though. In the years since the 1988 plan was written, land use patterns changed, impervious surface greatly increased, extreme storm events occurred with increased frequency, and customers demanded a higher level of service. Recent heavy rains have highlighted the problem of flood-prone areas inside the floodwall.

Although MSD has completed several capital projects, including both conveyance and basin projects in the last 15 years, including the recently completed Aluma Basin in the Pond Creek Watershed, the stormwater capital program is not currently being driven by any previous comprehensive master planning efforts. The 1997 flood and competing priorities, such as the EPA Consent Decree[1], diverted MSD's attention and resources away from master plan implementation. This, combined with the increased frequency of extreme events, represents a gap in planning that the recommended master planning effort will help bridge.

In addition, the rainfall rates that were used in the original 1988 master plan—and still used in the current MSD *Design Manual* (MSD, 2015a)—need to be updated to reflect current and projected rainfall data. This represents a gap that the recommended master planning can address. The 1988 master plan used rainfall data from the publication *Rainfall Frequency Values for Kentucky* (KDOW, 1971). This

[1] The Commonwealth of Kentucky, Plaintiff, and the United States of American, Plaintiff-Intervener, v. Louisville and Jefferson County Metropolitan Sewer District, Defendant, in the United States District Court, Western District of Kentucky, Louisville Division. Amended Consent Decree, Case 3-08-cv-00608-CRS. Filed April 15, 2009. Available at http://www.msdprojectwin.org/Portals/0/Library/Consent%20Decree/ Agreement/ Commonwealth%20of%20KY%20vs%20MSD%20%20Amended%20Consent%20Decree.pdf.

publication summarized rainfall frequency values for each county in Kentucky and was based on the technical publication *Technical Paper No. 40, Rainfall Frequency Atlas of the United States* (TP-40; NOAA, 1961) prepared for the U.S. Department of Commerce. TP-40 was developed using available rainfall information from far fewer stations than those that exist today and included the dust-bowl years of the 1930s. The newer drainage systems in Louisville (post 1987) are designed based on these historical rainfall amounts. Some older drainage systems adopted by MSD, when it took over drainage for most of Jefferson County, may not have been designed to these standards. Therefore, the drainage system has portions that likely do not provide the level of service consistent with MSD criteria, especially because storm events have been increasing in frequency and intensity over the past couple of decades.

Due to the reasons outlined above, it is recommended that MSD develop a new countywide comprehensive stormwater master plan. The recommended goals and objectives of the proposed comprehensive stormwater master plan are as follows:

- Work towards minimum level of service for everyone in the MSD drainage service area, based on rainfall intensity duration and frequency projections anticipated to occur at the end of the 20-year planning period.
- Maintain an up-to-date inventory of the stormwater infrastructure, including identified deficiencies.
- Prepare a process to develop ratings of stormwater infrastructure by comparing present conditions against established standards and required levels of service.
- Establish a methodology to review technical standards and design criteria for stormwater infrastructure in the MSD drainage service area within the MSD drainage service area, at least once every 10 years.
- Identify projects that conform to adopted design criteria and standards.
- Update rainfall and discharge data for watersheds and sub-basins to reflect the projected rainfall over the next 20 years.
- Look for opportunities to integrate green infrastructure into the planning of MSD projects to meet the objectives of the MS4 Program.
- Ensure content is consistent with elements identified in EPA’s Community Solutions for Stormwater Management: A Guide for Voluntary Long-Term Planning (2016a).

3.1.2 Recommendations for Plan Execution

The following are the recommendations for executing the proposed comprehensive stormwater master plan:

- Stormwater should be managed on a watershed-by-watershed basis and can be achieved by developing individual watershed master plans. These plans document the hydrologic, physiographic, drainage characteristics, and planning tools important in managing stormwater in each watershed. Using documented information within the context of various policies, goals, and objectives established for the watershed master plans, specific “action plans” may be developed for each watershed. These action plans would then be the basis for recommended regional projects, possible new or modified regulations for development, and the requirements for further updating and upgrading the planning data models.

- To help facilitate the watershed master planning, a set of up-to-date and accurate models are needed. Each watershed should have updated modeling for project development purposes. The updated modeling should account for existing and projected future rainfall (see Volume 3, Chapter 5 for the updated rainfall amounts). MSD has water surface profiles calculated for all of the FEMA-recognized floodplains in Jefferson County; however, the models are inconsistent and also are not housed on MSD servers. Currently, the models are hosted off site by a third-party consultant. Some models are outdated Hydrologic Engineering Center (HEC) HEC-1 and HEC-2 models, and not all are updated for current conditions.
- MSD should administer the floodplain modeling used to determine new development impacts. Currently, the development community obtains the existing model from MSD, if there is one, and modifies it accordingly for their development plan to exhibit existing and proposed development effects. However, this approach leads to inconsistent modeling methods and inconsistent models. With MSD administering the modeling, the models will be much more consistent and more accurate because they will be continuously updated, and will include approved developments. The method used to model the sewer system using an integrated catchment model (ICM) hosted on MSD's server is one that should be considered for future stormwater modeling.
- To supplement modeling and help identify problem areas outside of recognized floodplains, establishing new models using two-dimensional modeling should be considered to help identify and prioritize drainage problem areas. These models have proved promising for planning-level hydraulic modeling, especially at the subwatershed or neighborhood level. This software performs well with shallow depth flooding areas.

3.2 VIADUCT FLOODING MITIGATION PROJECTS

MSD is responsible for managing the drainage from 32 viaducts that are subject to flooding during storm events. Some viaducts become completely impassable in relatively minor storms. Viaduct flooding disrupts transportation routes and creates potential hazardous conditions (see Figure 3.3-2) if flooded roads are not barricaded in a timely manner or if drivers ignore the barricades and drive under the viaducts anyway. Most viaducts are connected to the CSS, thereby adding to the complexity of the solutions. Reducing the flooding potential at these viaducts will not be a simple task. MSD must partner with Louisville Metro Public Works and the railroad companies to develop solutions to these complex transportation and drainage issues.

Viaducts flood when there is insufficient capacity to remove stormwater during an event, either from the outlet pipes backing up or from insufficient inlet or pump capacity, or some combination of both. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area (see Figure 3.3-3). The water will collect and build up, often very rapidly, if the outlet pipes and/or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate (see Volume 3, Chapter 2 for documentation of the existing condition and estimated capacities of the viaducts).

While MSD does not own the viaduct infrastructure, responsibility for the through drainage at the viaducts belongs to MSD, per memorandums of understanding between the City of Louisville and the KYTC. While the cost to reduce the flooding frequency at these viaducts may seem prohibitively high, other project alternatives, such as eliminating the viaducts by building bridges over the railroads, for example, are, in some cases, just not feasible or are equally as expensive. While the responsibility lies with MSD for the drainage, pursuing discussions with the other public agencies to see where partnering and cost sharing opportunities may exist is recommended. The conceptual projects to relieve the viaduct flooding are explained below.

Figure 3.3-2. Floyd and Hill Street Viaduct after August 1992 Deadly Event

Figure 3.1-3. Viaduct at 3rd Street and Eastern Parkway

For this planning-level effort, six different storm scenarios were evaluated. The 10-year, 25-year, and 100-year return intervals were evaluated, and the return intervals were defined by using the updated NOAA Atlas 14 rainfall data (NOAA, 2004) and the 2035 projected data (CH2M, 2015). Figure 3.3-4 shows the viaduct locations.

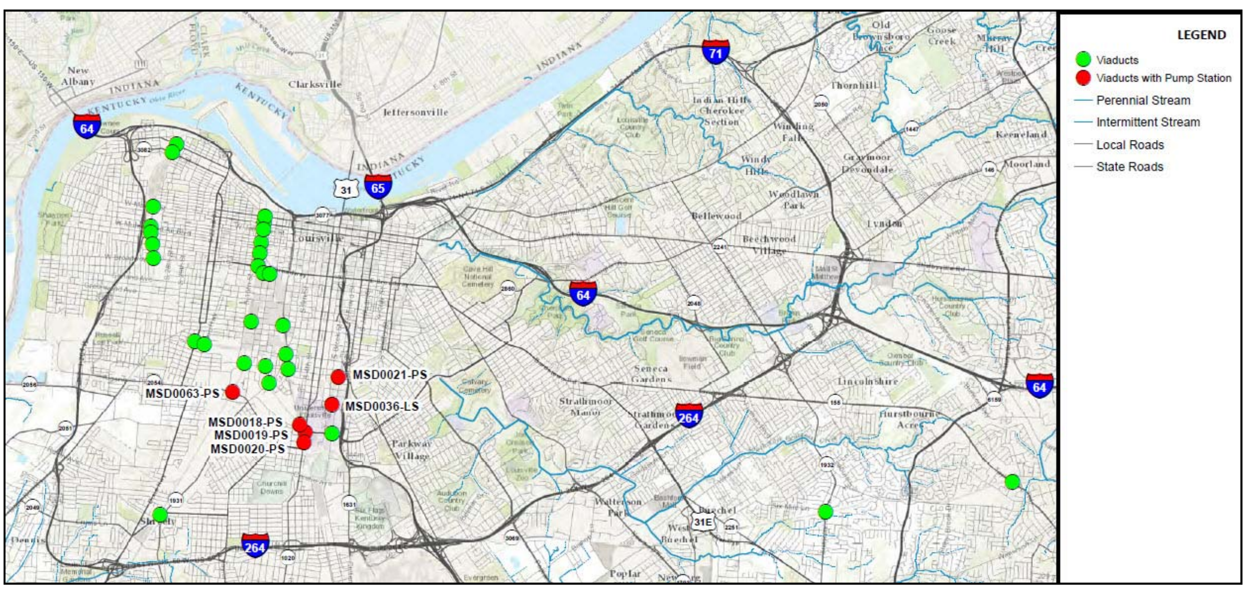

Figure 3.3-4. Location of MSD-Owned Viaducts (red indicates existing pump station)

3.2.1 Existing Studies

Currently, no historical records are available as to the extent and frequency of flooding for the viaducts, with the possible exception to the highly reported flooding at the viaducts near the UofL campus. UofL and MSD have initiated a draft preliminary study *University of Louisville Area Flooding Analysis* (Heritage Engineering, LLC, 2015) to better understand the cost of upgrading those viaducts, which include viaducts on 3rd Street, 4th Street, Brandeis Avenue, and Brook Street. The preliminary engineering costs for these four viaducts were derived from information contained in this report. However, this report was based on TP-40 rainfall data, which used historical rainfall through the early 1960s. A cost escalation percentage was calculated to project these costs for the updated Atlas 14 and 2035 projection rainfall amounts.

3.2.2 Planning Methodology

3.2.2.1 Viaducts with Pump Stations

Six viaducts have pumps associated with them. These pumps assist in draining the viaducts after storm events. However, they are not sized to adequately keep the viaducts dry during heavy rain events. Also, some appear to pump back into the system, which may be over capacity and surcharging, creating a circular pumping effect. For these viaducts, the information from the draft *University of Louisville Area Flooding Analysis* (Heritage Engineering, LLC, 2015) was used as a baseline to help determine a reasonable planning approach and costs for the viaduct solutions. However, as previously noted, the existing report is based on the TP-40 rainfall data. A scale factor (Table 3.3-1) was developed so the costs could be escalated to account for the projected increase in rainfall and the information contained in the existing UofL analysis could be used.

Table 3.3-1. Cost Scale Factors from the Baseline Condition (TP-40 rainfall)

ARI	TP-40 (Baseline)	TP-40 to Updated Atlas 14	Updated Atlas 14 to 2035 Projection	TP-40 to 2035 Projection
10-year	N/A	+7%	+5%	+12%
25-year	N/A	+12%	+7%	+19%
100-year	N/A	+21%	+7%	+27%

ARI average recurrence interval

The scale factor was developed by taking the percentage increase averaged from volume change, discharge change, and rainfall change between the MSD *Design Manual* (TP-40), NOAA Atlas 14, and the 2035 projection rainfall events for a given representative watershed area and storm duration. It is assumed that the costs for the individual projects are directly proportional and linear to the increase in rainfall volume from TP-40 to the newer rainfall projections. Appendix 3A contains the calculations.

For the two other viaducts that have pump stations (16th Street/Algonquin Parkway and Floyd Street/Hill Street), it was concluded that the Brandeis Avenue viaduct solutions could be used as planning level solutions for these viaducts as well.

3.2.2.2 Viaducts without Pump Stations

For the viaducts that do not have an existing pump station, it was assumed that a gravity-fed solution to a storage basin could be feasible. This would be necessary, because the viaducts are the lowest places in the surrounding topography and the first places that the CSS surcharges and backs up into. Three cost parameters were established: approximate property acquisition, storage, and pumping costs. The property costs were calculated using current Property Valuation Administrator values. A 22-percent factor was applied for acquisition and demolition costs.

The storage costs were established for three different recurrence intervals (10-year, 25-year, and the 100-year event), as well as three different rainfall calculation methodologies—MSD *Design Manual* (TP-40), updated Atlas 14, and 2035 projection; only the latter two are shown on the cost estimate. For this planning-level study, storage for all viaducts was assumed equal, and storage volumes for the viaducts were assumed to be approximately equal to the Brandeis Avenue viaduct as reported in Table 12 of the draft *Louisville Metropolitan Sewer District University of Louisville Area Flooding Analysis*. (Heritage Engineering, LLC, 2015). The storage volumes were then used to size an appropriate underground concrete basin.

The price of concrete was assumed as $118 per cubic yard, and the cost of steel was assumed as $1 per pound. The basins are assumed to be 30 feet deep, which would provide a “gravity-in” scenario but also would force a “pump-out” scenario. To obtain the costs for the other rainfall scenarios, the scale factors previously mentioned were applied.

The pump costs were calculated by sizing the pumps based on total storage volume and assuming a 24-hour pump-out period. This provided a cost for pumps, piping the concrete structure, and electrical equipment. The three parameters were then added together for all the viaducts to provide a total cost for the storage basins with a “gravity-in” scenario. A 30-percent contingency was applied to the total cost of all viaducts to account for miscellaneous items. Appendix 3B contains the cost information.

Note that a more in-depth study should be performed at each viaduct to develop site-specific solutions and alternatives. The cost numbers developed and presented here represent a planning-level opinion for addressing flooding at the viaducts. Table 3.3-2 summarizes estimated costs for the updated Atlas 14 and 2035 projected rainfall amounts. The MSD *Design Manual* recommends at least a 25-year design for this type of roadway in a sag condition. Appendix 3B contains the complete costing matrix.

Table 3.3-2. Summary of Viaduct Flood Relief Costs (2016 Dollars)

Viaduct ID	Location	2035 Projection (25-Year Storm)
VIA16	South 3rd Street and Eastern Parkway	$29,900,000
VIA17	South 4th Street and Industry Road	$29,900,000
VIA32	South 3rd Street and Winkler Avenue	$29,900,000
VIA11	East Brandeis Avenue and Brook Street	$28,000,000
VIA08	South 16th Street and Algonquin Parkway	$28,000,000
VIA10	South Floyd and East Hill Streets	$28,000,000
VIA01	13th and Market Streets	$5,000,000
VIA02	South 32nd and West Market Streets	$6,700,000
VIA03	North 13th and West Main Streets	$5,400,000
VIA04	South 13th Street and West Muhammad Ali Boulevard	$5,800,000
VIA05	North 30th Street and Portland Avenue	$4,400,000
VIA06	North 30th and Bank Streets	$4,300,000
VIA07	South 13th and West Jefferson Streets	$5,000,000
VIA09	South 6th and West Hill Streets	$4,000,000
VIA12	8th and Oak Streets	$4,000,000
VIA13	South 13th and West Hill Streets	$4,000,000
VIA14	South 31st Street and West Broadway	$4,600,000
VIA15	South 7th Street and West Magnolia Avenue	$4,000,000
VIA18	Eastern Parkway and Hahn Street	$6,500,000
VIA19	South 32nd Street and West Muhammad Ali Boulevard	$6,700,000
VIA20	31st Street and Vermont Avenue	$4,000,000
VIA21	30th Street and Del Park Terrace	$4,000,000
VIA22	22nd Street and Standard Avenue	$3,800,000
VIA23	Dixie Highway and Standard Avenue	$5,300,000
VIA24	South 15th and West Oak Streets	$5,300,000

Table 3.3-2. Summary of Viaduct Flood Relief Costs (2016 Dollars)

Viaduct ID	Location	2035 Projection (25-Year Storm)
VIA25	South 10th and West Hill Streets	$5,300,000
VIA26	South 7th Street and Davies Avenue	$5,300,000
VIA27	South 15th and West Chestnut Streets	$3,900,000
VIA28	South 15th Street and West Broadway	$3,900,000
VIA29	13th and Maple Streets	$3,800,000
VIA30	12th and Maple Streets	$3,800,000
VIA33	Taylorsville Road and Merioneth Drive	$4,400,000

3.3 COMMUNITY RATING SYSTEM

The NFIP's CRS is a voluntary incentive program that recognizes communities for implementing floodplain management practices that exceed the federal minimum requirements of NFIP to provide protection from flooding. In exchange for a community's proactive efforts to reduce flood risk, policyholders can receive reduced flood insurance premiums for structures in the community.

By participating, communities earn credit points that determine classifications. There are 10 CRS classes: Class 1 requires the most credit points and provides the largest flood insurance premium reduction (45 percent), while Class 10 means the community does not participate in the CRS or has not earned the minimum required credit points, and residents receive no premium reduction. The CRS classes are based on completing 19 creditable activities organized into four categories:

- Public Information
- Mapping and Regulations
- Flood Damage Reduction
- Warning and Response

Table 3.3-3 lists the credit points required for each CRS class and summarizes the flood insurance premium discounts for each CRS class.

Table 3.3-3. Community Rating System Classes, Credit Points, and Premium Discounts

CRS Class	Credit Points (cT)	Premium Reduction	
		In SFHA [a]	Outside SFHA [b]
1	4,500+	45%	10%
2	4,000 to 4,499	40%	10%

Table 3.3-3. Community Rating System Classes, Credit Points, and Premium Discounts

CRS Class	Credit Points (cT)	Premium Reduction	
		In SFHA [a]	Outside SFHA [b]
3	3,500 to 3,999	35%	10%
4	3,000 to 3,499	30%	10%
5	2,500 to 2,999	25%	10%
6	2,000 to 2,499	20%	10%
7	1,500 to 1,999	15%	5%
8	1,000 to 1,499	10%	5%
9	500 to 999	5%	5%
10	0 to 499	0%	0%

Notes:
Preferred Risk Policies are not eligible for CRS premium discounts because they already have premiums lower than other policies. Preferred Risk Policies are available only in B, C, and X Zones for properties that are shown to have a minimal risk of flood damage.

Some minus-rated policies may not be eligible for CRS premium discounts.

Premium discounts are subject to change.

[a] SFHA: Zones A, AE, A1-A30, V, V1-V30, AO, and AH
[b] Outside the SFHA: Zones X, B, C, A99, AR, and D

cT credit point
SFHA special flood hazard area

3.3.1 Community Rating System Program Recent History

MSD has recently integrated the CRS planning requirements into the Louisville Metro hazard mitigation planning process. The CRS 10-step planning process is consistent with the multihazard planning regulations under Code of Federal Regulations (CFR), Title 44, Part 201. This action will allow MSD to take advantage of additional funding and grant opportunities with a focus on flooding and repetitive loss prevention. MSD currently participates in and has been awarded CRS credit points for performing 18 different floodplain management activities:

- Elevation Certificates
- Map Information Service
- Outreach Projects
- Hazard Disclosure
- Flood Protection Information
- Flood Protection Assistance
- Flood Insurance Promotion

- Floodplain Mapping
- Open Space Preservation
- Higher Regulatory Standards
- Flood Data Maintenance
- Stormwater Management
- Floodplain Management Planning
- Acquisition and Relocations
- Flood Protection
- Drainage System Maintenance
- Flood Warning and Response
- Dams and Levees

In 2012, Louisville MSD's NFIP CRS increased from Class 5 to Class 4. The community's CRS Class 4 rating qualified for a 30-percent discount in the premium cost of flood insurance for NFIP policies issued or renewed in SFHAs. This new rate applies to all new policies and policies renewed on or after May 1, 2012. The premium reduction applies only to properties located in an SFHA. To obtain the higher classification, Louisville MSD increased its CRS credit points from 3,017 to 3,316 and met the prerequisites for Class 4.

On June 12, 2015, Insurance Services Office issued a much-anticipated letter to MSD, indicating MSD had acquired the 3,503 CRS credit points needed to move up to a CRS Class 3 community. This reclassification results in a 35-percent discount in flood insurance premiums for Louisville and Jefferson County residents located in SFHAs. The effective date for this discount was October 1, 2015.

3.3.2 Community Rating System Program Moving Forward

As MSD moves forward, the potential for moving to a higher CRS classification should be evaluated. A Class 2 CRS community rating would entitle MSD's customers located in SFHAs to an additional 5 percent discount on their flood insurance premiums. This new discount rate of 40-percent would reduce the annual premium paid by each individual flood insurance policyholder located in an SFHA by $71 per year, as compared with the 35-percent discount rate. This reduction in premium would result in a combined additional annual savings of $280,000 for the 3,900 SFHA flood insurance policyholders.

MSD has indicated the desire to continue to stand out as a model CRS community. To obtain a Class 2 CRS rating, MSD would be required to earn a total of 4,000 CRS credit points, which is an increase of about 500 points. Metro Louisville must maintain an International Organization for Standardization (ISO) Building Code Effectiveness Grading Schedule of 4/4 or better to be eligible for Class 2. The points MSD has obtained to date as well as the points available in each floodplain activity are shown in Table 3.3-4. Table 3.3-5 summarizes recommendations for the activities MSD should pursue moving forward from a Class 3 to a Class 2 community. Table 3.3-6 expands upon Table 3.3-5 and provides more detail regarding the types and cost of projects MSD can pursue to achieve its goal of becoming a Class 2 community.

Table 3.3-4. Community Rating System Program Evaluation—Summary of Community Rating System Activities

Activity	Maximum Points	Points Obtained by MSD to Date	Points Available	Current and Proposed Activities
300 Public Information Activities				
310 Elevation Certificates	116	38	78	Credits were obtained for maintaining elevation certificates for new and substantially improved buildings in SFHA.
320 Map Information Service	90	90	0	Maximum points obtained.
330 Outreach Projects	350	350	0	Maximum points obtained.
340 Hazard Disclosure	80	32	48	Credit provided for communities that disclose flooding hazards.
350 Flood Protection Information	125	90	35	Credit provided for making flood protection information available via public library and web sites.
360 Flood Protection Assistance	110	85	25	Credit is provided for providing advice on financial assistance, providing property protection advice, and visiting properties before giving advice.
370 Flood Insurance Promotion	110	110	0	Maximum points obtained.
400 Mapping and Regulations				
410 Floodplain Mapping	802	203	599	CRS credits are provided for new studies, higher study standards, more restrictive floodway standards, mapping of special flood-related hazards, and cooperating technical partner agreement.
420 Open Space Preservation	2,020	411	1,609	Community is provided credit for open space preservation, deed restrictions, preserving and restoring opens space natural function, keeping flood-prone portions of developments open, and low-density zoning.
430 Higher Regulatory Standards	2,042	501	1,541	Credit is provided for limiting development in SFHAs and incorporating, freeboard, foundation protection, building codes, and other higher standards into their regulations.

Table 3.3-4. Community Rating System Program Evaluation—Summary of Community Rating System Activities

Activity	Maximum Points	Points Obtained by MSD to Date	Points Available	Current and Proposed Activities
440 Flood Data Maintenance	222	210	12	CRS credits are provided for benchmark maintenance, firm maintenance, and erosion data maintenance.
450 Stormwater Management	755	478	277	Credit is provided for regulating development, watershed masterplan, erosion and sediment control regulations, and improving stormwater runoff quality.
500 Flood Damage Reduction Activities				
510 Floodplain Management Planning	622	258	364	CRS credits obtained for a community-wide floodplain management plan, detailed mitigation plan, and natural floodplain functions plan.
520 Acquisition and Relocations	2,250	190	2,060	A community can obtain points for relocating critical care facilities, removing buildings from floodplain, and acquiring or relocating repetitive loss properties.
530 Flood Protection	1,600	160	1,440	CRS credit points are provided for retrofitting buildings and for structural flood control projects.
540 Drainage System Maintenance	570	147	423	Points obtained for maintaining drainage channels, problem sites, and storage basins. Points obtained for having a capital improvements program for drainage improvements and for developing stream dumping regulations.
600 Warning and Responses				
610 Flood Warning and Response	395	140	255	A community can obtain credit points for providing emergency warnings to the public, developing a flood threat recognition system, coordination with critical care facilities, and being designated as a storm-ready community.
620 Levees	235	0	235	Points can be obtained for providing levee failure warnings to the public, coordinating levee failure with critical care facilities, and implementing a levee maintenance plan.
630 Dams	160	10	150	CRS credit points provided for State Dam Safety Program.
Totals	**12,654**	**3,503**	**9,151**	

Table 3.3-5. Community Rating System Program Evaluation—Strategy to Achieve a Class 2 Rating

Activity	Maximum Points	Points Obtained	Points Available	Recommendation
400 Mapping and Regulations				
410 Floodplain Mapping	802	203	599	Pursue, see Table 3.3-6.
420 Open Space Preservation	2,020	411	1,609	Pursue, see Table 3.3-6.
430 Higher Regulatory Standards	2,042	501	1,541	Pursue, see Table 3.3-6.
500 Flood Damage Reduction Activities				
510 Floodplain Management Planning	622	258	364	Pursue, see Table 3.3-6.
Totals	**5,486**	**1,373**	**4,113**	

Table 3.3-6. Community Rating System Program Evaluation—Recommended Projects to Achieve a Class 2 Rating

Recommended Activity	Estimated Points to Obtain by Activity	Potential Projects-Action Items	Estimated Cost to MSD
400 Mapping and Regulations			
410 Floodplain Mapping	100	Maintain and expand current mapping activities. Mapping activities would include identifying and remapping previously mapped areas in need of revision due to development and bringing unmapped areas up to FEMA mapping standards.	$200,000
420 Open Space Preservation	100	Expand stream buffers. Add incentives to maintain more open space in floodplains. Continue to collect information on open space as it is created.	$0 if completed with in-house staff.
430 Higher Regulatory Standards	100	Continue MSD's practice of setting local regulatory standards and policies higher than FEMA requirements. Potential changes include increasing freeboard up to 3 feet, increasing onsite floodplain compensation, increasing lowest finish floor requirements and updating current floodplain regulations to exceed recent regulatory changes.	$0 if completed with in-house staff.
500 Flood Damage Reduction Activities			
510 Floodplain Management Planning	100	Edit the current floodplain management plan. Revisions could include directives to prevent new problems, reduce losses, and protect the natural and beneficial functions of floodplains. Build a constituency that wants to see the plan's recommendations implemented.	$0 if completed with in-house staff.
Total	**500**		**$200,000**

The highest CRS community rating is Class 1. This classification would reduce the flood insurance premiums paid by all policyholders located in an SFHA by an additional 5-percent to the maximum allowable reduction of 45-percent. Communication with MSD personnel indicates that moving from a Class 2 to a Class 1 community would not be a cost-effective option for the community. The NFIP CRS Coordinator's Manual (FEMA, 2014) has specific prerequisites that a community must meet before obtaining Class 1 status, including the following:

1. Meet all Class 4 prerequisites.
2. Meet the minimum standards of the NFIP, as determined by a community assistance visit conducted by FEMA within the previous 12 months.
3. Promote flood insurance as a vital way to protect residents and business from the financial impact of a flood. This is demonstrated by obtaining at least 50-percent of the maximum points under Activity 370.
4. Demonstrate the community has a "No Adverse Impact" approach to floodplain management.
5. Mitigate repetitive loss problems and problems caused by other natural hazards.
6. Protect natural floodplain functions.
7. Develop a program that addresses the threat to life that flooding poses to the residents of the community.

MSD has completed the requirements defined by the first three prerequisites. Item 5 requires MSD to demonstrate that at least 25-percent of its repetitive loss properties have been protected from flood damage. This mitigation can be accomplished by acquisition, retrofitting, or structural flood control projects. MSD has removed approximately 81 repetitive loss properties through acquisition. If the situation was static, MSD would comply with the 25-percent criteria; however, the situation is not static. Flood event frequencies and magnitudes have been increasing. As a result, the number of repetitive loss properties continues to increase within the community. The cost associated with mitigating these properties is far in excess of the benefits derived from Class 1 status. Item 7 contains a required activity that MSD has identified as being cost prohibitive as well. Based on the findings presented, our recommendation is that MSD should not pursue Class 1 community status.

VOLUME 3—STORMWATER AND DRAINAGE

CHAPTER 4 MUNICIPAL SEPARATE STORM SEWER SYSTEM PROGRAM

4.1 MUNICIPAL SEPARATE STORM SEWER SYSTEM OVERVIEW AND GOALS OF THIS CHAPTER

Louisville MSD has been responsible for flood control and drainage for incorporated areas of Jefferson County since 1987. MSD began comprehensive water quality monitoring of local streams in collaboration with the USGS in 1988. When the MS4 KPDES permitting program began in the early 1990s, Louisville was the first Phase I MS4 permit issued in the Commonwealth of Kentucky. The mission of the MS4 Program is to enhance stormwater runoff quality and protect streams and riparian habitat in order to promote public health, safety, and welfare. The MS4 Program permit activities are divided into the following program areas:

- Public Involvement, Outreach, Participation, and Learning Experiences
- Illicit Discharge Detection and Elimination
- Industrial Stormwater Program
- Construction Site Stormwater Runoff Control
- Post Construction Stormwater Management in New and Redevelopment
- Pollution Prevention/Good Housekeeping for Municipal Operations Monitor and Control Pollutants in Stormwater Discharges
- Program Assessment and Reporting

As stated in Section 2 of the KPDES permit (KDOW, 2011):

> *The permittee is required to develop, implement, enforce and update as needed a Stormwater Quality Management Plan* [SWQMP] *which shall include controls intended to reduce the discharge of pollutants from its MS4 to the Maximum Extent Practicable* [MEP] *consistent with 40 CFR 122.26."*

Additionally, the permitting process requires compliance with the KDOW's antidegradation provisions. The fact sheet for MSD's current MS4 Program permit (KDOW, 2011) states:

> *The Division of Water has determined that for new or expanded discharges from the MS4 systems covered under this individual MS4 permit the antidegradation requirements of 401 KAR 10:029 Section 1 are satisfied; the Division of Water has concluded that requirements and conditions of this MS4 permit are sufficiently protective to prevent lowering of water quality in high quality and exceptional waters that exist in Jefferson County for new or expanded discharges occurring from the MS4.*

For Louisville's MS4 Program permit, which is renewed every 5 years, MSD serves as the Administrative Lead and are joined by several city governments as co-permittees. MSD's co-permittees include Louisville Metro and the cities of Anchorage, Jeffersontown, St. Matthews, and Shively. Some MS4 Program permit activities are performed independently, while others are performed cooperatively among MSD and the co-permittees. The required components of the program continue to be integrated into the various aspects of MSD's work in the community, as well as into many aspects of the co-permittee operations that include provisions for stormwater runoff pollution prevention, stream protection and restoration, and additional water quality or "green infrastructure" techniques to enhance stream corridors and reduce runoff volume and pollutants of concern. Additionally, MSD and its co-permittees have continually worked together to evaluate changes to the permit during renewal cycles, collaborated on the level of commitment of the MS4 Program based on MEP discussions, and reviewed and recalibrated their MS4 Program based on the previous EPA audit.

Along with MSD, all the co-permittees continually work to improve the water quality of local streams. Throughout each permit cycle, MSD and the co-permittees enhance and improve the MS4 Program planning and activities, regulatory authority, and environmental education programs to comply with the changing requirements of the permit. In 2014, MSD reorganized the Engineering Division to provide internal resources to better meet these goals. Regarding the MS4 Program, the Facility Plan Team will look towards the future and use their best engineering judgment, combined with examples from similar cities, to determine what is likely to represent what regulators may be looking for in future MS4 permitting, having a significant impact on MSD.

4.2 FUTURE MUNICIPAL SEPARATE STORM SEWER SYSTEM REGULATORY IMPACTS ANALYSIS ON POST-CONSTRUCTION REQUIREMENTS

4.2.1 Impact of Future Regulations

In recent years, EPA has evaluated the potential to promulgate updated stormwater management regulations. According to the EPA website, starting in December 2009, EPA began soliciting stakeholder input on key issues that would be considered in a new rulemaking process, including the following:

- Expanding the universe of regulated discharges beyond the urbanized area
- Establishing substantive post-construction requirements for new and redeveloped areas
- Developing a single set of requirements for Phase I and Phase II communities
- Addressing stormwater discharges from existing development through retrofitting

Two of these issues, post-construction and retrofitting requirements, could pose significant challenges for MSD. For example, one approach proposed by EPA was a new post-construction discharge standard that requires the matching of pre- and post-development hydrology (that is, peak flow and volume) for smaller storm events. Current MSD regulations require treatment, infiltration, or storage of the water quality event (0.6 inch in the MS4 Program area) and storage of a storm with a 50-percent chance of occurrence in a year (2-year storm, 3.2 inches) but nothing in between. A requirement to retain any additional post development runoff volume on site represents a difficult and, in many instances, unachievable standard to attain, particularly for areas with poor draining soils. This requirement could impact the local economy by increasing the cost and feasibility to develop land. Additionally, this requirement could impact the location of where development occurs, because it would be easier to meet the requirement in areas of the community with well-drained soils.

EPA's proposal to consider a requirement to retrofit (implementing BMPs in improving previously developed areas to reduce stormwater discharge volumes and pollutant loads) in existing urbanized areas with stormwater BMPs can be expensive depending on the level of retrofitting and pollutant reduction that is required.

While the current trend toward more stringent requirements on MS4 Program discharges is noteworthy, it is also important to mention that EPA is also discussing and/or promoting concepts such as water quality trading, integrated planning, and watershed permitting as strategies and mechanisms to potentially achieve water quality objectives more cost effectively than traditional end-of-pipe point source focused approaches. These tools can be particularly effective when dealing with pollutants such as nitrogen and phosphorous, which often include a significant non-point source contribution.

4.2.1.1 EXAMPLE PERMIT REGULATIONS

Improving water quality in the Chesapeake Bay has been a major initiative for EPA for over 20 years, with a particular focus on the reduction of nutrient loads to the bay. Wastewater treatment plants discharging to tributaries of the Chesapeake Bay have been required to meet some of the most stringent point-source discharge requirements covered under the National Pollutant Discharge Elimination System (NPDES) program. EPA has recognized that point-source discharges in the watershed have been reduced to the point of diminishing returns and are now shifting their focus on improving Chesapeake Bay water quality through nonpoint source control. The MS4 Program permit (EPA, 2012) for Washington, D.C., which governs several highly urbanized watershed tributaries to Chesapeake Bay, includes very stringent requirements. In a comment letter to EPA regarding the draft permit, the National Association of Clean Water Agencies (NACWA) noted that "The District [Washington D.C.] permit has been widely touted as a potential "model" for other permitting agencies" and expressed "significant concern" over some of the proposed permit provisions (NACWA, 2012).

Consistent with previous requirements of the NPDES program in the Chesapeake Bay area, the requirements in this permit are among the most stringent in the nation and are considerably more prescriptive requiring a much higher level of proactive pollutant control than MSD's current permit. The following summarizes some of the more stringent requirements from Washington D.C.'s current MS4 Program permit, signed in 2011:

- Require the design, construction, and maintenance of stormwater controls to achieve on-site retention of 1.2 inches for development greater than or equal to 5,000 square feet.
- Within 18 months of the effective date of this permit, require the permittee to develop and submit for review and comment an off-site mitigation and/or fee-in-lieu program to be used when projects will not meet stormwater management requirements. The permittee shall have

the option of implementing an off-site mitigation program, a fee-in-lieu program, or both. At a minimum these programs shall include the following:

- — Baseline requirements where on-site volume plus off-site volume (or fee-in-lieu equivalent or other relevant credits) must equal no less than the relevant volume required by full onsite management
- — Specific criteria for determining when compliance with the performance standard requirement for on-site retention cannot be met
- — A system or process, for a fee-in-lieu program, to assign monetary values at least equivalent to the cost of implementation of controls to account for the difference in the performance standard, and the alternative reduced value calculated
- — Policies and mechanisms to ensure that the required stormwater practices on-site and off-site stay in place and are maintained

- Within 2 years of the effective date of this permit, require the permittee to develop performance metrics for retrofit projects.
- For each retrofit project, estimate the potential pollutant load and volume reductions achieved through the DC Retrofit Program[1] by major waterbody (e.g., Rock Creek, Potomac, Anacostia) for the following pollutants: bacteria (*E. coli*), total nitrogen, total phosphorus, total suspended solids (TSSs), cadmium, copper, lead, zinc, and trash.
- Define a retrofit as an improvement in a previously developed area that results in reduced stormwater discharge volumes and pollutant loads and/or improvement in water quality over current conditions.
- Base retrofit performance metrics on the average annual retention achieved by a BMP from 1 square foot of impervious surface, normalized to a standard where 1 = 1.2 inches of retention.
- Require the DC Retrofit Program to implement retrofits for stormwater discharges from a minimum of 18,000,000 square feet of impervious surfaces during the permit term. A minimum of 1,500,000 square feet of this objective must be in transportation rights-of-way. (This is approximately 2.4 percent of their total impervious area.)
- Require permittee, no later than 18 months following issuance of this permit, through its updated DC stormwater regulations or other permitting or regulatory mechanisms, to implement an enforceable mechanism that will adopt and implement stormwater retention requirements for properties where less than 5,000 square feet of soil is being disturbed but where the buildings or structures have a footprint that is greater than or equal to 5,000 square feet and are undergoing substantial improvement.
- Require permittee to achieve a minimum net annual tree-planting rate of 4,150 plantings annually within the Washington D.C. MS4 Program area, with the objective of D.C.-wide urban tree canopy coverage equaling or greater than 40 percent by 2035. The annual total tree

[1] http://doee.dc.gov/stormwaterretrofitplan

planting shall be calculated as a net increase such that annual mortality is also included in the estimate.

- Require permittee to install, at a minimum, 350,000 square feet of green roofs on Washington D.C. properties during the term of the permit (including schools and school administration buildings).
- For all Total Maximum Daily Load (TMDL) waste-load allocations (WLA) assigned to Washington D.C. MS4 Program discharges, require permittee to develop public notice and submit to EPA for review and approval, a consolidated TMDL Implementation Plan within 30 months of the effective date of this permit provision. The TMDL Implementation Plan shall include a schedule of compliance for each TMDL with annual pollutant load reductions and control actions, interim numeric milestones, and demonstration of how each WLA will be attained using chosen controls. EPA will incorporate elements of the consolidated TMDL Implementation Plan as enforceable permit provisions, including milestones and final dates for attainment of applicable WLAs.

The Washington D.C. permit is certainly far more prescriptive than MS4 Program permits in this region. Some states, such as Tennessee, have adopted relatively stringent post-construction control requirements. The following summarizes some of the key elements of Nashville's current individual Phase I MS4 permit issued by Tennessee Department of Environment and Conservation:

- Standards shall require, combined or alone, management measures that are designed, built, and maintained to infiltrate, evapotranspire, harvest, and/or use, at a minimum, the stormwater runoff generated at a site by the first inch of every rainfall event preceded by 72 hours of no measurable precipitation. This site runoff from the first inch of rainfall must be 100 percent managed with no discharge to surface waters.
- For projects that cannot meet 100 percent of the runoff reduction requirement unless subject to the incentive standards, the remainder of the stipulated amount of rainfall must be treated before discharge with a BMP documented to remove 80 percent TSSs or the development project shall pursue offsite mitigation, or payment into the fund for public stormwater projects.
- Off-site mitigation must be for 1.5 times the amount of water not managed on site. The program shall identify priority areas within the watershed in which mitigation projects can be completed. The program must create an inventory of appropriate mitigation projects and develop appropriate institutional standards and management systems to value, evaluate, and track transactions.
- For projects that cannot meet 100 percent of the runoff reduction and pollutant removal standards and cannot provide for offsite mitigation, this element of the MS4 Program may enable the permittee to allow the owner to make payments in a public stormwater project fund established by the MS4 Program. Payment into a public stormwater fund must be at a minimum 1.5 times the estimated cost of onsite runoff reduction controls.
- When the permittee revises any of its urban development or community plans, effective water quality and watershed protection elements that require implementation of consistent water

quality protection measures for new development and redeveloped sites must be considered and included.

Additionally, the recently issued (April 2016) MS4 general permit for Massachusetts (EPA, 2016b), which was prepared by EPA, includes water quality-based effluent limitations and states:

> *Pursuant to Clean Water Act 402(p)(3)(B)(iii), this permit includes provisions to ensure that discharges from the permittee's small MS4 do not cause or contribute to an exceedance of water quality standards, in addition to requirements to reduce the discharge of pollutants to the maximum extent practicable.*

Section 2.1.1 of the Massachusetts MS4 general permit includes the following language:

> *Except where a pollutant of concern in a discharge is subject to the requirements of part 2.2.1 and/or part 2.2.2 of this permit or is the result of an illicit discharge and subject to part 2.3.4 of this Permit, if a pollutant in a discharge from the MS4 is causing or contributing to a violation of applicable water quality criteria[2] for the receiving water, the permittee shall, as expeditiously as possible, but no later than 60 days of becoming aware of the situation, reduce or eliminate the pollutant in its discharge such that the discharge meets applicable water quality criteria.*

The potential precedent of these provisions should be concerning to MS4 permittees. For example, the language in the Massachusetts MS4 general states "reduce or eliminate the pollutant in its discharge such that the discharge meets applicable water quality criteria" seems to indicate that MS4 Program discharges must meet water quality criteria at the discharge point, which is not practical or achievable. In addition to the water quality-based language, the Massachusetts permit includes numerous provisions that go well beyond what is actually required in the federal rule. While this permit will likely be challenged, it appears, based on the language in this permit, that EPA wants to see MS4 Program permits evolve into a far more prescriptive and stringent regulatory mechanism that is not limited to the MEP provisions of the current MS4 regulations.

4.2.1.2 POTENTIAL COST IMPLICATIONS

Based on a review of recent MSD budgets, it appears that MS4 compliance activities are implemented by various departments within MSD. The evaluation also indicates that MSD spends between $900,000 to $3 million per year on MS4 compliance initiatives, such as plan review, data collection, and water quality monitoring. Other efforts such as the USGS stream monitoring, project DRI, flooding, and other drainage O&M efforts are in addition to this cost. Table 3.4-1 summarizes the range of costs per person and cost per acre of the current MSD compliance efforts.

By comparison, Nashville, Tennessee, spends approximately $1.5 million on MS4 compliance activities annually; Nashville has its own in-house lab services and 93 employees on staff assisting with these services. With a population of nearly 650,000 and a MS4 Program service area covering 310,000 acres, this cost equates to $2.31 per person or $4.83 per acre.

Table 3.4-1. MSD Current MS4 Compliance Costs Based on FY2015 Budget Review

	Low Range [a]	High Range [a]
Budget	$900,000	$3,000,000
Based on population—cost per person (at 756,800 people)	$1.19	$3.96
Based on area—cost per acre (separate system developed area of 157,903 acres)	$5.70	$19.00

[a] This does not include budget for USGS stream monitoring, Project DRI, flooding, and other drainage operation and maintenance efforts currently performed by MSD.

Additionally, Indianapolis, Indiana, whose current permit requirements are more in line with Louisville MSD's, spends approximately $13.7 million per year between their Code Enforcement and Public Works Departments on MS4 Program compliance efforts, excluding capital design and construction costs. With a population of nearly 928,300 this equates to approximately $14.71 per person. Each community incorporates and includes different efforts and department roles in their tracking for MS4 Program compliance efforts. Based on the analysis completed for Nashville and Indianapolis, the costs presented have not included capital funds for design and construction.

Currently, MS4 Programs in the Chesapeake Bay watershed are implementing heavily, capital-intensive programs in response to nutrient TMDLs. Prince George's County, Maryland, has estimated that it will spend approximately $1.2 billion retrofitting 15,000 acres, approximately five percent of the county area, to meet current requirements; this equates to nearly $80,000 per acre. Currently, Jefferson County has approximately 157,903 acres of developed area within the separate system. If subject to retrofit regulations, this could have significant cost implications on MSD's stormwater program. Table 3.4-2 summarizes the potential cost implications to MSD if future regulations require installing water quality-based BMPs to treat the stormwater runoff from existing developed areas within the MS4 area. If held to similar retrofit requirements as Prince George's County, MSD could see costs ranging from $1.3 billion to $9.5 billion.

Table 3.4-2. Potential Cost Implications of Retrofit Requirements Based on Project Spending by Prince George's County, Maryland

	Retrofit Area (acres)	Estimated Retrofit Cost (billions)
Prince George's County (5%)	15,000	$1.2
Jefferson County (separate system developed area)	157,903	$1.3 to $9.5
For 10% of area	15,790	$1.3 [a]
For 25% of area	39,476	$3.2 [a]
For 50% of area	78,952	$6.3 [a]
For 75% of area	118,427	$9.5 [a]

[a] Assumes $80,000 per acre.

Additionally, since Washington D.C. has been working under a more stringent permit since 2012, their MS4 stormwater compliance costs have increased considerably. From FY2001 through FY2010, Washington D.C.'s expenditure on the MS4 Program averaged approximately $3 million per year.

However, since implementing the program under the new permit, Washington D.C.'s annual MS4 Program capital budget increased by more than $7.5 million, going from $11.9 million to $19.5 million in FY2013 to FY2014. Currently, Washington D.C.'s budget for FY2015 is just over $19 million. Table 3.4-3 provides a per acre and a per capita cost relationship for Washington D.C.'s MS4 Program. These budget numbers do include capital funds that can be spent over multiple years.

Table 3.4-3. Washington D.C.'s MS4 Spending Analysis

Washington D.C.'s MS4 Program	
Population	658,800
Service area (acres)	39,140
MS4 Program cost per person	$29
MS4 Program cost per acre	$487

This information is used to extrapolate the potential range of compliance costs to MSD should similar requirements be included in a future MS4 permit (Table 3.4-4). The results of this evaluation indicate that if MSD were required to implement MS4 Programs and projects like Washington D.C. but scaled to MSD population or service area, MSD's program costs could range from $22 to $77 million per year.

Table 3.4-4. Projected Cost Implications of Potential Future Regulations Based on Projected Spending by Washington D.C.

MSD's MS4 Service Area	
Population	756,800
Separate system developed area (acres)	157,903
Based on population (at $29 per person)	$22 million
Based on area (separate system developed area) (at $487 per acre)	$77 million

4.2.2 Preliminary Watershed Inventory and Analysis

Based on the pending, and likely more stringent, stormwater permit requirements, MSD could benefit from developing a methodology to integrate each of the many MSD projects and initiatives within a watershed to achieve the maximum water quality benefits for the lowest cost. A comprehensive watershed-based approach could also provide MSD the potential to leverage multiple benefits from planned projects. The first step in completing a watershed-based approach is to complete a detailed inventory and analysis for each watershed in MSD's service area. As part of the Future MS4 Regulatory Impact Analysis task in the Facility Plan initiative, preliminary watershed inventory information has been compiled, reviewed, and documented for each of MSD's 11 watersheds, focused on post-construction. The following sections summarize maps and data that can be found for each watershed in Appendix 3C. Table 3.4-5 provides a brief overview of the area, drainage system, development status and potential retrofit and water quality development costs for the 11 watersheds within MSD's service area. Included in this table is the estimated cost to retrofit 50 percent of the separate system developed area, per watershed, based on the information presented in Table 3.4-2 from Prince George's County.

Table 3.4-5. Jefferson County Watersheds—Summary of Size and System Type

Watershed	Combined System (acres)	Separate System: Developed (acres)	Separate System: Developed Cost to Retrofit 50% of Area	Separate System: Undeveloped (acres)	Separate System: Undeveloped Water Quality Treatment Cost	Total (acres)
Cedar Creek	---	5,182	$207,280,000	2,005	$22,055,000	7,187
City (Downtown Louisville Area)/ Ohio River	17,807	7,153	$286,120,000	516	$5,676,000	25,476
Floyds Fork	---	28,318	$1,132,720,000	38,147	$419,617,000	66,465 [b]
Goose Greek	---	11,894	$475,760,000	---		11,894
Harrods Creek	---	8,140	$325,600,000	1,644	$18,084,000	9,784 [b]
Middle Fork Beargrass Creek	3,112	12,970	$518,800,000	---		16,082
Mill Creek	338[a]	21,564	$862,560,000	---		21,902
Muddy Fork Beargrass Creek	895	4,748	$189,920,000	---		5,643
Pennsylvania Run	---	2,616	$104,640,000	1,834	$20,174,000	4,450 [b]
Pond Creek	139[a]	43,197	$1,727,880,000	13,800	$151,800,000	57,136[b]
South Fork Beargrass Creek	5,213	12,121	$484,840,000	---		17,334
Total	**27,504**	**157,903**	**$6,316,120,000**	**57,946**	**$637,406,000**	**243,353**

[a] A small portion of the watershed is served by combined sewers near the end of the drainage divide based on the data provided in the LOJIC and MSD GIS data.

[b] Portions of Floyds Fork, Harrods Creek, Pennsylvania Run, and Pond Creek extend outside of MSD's service area (the Jefferson County Boundary) into adjacent counties. The table represents the area within Jefferson County.

--- not applicable
GIS geographic information system
LOJIC Louisville and Jefferson County Information Consortium

This value is to serve as a guide of the magnitude of the potential cost implications of changes to the current post-construction regulations. In addition, based on post-construction water quality BMP design experience throughout the Commonwealth of Kentucky, an anticipated cost of $11,000 per acre was used to determine the potential cost to provide water quality treatment to the separate system undeveloped portions of the Jefferson County. The $11,000 per acre is based on professional judgment regarding design assumptions to provide water quality treatment for 0.6 inch from a 1-acre new development site that is 80-percent impervious. For the nearly 57,946 acres of undeveloped area in the county, this equates to approximately $637 million dollars. This treatment cost in the undeveloped areas will be borne by the developers and not MSD.

4.2.2.1 WATERSHED SUMMARY TABLES

The watershed tables, found in Appendix 3C, have been developed for each watershed and contain current, readily-available information from Louisville and Jefferson County Information Consortium (LOJIC) and MSD with the following summary:

- **Summary of Current Conditions—**Documents the watershed size, miles of stream, collection system type (combined versus separate), number of combined sewer overflows (CSOs) and/or sanitary sewer overflows (SSOs), number and type of trouble calls, and number of known credited, noncredited, and regional existing dry and wet/retention basins as defined in MSD's inventory in LOJIC.
- **Watershed Impairments—**Documents the current known water quality impairments for the watershed, including 303(d) stream segments and the pollutants of concern, segments with TMDLs under development, and segments with approved TMDLs. Water quality impairments for existing ponds were not included in this summary.
- **Summary of Current Efforts—**Documents the current known stormwater efforts and other known improvement projects taking place in the watershed. This includes a summary of the number of stream restoration projects, IOAP improvements, green infrastructure projects, DRI project locations, and number of regional basins analyzed for basin retrofit potential.
- **Summary of Monitoring Locations—**Documents the data summarized in the *State of the Streams: 2011 Water Quality Synthesis Report* (MSD, 2011b) for select stream monitoring locations within the MSD service area. This includes data on the following parameters: fish, insects, algae, habitat, dissolved oxygen, water temperature, fecal coliform, and nutrients.

4.2.2.2 WATERSHED INVENTORY MAPS

Watershed inventory maps, found in Appendix 3C, have been developed for each watershed and contain current, readily-available information from LOJIC and MSD with the following summary:

- **Existing Watershed—**Highlights the watershed boundary and stream network.
- **Existing System Type—**Highlights the collection system type (combined versus separate) and CSO and SSO locations within the watershed.

- **Existing Impairments and Flooding Locations—**Highlights 303(d) stream segments, streams with approved TMDLs and TMDLs underdevelopment, and the current floodplain and floodway within the watershed.
- **Stream Monitoring Locations—**Highlights stream monitoring locations within the watershed.
- **Trouble Calls—**Highlights locations with trouble calls related to cave-ins, catch basin issues, and other drainage issues within the watershed.
- **Existing and Potential Improvements—**Highlights current efforts and potential opportunities to leverage efforts within the watershed to achieve the maximum water quality benefits. This includes existing dry detention and wet/retention basins, DRI project locations, basins analyzed for retrofit potential, green infrastructure project sites, IOAP project areas, and MSD stream restoration project locations.
- **Overall Watershed Conditions—**Highlights all of the information summarized on the individual inventory maps.

4.2.3 Next Steps

The maps and tables in Appendix 3C compile relevant watershed information, including water quality, floodplain, CSOs, and planned and completed stormwater-related projects within each of MSD's 11 watersheds.

However, there are potentially other endeavors being implemented by MSD, other City or County agencies, community groups, and private organizations that impact the quality and quantity of stormwater runoff or that target overall improvement to local water quality. It is recommended that MSD continue to track and document all of these efforts within each watershed. Additionally, as stormwater projects are planned and implemented, it will be important to coordinate and leverage other stakeholder projects to enhance the overall water quality benefit and potentially reduce costs.

In addition to coordinating efforts within MSD's watersheds to enhance the overall water quality impact, it is recommended that MSD continue to monitor the status of any future EPA rulemaking and engage in the dialogue on proposed revisions to the current rule. As a large MS4 Program, MSD's voice can help ensure future permit requirements are reasonable and achievable. Potential cost implications have been projected for anticipated regulatory changes in this area but the timing of those changes is uncertain. The Facility Plan Team recommends planning for a smaller cost for now and adjust future budgets as the regulatory schedule becomes more certain.

MSD's voice includes participating early in the development of future TMDLs to ensure that these evaluations are technically sound, based on adequate and representative data, and generate practical and achievable allocations. As part of the next step for this effort, it is proposed that MSD perform a conceptual-level evaluation to determine the technical feasibility and costs of achieving the WLA identified in the approved TMDL for fecal coliform for the South Fork Beargrass Creek. The effort would include a theoretical desktop analysis of BMP implementation with the goal of determining the distribution and types of projects best suited to meet the WLA reduction based on land use, the TMDL parameters, and other existing watershed conditions. The outcome of this analysis will provide MSD with a better understanding of the feasibility of implementing a program to meet current and future TMDL requirements.

Additionally, KDOW is in the process of initiating a nutrient rulemaking process. If MSD joins in this dialogue, they can represent MS4 interests in the deliberations. While there has been and continues to be national discussions regarding the impact of nutrient criteria on the wastewater industry, MS4 permittees bear a considerable amount of the financial burden associated with proposed nutrient reduction requirements.

VOLUME 3—STORMWATER AND DRAINAGE

CHAPTER 5 INCREASED FREQUENCY OF EXTREME EVENTS

5.1 INTRODUCTION

This analysis focuses on the impacts of the increased frequency of extreme events and how MSD should prepare for these conditions over the next 20 years.

5.2 LEVEL OF SERVICE AND DESIGN CRITERIA EVALAUTION

This section documents the impacts on the rainfall rates and depths used by designers that define the level of service used by current MSD practices. The level of service provided to MSD's customers is defined by return intervals of rainfall, both in frequency and depth. A significant and long-term change in precipitation intensity, duration, and frequency (IDF) would affect current stormwater and drainage infrastructure. Evaluation of the potential for changes in IDF would allow MSD to develop mitigation strategies for existing infrastructure and incorporate revised design criteria for developing new stormwater facilities.

5.2.1 Return Interval Definition

The return interval (or recurrence interval) is used to set design criteria and the level of protection, or the level of service for the drainage systems. The probability that a rainfall event of a certain magnitude will occur in any given year is expressed in terms of the recurrence interval. This is the average length of time expected to elapse between rainfalls of equal or greater magnitude. The term "return interval" has led to some confusion in recent years in that it gives the illusion that a certain storm will happen at certain fixed, defined intervals. For example, if a 1 percent annual chance (100-year) storm is experienced, then some people believe, incorrectly, that another one will not happen for another 99 years.

There has been a shift in recent years to use different terms such as ARI and percent annual chance of occurrence. ARI is the same as the "return interval" but places emphasis that this is the expected average and not an absolute. A better way to speak about the return interval is by using probabilities. Table 3.5-1 shows the relationship between ARI and its associated probability.

Table 3.5-1. Common Ways to Express the Frequency of Rainfall Events

ARI (years)	Probability of Occurrence in Any Given Year	Percent Chance of Occurrence in Any Given Year
1000	1 in 1000	0.1
500	1 in 500	0.2
100	1 in 100	1.0

Table 3.5-1. Common Ways to Express the Frequency of Rainfall Events

ARI (years)	Probability of Occurrence in Any Given Year	Percent Chance of Occurrence in Any Given Year
50	1 in 50	2.0
10	1 in 10	10
5	1 in 5	20
2	1 in 2	50

5.2.2 Current Design Storm Return Intervals used at Louisville and Jefferson County Metropolitan Sewer District

MSD, like many other agencies across the United States, has adopted the industry-wide accepted standard of practice of using the storm defined by the 10-percent probability of occurring in any year (commonly referred to as the 10-year storm and will be called the 10-percent annual chance storm from this point forward) to design most stormwater conveyance infrastructure, with a "check" calculation on the 1-percent annual chance storm (commonly referred to as the 100-year storm), to make sure the runoff has a safe route (no structural inundation or loss of life potential) for the larger events. To design conveyance systems larger than the 10-percent annual chance storm would, in most situations, prove to be economically unfeasible. Table 3.5-2 outlines the return intervals in MSD's Design Manual (MSD, 2015a).

Table 3.5-2. Design Storm Return Interval from the MSD Design Manual[a]

Design Storm Return Interval								
Situation		**Return Interval (years)**						
Type of Analysis	**Limiting Values**	**2**	**5**	**10**	**25**	**50**	**100**	**500**
Bridge	ADT less than 400			●			●	
	400 less than ADT 1,500				●		●	
	ADT less than 1,500					●	●	
Culvert Capacity	ADT less than 400			●			●	
	400 less than ADT less than 1,500				●		●	
	ADT more than 1,500				●		●	
Bridge Scour Analysis							●	●
Storm Sewer				●			●	
Channel Change		●		●			●	
Roadway Ditch				●			●	
Drop Inlets				●			●	
Detention or Retention Basin		●		●	●		●	

[a] The lower return intervals are design—the others "check" storms.

The Design Manual outlines design specifications for new facilities, and thus Figure 3.5-1 represents the level of service that is expected for new facilities or rehabilitation of existing facilities. The exception is for green infrastructure, which has different requirements as outlined in the Green Infrastructure Manual (URS Corporation, 2013).

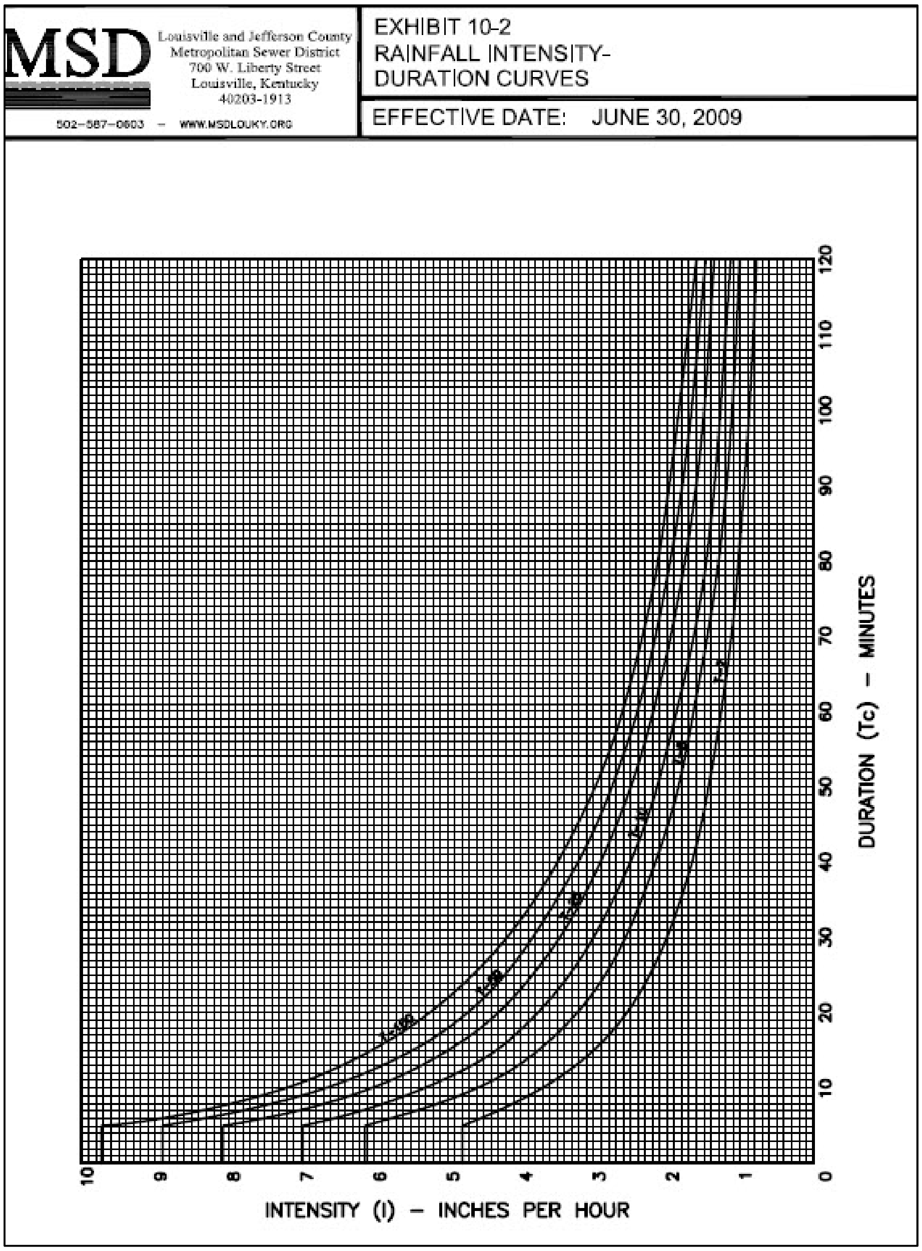

Figure 3.5-1. Intensity, Duration, and Frequency curves in current MSD Design Manual

5.2.3 Rainfall Statistics

The ARI is defined by a statistical analysis of precipitation records. Publications of IDFs for the United States began in 1935 with *Miscellaneous Publication No. 204*: *Rainfall Intensity-Frequency Data* (U.S. Department of Agriculture [USDA], 1935). Since that time, several other papers have been published using updated data and methods to categorize rain events. MSD uses the 1979 edition of TP-40, which is based on rainfall data through 1961. The most recent publication is the NOAA Atlas 14, which was released in 2006 and includes data back to 2000. This document has been the industry standard for the past several years in defining rainfall amounts to use.

5.2.3.1 Rainfall Depth Analysis

Rainfall depth is an important consideration in designing stormwater storage basins, complex hydrologic modeling, and floodplain mapping. In 2015, the Facility Plan Team updated data from NOAA Atlas 14 using the average of three National Weather Service (NWS) stations in the Louisville area (MLUK2—Ohio River at McAlpine Upper; Louisville WSO Airport; and SHPK2—Salt River at Shepherdsville, Kentucky) to develop IDFs that included data through 2014. Table 3.5-3 summarizes of the rainfall depth (in inches) for a 24-hour storm at various return intervals.

Table 3.5-3. Comparison of Jefferson County, Kentucky, Rainfall Depths Amounts (inches) for a 24-hour Storm Duration by Rainfall Atlas

Percent Annual Chance	MSD Design Manual (TP-40 through 1961)	NOAA Atlas 14 (through 2000)	Updated NOAA Atlas 14 (through 2014)
50 (2-year)	3.2	2.87	3.03
20 (5-year)	4.0	3.78	4.05
10 (10-year)	4.5	4.45	4.82
4 (25-year)	5.2	5.37	5.91
2 (50-year)	5.7	6.12	6.82
1 (100-year)	6.2	6.93	7.81

Storms with shorter recurrence intervals have similar depths, but longer recurrence interval storms show much greater differences. Because TP-40 had a shorter period of station record data, it could more adequately evaluate the shorter recurrence intervals; longer recurrence intervals were less accurate. NOAA Atlas 14 is based on more stations and longer periods of rainfall data than other documents. Some stations had an additional 40 years of data than that of TP-40. NOAA Atlas 14 also had more than 10 times the stations used with TP-40. The additional 14 years of information for NOAA Atlas 14 improved the accuracy of the rainfall frequency data and shows a trend toward fewer but more intense storms in the Louisville area, as demonstrated in comparing the storm events that generate more than 3 inches of precipitation. Between 1949 and 2004, 21 events occurred in which 3 inches or more of precipitation was recorded in the Louisville area; 11 events have occurred from 2005 to April 10, 2015.

5.2.3.2 Changes to Future Rainfall Depth from the Increased Frequency of Extreme Storms

Combined with the study that updated the NOAA Atlas 14 with 2000 to 2014 data, the Facility Plan Team prepared a technical memorandum that predicted changes to Louisville area storm events in the next 20 and 50 years. Summarized in Table 3.5-4, these projections show similar trends to those listed in Table 3.5-3.

Table 3.5-4. Comparison of Jefferson County, Kentucky, Rainfall Depth Amounts (inches) for 24-hour Storm Duration by Rainfall Atlas

Percent Annual Chance	MSD Design Manual (TP-40 through 1961)	NOAA Atlas 14 (through 2000)	Updated NOAA Atlas 14 (through 2014)	2035 Projection	2065 Projection
50 (2-year)	3.2	2.87	3.03	3.0	3.0
20 (5-year)	4.0	3.78	4.05	4.2	4.4
10 (10-year)	4.5	4.45	4.82	5.1	5.3
4 (25-year)	5.2	5.37	5.91	6.3	6.7
2 (50-year)	5.7	6.12	6.82	7.3	7.8
1 (100-year)	6.2	6.93	7.81	8.4	9.1

5.2.3.3 Rainfall Intensity Analysis

Rainfall intensities are an important factor in designing stormwater conveyance systems, such as pipes and ditches. MSD uses the "rational method" to estimate peak flows for watersheds that are less than 50 acres in size, and no storage requirements are needed. Similar to rainfall depth, the current IDF curves used by MSD are based on TP-40, which does not represent current practice in the industry. The published NOAA Atlas 14 amounts are currently the minimum standard common in the industry. Figure 3.5-1 shows a graphic of the IDF curves contained in the current MSD Design Manual. Tables 3.5-5, 3.5-6, and 3.5-7 illustrate the updated NOAA Atlas 14 (through year 2014), as well as the 2035 and 2065 projections that were developed by the Facility Plan Team (CH2M, 2015).

Table 3.5-5. Updated NOAA Atlas 14 Rainfall Intensities (in/hr) for Given Duration and Frequency

Percent Annual Chance	5-Minute	10-Minute	15-Minute	30-Minute	60-Minute	120-Minute	3-Hour	6-Hour	12-Hour	24-Hour
50 (2-year)	5.08	3.95	3.24	2.19	1.35	0.81	0.58	0.36	0.21	0.13
20 (5-year)	6.34	5.00	4.11	2.83	1.79	1.08	0.78	0.48	0.28	0.17
10 (10-year)	7.31	5.70	4.71	3.29	2.11	1.27	0.92	0.57	0.33	0.20
4 (25-year)	8.52	6.55	5.42	3.87	2.53	1.54	1.12	0.69	0.41	0.25
2 (50-year)	9.42	7.22	5.96	4.32	2.86	1.76	1.29	0.79	0.47	0.28
1 (100-year)	10.35	7.85	6.52	4.77	3.21	1.99	1.46	0.91	0.53	0.33

in/hr inches per hour

Table 3.5-6. 2035 Rainfall Intensities (in/hr) for Given Duration and Frequency

Percent Annual Chance	5-Minute	10-Minute	15-Minute	30-Minute	60-Minute	120-minute	3-Hour	6-Hour	12-Hour	24-Hour
50 (2-year)	5.08	3.95	3.24	2.19	1.35	0.81	0.59	0.36	0.21	0.13
20 (5-year)	6.57	5.18	4.26	2.93	1.85	1.11	0.80	0.49	0.29	0.17
10 (10-year)	7.67	5.98	4.94	3.45	2.21	1.33	0.97	0.59	0.35	0.21
4 (25-year)	9.05	6.95	5.76	4.11	2.68	1.64	1.19	0.73	0.43	0.26
2 (50-year)	10.07	7.71	6.37	4.62	3.06	1.88	1.37	0.85	0.50	0.30
1 (100-year)	11.11	8.43	7.00	5.12	3.44	2.14	1.57	0.97	0.57	0.35

Table 3.5-7. 2065 Rainfall Intensities (in/hr) for Given Duration and Frequency

Percent Annual Chance	5-Minute	10-Minute	15-Minute	30-Minute	60-Minute	120-Minute	3-Hour	6-Hour	12-Hour	24-Hour
50 (2-year)	5.09	3.96	3.25	2.20	1.35	0.81	0.59	0.36	0.21	0.13
20 (5-year)	6.82	5.38	4.42	3.05	1.93	1.16	0.84	0.51	0.30	0.18
10 (10-year)	8.09	6.31	5.21	3.64	2.33	1.41	1.02	0.62	0.37	0.22
4 (25-year)	9.66	7.42	6.15	4.38	2.86	1.75	1.27	0.78	0.46	0.28
2 (50-year)	10.81	8.28	6.84	4.96	3.28	2.01	1.47	0.91	0.53	0.33
1 (100-year)	11.98	9.09	7.55	5.52	3.71	2.30	1.69	1.05	0.62	0.38

Figures 3.5-2, 3.5-3, and 3.5-4 show the 10-, 30-, and 60-minute duration intensities plotted against the ARI for the five different scenarios: the current MSD Design Manual, NOAA Atlas 14, updated NOAA Atlas 14 (through 2014), 2035 predictive model, and the 2065 predictive model. The most frequently used durations corresponding to time of concentration of small watersheds (less than 50 acres), usually fall between the 10- and 60-minute range, which is why the 10-, 30-, and 60-increments were compared for the aforementioned scenarios.

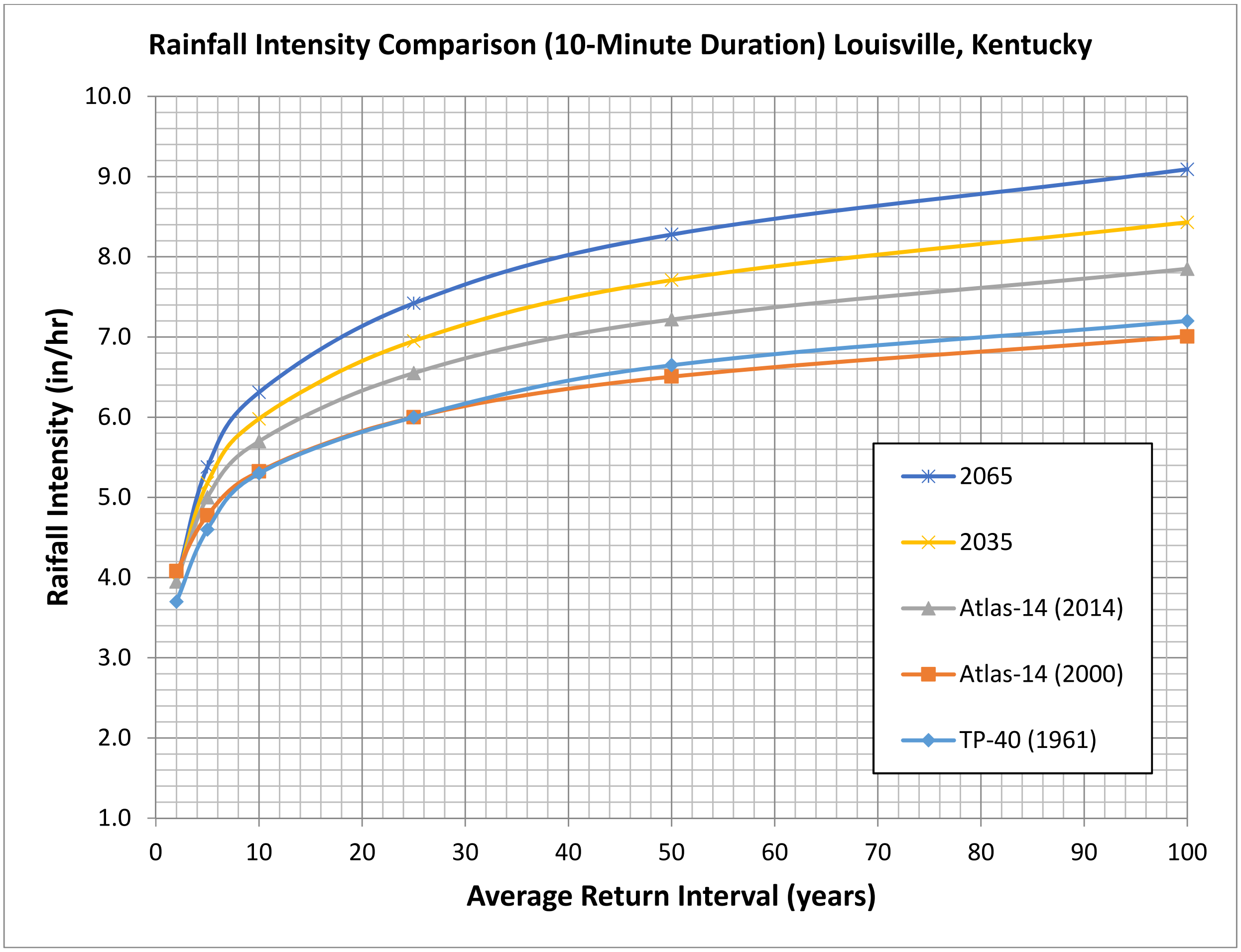

Figure 3.5-2. Intensity, Duration, and Frequency Comparison for Five Different Rainfall Scenarios for the 10-Minute Duration Storm

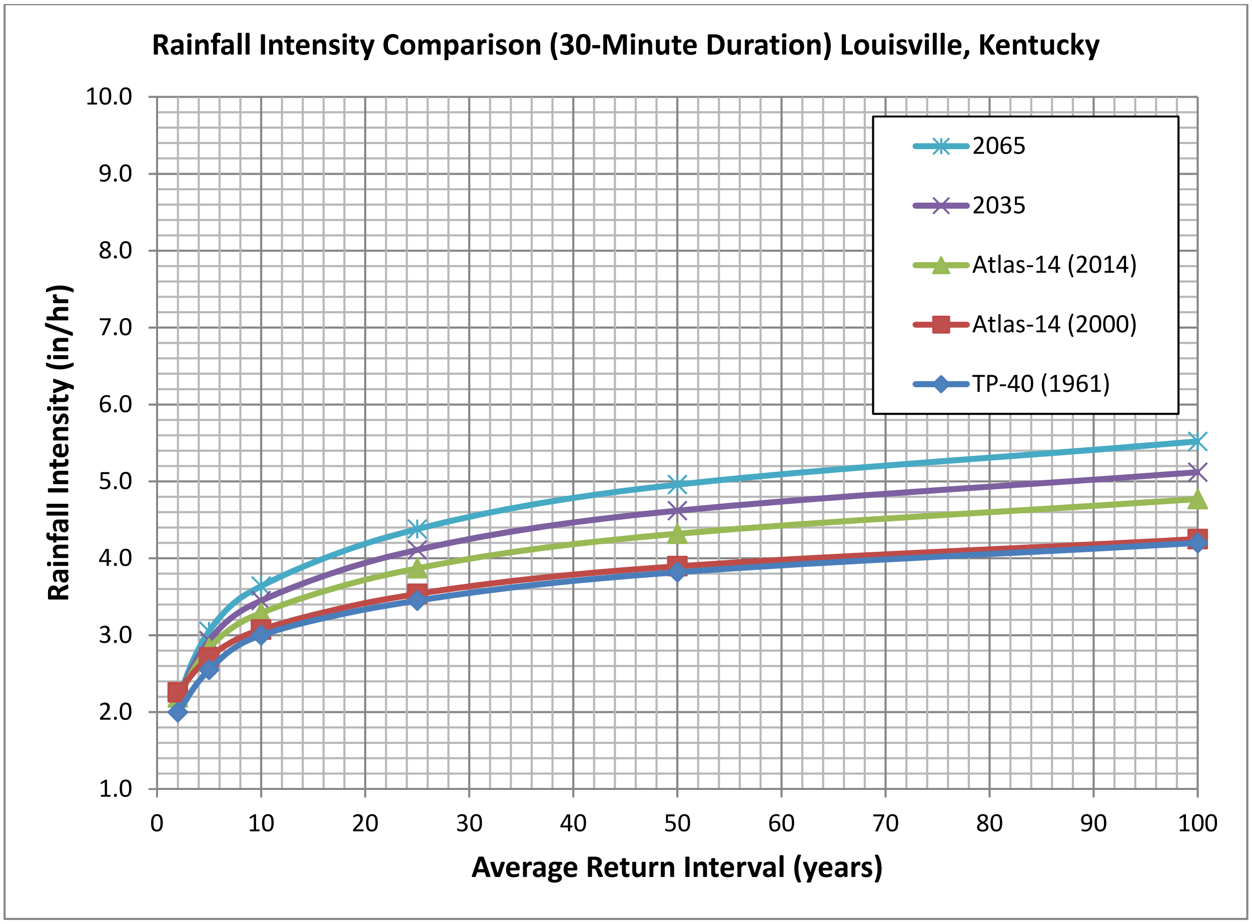

Figure 3.5-3. Intensity, Duration, and Frequency Comparison for Five Different Rainfall Scenarios for the 30-Minute Duration Storm

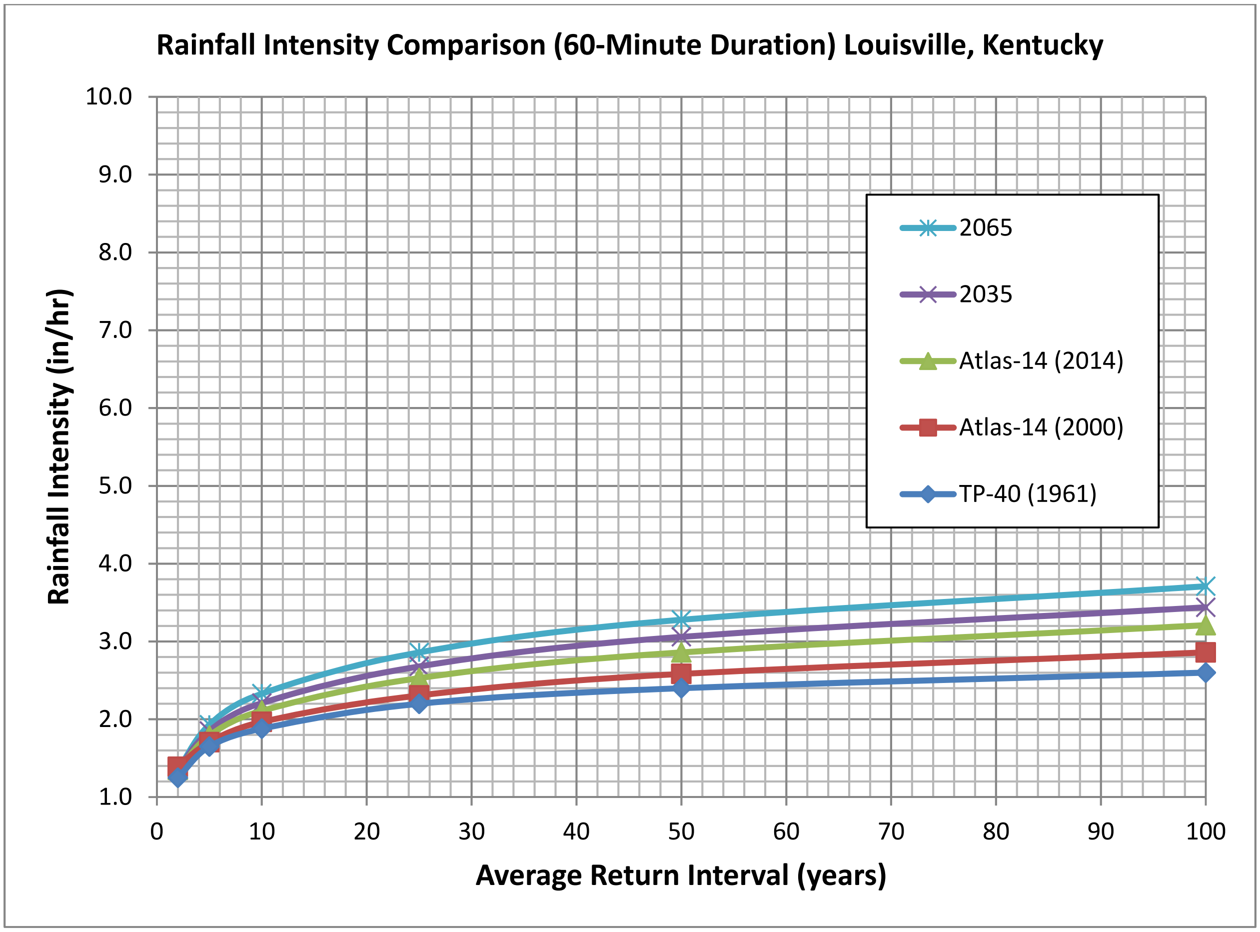

Figure 3.5-4. Intensity, Duration, and Frequency Comparison for Five Different Rainfall Scenarios for the 60-Minute Duration Storm

The data used to make Figures 3.5-3, 3.5-4, and 3.5-5 were compiled in Tables 3.5-8, 3.5-9, and 3.5-10. The trend is clearly upward, similar to the rainfall depths.

Table 3.5-8. Rainfall Intensity Comparison—10-Minute Duration (in/hr)

Percent Annual Chance	TP-40 (1961)	NOAA Atlas 14 (2000)	NOAA Atlas 14 (2014)	2035	2065
50 (2-year)	3.70	4.08	3.95	3.95	3.96
20 (5-year)	4.60	4.78	5.00	5.18	5.38
10 (10-year)	5.30	5.32	5.70	5.98	6.31
4 (25-year)	6.00	6.00	6.55	6.95	7.42
2 (50-year)	6.65	6.51	7.22	7.71	8.28
1 (100-year)	7.20	7.01	7.85	8.43	9.09

Table 3.5-9. Rainfall Intensity Comparison—30-Minute Duration (in/hr)

Percent Annual Chance	TP-40 (1961)	NOAA Atlas 14 (2000)	NOAA Atlas 14 (2014)	2035	2065
50 (2-year)	2.00	2.26	2.19	2.19	2.20
20 (5-year)	2.55	2.71	2.83	2.93	3.05
10 (10-year)	3.00	3.07	3.29	3.45	3.64
4 (25-year)	3.45	3.54	3.87	4.11	4.38
2 (50-year)	3.82	3.90	4.32	4.62	4.96
1 (100-year)	4.20	4.25	4.77	5.12	5.52

Table 3.5-10. Rainfall Intensity Comparison—60-Minute Duration (in/hr)

Percent Annual Chance	TP-40 (1961)	NOAA Atlas 14 (2000)	NOAA Atlas 14 (2014)	2035	2065
50 (2-year)	1.25	1.39	1.35	1.35	1.35
20 (5-year)	1.65	1.71	1.79	1.85	1.93
10 (10-year)	1.88	1.97	2.11	2.21	2.33
4 (25-year)	2.20	2.31	2.53	2.68	2.86
2 (50-year)	2.40	2.58	2.86	3.06	3.28
1 (100-year)	2.60	2.86	3.21	3.44	3.71

5.2.4 Conclusions and Recommendations

5.2.4.1 Conclusions

Rainfall amounts and rates are different today than 50 years ago, and they are trending upward. The rainfall used to define the return interval used by MSD to provide a level of service to its ratepayers needs to be reviewed and updated periodically, every decade or so. The Louisville area has seen a significant increase in both depth and intensity of rainfall events from years 2000 through 2014.

Over time, there is a clear trend for storms with longer recurrence intervals to increase in rainfall depths as more data with higher levels of accuracy are collected and analyzed. The net result of this effect is a diminished level of protection against flood events. Infrastructure sized to meet a certain level of protection based on information in TP-40 would not be able to perform as expected when updated storm information is applied. For example, infrastructure sized to manage a 1-percent annual chance (100-year) 24-hour storm as defined by TP-40 would only be able to manage a 4-percent annual chance (25-year) to 2-percent annual chance (50-year) 24-hour storm as defined by the updated NOAA Atlas 14; thus, the actual level of protection infrastructure can provide would be less than what had been planned.

Rainfall depths and intensity define the return intervals that MSD uses to provide a level of service to the ratepayer. When rainfall amounts and intensities increase, the frequency of the same event happening also increases, and thus the level of service decreases for existing facilities. Even new facilities that are being constructed, as well as rehabilitation projects to existing facilities, are immediately underperforming the expected level of service because of the use of rainfall amounts published by NOAA in 1961 (TP-40).

Although the rainfall depth for the 10-percent annual chance storm did not increase significantly, the rainfall intensity did. This leads to the undersizing of small-scale (neighborhood level) conveyance systems and could lead to nuisance flooding to structural flooding, depending on the circumstances. The larger storms (1-percent annual chance storm, commonly referred to as the 100-year storm) increased significantly in depth and intensity. Rainfall depths are used primarily for storage modeling and floodplain modeling. Therefore, the 1-percent annual chance storm (100-year storm) depth has a huge impact on how storage basins perform and how floodplains are defined.

5.2.4.2 Recommendations

MSD should revise the rainfall amounts that define the return intervals used for the design of stormwater conveyance and storage systems and for floodplain definitions. The recommended minimum would be the 2035 projections. This provides for a 20-year planning window. Even using these numbers, design criteria should be tightened by using larger freeboard levels to account for the expected increases for the following 30 years (2065 rainfall projections). For example, storm sewers are currently designed for 100 percent full flow during the 10-percent annual chance (10-year) storm event. This should be revised to 80 percent full flow to allow for some freeboard and to address the increasing rainfall amounts. Note that this freeboard will not account for all of the expected 2065 forecast rainfall amounts, but it is a start in the right direction. Also, as previously stated, rainfall statistics should be revisited on a periodic basis because of the dynamic nature of the current climate conditions.

While it is relatively easy to change design standards for new facilities and projects, it is more difficult to retrofit existing infrastructure to meet the level of service for which it was intended to be designed. For these areas, which encompasses nearly all of MSD's service area, projects should be planned to address problem areas where the runoff from large events overwhelms the existing conveyance systems and runs unabated through neighborhoods and commercial areas. Because it is cost-prohibitive to dig up and replace every pipe and ditch in the MSD service area, the focus should be on conveyance of the large (1 percent chance) storm events—it should have a safe path to travel without endangering lives or causing structural flooding. These will likely be the retrofit projects of the future—making sure runoff from the larger storms has a defined place to go without causing loss of life or significant damage. It is recommended that the width of new easements be increased to ensure the projected 2035 1-percent chance (100-year) storm stays within the easement limits. In summary, the following are recommended changes:

- Keep the return intervals used for designing new and rehabilitation projects as they are. This represents the common practice in the industry and should be adequate, assuming the intervals are defined with accurate and up-to-date rainfall statistical analysis.
- Update the rainfall depths and intensities used to define the return intervals. This should be accomplished by using the 2035 rainfall projections.
- Increase freeboard requirements to account for the upward trend in rainfall amounts. Large storm events (100- to 500-year return intervals) should be checked to ensure the overflow has a safe route in which to be conveyed that does not lead to structure flooding or increased potential for loss of life.
- Review rainfall statistics at least every 10 years and update accordingly.
- Increase the width of new easements to ensure the projected 2035 1-percent chance (100-year) storm stays within the easement limits.
- Look for ways to retrofit existing neighborhoods without replacing entire systems so that the larger storms have a safe path to travel.

5.3 SUMMARY OF CLIMATE CHANGE IMPACTS ON FLOODPLAINS

This section discusses the effects of climate change on Jefferson County floodplains. The current 1-percent annual chance (100-year) SFHA flood maps may underestimate potential risk because of the increased rainfall frequency that has been observed in recent years. This section outlines the impacts to water surface elevations (WSELs) on existing flood maps using updated rainfall hydrology as outlined previously in this chapter.

5.3.1 Floodplains in Jefferson County

Louisville Metro is a participant in the NFIP, and MSD is responsible for enforcing the local Floodplain Management Ordinance (Louisville Metro, 2006) and for administrating the Floodplain Management Program. MSD has elected to regulate the Local Regulatory Floodplain (LRF), in addition to the SFHA. Both are defined herein.

5.3.1.1 Local Regulatory Floodplain

The LRF is defined in the local Floodplain Management Ordinance as any stream course or normally dry land area susceptible to being partially or completely inundated by the overflow of water from sources of public water or by the unusual and rapid accumulation or runoff of public surface waters and subject to a local regulatory flood. A "local regulatory flood" is defined as the flood having a 1 percent probability of being equaled or exceeded in any given year based on a *fully developed watershed*. The LRF provides a basis to set safe and reasonable first floor elevations on all proposed development, as defined in the local Floodplain Management Ordinance. Highlights of the Floodplain Management Ordinance include the following:

- Construction or filling cannot reduce the "storage capacity" for floodwaters in a floodplain.
- Road access must be provided above the level of a 1-percent annual chance (100-year) flood for new development.
- The first floor of a new building and additions must be at a level at least 1 foot above the 1-percent annual chance (100-year) flood level (the LRF flood level).
- Changes, improvements, and additions must meet the substantial improvement requirement for pre-Flood Insurance Rate Maps (FIRM) structures.
- Development cannot occur within the Local Regulatory Conveyance Zone (LRCZ), which is defined as the channel or a solid blue line stream and the land adjacent to that river or stream that, if unobstructed, will discharge a local regulatory flood without cumulatively increasing the WSEL more than 0.1 foot. This is a very restrictive part of the ordinance and significantly limits development within the floodplain, if enforced.

5.3.1.2 Special Flood Hazard Area

A SFHA is defined in a similar fashion as the LRF, except it is not based on a *fully developed watershed.* This floodplain is shown on the FIRM. These maps are used by the NFIP as a way to communicate risk and help establish insurance needs and rates. The SFHA mapping is explained herein.

Louisville Metro participates in the NFIP so community members can purchase flood insurance to protect themselves from flood losses and so the community is eligible to receive federal disaster assistance. Flood Insurance Studies (FISs) document the hydrologic and hydraulic parameters that are used to produce the FIRM.

The current Jefferson County SFHA floodplain mapping, found on the FIRM, is based on current MSD Design Manual standards for rainfall depths. NFIP and FEMA set the standards for mapping. To provide a national standard without regional discrimination, FEMA has adopted the 1-percent annual chance flood (100-year flood) as the base flood for floodplain management purposes. The 0.2-percent annual change (500-year) flood is employed to indicate additional areas of flood risk in the community. However, the hydrology used to determine the actual runoff from these recurrence intervals is based on local standards. The current local standard for the 1-percent annual chance (100-year) rainfall is 6.2 inches of depth over a 24-hour period, as defined in the current MSD Design Manual. The 6.2 inches of rainfall is based on TP-40 rainfall data (NOAA, 1961).

The level and accuracy of the mapping for each major watershed in Jefferson County vary, and some watersheds have better hydrologic and hydraulic modeling than others. At the time of this analysis, the watersheds with the most up-to-date mapping were as follows: 1) the Combined Sewer System Area (CSSA), 2) Pond Creek, and 3) South Fork Beargrass Creek. These models were used as the basis of this analysis.

5.3.2 Federal Directives on Climate Change

Executive Order 13690 establishes a Federal Flood Risk Management Standard (FFRMS) to reduce the risk and cost of future flood disasters by ensuring federal investments in and affecting floodplains are constructed to better withstand the impacts of flooding and will help ensure federal projects last as long as intended. The FFRMS applies to the FEMA Hazard Mitigation Assistance Grants, Public Assistance Program, and any other FEMA grants when they fund construction activities in or affecting a floodplain.

For new federal facilities, the FFRMS dictates that the floodplain elevation shall be calculated by one of these three methods:

- Using a climate-informed scientific approach
- Adding 2 feet of elevation to the currently mapped 1-percent annual chance (100-year) floodplain (3 feet for critical facilities)
- Using the currently mapped 500-year floodplain

Executive Order 13690 only applies for new federal facilities. This program does not affect the NFIP; however, it could affect any FEMA hazard mitigation grants for which MSD applies.

While this does not directly impact MSD's practices and design methodologies, it may be in MSD's best interest to initiate a dialog of recommended changes to floodplain mapping procedures. Currently, the floodplain modeling is done by using a rainfall depth of 6.2 inches for a 24-hour storm. The updated NOAA Atlas 14 number, based on historical data through 2014, is 7.8 inches, and the 2065 predictive amount is 9.1 inches. Approximately 16,000 structures are in the mapped floodplain. If the current return interval for the 1-percent annual chance (100-year) rainfall amount is not adjusted, then structures that are being approved for development and occupancy may be in danger based on the updated rainfall data.

5.3.3 Climate Change Hydrology

As outlined in Section 5.2, rainfall amounts and rates have increased from their levels of 50 years ago. Rainfall amounts and rates are still changing and trending upward. The Louisville area has seen a significant increase in depth and intensity of rainfall events from 2000 through 2014. Table 3.5-11 summarizes the updated rainfall amounts for 24-hour storms in Jefferson County. MSD's current practice is to use the first column, based on TP-40, to define Jefferson County floodplains.

Table 3.5-11. Comparison of Jefferson County, Kentucky, Intensity, Duration, and Frequency Amounts (inches) for 24-Hour Storm Duration by Rainfall Atlas

Percent Annual Chance	MSD Design Manual (TP-40, 1961)	NOAA Atlas 14 (through 2000)	Updated NOAA Atlas 14 (through 2014)	2035 Projection	2065 Projection
50 (2-year)	3.2	2.87	3.03	3.0	3.0
20 (5-year)	4.0	3.78	4.05	4.2	4.4
10 (10-year)	4.5	4.45	4.82	5.1	5.3
4 (25-year)	5.2	5.37	5.91	6.3	6.7
2 (50-year)	5.7	6.12	6.82	7.3	7.8
1 (100-year)	6.2	6.93	7.81	8.4	9.1

5.3.4 Effects on Floodplains in Jefferson County

For this study, the updated NOAA Atlas 14 and the 2065 projection data were used to analyze the effects of the higher rainfall for floodplain impacts. The 2065 projection data were used to help understand the uppermost boundary or the worst-case scenario. This also made it easier to interpolate other storm scenarios like the 2035 projection and other rainfall atlases. This was done on three pilot watersheds: CSSA, Pond Creek, and South Fork Beargrass Creek.

Existing models were obtained from MSD for the aforementioned watersheds. The models from Pond Creek and South Fork Beargrass Creek were HEC-Hydrologic Modeling System (HEC-HMS) and HEC-River Analysis System (HEC-RAS) models. A comprehensive detailed model for the CSSA previously had not been performed. The CSSA model was done using InfoWorks software that uses a two-dimensional engine.

5.3.4.1 Pond Creek and South Fork Beargrass Creek

The Pond Creek watershed was previously modeled with HEC-HMS and an unsteady state HEC-RAS model. The models incorporate the following major streams in the Pond Creek watershed: Blue Spring Ditch, Fishpool Creek, Northern Ditch, Pond Creek, Southern Ditch, and Wilson Creek. The hydrologic analyses performed for South Fork Beargrass Creek ranges from its headwaters in eastern Jefferson County to the flood pumping station 300 feet downstream of Brownsboro Road at stream mile 0.76.

The existing HEC-HMS models for both watersheds use 6.2 inches of rain for the 24-hour storm (TP-40; revised 1979) and were applied to a Natural Resources Conservation Service Type II rainfall distribution. Changing the rainfall depth to the updated NOAA Atlas 14 and the 2065 projection, 7.81 and 9.10 inches, respectively, required updates to the model enabling it to handle the increased flow rates at specific location and nodes, mostly at reservoirs or other detention areas. Once the new flow rates were obtained from the HEC-HMS model, the unsteady state HEC-RAS model was modified to reflect the new hydrographs. The increased flows required other parameters in the HEC-RAS model to be modified, primarily the cross sections. Cross-sections had to be extended because of the wider and deeper flood flows. If the cross-sections were not widened, then HEC-RAS assumes a vertical wall at the edges of the cross sections, which results in an erroneous, higher WSEL. The cross sections were extended by using the LOJIC contour data. Boundary conditions for both models had to be updated as well.

5.3.4.2 Combined Sewer System Area

The CSSA has a comprehensive hydraulic model which was recently developed. These models were used with the updated rainfall amounts to determine the impacts in this watershed.

5.3.5 Results—Effects of Higher Water Surface Elevations relative to Primary Structures

Table 3.5-12 shows the results from the Pond Creek and South Fork Beargrass Creek watersheds. Appendix 3D and 3E contain updated mapping exhibits.

Table 3.5-12. Results from the updated Hydrology and Hydraulic Modeling in the Pond Creek and South Fork Beargrass Creek Watersheds

	Updated NOAA Atlas 14 Rainfall		Projected 2065 Rainfall	
	Range of increase in WSEL (feet)	Average increase in WSEL (feet)	Range of Increase in WSEL (feet)	Average increase in WSEL (feet)
South Fork Beargrass Creek	-0.73 to 10.76	3.50	-1.1 to 17.35	5.58
Pond Creek—Blue Springs	0.53 to 1.69	0.84	0.84 to 2.78	1.47
Pond Creek—Fishpool Creek	0.52 to 2.79	1.17	1.07 to 4.98	2.07
Pond Creek—Northern Ditch	0.30 to 5.13	1.56	0.37 to 10.69	2.67
Pond Creek—Pond Creek	0.84 to 2.25	1.25	1.48 to 3.80	2.13
Pond Creek—Southern Ditch	0.17 to 1.63	0.94	0.29 to 2.49	1.50
Pond Creek—Wilson Creek	0.25 to 1.17	0.65	0.48 to 1.82	1.11

After the modeling was completed, the next step was to examine the effects on the number of primary structures that were affected by the new floodplains. New shape files were created to represent the new WSELs from the newly updated hydrologic and hydraulic modeling. These shape files were then used with the LOJIC data to determine the number of structures affected for the three watersheds. Table 3.5-13 summarizes the findings. The numbers for the 2035 projected rainfall were interpolated using the percentage of rainfall relative to the existing 6.2 inches as a basis.

Table 3.5-13. Summary of the Number of Primary Structures Affected

	Existing SFHA Floodplains (6.2 inches)	Updated NOAA Atlas 14 (7.81 inches)	Percent Increase	2035 Projection (interpolated) (8.4 inches)	Percent Increase	2065 Projection (9.1 inches)	Percent Increase
South Fork Beargrass Creek	1461	1994	36	2235	53	2521	73
Pond Creek	2190	4142	89	4598	110	5138	135
CSSA	3306	7354	122	8482	157	9821	197
Average Increase			**83**		**106**		**135**

5.3.6 Countywide Extrapolation and Its Cost

Using the data from these three pilot watersheds, the number of primary structures affected was extrapolated throughout the rest of the Jefferson County watersheds. To do this, data were used from the *Project Summary Report: Countywide Flooding Prioritization* (PRIME AE Group, Inc., 2016b). This study is identifying the most severe flooding issues in Jefferson County based on existing SFHA flood maps. The most severe flooding is defined by a depth of water that is 1.5 feet or greater in all watersheds except for CSSA. In CSSA, any surface flooding is considered severe because of the polluted nature of the flood waters. For the CSSA, new modeling was utilized since no SFHA flood maps exist in this watershed.

Data from the *Project Summary Report: Countywide Flooding Prioritization* include the following:

- Jefferson County primary structures that touch the existing floodplain = 11,044
- Primary structures affected by most severe flooding (greater than or equal to 1.5 feet depth, any in CSSA) = 916
- Percentage of structures affected by severe flooding in Jefferson County = 8.29 percent

Using the percentages developed in Table 3.5-13, and the above information from the *Project Summary Report: Countywide Flooding Prioritization*, a county-wide extrapolation was performed (Table 3.5-14).

Table 3.5-14. Summary of the Number of Primary Structures Affected

	Current TP-40 (PRIME)	Updated NOAA Atlas 14	2035 Projection	2065 Projection
Any Flooding	11,044	20,176	22,806	25,925
Most Severe (8.29 percent of any)	916	1,673	1,892	2,149

Planning costs to remedy the flooding are estimated based on buy-out costs. This is because in a large percentage of cases an engineering project would not provide an adequate solution for the floodplain flooding. Either the quantity of water is too large to manage with reasonable funds, or in some watersheds, much of what can be done has already been done in the past 20 years by building regional detention basins. While some locations exist where a range of nonstructural options may work, such as structure elevation or structure flood-proofing (dry and wet), those projects represent the minority of feasible solutions. In most cases, because it would not make sense to spend more on a project than the value of the buy-out, the buy-out costs are shown to obtain reasonable planning level cost estimates. These cost estimates are based on the information in the Flood Prioritization & Mitigation Report regarding home values using Property Valuation Administration (PVA) valuations. Table 3.5-15 shows the average cost per structure for the 11,044 structures that touch the current floodplains.

Table 3.5-15. Property Valuation Administration Costing Basis (based on 11,044 structures)

PVA total	$3,075,115,198
Average value per structure	$278,442
Acquisition and demolition (22 percent)	$61,257
Cost per structure:	**$339,699**

Based on the information provided herein, the cost can be applied over Jefferson County for the different rainfall scenarios and the case of "all" structures and the most "severe" structures (Tables 3.5-16 and 3.5-17). The total cost is shown, and then beneath the total costs are annual costs for different lengths of time, adjusted for inflation. This is useful to see how much money is needed every year to pay for the total cost over what period of time. The inflation adjustment is 1 percent per year using the formula F = P * (1 + 1 percent) ^ years, where F= future cost and P = present cost.

Table 3.5-16. Costs Associated with Property Buyouts—All Structures in the Floodplain [a]

	Current TP-40	Updated NOAA Atlas 14	2035 Projection	2065 Projection
Primary structures (all)	11,044	20,176	22,086	25,925
Cost per structure	$339,699	$339,699	$339,699	$339,699
Total cost	**$3,751,640,542**	**$6,853,775,767**	**$7,747,185,276**	**$8,806,707,809**
5-year annual cost	$788,602,383	$1,440,677,442	$1,628,473,917	$1,851,187,683
10-year annual cost	$414,414,515	$757,083,235	$855,771,227	$972,808,430
20-year annual cost	**$228,885,721**	**$418,145,446**	**$472,651,916**	**$537,292,858**
50-year annual cost	$123,401,348	$225,438,755	$254,825,349	$289,675,838
100-year annual cost	$101,474,892	$185,381,875	$209,546,939	$238,205,051

[a] Annual cost are adjusted for inflation by 1 percent per year with the formula $F = P(1 + 0.01)^{years}$, where F=future cost and P = present cost.

Table 3.5-17. Costs Associated with Property Buyouts—Most Severely Affected Structures in the Floodplain [a]

	Current TP-40	Updated NOAA Atlas 14	2035 Projection	2065 Projection
Primary structures (most severe)	916	1,673	1,892	2,150
Cost per structure	$339,699	$339,699	$339,699	$339,699
Total cost	**$311,164,681**	**$568,317,152**	**$642,711,328**	**$730,353,782**
5-year annual cost	$65,407,441	$119,461,408	$135,099,213	$153,521,833
10-year annual cost	$34,371,939	$62,777,570	$70,995,315	$80,676,495
20-year annual cost	**$18,984,002**	**$34,672,746**	**$39,211,498**	**$44,558,520**
50-year annual cost	$10,235,027	$18,693,449	$21,140,470	$24,023,261
100-year annual cost	$8,416,425	$15,371,921	$17,384,145	$19,754,710

[a] Annual cost are adjusted for inflation by 1 percent per year with the formula $F = P(1 + 0.01)^{years}$, where F= future cost and P = present cost.

5.3.7 Summary

If the current flood maps are not adjusted for the updated rainfall amounts, then property owners may not be fully aware of the current and future risk that they face with regard to structure flooding. As shown in Tables 3.5-15 and 3.5-16, buyouts or the projects they represent would require perhaps prohibitive investments of dollars over significant periods of time. However, by enforcing the Floodplain Management Ordinance when new development is proposed in or near existing floodplains, MSD has reduced the potential for future damages. Buildings must be elevated to a point 1 foot above the local regulatory floodplain. This floodplain, while still based on 6.2 inches of rain over a 24-hour period, is calculated based on a fully developed watershed condition, so the projected surface elevations are somewhat conservative.

5.3.8 Recommendations

Following are recommendations to MSD for potential climate change impacts on floodplains:

- To convey to the public the possible risk of future floods because of the increased rainfall, the local regulatory floodplain should be calculated to the projected 2035-year level (from the current 6.2 inches to 8.4 inches in 2035) in each watershed. This calculation would show property owners the flooding risk outside the already mapped SFHA floodplains so they can decide whether or not to purchase flood insurance. Purchasing flood insurance in these areas would not be mandatory. This also would communicate the risk to the public with respect to real estate transactions. The LRF has implications on the repetitive loss definition as in the Jefferson County Floodplain Management Ordinance.
- MSD should calculate new conveyance zones based on the projected 2035 floodplain and strictly enforce the “no development rule” inside these floodways.

- MSD should consider a first right to purchase from people selling their home in the LRF. This purchase would be contingent upon the degree and severity of flooding. Because it is not feasible to buyout all floodplain structures in Jefferson County at one time, a Flood Mitigation Response Fund should be established and funded annually at $4 million per year. This funding will go toward floodplain buyouts, future maintenance of the purchased property, local matches for grants after a major flooding event occurs, and annual grant programs that support purchasing and removing homes from the floodplain.
- Rainfall data and floodplain mapping should be reviewed at least every 10 years to ensure the current flood maps portray the real risk to the community. This new policy should be written in such a way as to make it the review mandatory.
- Floodplain definitions should be reviewed in context of the new Executive Order 13690.

5.4 DRAINAGE PROBLEM AREA IDENTIFICATION—EXTREME STORM EVENTS

During spring and summer 2015, the Louisville area experienced several extreme events that led to major flooding in areas outside of the mapped floodplains. Through many public meetings with the affected neighborhoods, MSD found one common recurring theme. Homeowners, some that had never seen flooding “this bad” before, expected MSD to fix the problems so that this would never happen again. To build infrastructure to handle the type of extreme events (7+ inches in a few hours, for example), would be economically challenging. The Facility Plan Team was tasked to calculate the cost to protect the entire county from flooding caused by extreme storm events. To determine this calculation, the following steps were employed:

- Selected six areas that are typical of the various drainage and flooding problems experienced throughout the Metro Louisville area that are not in FEMA designated floodplains.
- Determined the most intense extreme event that has occurred in recent history.
- Applied the extreme event to the Facility Plan Team’s six project areas using the HEC-RAS 5.0 two-dimensional hydrological model.
- Evaluated and developed planning-level solutions for each of the areas.
- Developed a planning level cost estimate for each of the Facility Plan Team’s six areas.

5.4.1 Summary of Cost Estimates Recommendations

Table 3.5-18 summarizes the cost to build the infrastructure to a level that would have handled the August 4, 2009, extreme event. The costs of the other four areas being evaluated by others are not available yet.

An extrapolation of these numbers across the entire county, based on impervious area, leads to a total of $13 billion. That amount translates to approximately $17,500 per capita for Jefferson County. Appendix 3K contains the calculations and more detailed information on the analysis and solutions for each area.

Table 3.5-18. Summary of Extreme Event Costs for Each Project Area

Project Area	Cost
No. 1 Pope Lick	$ 88 million
No. 2 Seatonville	$ 45 million
No. 3 Whispering Hills	$ 40 million
No. 4 Newburg	$ 57 million
No. 5 Auburndale	$ 92 million
No. 6 Valley Creek	$ 125 million

5.4.2 Extreme Storm Events—Conclusions and Recommendations

The cost to protect the entire county from an extreme storm is prohibitively high. However, MSD can now answer the question of what it would cost for this type of protection when the community asks. If particular areas or communities wish to address this problem at their own cost, it is anticipated that they will draw the same conclusion given the same cost data.

During the analysis using the HEC-RAS 5 two-dimensional model, this software was determined to be suitable for a high-level planning tool to see where the worst drainage problems are throughout the county; this is especially true in areas outside of mapped floodplains. Light Detection and Ranging (LiDAR) information is available countywide. Some effort would be needed to build the model accurately for the entire county, but it could be a worthwhile endeavor for future stormwater planning in Jefferson County.

VOLUME 3—STORMWATER AND DRAINAGE

CHAPTER 6 PROJECT DEVELOPMENT AND PRIORITIZATION

6.1 PROJECT DEVELOPMENT

This chapter documents the stormwater and drainage projects being recommended in the 20-Year Comprehensive Facility Plan. This chapter also summarizes all policy and design recommendations made throughout volume 3.

6.2 EARLY ACTION PLAN PROJECTS

As documented in Volume 3, Chapter 3, a comprehensive stormwater master plan needs to be completed to identify and prioritize areas that need stormwater infrastructure upgrades and improvements. This plan will take some time to put together. However, in the interim, 10 early action project areas have been identified that some improvements may be designed and constructed while the master planning is being performed if funding is available. Planning-level cost have been calculated to achieve a 10-percent annual chance (10-year) level of service in these 10 areas. Four of these areas were included due to extreme storm events that hit neighborhoods during spring and summer 2015. These four areas, along with the other six areas that were carefully screened as poor drainage areas, will make up an EAP that MSD could implement while the comprehensive stormwater master plan is being crafted. The ten EAP projects may include only the first phase of a larger improvements program. These areas are not necessarily the worst areas in the county.

The four areas that were included due to the 2015 extreme storm events were studied and determined to contain worthwhile drainage improvement projects. At least one of these areas previously rejected a solution and proposed improvements may not be acceptable. These studies and associated cost estimates were developed outside of the Facility Plan Team. However, as described herein, the projects are a part of the stormwater EAP and the overall 20-year facility plan recommendations.

The other 6 areas will be referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. All areas were also screened to be outside of known mapped floodplains, because floodplain issues are their own complex problem in and of themselves, and were examined separately in the *Project Summary Report: Countywide Flooding Prioritization* (PRIME AE Group, Inc., 2016b).

The following are the 10 study areas included in the early action plan projects. Again, these do not necessarily represent the worst areas of Jefferson County; Figure 3.6-1 shows the locations of each one:

- Pope Lick—Pilot Area
- Seatonville—Pilot Area
- Whispering Hills—Pilot Area
- Newburg—Pilot Area

- Auburndale—Pilot Area
- Valley Creek—Pilot Area
- City of Prospect—Extreme Storm Event Area
- City of Hurstbourne—Extreme Storm Event Area
- Ten Broeck—Extreme Storm Event Area
- Richlawn—Extreme Storm Event Area

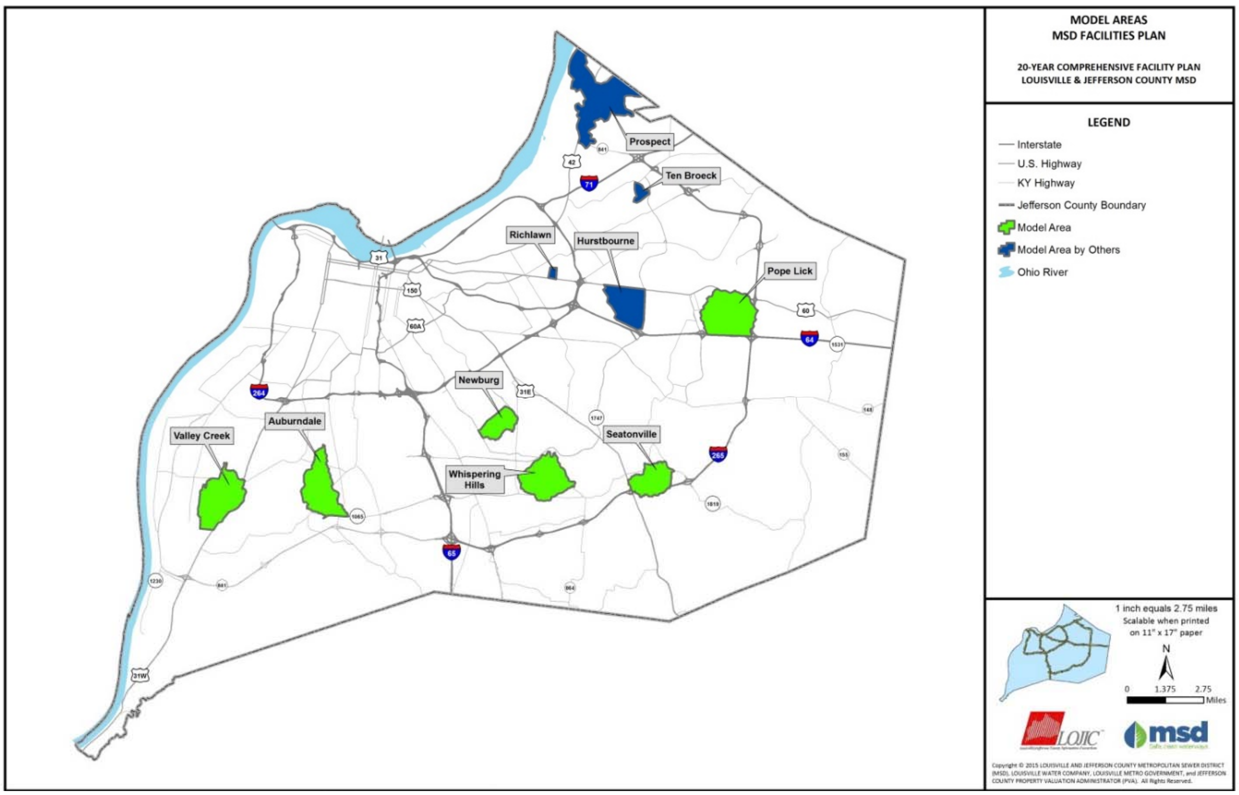

Figure 3.6-1. Early Action Plan Project Locations

6.2.1 Pilot Area Analysis Procedures

The following sections document the procedure used to determine the 10-percent annual chance (10-year) planning-level cost for the six pilot areas. This storm event was chosen because it is the level of service the existing stormwater systems in these areas are supposed to meet.

The project area maps are shown in the Appendix 3I. Appendix 3I also contains an existing conditions map of each of the areas that show the area boundary, the major drainage features, drainage infrastructure, major roads, and other significant features.

Section 5.4 provides the background data for selecting, modeling, analyzing, and costing the six areas for the selected extreme storm event. This section describes the 10-percent annual chance (10-year) hydrology, hydraulics, potential solutions, and costs.

6.2.2 Hydrologic Analysis and Accounting for Existing Storm Sewers

As previously stated, the 10-percent annual chance (10-year) 24-hour storm event was chosen for analysis, because it is the design standard for the County. Two different 10-percent annual chance (10-year) storm definitions were analyzed: the current MSD Design Manual definition, based on the TP-40 rainfall depths and the projected 2035 depths. The 24-hour rainfall totals for these different definitions are 4.5 and 5.1-inches, respectively (see Table 3.6-1). HEC-HMS 4.1 was used to determine rainfall hyetographs for each area that were then imported and used in the HEC-RAS 5.0 model.

Table 3.6-1. Comparison of Jefferson County, Kentucky, Rainfall Depth Amounts (Inches) for 24-Hour Storm Duration by Rainfall Atlas

Percent Annual Chance (average return interval)	MSD Design Manual (TP-40; NOAA, 1961)	Projection for 2035
50 (2-year)	3.2	3.0
20 (5-year)	4.0	4.2
10 (10-year)	4.5	5.1
4 (25-year)	5.2	6.3
2 (50-year)	5.7	7.3
1 (100-year)	6.2	8.4

One limitation of the HEC-RAS 5.0 model is that it cannot directly model the underground storm sewer infrastructure. While not as critical for modeling an extreme event because the underground systems are quickly overwhelmed, it does become a factor in modeling higher frequency storms such as the 10-percent annual chance (10-year) event. Without accounting for this factor in some way, the analysis would be overly conservative for the 10-percent annual chance (10-year) event.

In general, the existing MSD stormwater infrastructure is believed to be able to handle rainfall up to approximately 3 inches in a 24-hour period without localized flooding, which equates to a 50-percent annual chance (2-year) return interval. Therefore, deducting a portion of the 50-percent annual chance (2-year) storm from the 10-percent annual chance (10-year) storm was decided to account for the storm portion that the existing underground system is conveying but is not being accounted for in the HEC-RAS 5.0 models. The amount deducted was based on the ratio of underground conveyance to aboveground conveyance (that is, storm sewer pipe versus open channels). Table 3.6-2 shows the percentages used to reduce the 50-percent annual chance (2-year) storm for both TP-40 and the 2035 storm event. Using the percentages in Table 3.6-2, the amount of rainfall to deduct from the 50-percent annual chance (2-year) storm could be determined. Again, this represents flow that the underground system is safely conveying. Once this amount was determined, it was subtracted from the 10-percent annual chance (10-year) hyetograph for the 10-percent annual chance (10-year) storm event. This final hyetograph is what was used for the hydraulic overland flow analysis. See Appendix 3L for more details on how these hyetographs were created.

Table 3.6-2. Percentages of Storm Sewers for Study Areas

Model Area	Storm Sewers Length (feet)	Drainage Channel Length (feet)	Storm Sewers Percentage
Pope Lick	82,938	293,209	22
Seatonville	35,367	144,570	20
Whispering Hills	50,187	268,174	16
Newburg	74,249	166,909	31
Auburndale	72,915	269,630	21
Valley Creek	77,854	330,396	19

To show a graphical example of how this methodology works, see Figure 3.6-2, which graphically shows the original 10-percent annual chance (10-year) storm event for Valley Creek compared to the modified storm event.

Note, both the TP-40 and 2035-projected storm events were modeled. However, when the modeled results were superimposed, the difference of the two flooded areas between the two storms was approximately 10 percent. This was considered minor for a planning-level evaluation. For this reason, only the 2035-projected storm event was given a cost and mapped. Figure 3.6-3 shows the comparison between inundation areas for the TP-40 storm and 2035-projected storm. The blue inundation area represents the TP-40 storm. The red area surrounding the blue area represents the inundation area of the 2035-projected storm.

6.2.3 Hydraulic Analysis

The HEC-RAS 5.0 (two-dimensional software using unsteady flow simulations) was used to perform this planning-level hydraulic analysis for this project. The primary reason HEC-RAS 5.0 was chosen for this project was its ability to model two-dimensional flow in shallow depth overland flow areas. In addition, the model could easily output discharge, velocities, and depths anywhere of interest in the modeled watershed. It also provides a very dynamic and visually-engaging presentation that easily communicates problem area locations to the public and elected officials.

6.2.4 Louisville and Jefferson County Information Consortium Mapping

The data from the LOJIC GIS are critical to the development of the stormwater program for Louisville and Jefferson County. The data are the basis for developing the six project areas and solutions.

Additionally, the Facility Plan Team created an easy-to-use GIS web application program that does not require a trained ArcGIS® operator. This web application was used to aid in selecting the project areas, understand the drainage system, develop solutions, and determine costs.

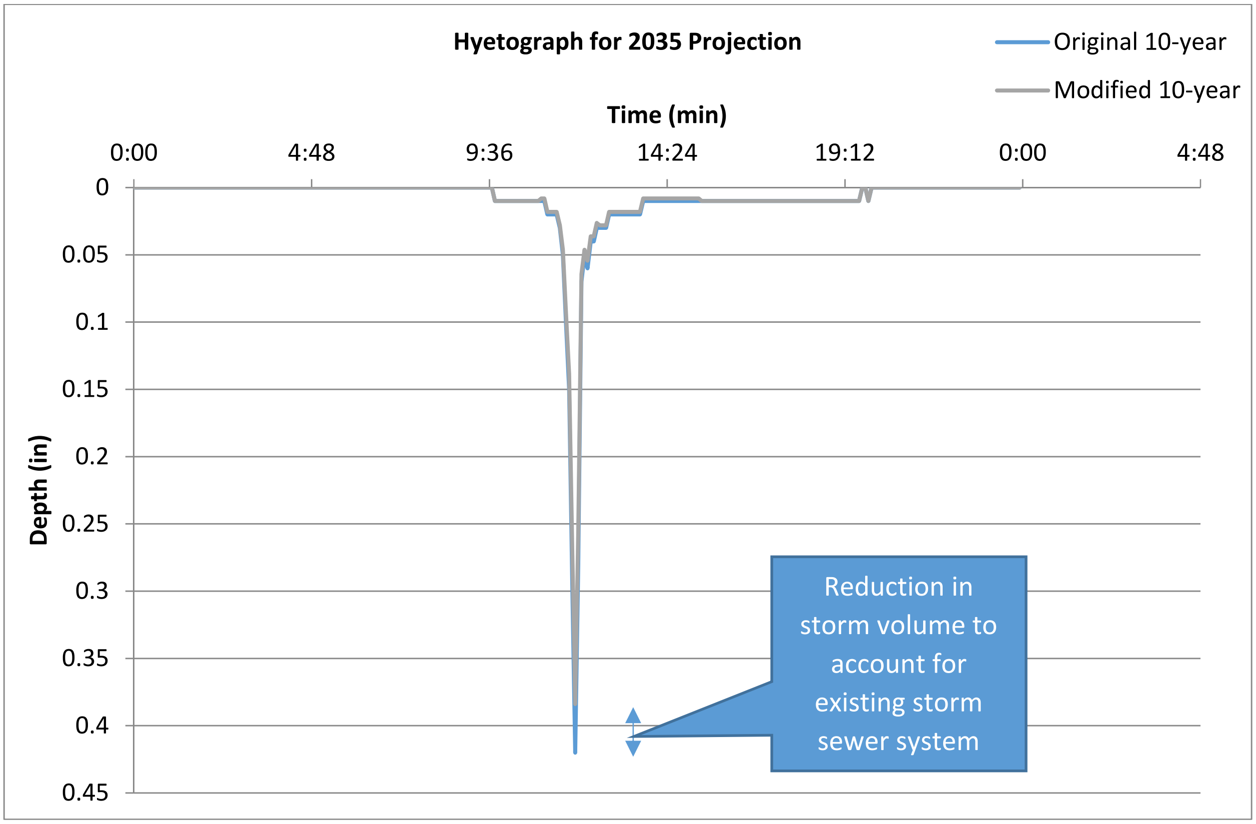

Figure 3.6-2. Comparison of the 10-year Hyetograph with the Hyetograph minus a percentage of the two-year storm

6.2.5 Potential Solutions

Solutions were developed only on the 2035 10-percent annual chance (10-year) event because the difference between the 2035 10-percent annual chance (10-year) event and TP-40 10-percent annual chance (10-year) event were not enough to identify different solution sets for each one, especially at a planning level. In many areas, street-level flooding was observed in the models. Street-level flooding is flooding caused when the storm sewer and ditch systems are overwhelmed, thereby flooding the streets and/or adjacent properties. This can be solved, most effectively, by increasing the storm-system conveyance. Some, but not all, of the six areas required storage basins when the downstream system was unable to handle the additional flows from increasing the conveyance. The optimal solution, where storage should actually be constructed, needs to be addressed on a watershed basis. This solution is accomplished when the comprehensive stormwater master plan is completed for the County. For now, some areas have storage basins included to make sure that cost is captured in this effort.

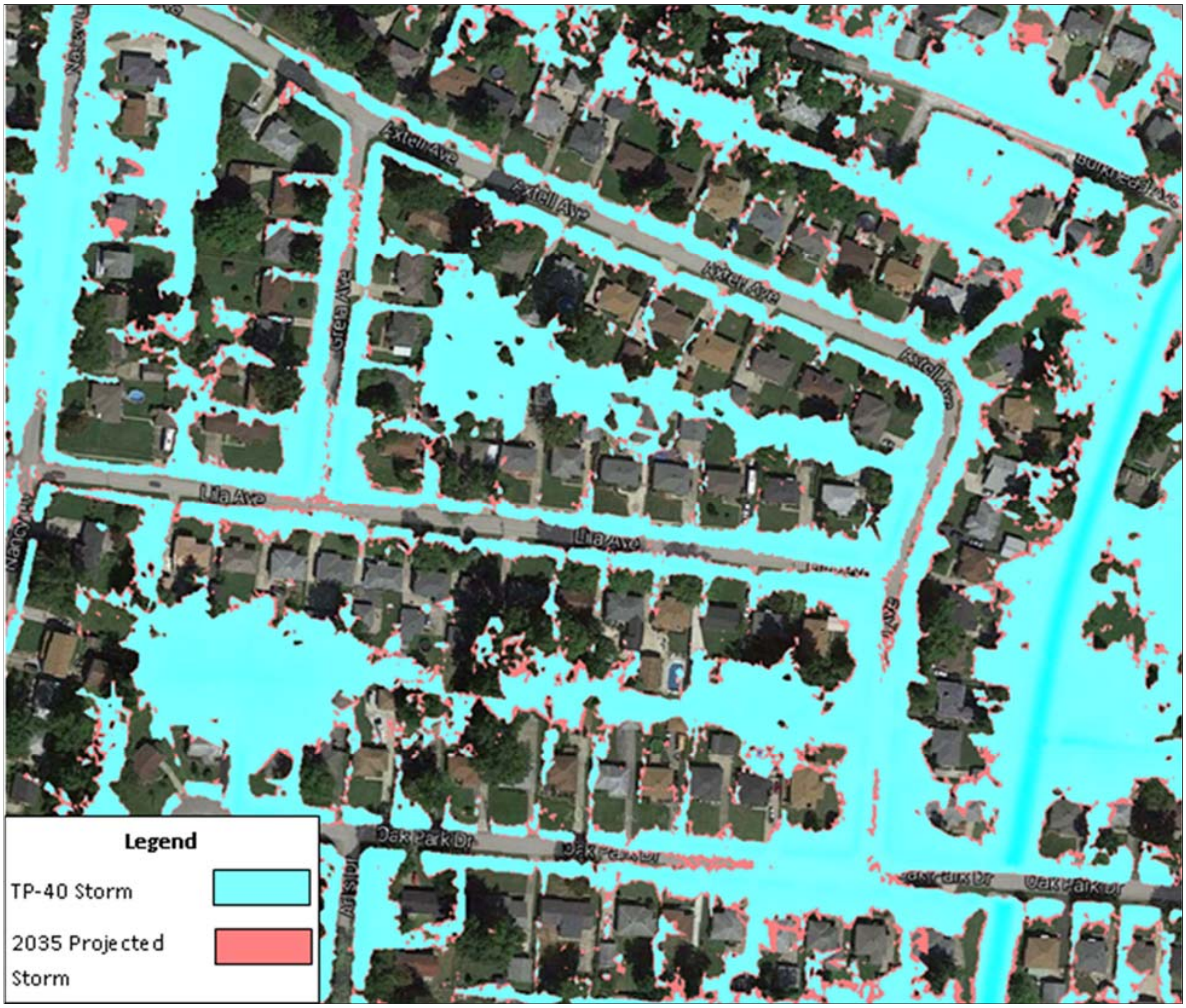

Figure 3.6-3. Comparison of the TP-40 and 2035 projected storm event inundation areas

The general approach in each area is to increase the conveyance by increasing the size of pipes or adding pipes to the system, increasing the number of inlets, and/or adding detention to reduce the flooding downstream. Because these are urbanized areas, systems will be difficult (and expensive) to construct, and the detention storage that has been recommended and estimated for costs is underground storage. However, in some cases, this could be surface (at-grade) storage. During preliminary engineering, these areas will have to be examined more closely and an appropriate selection made at that time. In some cases, homes will need to be purchased to obtain the volume of storage that is needed. The advantage of the underground storage is that the facility is out of sight and the area on top of the facility might be able to be used for other purposes. Because this is a 10-percent annual chance (10-year) storm, other alternatives, such as green infrastructure, may be acceptable solutions in decreasing peaks and volumes. Infiltration, critical infrastructure protection, flood proofing, and diversions can help mitigate certain drainage problems. Because this analysis is a planning-level analysis, these options were not modeled in a detailed manner. These alternatives should be investigated when the project moves into preliminary design.

The work performed in this task is a planning-level effort. This means that the data and information collected include analysis and modeling, and both the solutions and costing performed have limitations and are estimates that may contain inconsistencies. The data and results of this study should not be used for designing and constructing stormwater facilities; they should be limited to planning. The Facility Plan Team recommends additional stormwater master planning, watershed planning, and design studies.

6.2.6 Results for the Six Pilot Project Areas

A summary of the solutions for each area is described herein and a solution map for each area is included in Appendix 3M. For several project areas, purchasing several homes would be required to construct infrastructure and/or remove flood-prone structures. These purchases were incorporated into the solution because they were less costly than the addition of conveyance or detention solutions. An estimated planning-level cost was determined for each solution and totaled for each project area. The project area descriptions provide a summary of those costs.

The following subsections summarize the results, including possible solutions and cost determinations for each area. Each subsection discusses the location, watershed, basin, neighborhood, existing stormwater infrastructure, flooding and drainage issues, flooding and drainage solution and cost for the project areas.

6.2.6.1 Project Area 1—Upper Pope Lick Drainage Area

Watershed—Floyds Fork.

Basin—Pope Lick, the upper most subbasins above Interstate 64 (I-64).

Neighborhood Area – Bordered on the north by Shelbyville Road, on the east by Creek Valley Road, on the south by I-64, and on the west by Tucker Station Road.

Storm Sewer Percentage—22 percent.

Existing Stormwater Infrastructure—The Pope Lick area has a combination of pipe and inlet systems with open-channel systems. Open channels are located along roads and along the back of properties. The pipe and inlet systems connect the open channel systems to convey stormwater under roads and along roads, and discharge to major stream systems.

Flooding and Drainage Issues—Key areas of concern are in a subdivision just west of Woodland Hills and along Running Creek Road.

Flooding and Drainage Solutions—Solutions for the Pope Lick area include increasing system conveyance and purchasing several homes for placing infrastructure and/or removing flood-prone structures. Table 3.6-3 summarizes the flooding and drainage solutions and estimated costs for the Pope Lick Area.

Table 3.6-3. Pope Lick Area

Element	10-Percent Annual Chance (10-Year) Storm Solution	Cost
System	Existing systems were increased in diameter and new pipes added.	$1 million
Detention	None.	$0
Property and Easements	The cost includes easement and home purchases.	$5.1 million
	Total	**$6.1 million**

6.2.6.2 Project Area 2—Seatonville

Watershed—Cedar Creek.

Basin—Hawkins Rill.

Neighborhood Area—Bordered on the north by Seatonville Road, although it turns and goes through the center of the basin, on the east by Billtown Road, on the South by Interstate 265 (I-265) Kentucky State Route 841 (KY 841), and on the west by Bardstown Road.

Storm Sewer Percentage—20 percent.

Existing Stormwater Infrastructure—Most of the storm infrastructure system is roadside drainage channels and backyard drainage channels. Underground pipe systems are located near street intersections and convey stormwater from the roadside and backyard channels to downstream conveyance. Pipe sizes range from 12 to 36 inches. The entire area flows to the southeast into Hawkins Rill, which is a tributary of Cedar Creek.

Flooding and Drainage Issues—Certain areas, such as a subdivision northeast of Brookridge Village Apartments, have street-level flooding that will potentially cause structure flooding and damage. Other areas have downstream systems that are smaller than the upstream systems. For example, a system around Brighton Springs Lane has a 24-inch reinforced concrete pipe (RCP) that system drains into a backyard drainage channel and then to an 18-inch and 24-inch system, with additional discharge entering the system at that point. The sizes of the systems that drain from the neighborhoods (to the north) to Hawkins Rill and under I-265 (to the south) are not in the LOJIC system.

Flooding and Drainage Solutions—Solutions for the Seatonville area include an increase in system conveyance, increase in storage, and the purchase of several homes for placement of infrastructure and/or the removal of flood-prone structures. Table 3.6-4 summarizes the flooding and drainage solutions and estimated costs for the Seatonville area.

Table 3.6-4. Seatonville Area

Element	10-Percent Annual Chance (10-Year) Storm Solutions	Cost
System	Existing systems were increased in diameter and new pipes added.	$1.9 million
Detention	All storage is in a 10-foot-diameter underground storage system: • Storage 1— Brighton Springs Lane (0.36 acre-foot) • Storage 2—North of Seatonville Road, Monty Lane, and Sonic Drive (0.54 acre-foot)	$260,000
Property and Easements	The cost includes easement and home purchases	$ 1.3 million
	Total	**$3.4 million**

6.2.6.3 Project Area 3—Whispering Hills

Watershed—Pond Creek.

Basin—Fern Creek and unnamed tributaries.

Neighborhood Area—Bordered on the north by the main channel of Fern Creek, on the east by Fegenbush Road and Downs Branch, on the south by Outer Loop, and on the west by Shepherdsville Road.

Storm Sewer Percentage—16 percent.

Existing Stormwater Infrastructure—Roadside and backyard-open channels. Short sections of pipe and culverts are located under roads.

Flooding and Drainage Issues—There is a need to address property and structure flooding in the Fegenbush Lane and Vaughn Mill Road area. The system in the Wynde Manor Road, Fendwick Drive Woodrow Way, and Brightstone and Crispa Court area is undersized.

Flooding and Drainage Solutions—Solutions for the Whispering Hills area include increasing system conveyance and purchasing several homes for placing infrastructure and/or removing flood-prone structures. Table 3.6-5 summarizes the flooding and drainage solutions and estimated costs for the Whispering Hills area.

Table 3.6-5. Whispering Hills Area

Element	10-Percent Annual Chance (10-Year) Storm Solutions	Cost
System	Existing systems were increased in diameter.	$ 943,000
Detention	None.	$ 0
Property and Easements	The cost includes easement and home purchases.	$ 2.3 million
	Total	**$ 3.2 million**

6.2.6.4 Project Area 4—Newburg Area

Watershed—Pond Creek, Northern Ditch.

Basin—Greasy Ditch Tributary.

Neighborhood Area—Bordered on the north by East Indian Trail, on the east by Newburg Road and the South Fork Beargrass Creek Watershed, on the south by Rangeland Road, and on the west by Poplar Level Road.

Storm Sewer Percentage—31 percent.

Existing Stormwater Infrastructure—The major stormwater conveyance for the Newburg area is a channel (with approximately 40 feet top width and 5 to 6 feet deep) that is an unnamed tributary of Greasy Ditch (a tributary of Northern Ditch Pond Creek). This channel begins near Unseld Boulevard (at the confluence of a 108-inch RCP storm system, a 48-inch storm system, and a 36-inch RCP storm system) and flows southwest to Greasy Ditch near Poplar Level Road. In addition to the three systems (108-inch, 48-inch, and 36-inch) at the confluence of the tributary to Greasy Ditch, a channel (approximately 35 feet top width and 5 to 6 feet deep) flows from east to west and intersects the unnamed tributary of Greasy Ditch near Ilex Avenue.

Flooding and Drainage Issues—The Newburg area is a very flat, low-lying area near the Northern Ditch Floodplain, which has had numerous drainage complaints and as many as 20 DRI projects. The 10-percent annual chance (10-year) storm event inundates the area and causes street, yard, and structure flooding. The large conveyance channel appears to contain the extreme storm with only minor flooding; however, the collection system that conveys flow to that system is undersized and needs to be upgraded by one pipe size.

Flooding and Drainage Solutions—Solutions for the Newburg area include increasing system conveyance and purchasing a number of homes for placing infrastructure and/or removing flood-prone structures. Table 3.6-6 summarizes the flooding and drainage solutions and estimated costs for the Newburg area.

Table 3.6-6. Newburg Area

Element	10-Percent Annual Chance (10-Year) Storm Solutions	Cost
System	Existing systems were increased in diameter.	$19.7 million
Detention	None.	$0
Property and Easements	The cost includes easement and home purchases.	$ 801,000
	Total	**$20.5 million**

6.2.6.5 Project Area 5—Auburndale

Watershed—Pond Creek.

Basin—Bruce Creek.

Neighborhood Area—Bordered on the north by Iroquois Park, on the east by New Cut Road, on the south by Outer Loop, and west by Slate Run Creek and Saint Anthony Church Road.

Storm Sewer Percentage—21 percent.

Existing Stormwater Infrastructure—Combination of pipe and inlet systems with drainage channels that convey stormwater along roads and in backyards.

Flooding and Drainage Issues—Flooding occurs upstream of the railroad culvert near Third Street along Bruce Creek, as well as along Bruce Creek and the parallel collection systems from Third Street to Palatka Road.

Flooding and Drainage solutions—Solutions for the Auburndale area include increasing system conveyance, increasing storage, and purchasing a number of homes for placing infrastructure and/or removing flood-prone structures. Table 3.6-7 summarizes the flooding and drainage solutions and estimated costs for the Auburndale area.

Table 3.6-7. Auburndale Area

Element	10-Percent Annual Chance (10-year) Storm Solutions	Cost
System	Existing systems were increased in diameter and new pipes were added to the system.	$3.1 million
Detention	All storage is in a 10-foot-diameter underground storage system: • Storage 1—Park above Palatka Avenue (6.3 acre-feet) • Storage 2—Bruce Avenue (4.5 acre-feet) • Storage 3—Justan Avenue (4.5 acre-feet) • Storage 4—1120 Cristland Road (2.7 acre-feet) • Storage 5—3rd Street (4.1 acre-feet) • Storage 6—Railroad and 3rd Street (4.7 acre-feet)	$7.8 million
Property and Easements	The cost includes easement and home purchases.	$1.8 million
	Total	**$12.7 million**

6.2.6.6 Project Area 6—Valley Creek

Watershed—Mill Creek.

Basin—Valley Creek.

Neighborhood Area—Bordered on the north by Greenwood Road and Big Run Diversion, east by Dixie Highway, on the south by Speedway Avenue, and on the west by Devonshire Drive.

Storm Sewer Percentage—19 percent.

Existing Stormwater Infrastructure—Most of the collection system consists of roadside and backyard open channel systems with pipe and culvers to deliver flow under streets and roads. Some longer runs of underground system connect Nancy Lane and Gerald Avenue to Valley Creek in the Alyssum and Hepatica Drive area, Daisy Avenue area, south of Jessamine Lane, and Rogers Road, Walker Road, Julia Road, and Johnsontown Road area. Three streams drain to Mill Creek and Valley Creek and the east and west unnamed tributaries for the trunk system for the area.

Flooding and Drainage Issues—The 10-percent annual chance (10-year) storm event inundate most of the Valley Creek Basin. However, the following are areas of elevated flooding where a greater focus of solutions was concentrated:

- Clover Avenue
- Johnsontown Road
- Area above Stephan Drive and West Pages to Marryman Road
- Greenwood Road area
- West of Jessamine Lane
- Scattered areas of flooding along the three main channels

Flooding and Drainage Solutions—Solutions for the Valley Creek area include increasing system conveyance, increasing storage, and purchasing several homes for placing infrastructure and/or removing flood-prone structures. Table 3.6-8 summarizes the flooding and drainage solutions and estimated costs for the Valley Creek area.

Table 3.6-8. Valley Creek Area

Element	10-Percent Annual Chance (10-year) Storm Solutions	Cost [a]
Conveyance System Upgrades	Existing systems were increased in diameter and new pipes and drainage channels added.	$5.0 million
Detention	All storage is in a 10-foot-diameter underground storage system: Storage 1— West Pages Lane (5.4 acre-feet)	$ 2.1 million
Land Purchase	The cost includes easement and home purchases.	$2.7 million
	Total Cost	**$9.8 million**

[a] Summary of Valley Creek Area solutions and costs

6.2.7 Summary of Project Costs

Project costs were determined for each of the six project areas as shown in Tables 3.6-3 through 3.6-8. Table 3.6-9 summarizes the cost for each of the six project areas for the 10-percent annual chance (10-year) 2035 projection storm.

Table 3.6-9. Project Areas Costs

Project Area	10-Percent Annual Chance (10-year) Storm Solution
1 Pope Lick	$ 6.1 million
2 Seatonville	$ 3.4 million
3 Whispering Hills	$ 3.2 million
4 Newburg	$ 20.5 million
5 Auburndale	$ 12.7 million
6 Valley Creek	$ 9.8 million
Average Cost per Area	$ 9.3 million

6.2.8 10-Percent Annual Chance (10-Year) Storm Level of Service Countywide Extrapolation

The purpose of the countywide extrapolation is to get an idea of the cost to implement the projects likely recommended from the future stormwater master planning effort to provide a minimum 10-percent annual chance (10-year) Storm level of service across the entire county.

The countywide 10-percent annual chance (10-year) storm event cost extrapolation is based on a two-step process. The first step calculates the total impervious area of single-family homes in the project areas and compares that to the total impervious areas of single-family homes in the entire county. This ratio is then used to extrapolate cost over the county and establishes the baseline cost. Since the six areas of study are older neighborhoods with very poor drainage, this step alone may overestimate the cost for the entire county. The next step in the process was to develop a baseline cost for three conditions:

- Older neighborhoods with poor drainage
- Neighborhoods with moderate drainage problems
- Newer neighborhoods with relatively few drainage problems

Using the baseline cost from the first step, a factor was applied to establish the baseline cost for each of the three conditions. Once those costs were known, an estimated percentage was assigned to each condition that represented the percentage of those conditions present in Jefferson County. Please refer to Appendix 3N for all calculations. The total cost for the 10-percent annual chance (10-year) flooding and drainage issues for a countywide, planning-level basis is estimated to be $600 million but could be as high as $1.1 billion. There is a fair amount of uncertainty and variability with this calculation because the overall proposed comprehensive stormwater master plan will define the actual cost of this level of service. The calculation above does not specifically address the combined sewer system, which will be undoubtedly more expensive and difficult to upgrade versus a typical suburban neighborhood; that is the reason for the large gap in cost estimation. However, it is recommended that the $600 million number be used for programming purposes until the proposed comprehensive stormwater master plan can be completed.

6.2.9 Summary of Modeling Assumptions

The following are project assumptions in developing the 10-percent annual chance (10-year) planning-level cost for the six pilot areas:

- The current storm sewers can convey the 50-percent annual chance (2-year) 24-hour storm or approximately 3 inches of rainfall depth.
- By removing a percentage of the rainfall to approximate the flow in the underground storm sewers provides a feasible way to account for underground conveyance of some of the rainstorm.
- The analysis performed is a planning-level analysis using the HEC-RAS 5.0 two-dimensional model, a digital terrain model that was provided by MSD, and precipitation data from the NWS. The results from this analysis are not to be used for the design or construction of any facilities or projects and should only be used for preliminary planning and a general understanding of the problems and possible solutions available. Additional detailed analysis will need to be performed for each of the project areas.
- Cost estimating used standard engineering cost estimating procedures. Data were obtained from recent design cost estimates, product manufacturers, and RSMeans cost data. The following cost assumptions are applied to each project area cost estimate:
  - All main resizing will require concrete curb and sidewalk replacement where applicable.
  - Traffic control will last for 1 year.
  - All resized mains will require saw-cutting and removing asphaltv3.
  - All main resizing will require asphalt pavement restoration.
  - All unknown main sizes were assumed smaller than 18 inches.
  - All trench excavation will require dirt to be hauled off site.
  - All existing pipe to be resized will require removal and haul-off.
  - All backfill will require flowable fill (conservative for planning estimate).
  - Underground detention volume uses the entire pipe.

6.2.10 Pilot Area Analysis—Conclusions and Recommendations

The following are the conclusions and recommendations to determine the 10-percent annual chance (10-year) storm planning-level cost for the six pilot project areas:

- The solutions for the six pilot areas should be refined further by advancing them to the preliminary design engineering stage. The project areas identified in this section can become an early action plan while the proposed comprehensive stormwater master plan for the entire county is underway.
- The cost of the countywide level of service contains a lot of variability. A detailed comprehensive stormwater master plan is needed to determine actual communitywide cost.
- MSD should use the 2035 rainfall to define all future stormwater projects, both in planning and design.
- MSD should institute a policy to design for 80 percent of full flow for all pipes and drainage channels. This policy will help against unforeseen events such as increased climate change, or increased unforeseen developments.
- The HEC-RAS 5.0 model, combined with the new LiDAR data, make a powerful planning-level tool that MSD can use to assist in developing the countywide comprehensive drainage master plan. This type of analysis can be very efficient for a large scale, countywide analysis.

6.2.11 2015 Extreme Storm Event Areas

As noted in Section 6.2, four of the ten early action project areas experienced extreme storm events during spring and summer 2015 and underwent planning-level engineering for inclusion in the early action plan projects. The most recent cost to date for the four project areas are as follows:

- Prospect—$7 million
- Hurstbourne—$11 million
- Ten-Broeck—$4 million
- Richlawn—$350,000 (dry-well only solution)

These costs provide projects that address the 2035 projected 10-percent annual chance (10-year) storm event by a combination of increased conveyance and detention basins.

6.3 PROJECTS IDENTIFIED FROM THE GAP ANALYSIS

Table 3.6-10 summarizes the individual projects identified from Volume 3, Chapter 3 and should be referenced for a complete description of how these projects were planned. Note that these are planning-level numbers; detailed preliminary engineering would need to be performed to get a more accurate cost for each site. MSD has drainage responsibilities for all the viaducts listed in Table 3.6-10.

Table 3.6-10. Summary of Viaduct Flood Relief Costs (2016 Dollars)

Viaduct ID	Location	2035 Projection (25-year Storm)
VIA16	South 3rd Street and Eastern Parkway	$29,900,000
VIA17	South 4th Street and Industry Road	$29,900,000

Table 3.6-10. Summary of Viaduct Flood Relief Costs (2016 Dollars)

Viaduct ID	Location	2035 Projection (25-year Storm)
VIA32	South 3rd Street and Winkler Avenue	$29,900,000
VIA11	East Brandeis Avenue and South Brook Street	$28,000,000
VIA08	South 16th Street and Algonquin Parkway	$28,000,000
VIA10	South Floyd Street and East Hill Street	$28,000,000
VIA01	13th Street and Market Street	$5,000,000
VIA02	South 32nd Street and West Market Street	$6,700,000
VIA03	North 13th Street and West Main Street	$5,400,000
VIA04	South 13th Street and West Muhammad Ali Boulevard	$5,800,000
VIA05	North 30th Street and Portland Avenue	$4,400,000
VIA06	North 30th Street and Bank Street	$4,300,000
VIA07	South 13th Street and West Jefferson Street	$5,000,000
VIA09	South 6th Street and West Hill Street	$4,000,000
VIA12	8th Street and Oak Street	$4,000,000
VIA13	South 13th Street and West Hill Street	$4,000,000
VIA14	South 31st Street and West Broadway	$4,600,000
VIA15	South 7th Street and West Magnolia Avenue	$4,000,000
VIA18	Eastern Parkway and Hahn Street	$6,500,000
VIA19	South 32nd Street and West Muhammad Ali Boulevard	$6,700,000
VIA20	South 31st Street and Vermont Avenue	$4,000,000
VIA21	30th Street and Del Park Terrace	$4,000,000
VIA22	South 22nd Street and Standard Avenue	$3,800,000
VIA23	Dixie Highway and Standard Avenue	$5,300,000
VIA24	South 15th Street and West Oak Street	$5,300,000
VIA25	South 10th Street and West Hill Street	$5,300,000
VIA26	South 7th Street and Davies Avenue	$5,300,000

Table 3.6-10. Summary of Viaduct Flood Relief Costs (2016 Dollars)

Viaduct ID	Location	2035 Projection (25-year Storm)
VIA27	15th Street and Chestnut Street	$3,900,000
VIA28	15th Street and Broadway	$3,900,000
VIA29	13th Street and Maple Street	$3,800,000
VIA30	12th Street and Maple Street	$3,800,000
VIA33	Taylorsville Road and Merioneth Drive	$4,400,000

6.4 PROJECTS FROM THE 2016 COUNTYWIDE FLOOD MITIGATION PRIORITIZATION REPORT

The *Project Summary Report: Countywide Flooding Prioritization* (PRIME AE Group, Inc., 2016b) was generated to document both the inventory and prioritization of structures that are in the current floodplains and also to examine possible mitigation projects for those high-priority structures. This report provides the complete details on the process, results, and conclusions.

Unfortunately, with the current hydraulic modeling data that were used in the report, no mitigation projects were cost beneficial when compared with buying out the property. Therefore, no mitigation projects were included in the facility plan recommendations. The report did recommend, however, updated hydrologic and hydraulic models in several areas of known flooding to determine whether structural mitigation is viable.

6.5 PROJECTS FROM THE LOUISVILLE METRO HAZARD MITIGATION PLAN 2016 UPDATE

The plan (Louisville Metro et al., 2016) was reviewed and the following projects are recommended for inclusion:

- I-64 and Douglass Hills Culvert Replacement
- LaClede Detention Basin
- Tin Dor Way Detention Basin

The I-64 and Douglas Hills Culvert Replacement is on the boundary of the Pope Lick Early Action Project and can be easily rolled into that project. This should be done during the preliminary engineering for that project. The other two detention basin projects have not been studied in detail. Therefore, there are not enough data to prioritize these projects with the rest of the plan. It is recommended these be further studied and cost determined during the stormwater master planning efforts.

6.6 OTHER BUDGETARY LINE ITEM RECOMMENDATIONS

Along with the identified projects, recommended budgetary items have been set up to handle or address certain stormwater needs. They are each explained in Sections 6.6.1 to 6.6.5.

6.6.1 Floodplain Buyouts ("Flood Response Fund")

As mentioned in Section 6.5, no mitigation projects were found to be cost-effective for the structures in the 68 areas studied. Buyouts are primarily recommended for floodplain mitigation. However, because of the extraordinary cost involved in buying all affected property at once, it is recommended to fund a "flood response fund" account by $4 million annually. This amount should be sufficient to adequately respond to a localized flooding event. It should be used for events like the ones that occurred in the spring and summer of 2015, for quick buy-outs of substantially damaged properties after a flooding event. It can also be used for applying for, administering, and providing local matching funds for FEMA and other flood relief grants. Doing this is prudent, because as evidenced by the *Project Summary Report: Countywide Flooding Prioritization* (PRIME AE Group, Inc., 2016b), it is in the majority of cases economically prudent to buy the homes as opposed to a major stormwater project that would try to eliminate the home from being flooded again.

6.6.2 Stormwater Master Plan

Funding an updated comprehensive stormwater master plan is recommended with a budget of at least $4 million for the initial update. This amount is an estimate of the effort it would take to complete comprehensive master planning at this level. A similar amount was expended for planning efforts and the wastewater countywide model, soon after the EPA Consent Decree became reality. Volume 3, Chapter 3 provides more information regarding the need for the proposed comprehensive stormwater master plan.

6.6.3 EPA Community Solutions for Stormwater Management: A Guide for Voluntary Long-Term Planning

In October 2016, EPA published a guidance document titled *Community Solutions for Stormwater Management: A Guide for Voluntary Long-Term Planning* (EPA, 2016a). The purpose of this document is to promote long-term, cost-effective stormwater management that integrates water quality, infrastructure resiliency and economic development into a single comprehensive plan. MSD's Facility Plan was reviewed to determine how well it aligned with the 35 recommended elements suggested in the EPA guidance.

The review indicates that 8 elements appear to be adequately addressed and 17 elements are briefly mentioned or discussed in the Facility Plan; the remaining 10 elements are not addressed. This MSD Facility Plan will serve as the foundation for more detailed regional stormwater master planning in the future. The Facility Plan Team recommends that MSD further evaluate opportunities to more fully integrate the EPA elements into the future planning initiatives.

6.6.4 Drainage Response Initiative Budgeting

Continuing the highly successful DRI program is recommended at a cost of $5 million annually. This amount is just above spending for DRI over the last several years. This program is based on customer requests. There are many success stories about the program, and it often paints MSD in a very good light in the community, because it is a hands-on, boots-on-the-ground approach to minor drainage problems. From 2003 to 2010, MSD expended approximately $125 million on this program, which was necessary and essential to continue this program. There is still a long list of open drainage request. This program, working in concert with the new capital program to be established by the proposed comprehensive stormwater master plan, will be a perfect combination of low-level maintenance type projects to the major neighborhood and watershed capital projects that are needed to bring everyone up to a minimum stormwater level of service.

6.6.5 MS4 Program and Basin Retrofit Projects

Funding the MS4 Program is recommended at a cost of $2 million per year for years 2017 to 2021 and then $6.5 million annually for the following 15 years. Volume 3, Chapter 4 provides more information on the existing and potential future of the MS4 Program; this chapter looks at worst-case scenarios for funding, based on the existing stringent permits of Washington, D.C., and Prince George's County, Maryland. However, funding will not likely reach that level in Louisville during the next 20 years. For budgeting, the Facility Plan team recommends that MSD continue on its historical spending of approximately $2 million per year for the next 5 years (2016 dollars) and then using the average Nashville and Indianapolis spending, which is approximately $6.5 million per year over the next 15 years (2016 dollars).

In addition, funding of basin retrofit projects is recommended. The purpose of the basin retrofit projects is to modify the outlet structures and the materials in the bottom of the basins so that it will promote infiltration of at least the first flush of stormwater runoff. The projects were identified in the report *Retrofit Feasibility Report for MSD's Regional Basins* (LD&D, Inc., 2012) and are as follows:

- Gerald Court Basin Retrofit—$68,000
- Downing Way Basin Retrofit—$120,000
- Woodlawn Park Basin Retrofit—$145,000
- Hikes Lane Basin Retrofit—$210,000
- Richland Ave Basin Retrofit—$215,000
- Breckenridge Lane Basin Retrofit—$225,000
- Fountain Square Basin Retrofit—$230,000
- Old Shepherdsville Rd Basin Retrofit—$256,000

These basins were chosen based on a feasibility assessment of all 17 of MSD's regional basins. The first step in the assessment was to determine whether a basin was already providing a water quality benefit. Basins that were not already providing water quality benefits and not serving another purpose (such as a dam or CSO overflow) that could be impeded by retrofitting, were evaluated for their ease of retrofitting and benefit to water quality. Generally speaking, any basin not already providing a water quality benefit or serving an additional purpose could be retrofitted easily and so all of the eligible basins were recommended for retrofit. Please see the *Retrofit Feasibility Report for MSD's Regional Basins* (LD&D, Inc., 2012) for more detailed information on this process.

6.7 SCORING, PRIORITIZATION, AND SCHEDULING

6.7.1 Summary

Project prioritization and scheduling followed the development and mining of the stormwater projects presented herein. The projects were scored based on the benefit/cost ratio and adjusted for risk reduction. Benefits scores considered environmental impacts, regulatory compliance, public health protection, property protection, sustainability, and economic vitality.

Multiple risk reduction factors were calculated based on probability and consequence of flood occurrence. Probabilities included both age and average recurrence interval values. Consequences included the number of buildings affected, roadway average daily traffic, discharge velocities and depths, and contribution of pollutants of concern (POCs). Inundation mapping and output from the HEC-RAS 5.0 models and published traffic data helped to determine the consequences.

A before-and-after scenario was applied to obtain the difference in the risk multipliers. The difference in the risk factors in the before-and-after scenario is called the risk reduction factor. This was then multiplied by the benefit score to calculate the final rank. In general, the viaducts located on major arterials scored the highest risk reduction factors since they significantly reduced flooding potential on these heavily traveled roadways.

The viaducts, EAP projects (neighborhood projects), and the basin retrofits were all scored and prioritized using this formula. The programs with a monetary amount that was recommended, like the MS4 Program or the annual Flood Response Fund, were not ranked using this method. Table 3.6-11 shows the prioritization of all the proposed capital projects. For additional information on how the benefit cost ratios and risk factors were calculated, please reference Volume 1, Chapter 3.

Table 3.6-11. Preliminary Project Prioritization by Prioritization Score

Project	Budget (2016 $)	Benefit Score	Benefit/ Cost Ratio	Risk Reduction Factor	Prioritization Score
Gerald Court Basin Retrofit	$68,000	4098	60265	1.25	75331
Downing Way Basin Retrofit	$120,000	4098	34150	1.25	42688
Woodlawn Park Basin Retrofit	$145,000	4098	28262	1.50	42393
Breckenridge Lane Basin Retrofit	$225,000	4098	18213	1.50	27320
Stormwater Master Plan - Early Action Projects – Richlawn Avenue	$350,000	9016	25760	1.00	25760
Richland Avenue Basin Retrofit	$215,000	4098	19060	1.20	22873
Hikes Lane Basin Retrofit	$210,000	4098	19514	1.10	21466
Fountain Square Basin Retrofit	$230,000	4098	17817	1.20	21381

Table 3.6-11. Preliminary Project Prioritization by Prioritization Score

Project	Budget (2016 $)	Benefit Score	Benefit/ Cost Ratio	Risk Reduction Factor	Prioritization Score
Old Shepherdsville Road Basin Retrofit	$256,000	4098	16008	1.20	19209
Stormwater Master Plan - Early Action Projects - Whispering Hills	$3,200,000	9886	3089	1.40	4325
Viaduct28 South 15th Street and West Broadway	$3,873,000	10180	2628	1.60	4206
Viaduct09 South 6th Street and West Hill Street	$3,984,000	10180	2555	1.60	4088
Stormwater Master Plan - Early Action Projects – Seatonville Road	$3,400,000	9886	2908	1.40	4071
Viaduct33 Taylorsville Road & Merioneth Drive	$4,388,000	10180	2320	1.75	4060
Viaduct22 South 22nd Street and Standard Avenue	$3,804,000	10180	2676	1.45	3880
Viaduct27 South 15th Street and West Chestnut Street	$3,855,000	10180	2641	1.45	3829
Viaduct12 8th Street and Oak Street	$3,991,000	10180	2551	1.45	3699
Viaduct13 South 13th Street and West Hill Street	$4,093,000	10180	2487	1.45	3606
Viaduct14 South 31st Street and West Broadway	$4,604,000	10180	2211	1.60	3538
Viaduct29 13th Street and Maple Street	$3,755,000	10180	2711	1.30	3524
Viaduct30 12th Street and Maple Street	$3,799,000	10180	2680	1.30	3484
Viaduct06 North 30th Street and Bank Street	$4,255,000	10180	2392	1.45	3469
Viaduct21 30th Street and Del Park Terrace	$4,000,000	10180	2545	1.30	3309
Viaduct20 South 31st Street and Vermont Avenue	$4,015,000	10180	2535	1.30	3296
Viaduct15 South 7th Street and West Magnolia Avenue	$4,054,000	10180	2511	1.30	3264
Stormwater Master Plan - Early Action Projects - Ten Broeck Way	$4,000,000	11222	2806	1.15	3226
Stormwater Master Plan - Early Action Projects - Pope Lick	$6,100,000	13367	2191	1.40	3068
Viaduct26 South 7th Street and Davies Avenue	$5,332,000	10180	1909	1.60	3055

Table 3.6-11. Preliminary Project Prioritization by Prioritization Score

Project	Budget (2016 $)	Benefit Score	Benefit/ Cost Ratio	Risk Reduction Factor	Prioritization Score
Viaduct23 Dixie Highway and Standard Avenue	$5,347,000	10180	1904	1.60	3046
Viaduct05 North 30th Street and Portland Avenue	$4,354,000	10180	2338	1.30	3040
Viaduct01 13th Street and Market Street	$5,019,000	10180	2028	1.45	2941
Viaduct07 South 13th Street and West Jefferson Street	$5,019,000	10180	2028	1.45	2941
Viaduct24 South 15th Street and West Oak Street	$5,288,000	10180	1925	1.45	2791
Viaduct25 South 10th Street and West Hill Street	$5,332,000	10180	1909	1.45	2768
Viaduct03 North 13th Street and West Main Street	$5,368,000	10180	1896	1.45	2750
Viaduct18 Eastern Parkway and Hahn Street	$6,498,000	10180	1567	1.60	2507
Viaduct04 South 13th Street and West Muhammad Ali Boulevard	$5,822,000	10180	1749	1.30	2273
Viaduct02 South 32nd Street and West Market Street	$6,716,000	10180	1516	1.45	2198
Viaduct19 South 32nd Street and West Muhammad Ali Boulevard	$6,716,000	10180	1516	1.30	1971
Stormwater Master Plan - Early Action Projects - Prospect	$7,000,000	10908	1558	1.25	1948
Stormwater Master Plan - Early Action Projects - City of Hurstbourne	$11,000,000	13367	1215	1.40	1701
Stormwater Master Plan - Early Action Projects - Valley Creek	$9,700,000	9886	1019	1.60	1631
Stormwater Master Plan - Early Action Projects - Auburndale	$12,600,000	12504	992	1.60	1588
Stormwater Master Plan - Early Action Projects - Newburg	$20,500,000	9886	482	1.45	699
Viaduct16 South 3rd Street and Eastern Parkway	$29,912,000	10180	340	1.75	596
Viaduct32 South 3rd Street and Winkler Avenue	$29,912,000	10180	340	1.75	596

Table 3.6-11. Preliminary Project Prioritization by Prioritization Score

Project	Budget (2016 $)	Benefit Score	Benefit/ Cost Ratio	Risk Reduction Factor	Prioritization Score
Viaduct08 South 16th Street and Algonquin Parkway	$28,043,000	10180	363	1.60	581
Viaduct10 South Floyd Street and East Hill Street	$28,043,000	10180	363	1.60	581
Viaduct11 East Brandeis Avenue and South Brook Street	$28,043,000	10180	363	1.60	581
Viaduct17 4th Street and Industry Road	$29,912,000	10180	340	1.45	493

6.7.2 Application of Best Professional Judgment

To verify the validity of the results of the prioritization, the Facility Plan Team reviewed the proposed project prioritizations and applied best professional judgment to adjust the project rankings. With regard to stormwater projects, it made sense to escalate the early action plan projects so that those could be designed and constructed while the proposed comprehensive stormwater master plan is being implemented. These projects provide great value and public relations while the countywide master planning can be undertaken. In addition, the viaducts located near UofL were moved up. These viaducts flood frequently and represent a real threat to the travelling public; one fatality has already occurred at Floyd and Hill Streets. Finally, some projects were slightly adjusted in the rankings, like the basin retrofit projects, to help balance the projected spending over the 20 years. Table 3.6-12 shows the final ranking and schedule of all the capital stormwater projects in future dollars. Notably, whenever possible, opportunities to perform MS4-related activities should be investigated and performed in conjunction with stormwater quantity projects.

6.8 RECOMMENDED PROJECTS

The recommendations are divided between capital projects and design/policy recommendations made throughout volume 3 (noncapital recommendations).

6.8.1 Noncapital Recommendations

Table 3.6-12 lists all the noncapital recommendations made throughout Volume 3; this table also references where more information about that recommendation can be found.

Table 3.6-12. Noncapital Stormwater and Drainage Recommendations

Recommendation Number	Description	Volume Location
3.1	Have future O&M budgets consider that parts of the existing stormwater system are more than 100 years old, and examination of work order trends shows that the number of work orders increase with asset age for all assets studied. Reference Volume 1, Chapter 7 for more information on recommended O&M cost.	Chapter 2, Section 2.6
3.2	Enhance the high-hazard dams with continuation of the dam breach analysis project, continue to update Emergency Action Plans, and consider installing dam monitoring and public warning systems.	Chapter 2, Section 2.5.3
3.3	Continue to support activities that maintain and possibly increase the CRS rating.	Chapter 3, Section 3.2
3.4	MSD is recommended to continue to track and document relevant watershed information including water quality, floodplain, CSOs, and planned and completed stormwater-related projects within each of MSD's 11 watersheds.	Chapter 4, Section 4.2.3
3.5	MSD should continue to monitor the status of any future EPA rulemaking and take steps to engage in the dialogue on proposed revisions to the current rule.	Chapter 4, Section 4.2.3
3.6	MSD is recommended to perform a conceptual-level evaluation to determine the technical feasibility and costs of achieving the WLA identified in the approved TMDL for fecal coliform for the South Fork Beargrass Creek. The effort would include a theoretical desktop analysis of BMP implementation with the goal of determining the distribution and types of projects best suited to meet the WLA reduction based on land use, the TMDL parameters, and other existing watershed conditions.	Chapter 4, Section 4.2.3
3.7	The KDOW is currently initiating a nutrient rulemaking process. MSD should join in this dialogue, so that it can represent MS4 Program interests in the deliberations.	Chapter 4, Section 4.2.3
3.8	Keep the return intervals used for designing new and rehabilitation projects as they are. This represents the common practice in the industry and should be adequate, assuming the intervals are defined with accurate and up-to-date rainfall statistical analysis.	Chapter 5, Section 5.2.4.2
3.9	Update the rainfall depths and intensities used to define the return intervals by using the 2035 rainfall projections.	Chapter 5, Section 5.2.4.2

Table 3.6-12. Noncapital Stormwater and Drainage Recommendations

Recommendation Number	Description	Volume Location
3.10	Increase freeboard requirements to account for the upward trend in rainfall amounts. Large storm events (100- to 500-year return intervals) should be checked to ensure the overflow has a safe route in which to be conveyed that does not lead to structure flooding or increased potential for loss of life.	Chapter 5, Section 5.2.4.2
3.11	Design new storm sewers for a maximum 80-percent full flow, instead of the current 100-percent full flow, leaving some freeboard for future capacity.	Chapter 5, Section 5.2.4.2
3.12	Review rainfall statistics at least every 10 years and update accordingly.	Chapter 5, Section 5.2.4.2
3.13	Increase the width of new easements to ensure the projected 2035 one-percent chance (100-year) storm stays within the easement limits.	Chapter 5, Section 5.2.4.2
3.14	To convey to the public the possible risk of future floods because of the increased rainfall, calculate the local regulatory floodplain to the projected 2035 year level (from the current 6.2 inches to 8.4 inches in 2035) in each watershed. These new flood maps would show property owners the risk of flooding outside the already mapped SFHA floodplains so they can decide whether or not to purchase flood insurance. The purchase of this flood insurance in these areas would not be mandatory. This also would communicate the risk to the public with respect to real estate transactions.	Chapter 5, Section 5.3.8
3.15	Calculate new conveyance zones based on the projected 2035 floodplain and strictly enforce the “no development rule” inside these conveyance zones.	Chapter 5, Section 5.3.8
3.16	Consider a first right to purchase from people selling their home in the LRF. This purchase would be contingent upon the degree and severity of flooding.	Chapter 5, Section 5.3.8
3.17	Review floodplain mapping at least every 10 years to ensure the current flood maps portray the real risk to the community. This new policy should be written in such a way as to make it the review mandatory.	Chapter 5, Section 5.3.8
3.18	Review floodplain definitions in context of the new Executive Order 13690.	Chapter 5, Section 5.3.8

6.8.2 Capital Recommendations

Table 3.6-13 shows the final ranking and schedule of all the capital stormwater projects in future dollars. The contents of the table summarize the projects mentioned herein. Their final ranking reflects the best professional judgment as explained in Section 6.8.1 of this chapter.

Table 3.6-13. Recommended Projects

Project	Project Start Year	FY17 to FY21	FY22 to FY26	FY27 to FY31	FY32 to FY36	20-Year Total	Budget ID
MS4 Program	2017	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$40,000,000	X_0067 & Various
DRI	2017	$20,000,000	$25,000,000	$25,000,000	$25,000,000	$95,000,000	X_0316
Flood Response (Buy-outs, Mitigation and Grants)	2017	$17,500,000	$20,000,000	$20,000,000	$20,000,000	$77,500,000	X_0024
Stormwater Master Plan	2017	$4,000,000	$0	$0	$0	$4,000,000	X_0027
Richlawn Avenue Early Action Project	2017	$350,000	$0	$0	$0	$350,000	X_0105
Whispering Hills Early Action Project	2018	$3,200,000	$0	$0	$0	$3,200,000	X_0101
Seatonville Road Early Action Project	2018	3,400,000	$0	$0	$0	$3,400,000	X_0099
VIA11 East Brandeis Avenue and South Brook Street Viaduct Flood Relief	2018	$28,040,000	$0	$0	$0	$28,040,000	X_0144
Master Plan and Implementation (Projects to be Defined)	2019	$16,000,000	$184,000,000	$200,000,000	$200,000,000	$600,000,000	X_0028
Ten Broeck Way Early Action	2019	$4,000,000	$0	$0	$0	$4,000,000	X_0102
Pope Lick Early Action Project	2019	$6,100,000	$0	$0	$0	$6,100,000	X_0096
Prospect Early Action Project	2019	$7,000,000	$0	$0	$0	$7,000,000	X_0103
City of Hurstbourne Early Action Project	2019	$11,000,000	$0	$0	$0	$11,000,000	X_0104
Valley Creek Early Action Project	2020	$9,700,000	$0	$0	$0	$9,700,000	X_0100
Auburndale Early Action Project	2020	$12,600,000	$0	$0	$0	$12,600,000	X_0098
VIA16 South 3rd Street and Eastern Parkway Viaduct Flood Relief	2020	$15,000,000	$14,910,000	$0	$0	$29,910,000	X_0145
Newburg Early Action Project	2021	$20,500,000	$0	$0	$0	$20,500,000	X_0097
VIA10 South Floyd Street and East Hill Street Viaduct Flood Relief	2021	$5,610,000	$22,430,000	$0	$0	$28,040,000	X_0143
VIA17 4th Street and Industry Road Viaduct Flood Relief	2021	$500,000	$29,410,000	$0	$0	$29,910,000	X_0146
Gerald Court Basin Retrofit	2022	$0	$70,000	$0	$0	$70,000	X_0106
Downing Way Basin Retrofit	2022	$0	$120,000	$0	$0	$120,000	X_0107
Woodlawn Park Basin Retrofit	2022	$0	$150,000	$0	$0	$150,000	X_0108
Breckenridge Lane Basin Retrofit	2022	$0	$230,000	$0	$0	$230,000	X_0111
Richland avenue Basin Retrofit	2022	$0	$220,000	$0	$0	$220,000	X_0110
Hikes Lane Basin Retrofit	2022	$0	$210,000	$0	$0	$210,000	X_0109

Table 3.6-13. Recommended Projects

Project	Project Start Year	FY17 to FY21	FY22 to FY26	FY27 to FY31	FY32 to FY36	20-Year Total	Budget ID
Fountain Square Basin Retrofit	2022	$0	$230,000	$0	$0	$230,000	X_0112
Old Shepherdsville Road Basin Retrofit	2022	$0	$260,000	$0	$0	$260,000	X_0113
VIA28 South 15th Street and West Broadway Viaduct Flood Relief	2022	$0	$3,870,000	$0	$0	$3,870,000	X_0119
VIA09 South 6th Street and West Hill Street Viaduct Flood Relief	2022	$0	$3,980,000	$0	$0	$3,980,000	X_0121
VIA22 South 22nd Street and Standard Avenue Viaduct Flood Relief	2022	$0	$3,800,000	$0	$0	$3,800,000	X_0117
VIA32 South 3rd Street and Winkler Avenue Viaduct Flood Relief	2022	$0	$29,910,000	$0	$0	$29,910,000	X_0147
VIA27 South 15th Street and West Chestnut Street	2027	$0	$0	$3,860,000	$0	$3,860,000	X_0118
VIA12 8th Street and Oak Street Viaduct Flood Relief	2027	$0	$0	$3,990,000	$0	$3,990,000	X_0122
VIA13 South 13th Street and West Hill Street Viaduct Flood Relief	2027	$0	$0	$4,090,000	$0	$4,090,000	X_0126
VIA14 South 31st Street and West Broadway Viaduct Flood Relief	2027	$0	$0	$4,600,000	$0	$4,600,000	X_0130
VIA29 13th Street and Maple Street Viaduct Flood Relief	2027	$0	$0	$3,760,000	$0	$3,760,000	X_0114
VIA30 12th Street and Maple Street Viaduct Flood Relief	2027	$0	$0	$3,800,000	$0	$3,800,000	X_0115
VIA21 30th Street and Del Park Terrace Viaduct Flood Relief	2027	$0	$0	$4,000,000	$0	$4,000,000	X_0123
VIA06 North 30th Street and Bank Street Viaduct Flood Relief	2027	$0	$0	$4,260,000	$0	$4,260,000	X_0127
VIA20 South 31st Street and Vermont Avenue Viaduct Flood Relief	2027	$0	$0	$4,020,000	$0	$4,020,000	X_0124
VIA19 South 32nd Street and West Muhammad Ali Boulevard Viaduct Flood Relief	2027	$0	$0	$6,720,000	$0	$6,720,000	X_0141
VIA33 Taylorsville Road and Merioneth Drive Viaduct Flood Relief	2032	$0	$0	$0	$4,390,000	$4,390,000	X_0129

Table 3.6-13. Recommended Projects

Project	Project Start Year	FY17 to FY21	FY22 to FY26	FY27 to FY31	FY32 to FY36	20-Year Total	Budget ID
VIA15 South 7th Street and West Magnolia Avenue Viaduct Flood Relief	2032	$0	$0	$0	$4,050,000	$4,050,000	X_0125
VIA26 South 7th Street and Davies Avenue Viaduct Flood Relief	2032	$0	$0	$0	$5,330,000	$5,330,000	X_0135
VIA23 Dixie Highway and Standard Avenue Viaduct Flood Relief	2032	$0	$0	$0	$5,350,000	$5,350,000	X_0136
VIA05 North 30th Street and Portland Avenue Viaduct Flood Relief	2032	$0	$0	$0	$4,350,000	$4,350,000	X_0128
VIA01 13th Street and Market Street Viaduct Flood Relief	2032	$0	$0	$0	$5,020,000	$5,020,000	X_0131
VIA07 South 13th Street and West Jefferson Street Viaduct Flood Relief	2032	$0	$0	$0	$5,020,000	$5,020,000	X_0132
VIA24 South 15th Street and West Oak Street Viaduct Flood Relief	2032	$0	$0	$0	$5,290,000	$5,290,000	X_0133
VIA25 South 10th Street and West Hill Street Viaduct Flood Relief	2032	$0	$0	$0	$5,330,000	$5,330,000	X_0134
VIA03 North 13th Street and West Main Street Viaduct Flood Relief	2032	$0	$0	$0	$5,370,000	$5,370,000	X_0137
VIA18 Eastern Parkway and Hahn Street Viaduct Flood Relief	2032	$0	$0	$0	$6,500,000	$6,500,000	X_0139
VIA04 South 13th Street and West Muhammad Ali Boulevard Viaduct Flood Relief	2032	$0	$0	$0	$5,820,000	$5,820,000	X_0138
VIA02 South 32nd Street and West Market Street Viaduct Flood Relief	2032	$0	$0	$0	$6,720,000	$6,720,000	X_0140
VIA08 South 16th Street and Algonquin Parkway Viaduct Flood Relief	2032	$0	$0	$0	$16,825,536	$16,825,536	X_0142

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ATTACHMENT 1 PROJECT FACT SHEETS

Note: Fact sheets were not made for projects under contract for construction as of December 31, 2015.

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

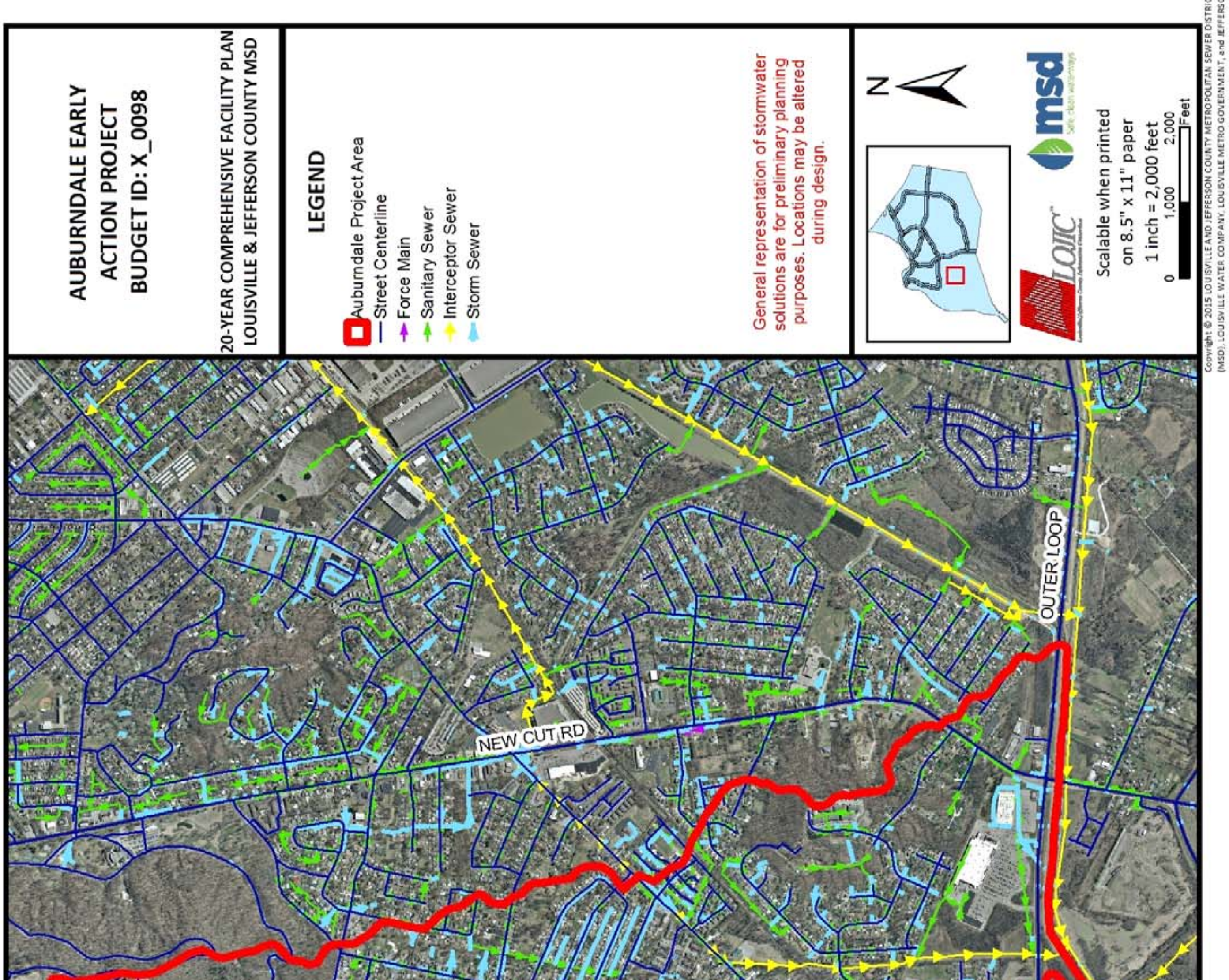
Project Name	AUBURNDALE EARLY ACTION PROJECT		
Budget ID	X_0098		
Start FY	2020	**Completion FY**	2021
Project Budget (2016 Dollars)	$12,600,000	**Project Budget** (Escalated Dollars)	$14,363,820
Service Type	Stormwater	**Program**	Drainage

Project Description
The Auburndale area is generally bordered on the north by Iroquois Park, on the east by New Cut Road, on the south by Outer Loop, and on the west by Slate Run Creek and Saint Anthony Church Road. This area lies within the Pond Creek watershed. Key flooding and drainage issues within the area are upstream of the railroad culvert near Third Street along Bruce Creek, as well as along Bruce Creek and the parallel collection systems from Third Street to Palatka Road. These areas are prone to flooding during the 10 percent annual chance (10-year) storm. Possible solutions include an increase in system conveyance, increase in storage, and the purchase of a number of homes for placement of infrastructure or the removal of flood-prone structures. These solutions were developed using the results from a preliminary overland 2-D model of the 10 percent annual chance storm event. Increasing the diameter of the existing system and in some instances replace the existing open channel with a larger capacity storm sewer system along Ticonderoga Drive/Oneida Avenue, Bruce and Lower Bruce Avenue, Paiute Road, Runell Road, Clayborne Road, Franelm Road, Palatka Road, Cristland Road, and Afterglow Drive. Possible detention areas include the park above Palatka Avenue (6.3 ac-ft), Bruce Avenue (4.5 ac-ft), Justan Avenue (4.5 ac-ft), Cristland Road (2.7 ac-ft), 3rd Street (4.1 ac-ft), and between the railroad and 3rd Street (4.7 ac-ft).

Project Justification
Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations
The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.

Last Updated: 6/5/2017 **Printed:** 6/9/2017



Last Updated: 6/5/2017 **Printed:** 6/9/2017

COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	BRECKENRIDGE LANE BASIN RETROFIT		
Budget ID	X_0111		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$225,000	**Project Budget** (Escalated Dollars)	$285,278
Service Type	Stormwater	**Program**	Stormwater Quality (MS4)

Project Description
The Breckinridge Lane Basin has three basins for retrofit.

Basin #1: This basin is proposed to include a 300 foot long, 6 inch low-flow channel, lined with native seed and erosion control matting. Along the sides of the channel will be a series of 3 tiered micropools with emergent wetland seed mix. In larger rain events, the drainage will leave the channel and enter into micropools for infiltration. The basin also will include 2 diversion berms. This project includes a diversion structure in the adjacent right of way paved ditch that would accept the entire 1 inch rain event and this drainage will be routed through a rock forebay. Because it has been designed to infiltrate the entire 1 inch rain event, no low flow outlet structure or pipe is proposed.

Basin #2: This is separated from basin #1 by a large "through" drainage ditch that has a 36 inch pipe inletting into it. The proposed plan includes adding a diversion structure to the 36 inch pipe within the Hillcreek Road pavement, and diverting the flow from the 1 inch rain event. Once diverted, the drainage will go through a rock forebay for sediment and trash removal, then ultimately into a constructed wetland. This area will be a trapped system, causing water to either percolate, or stand. The constant ponding level of the wetland is approximately 24 inches below the overflow berm. This berm will be raised by 12 inches from the existing condition to contain the required water quality volume.

Basin #3: Currently, this basin does not receive any pipes or ditches, and only acts as compensation for South Fork Beargrass Creek. The project includes several green practices to remove the 1 inch rain event volume from the system. First, the existing paved ditch is proposed to be demolished, and the associated 12 inch pipe will be re-directed, through a new 20 foot long paved ditch into the basin. The drainage will be routed through a rock forebay. In larger rain events, the runoff that leaves the forebay will continue along a circuitous channel. To encourage the runoff to remain in the channel, 2 earthen diversion berms will be incorporated. A micropool will capture any runoff that leaves the banks.

Project Justification
The Breckinridge Lane Basin drains to Beargrass Creek which is on the 303(d) list of impaired streams. MSD is responsible for water quality within Jefferson County and is working towards removing pollutants from local waterways as part of their MS4 permit and larger mission. Incorporating water quality components to the existing basin is a cost-effective method to remove pollutants from stormwater before they enter Beargrass Creek.

Other Considerations
Initial percolation tests taken during a dry period were favorable. Additional percolation tests should be performed prior to final design and construction.

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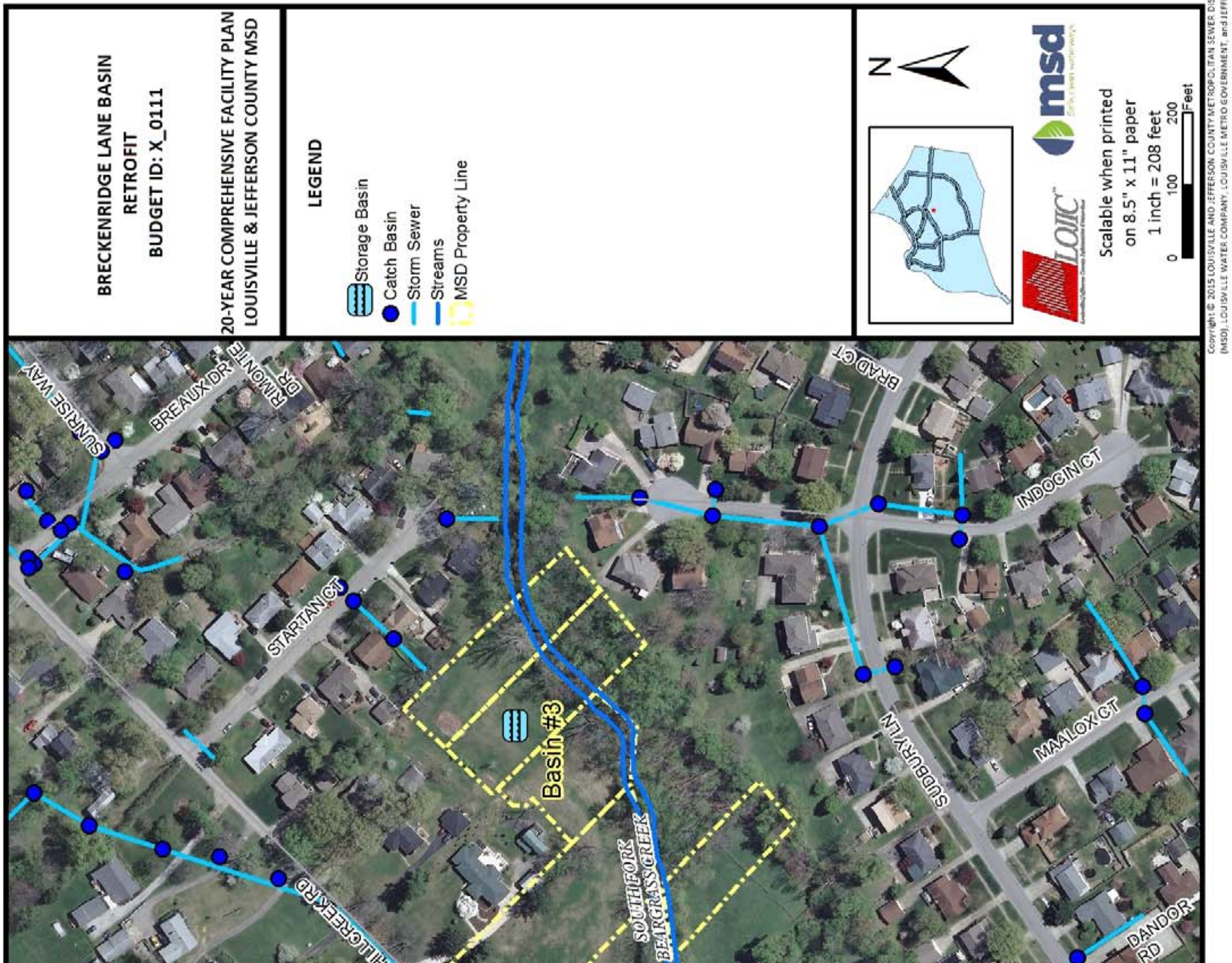

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	CITY OF HURSTBOURNE EARLY ACTION PROJECT		
Budget ID	X_0104		
Start FY	2019	**Completion FY**	2021
Project Budget (2016 Dollars)	$11,000,000	**Project Budget** (Escalated Dollars)	$12,516,700
Service Type	Stormwater	**Program**	Drainage

Project Description

The City of Hurstbourne is generally bordered on the north by Shelbyville Road, on the east by South Hurstbourne Way, on the south by I-64, and on the west by Oxmoor Woods Parkway. This area lies within the Middle Fork Beargrass Creek watershed. The current stormwater infrastructure includes a combination of pipe and inlet systems with open-channel systems. Key flooding and drainage issues within the area include properties along Blairwood Road southeast areas by I-64, Nottingham/Rugby residential areas, Williamsburg Plaza, and Wessex Place. Possible solutions include an increase in system conveyance and the addition of detention basins.

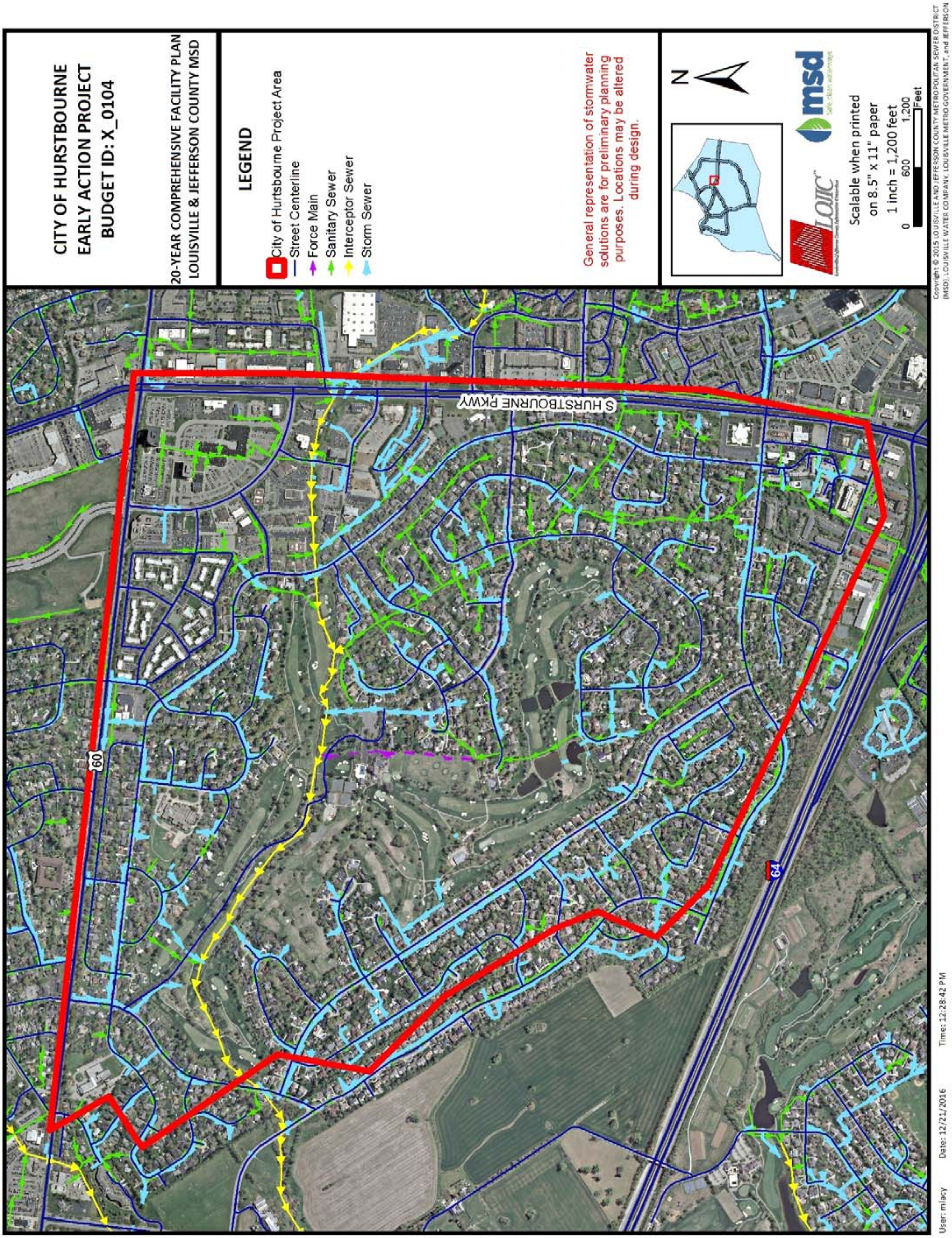
Project Justification

Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations

The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.

Last Updated: 6/5/2017 **Printed:** 6/9/2017



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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	DOWNING WAY BASIN RETROFIT		
Budget ID	X_0107		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$120,000	**Project Budget** (Escalated Dollars)	$152,148
Service Type	Stormwater	**Program**	Stormwater Quality (MS4)

Project Description

Downing is a small regional basin behind a church. There is one existing pipe, an 8 inch roof drain that drains into this basin. The rest of the storage is used for back up of Beargrass Creek during the 100 year storms. The proposed water quality for this basin is diverting the two ditches on either side of the basin into the basin and creating 3 water quality storage areas in front of each pipe. The water quality storage was designed to control the 1-inch water quality event. The proposed pipes were designed for the capacity of the 2-year storm and the meandering flat bottom ditches were designed to carry the 2-year flow 1 foot deep but not to exceed a 6 foot flat bottom ditch. The ditch design is based on a flat bottom ditch at 0.3 percent slope with a manning's roughness coefficient of 0.03. The 2-year storm for design of the pipes and ditches was used because the basin is a regional basin and there was a desire to not interefere with the required storage for Beargrass Creek during the 100 year storms. Along the meandering swales a couple of micro pools were proposed to allow for plantings.

Project Justification

This basin drains to Beargrass Creek which is on the 303(d) list of impaired streams. MSD is responsible for water quality within Jefferson County and is working towards removing pollutants from local waterways as part of their MS4 permit and larger mission. Incorporating water quality components to the existing basin is a cost-effective method to remove pollutants from stormwater before they enter Beargrass Creek.

Other Considerations

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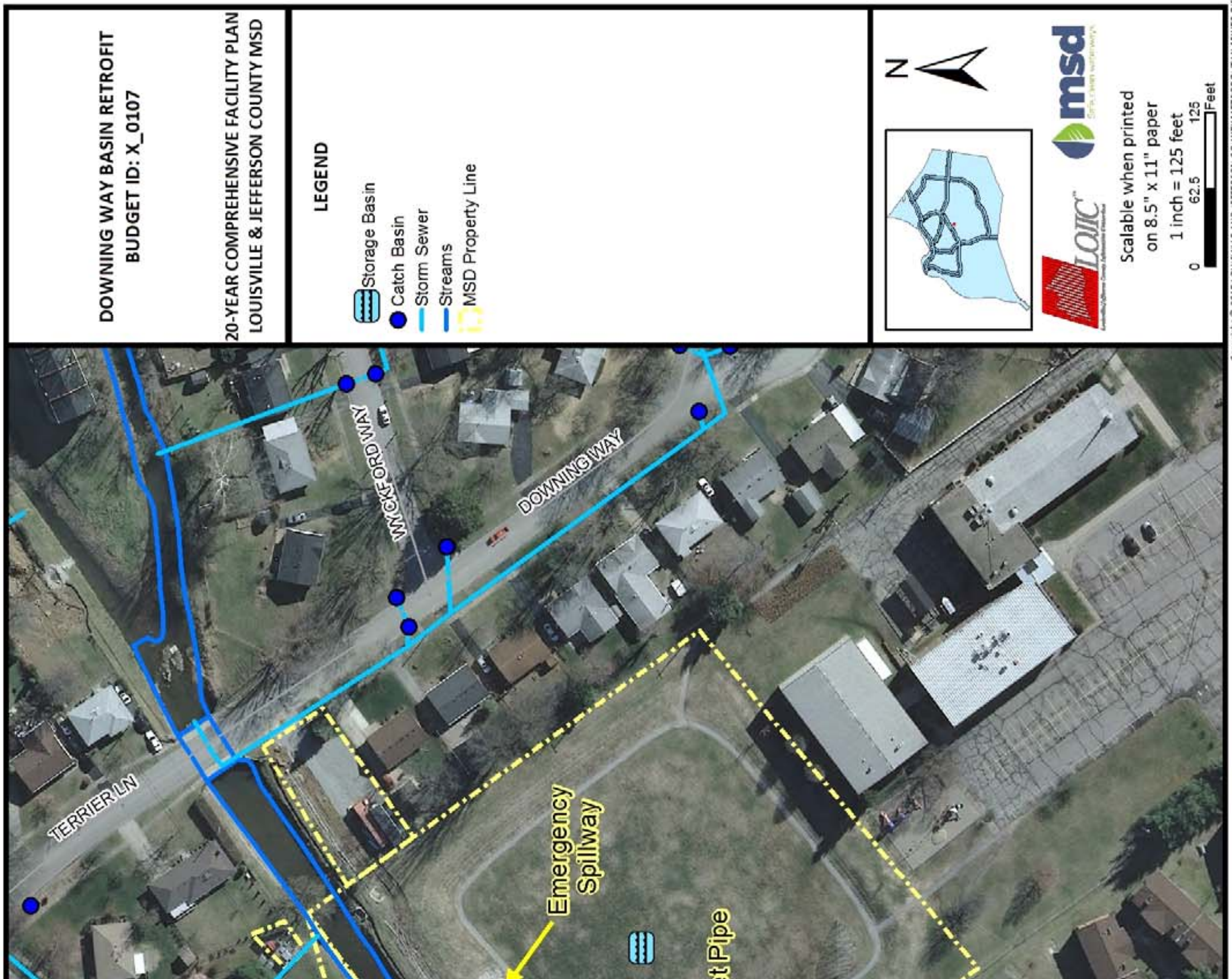

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	DRAINAGE RESPONSE INITIATIVE		
Budget ID	X_0316		
Start FY	2018	**Completion FY**	2036
Project Budget (2016 Dollars)	$95,000,000	**Project Budget** (Escalated Dollars)	$133,232,500
Service Type	Stormwater	**Program**	Drainage

Project Description
In January 2003, MSD launched a highly successful program called Project Drainage Response Initiative (DRI). This program was developed after the 2003 general election as MSD looked for a way to respond more quickly to citizen's drainage concerns. Project DRI prioritizes drainage request, meets with property owners at their home to discuss the problem, triages the problem, develops solutions, and prioritizes the remedial work necessary to address the request. To date, it has been a highly successful program in the view of the community. Continuing the highly successful DRI program is recommended at a cost of $5 million annually. This amount is just above spending for DRI over the last several years.

Project Justification
This program is based on customer requests. There are many success stories about the program, and it often paints MSD in a very good light in the community, because it is a hands-on, boots-on-the-ground approach to minor drainage problems. From 2003 to 2010, MSD expended approximately $125 million on this program, which was necessary and essential to continue it. There is still a long list of open drainage requests.

Other Considerations
This program, working in concert with the new capital program to be established by the proposed comprehensive stormwater master plan, will be a perfect combination of low-level maintenance type projects to the major neighborhood and watershed capital projects that are needed to bring everyone up to a minimum stormwater level of service.

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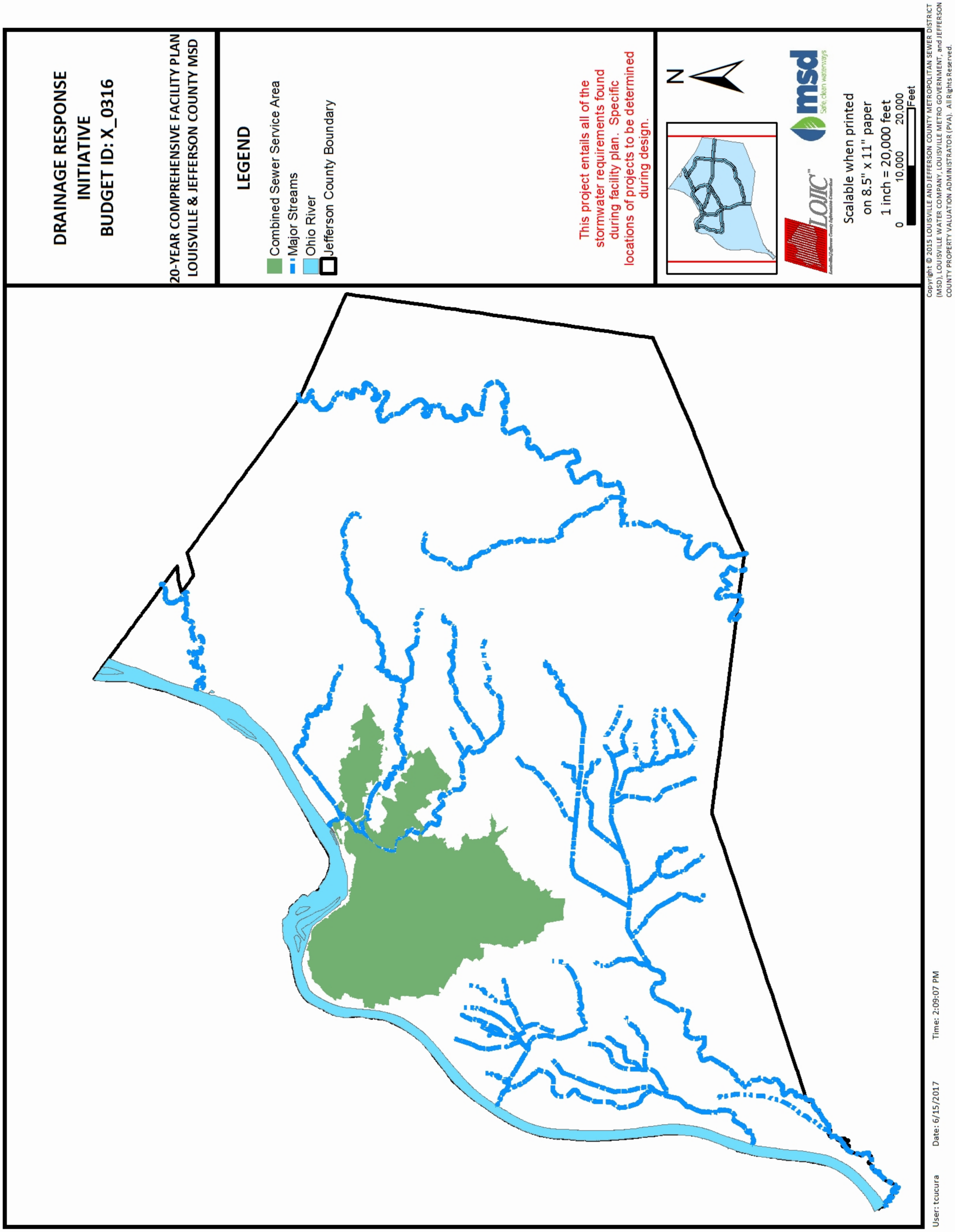

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COMPREHENSIVE 20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	FLOOD RESPONSE (BUY-OUTS, MITIGATION AND GRANTS)		
Budget ID	X_0024		
Start FY	2017	**Completion FY**	2036
Project Budget (2016 Dollars)	$77,500,000	**Project Budget** (Escalated Dollars)	$108,131,000
Service Type	Stormwater	**Program**	Floodplain Management

Project Description
Buyouts are primarily recommended for floodplain mitigation. However, because of the extraordinary cost involved in buying all affected property at once, it is recommended to fund a “flood response fund” account by $4 million annually. This amount should be sufficient to adequately respond to a localized flooding event. It should be used for events like the ones that occurred in the spring and summer of 2015, for quick buy-outs of substantially damaged properties after a flooding event. It can also be used for applying for, administering, and providing local matching funds for FEMA and other flood relief grants.

Project Justification
Funding this effort is prudent, because as evidenced by the Project Summary Report: Countywide Flooding Prioritization (PRIME AE Group, 2016), it is in the majority of cases economically justifiable to buy the homes as opposed to a constructing a major stormwater project that would try to eliminate the home from being flooded again. These actions also have a positive impact on the community rating system (CRS) program.

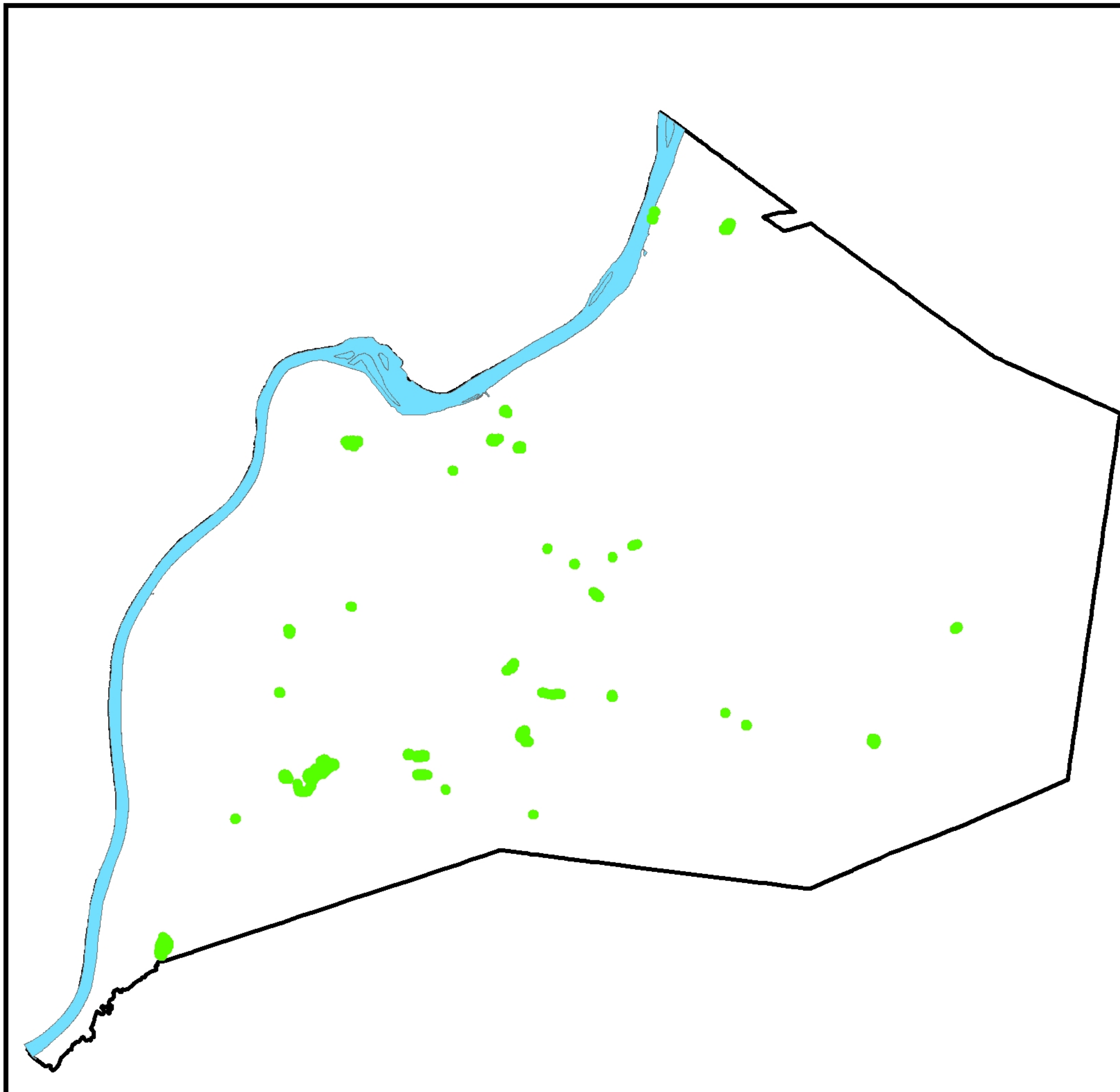
Other Considerations
MSD should calculate new conveyance zones based on the projected 2035 floodplain and strictly enforce the “no development rule” inside of these conveyance zones. MSD should consider requesting a first right to purchase from people selling their home in the LRF. This purchase would be contingent upon the degree and severity of flooding.

Last Updated: 6/5/2017 **Printed:** 6/9/2017

FLOOD RESPONSE (BUY-OUTS, MITIGATION, AND GRANTS)

BUDGET ID: X_0024

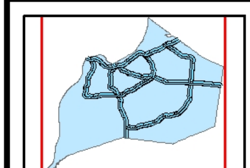
20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD



LEGEND

- MSD Flood Mitigation Property
- Ohio River
- Jefferson County Boundary

Properties shown on maps include MSD properties designated for flood mitigation as of 12/23/2016.



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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	FOUNTAIN SQUARE BASIN RETROFIT		
Budget ID	X_0112		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$230,000	**Project Budget** (Escalated Dollars)	$291,617
Service Type	Stormwater	**Program**	Stormwater Quality (MS4)

Project Description

The Fountain is a regional basin located between commercial properties and apartments. There are several existing pipes draining into this basin, three from the apartments and from a commercial site to the east of the basin. The main storage of the basin is back up from Beargrass Creek during the 100-year storm event. The proposed water quality for the basin is diverting the commercial area to the south of the basin into the basin and placing an Agri Drain at the outlet of it. The Agri Drain will create the water quality storage area at the outlet of the basin. Each pipe is drained by a meandering flat bottom swale. The meandering flat bottom ditches were designed to carry the 2-year flow 1 foot deep but not to exceed a 6 foot flat bottom ditch. The ditch design is based on a flat bottom ditch at 0.3 percent slope with a manning's roughness coefficient of 0.03. The diverted pipe is also designed to carry the 2-year storm. The 2-year storm for design of the pipes and ditches was used because the basin is a regional basin and there was a desire to not interfere with the design storage for Beargrass Creek during the 100 year storms. The two pipes draining the commercial areas have rock forebays to collect silt and trash before draining into the basin. The forebays were not used on the pipes draining the apartments so to not back up water into the ditches and cause water to sit before eventually draining back into the basin. Along the meandering swales a couple of micropools were proposed to allow for plantings.

Project Justification

This basin drains to Beargrass Creek which is on the 303(d) list of impaired streams. MSD is responsible for water quality within Jefferson County and is working towards removing pollutants from local waterways as part of their MS4 permit and larger mission. Incorporating water quality components to the existing basin is a cost-effective method to remove pollutants from stormwater before they enter Beargrass Creek.

Other Considerations

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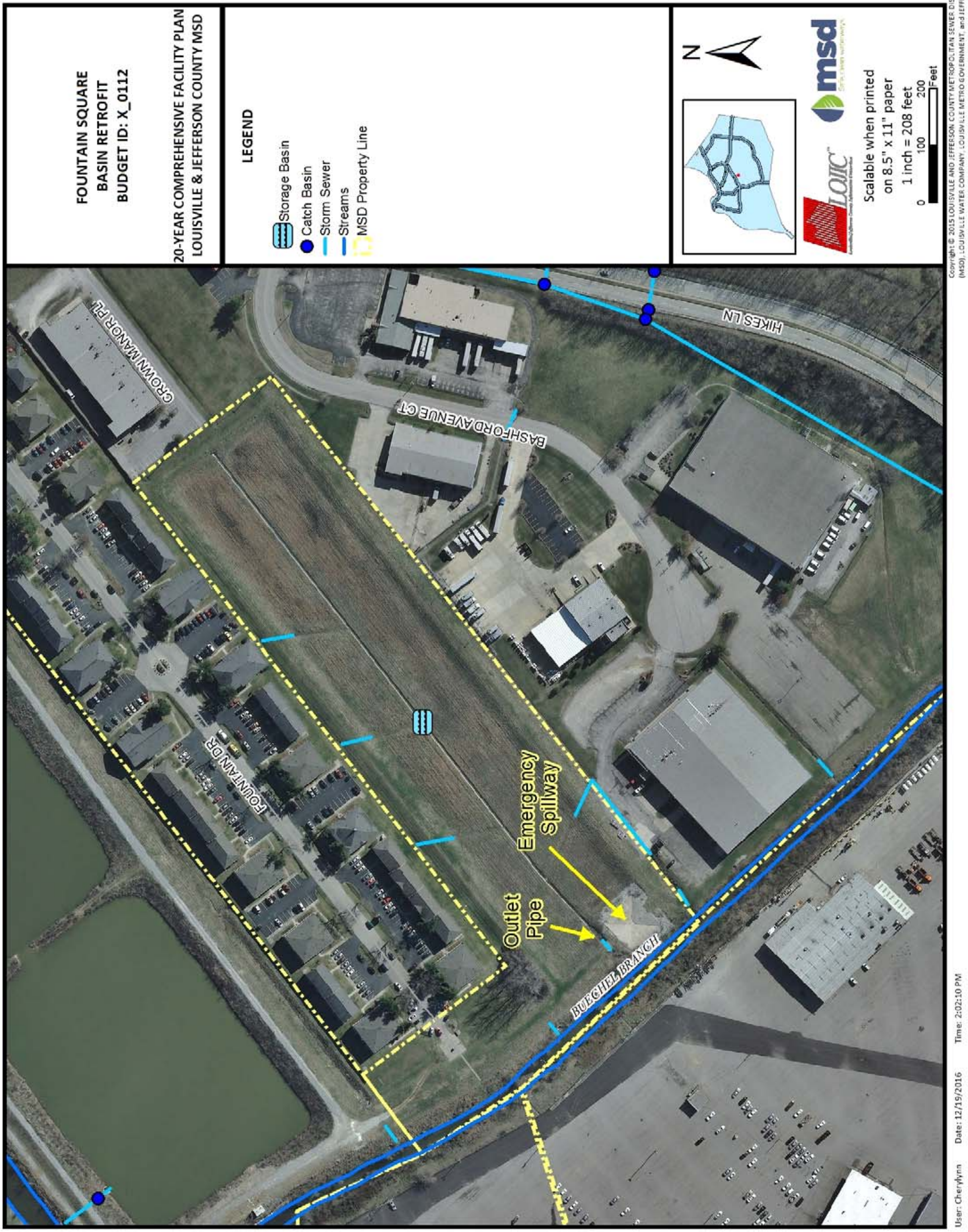

Last Updated: 6/5/2017 **Printed:** 6/9/2017

COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	GERALD COURT BASIN RETROFIT		
Budget ID	X_0106		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$68,000	**Project Budget** (Escalated Dollars)	$86,217
Service Type	Stormwater	**Program**	Stormwater Quality (MS4)

Project Description
Gerald is a regional basin behind a commercial site and it is a small regional basin designed to be overflow storage for Beargrass Creek during 100-year storm events. There is one existing pipe, a 24 inch RCP that drains into this basin. The proposed water quality for this basin is diverting 28 x 42 inch CMP into the basin and placing an Agri Drain on the outlet pipe. The water quality storage area is the bottom 2 feet of the basin. The water quality storage was designed to control the 1 inch water quality event. The proposed pipe was designed for the capacity of the 2-year storm and the meandering flat bottom ditches were designed to carry the 2-year flow 1-foot deep but not to exceed a 6 foot flat bottom ditch. The ditch design is based on a flat bottom ditch at 0.3 percent slope with a manning's roughness coefficient of 0.03. Two small 1 foot diversion berms were proposed to help force the water to meander and not erode the bottom of the basin. The 2-year storm for design of the pipe and ditches were used because the basin is a regional basin and there was a desire to not intereference with the required storage for Beargrass Creek during the 100 year storms. Along the meandering swales several micro pools were proposed to allow for plantings.

Project Justification
This basin drains to Beargrass Creek which is on the 303(d) list of impaired streams. MSD is responsible for water quality within Jefferson County and is working towards removing pollutants from local waterways as part of their MS4 permit and larger mission. Incorporating water quality components to the existing basin is a cost-effective method to remove pollutants from stormwater before they enter Beargrass Creek.

Other Considerations

Last Updated: 6/5/2017 **Printed:** 6/9/2017

GERALD COURT BASIN RETROFIT
BUDGET ID: X_0106

20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD

LEGEND

- Storage Basin
- Catch Basin
- Storm Sewer
- Streams
- MSD Property Line

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COMPREHENSIVE 20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	HIKES LANE BASIN RETROFIT		
Budget ID	X_0109		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$210,000	**Project Budget** (Escalated Dollars)	$266,259
Service Type	Stormwater	**Program**	Stormwater Quality (MS4)

Project Description
Hikes Lane is a regional basin by the Newburg off ramp and a commercial site designed to be overflow storage for Beargrass Creek during 100-year storm events. There are two existing pipes that drain 23.35 acres into this basin. The proposed water quality for this basin is diverting 2.65 acres of commercial property. A 1 foot deep rock forebay is proposed in front of all three pipes, to collect trash and silt before filtering into the basin. An Agri drain is proposed on the outlet of the basin to create the water quality storage at the outlet. The water quality storage was designed to control the 1 inch water quality event. The proposed pipe was designed for the capacity of the 2-year storm and the meandering flat bottom ditches were designed to carry the 2 year flow 1 foot deep but not to exceed a 6 foot flat bottom ditch. The ditch design is based on a flat bottom ditch at 0.3 percent slope with a manning's roughness coefficient of 0.03. The 2-year storm for design of the pipe and ditches were used because the basin is a regional basin and there was a desire to not interefere with the required storage for Beargrass Creek during the 100 year storms.

Project Justification
This basin drains to Beargrass Creek which is on the 303(d) list of impaired streams. MSD is responsible for water quality within Jefferson County and is working towards removing pollutants from local waterways as part of their MS4 permit and larger mission. Incorporating water quality components to the existing basin is a cost-effective method to remove pollutants from stormwater before they enter Beargrass Creek.

Other Considerations

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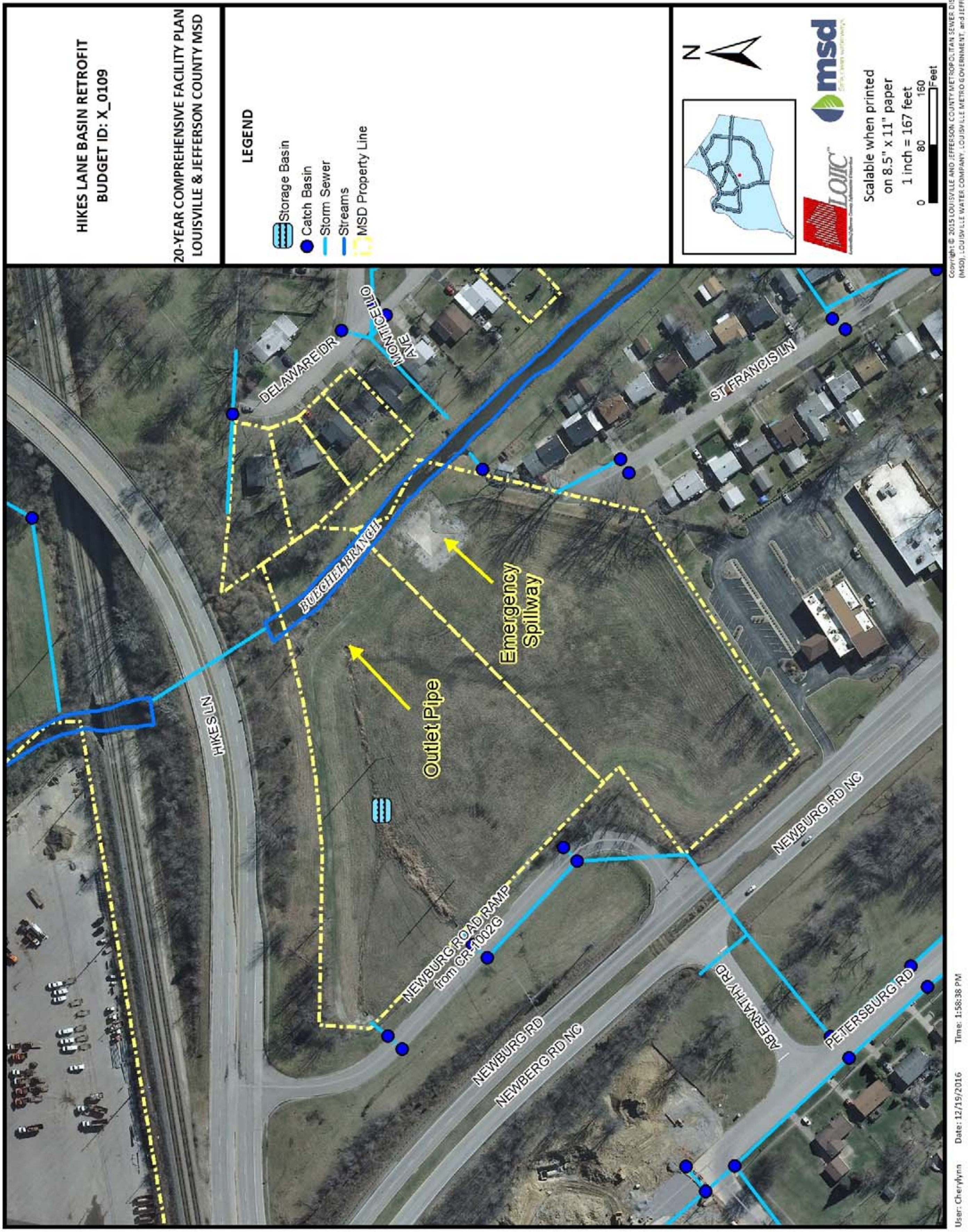

Last Updated: 6/5/2017 **Printed:** 6/9/2017

COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	MASTER PLAN IMPLEMENTATION (PROJECTS TO BE DEFINED)		
Budget ID	X_0028		
Start FY	2019	**Completion FY**	2036
Project Budget (2016 Dollars)	$600,000,000	**Project Budget** (Escalated Dollars)	$887,531,600
Service Type	Stormwater	**Program**	Drainage

Project Description
This project represents a placeholder for the anticipated projects that will be created from the comprehensive stormwater master plan document (see Project X_0027). The total cost for the 10-percent annual chance (10-year) flooding and drainage issues for a countywide, planning-level basis is estimated to be $600 million but could be as high as $1.1 billion. There is a fair amount of uncertainty and variability with this calculation because the overall proposed comprehensive stormwater master plan will define the actual cost of this level of service. The calculation above does not specifically address the combined sewer system, which will be undoubtedly more expensive and difficult to upgrade versus a typical suburban neighborhood, which is the reason for the large gap in cost estimation. However, it is recommended that the $600 million number be used for programming purposes until the proposed comprehensive stormwater master plan can be completed. Volume 3, Chapter 3 and Chapter 6, provide more information regarding the need for the proposed comprehensive stormwater master plan and its implementation cost.

Project Justification
Although MSD has completed several capital projects, including both conveyance and basin projects in the last 15 years and the recently completed Aluma Basin in the Pond Creek Watershed, the stormwater capital program is not currently being driven by any previous comprehensive master planning efforts. The 1997 flood and competing priorities, such as the EPA Consent Decree, diverted MSD's attention and resources away from master plan implementation. This, combined with the increased frequency of extreme events, represents a gap in planning that the recommended master planning effort will help bridge.

Other Considerations

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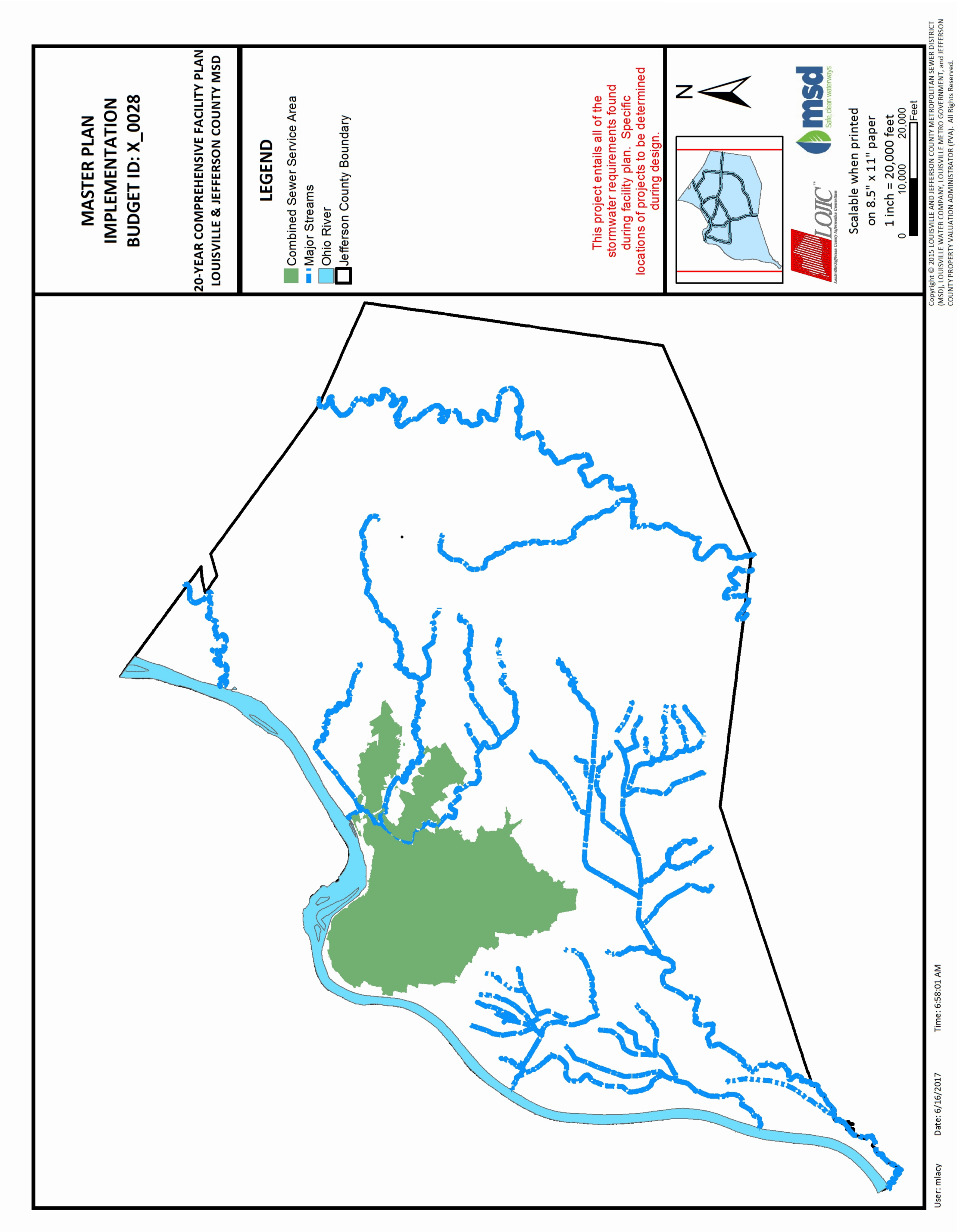
MASTER PLAN
IMPLEMENTATION
BUDGET ID: X_0028
20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD
LEGEND
Combined Sewer Service Area
Major Streams
Ohio River
Jefferson County Boundary
This project entails all of the stormwater requirements found during facility plan. Specific locations of projects to be determined during design.
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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	MELCO BASIN		
Budget ID	F16072		
Start FY	2017	**Completion FY**	2017
Project Budget (2016 Dollars)	$500,000	**Project Budget** (Escalated Dollars)	$500,000
Service Type	Stormwater	**Program**	Drainage

Project Description

The Melco Greer Detention Basin is located on the south side of Northern Ditch and south of the Ford Motor Plant. This flood storage basin has lost storage volume due to sedimentation. This project involves restoring the original capacity of the Melco Greer basin by removal of the deposited sediment and restoring the original contours of the basin.

Project Justification

The basin has lost volume due to the sedimentation, and therefore does not function as originally intended and downstream peak flows are not being mitigated as effectively as designed. Removing the sediment and restoring the original volume will ensure the basin is operating at its intended design parameters.

Other Considerations

The original Melco Greer Detention Basin was completed in 2001. It expanded an existing 15-acre borrow pit to 80 acres, which increased the storage capacity to 1,500 acre-feet.

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COMPREHENSIVE 20-YEAR FACILITY PLAN PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	MUNICIPAL SEPARATE STORM SEWER SYSTEMS PROGRAM		
Budget ID	X_0067		
Start FY	2022	**Completion FY**	2036
Project Budget (2016 Dollars)	$30,000,000	**Project Budget** (Escalated Dollars)	$44,416,200
Service Type	Stormwater	**Program**	Stormwater Quality (MS4)

Project Description

The mission of the MS4 Program is to enhance stormwater runoff quality and protect streams and riparian habitat in order to promote public health, safety, and welfare. Stormwater runoff quality and volume have been ongoing concerns in Louisville since its inception. MSD has been responsible for flood control and drainage for developed areas of Jefferson County since 1985. MSD began comprehensive water quality monitoring of local streams in collaboration with the U.S. Geological Survey (USGS) in 1988. When the MS4 KPDES permitting program began in the early 1990s, KYS000001 was the first Large MS4 Permit issued in EPA Region IV. MSD is the lead agency and is co-permittees with cities of Shively, Anchorage, St. Matthews, and Jeffersontown.

The MS4 Permit program activities are divided into the following program areas:
1. Illicit Discharge Detection and Elimination;
2. Construction Site Runoff Controls;
3. Post Construction Site Runoff Controls;
4. Public Involvement and Outreach Programs;
5. Facility Good Housekeeping and Pollution Prevention;
6. Monitoring; and
7. Reporting and Program Assessment.

Requirements for future MS4 permits and the costs associated with compliance are expected to increase. This project provides funding to support MS4 activities based on projected compliance costs developed through best engineering judgement, benchmarking to peer cities, and discussions with regulators.

Project Justification

Compliance with the permit of this program is a federal and state requirement. Failure to meet these requirements could result in enforcement action(s).

Other Considerations

Budgeted amounts are based on bench-marking against peer cities with more recent permits. Regulatory changes could necessitate budget increases in order to stay in compliance.

Note that the budget line item for Green Infrastructure is included in this item.

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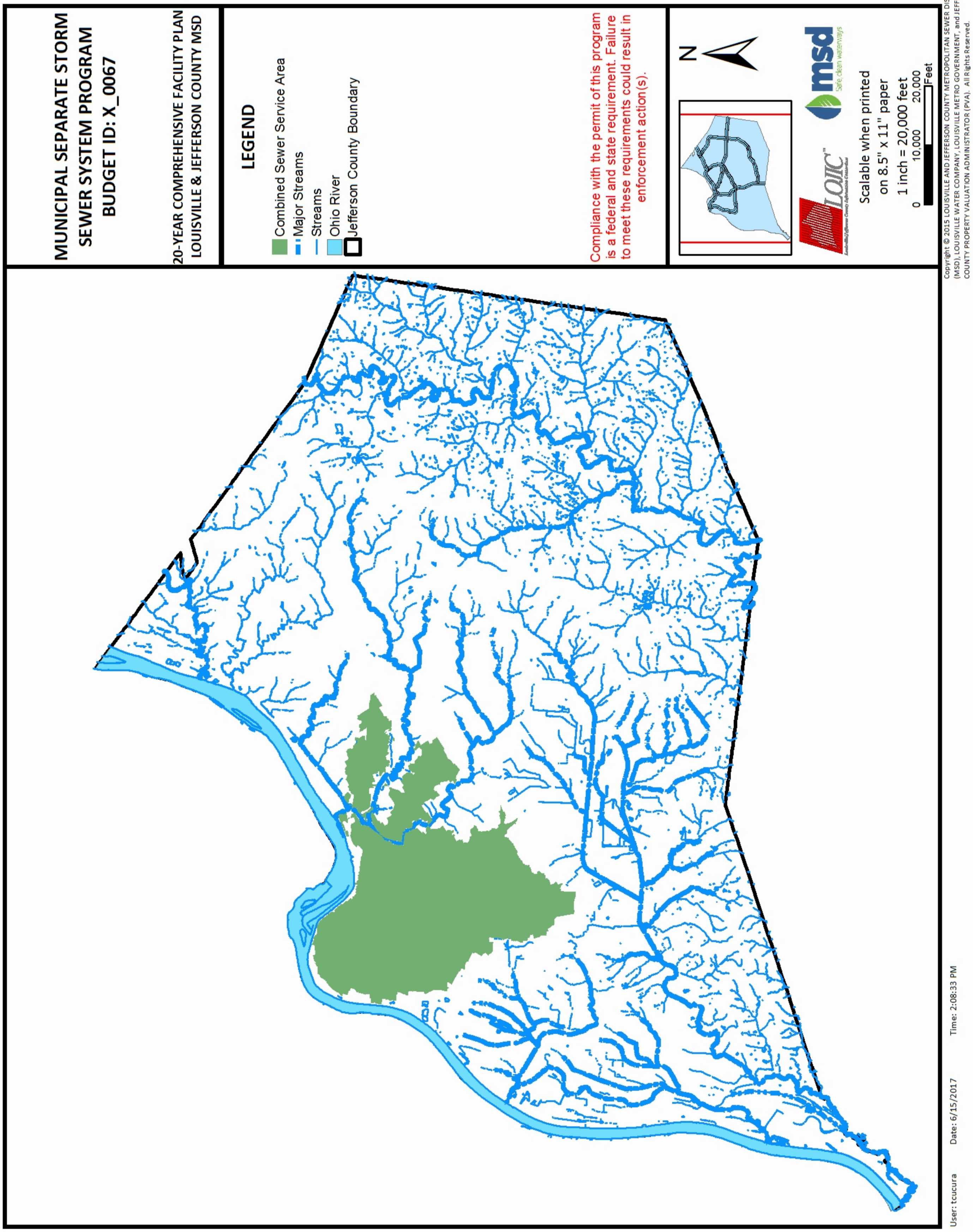

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COMPREHENSIVE 20-YEAR FACILITY PLAN PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	NEWBURG EARLY ACTION PROJECT		
Budget ID	X_0097		
Start FY	2021	**Completion FY**	2021
Project Budget (2016 Dollars)	$20,500,000	**Project Budget** (Escalated Dollars)	$23,765,650
Service Type	Stormwater	**Program**	Drainage

Project Description

The Newburg area is generally bordered on the north by East Indian Trail, on the east by Newburg Road and the South Fork Beargrass Creek Watershed, on the south by Rangeland Road, and on the west by Poplar Level Road. This area lies within the Northern Ditch subwatershed of Pond Creek. Key flooding and drainage issues within the area are primarily due to the flat, low-lying terrain near the Northern Ditch floodplain, which has had numerous drainage complaints and as many as 20 recent DRI projects. The 10 percent annual chance (10-year) storm event inundates the area and causes street, yard, and structure flooding. It does appear the large conveyance outlet channel (an unnamed tributary of Greasy Ditch) will contain the entirety of the 10 percent annual chance storm and nearly all of the larger storms such as the 1 percent annual chance storm with only minor flooding. However, the collection system that conveys flow to that outlet channel is undersized, even for the 10 percent annual chance event. Possible solutions include an increase in system conveyance by at least one pipe size and the purchase of select flood-prone structures. These solutions were developed using the results from a preliminary overland flow 2-D model of the 10 percent annual chance storm event. Preliminary engineering is needed to further refine the problem areas and solutions. It appears that new detention is not necessary for the 10 percent annual chance storm event solution, however, during preliminary engineering it would be prudent to look for areas of possible detention for the larger storm events.

Project Justification

Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations

The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	OLD SHEPHERDSVILLE ROAD BASIN RETROFIT		
Budget ID	X_0113		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$256,000	**Project Budget** (Escalated Dollars)	$324,582
Service Type	Stormwater	**Program**	Stormwater Quality (MS4)

Project Description
Old Shepherdsville is a regional basin along Old Shepherdsville Road, downstream of commercial property and is designed to be overflow storage for Beargrass Creek during 100-year storm events. There are two existing pipes that drain 5.45 acres into this basin. The proposed water quality for this basin is diverting 14.90 acres of commercial and open space property and 11.20 acres of mostly roadway. The water quality for this basin is proposed in stages, first 1 foot deep rock forebays are proposed in front of all the pipes, to collect trash and silt before filtering into the basin. Then two of the pipes will be drained by meandering ditches to a water quality storage area. From there it drains through a rock outlet into another meandering swale where the other two pipes join together to drain to another water quality area where an Agri drain is proposed on the outlet pipe. The water quality storage was designed to control the 1 inch water quality event. The proposed pipe was designed for the capacity of the 2-year storm and the meandering flat bottom ditches were designed to carry the 2-year flow 1 foot deep but not to exceed a 6 foot flat bottom ditch. The ditch design is based on a flat bottom ditch at 0.3 percent slope with a manning's roughness coefficient of 0.03. The 2-year storm for design of the pipe and ditches were used because the basin is a regional basin and there was a desire to not interfere with the required storage for Beargrass Creek during the 100 year storms. No micropools were proposed for this basin because there are two large areas of cattails that the meandering ditches travel through which are already low lying areas.`

Project Justification
This basin drains to Beargrass Creek which is on the 303(d) list of impaired streams. MSD is responsible for water quality within Jefferson County and is working towards removing pollutants from local waterways as part of their MS4 permit and larger mission. Incorporating water quality components to the existing basin is a cost-effective method to remove pollutants from stormwater before they enter Beargrass Creek.

Other Considerations

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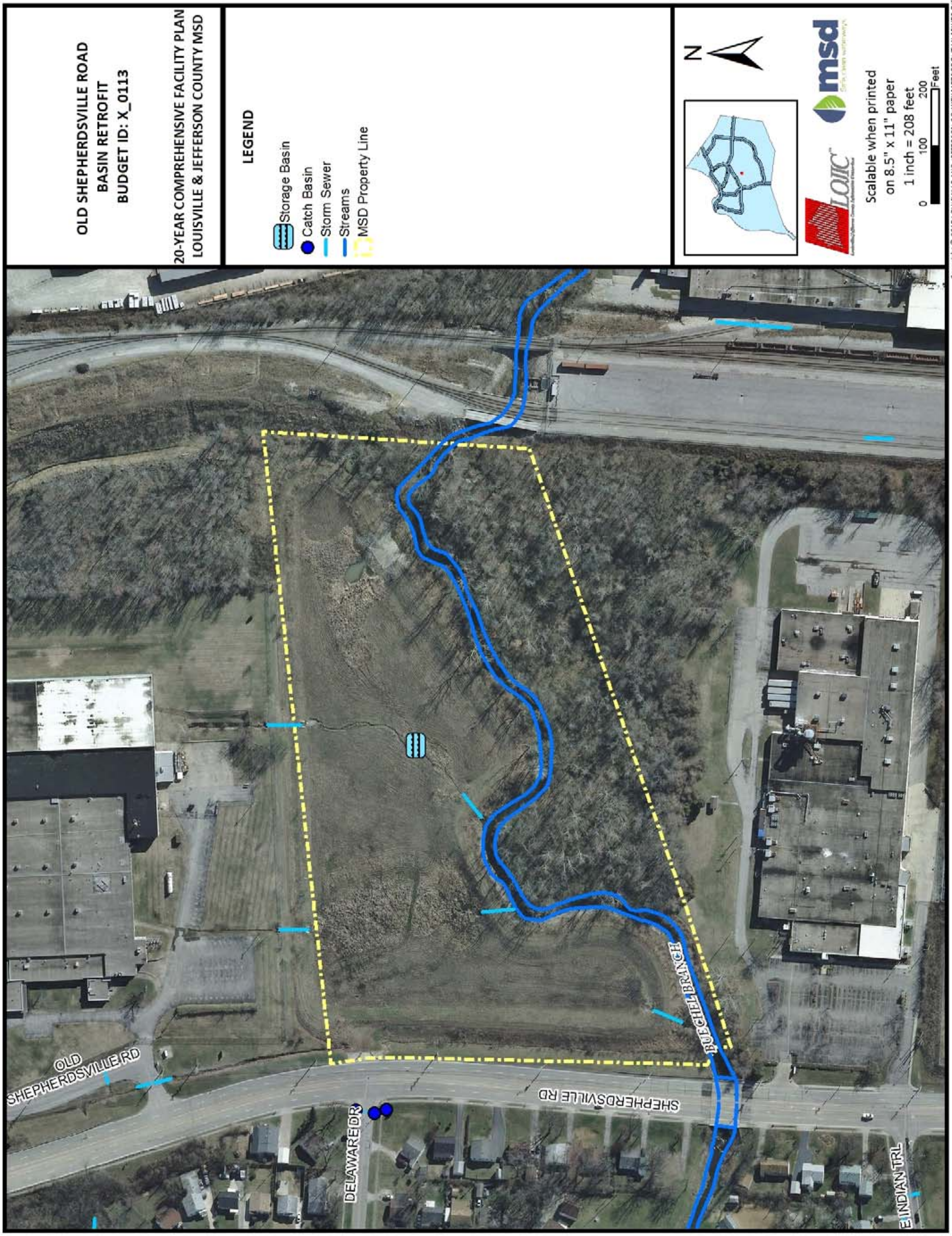

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	POPE LICK EARLY ACTION PROJECT		
Budget ID	X_0096		
Start FY	2019	**Completion FY**	2021
Project Budget (2016 Dollars)	$6,100,000	**Project Budget** (Escalated Dollars)	$6,866,770
Service Type	Stormwater	**Program**	Drainage

Project Description
The Pope Lick area is generally bordered on the north by Shelbyville Road, on the east by Creek Valley Road, on the south by I-64, and on the west by Tucker Station Road. This area lies within the Floyds Fork watershed. The current stormwater infrastructure includes a combination of culverts, storm sewers, and open-channel systems. Key flooding and drainage issues within the area, especially during large events, include Douglass Hills Estates, Wooded Falls Road/Ledges Drive, Middletown Station Shoppes, Running Creek road, Woodland Hills, and the culvert under I-64 at Pope Lick Creek. The 10 percent annual chance storm problem areas are concentrated in the Running Creek Road and Woodland Hills areas. To address the 10 percent annual chance storm, possible solutions include an increase in system conveyance and the purchase of select flood-prone structures. These solutions were developed using the results from a preliminary overland 2-D model of the 10 percent annual chance storm event. In many areas, “street-level flooding” as well as some structural flooding, was observed in the models. This occurs when the storm sewer and open-channel systems are overwhelmed, thereby flooding the streets and/or adjacent properties. Preliminary engineering is needed to further refine the problem areas and solutions. It appears that new detention is not necessary for the 10 percent annual chance storm event solution, however, during preliminary engineering it would be prudent to look for areas of possible detention for the larger storm events.

Project Justification
Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations
The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.

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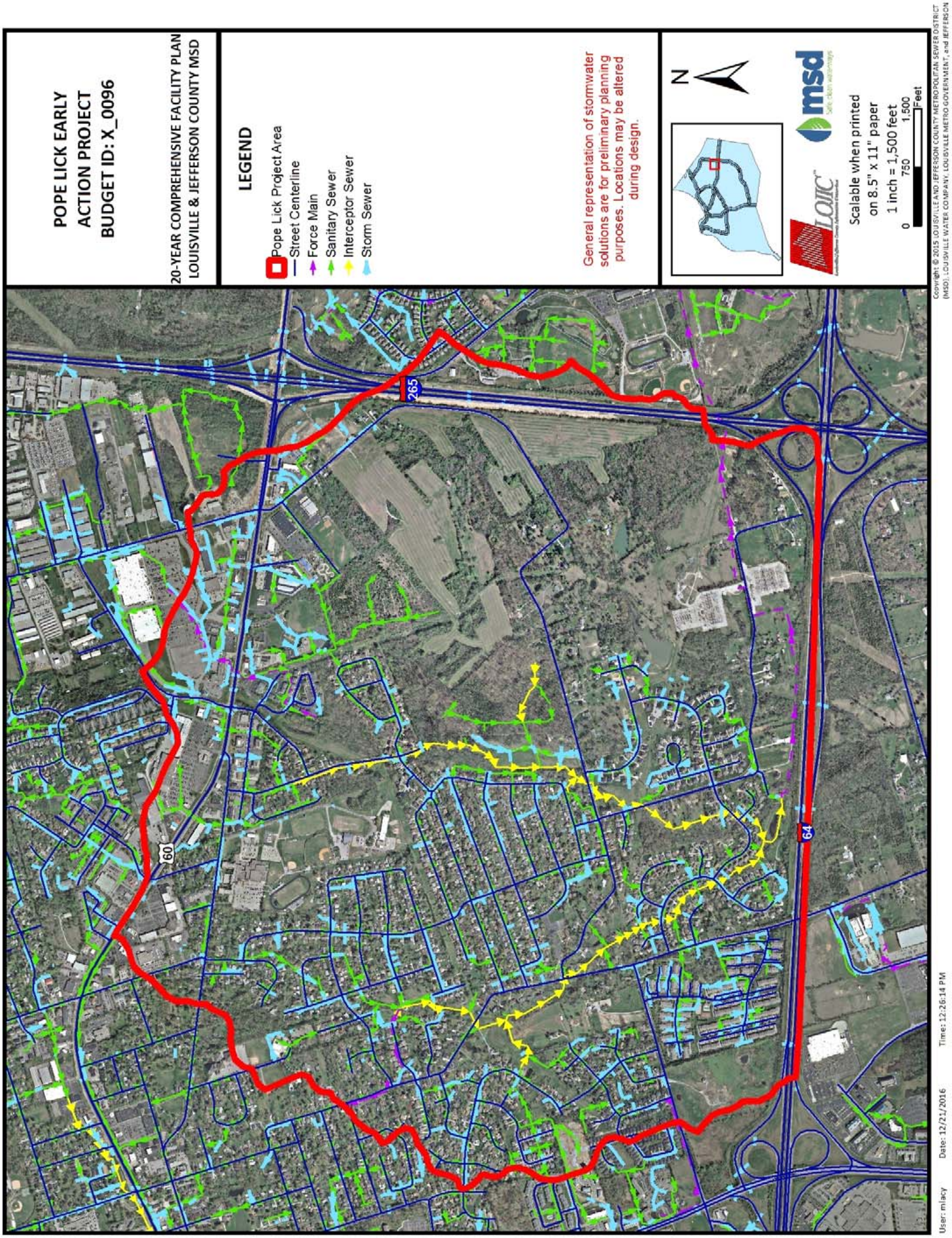

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	PROSPECT EARLY ACTION PROJECT		
Budget ID	X_0103		
Start FY	2019	**Completion FY**	2019
Project Budget (2016 Dollars)	$7,000,000	**Project Budget** (Escalated Dollars)	$7,648,900
Service Type	Stormwater	**Program**	Drainage

Project Description
The Prospect area is generally bordered on the north by Oldham County, on the east and south by Harrods Creek, and on the west by the Ohio River. This area lies within the Harrods Creek and Goose Creek watersheds. The current stormwater infrastructure includes a combination of pipe systems, roadside swales and ditches, trench drains, subdivision drainage ways, Hunting Creek, and Wallace Creek. Key flooding and drainage issues within the area include neighborhoods south of Sutherland subdivision. Possible solutions include an increase in system conveyance and the placement of infrastructure and/or the development or increase of storage volume with in the watershed. The following summarizes the drainage solutions for the Prospect Area:
- Increasing the capacity of the existing system along Cannonade Court, Gunpowder Court, Foxcroft Road, Fox Harbor, Fox Valley, Gunpowder Lane, and Montero Drive;
- Redirecting flow by adding additional pipes to the storm system along Gunpowder Lane and Montero Drive;
- Installing new catch basins to reduce localized flooding along Cannonade Court, Gunpowder Court, Foxcroft Road, and Gunpowder Lane;
- Installing new curbing to reduce localized flooding along Foxcroft Road;
- Increasing the conveyance of the system by installing new berms, re-aligning open channels and ditches and/or creating new ditches along Cannonade Court, Gunpowder Court, Foxcroft Road, Fox Harbor, Fox Valley, and Montero Drive;
- Increasing storage with the addition of a detention basin near Cannonade Court and Gunpowder Court; and
- Purchasing a few select homes in the project area.

Project Justification
Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations
The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.

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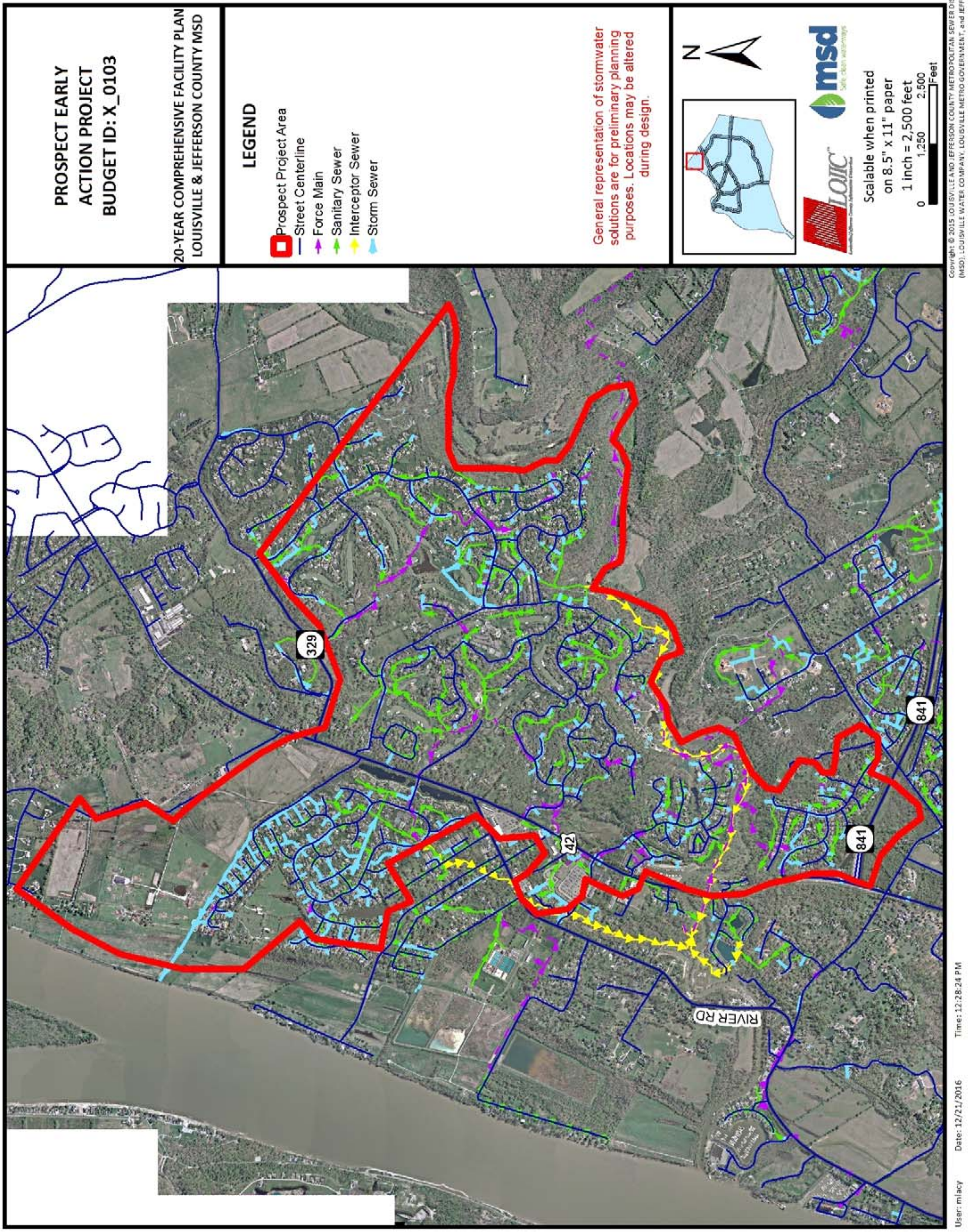

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COMPREHENSIVE 20-YEAR FACILITY PLAN PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	RICHLAND AVENUE BASIN RETROFIT		
Budget ID	X_0110		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$215,000	**Project Budget** (Escalated Dollars)	$272,599
Service Type	Stormwater	**Program**	Stormwater Quality (MS4)

Project Description

Richland is a regional basin within a neighborhood designed to be overflow storage for Beargrass Creek during 100 year storm events. There are no existing inflow pipes, only an overflow that allows Beargrass Creek flow over in large storm events. There is an existing outlet pipe that once the creek goes down outlets again into Beargrass Creek. The proposed water quality for this basin is diverting a 36 inch pipe from the basin that drains 27.84 acres of the subdivision across the railroad tracks. The water quality storage area would be located directly downstream of the diverted pipe. The treated water will filter through a rock outlet into a meander swale to the outlet of the basin. Along the swale there is a large micro pool/infiltration area proposed for a settling area with plantings. The water quality storage was designed to control the 1 inch water quality event. The proposed pipe was designed for the capacity of the 2-year storm and the meandering flat bottom ditches were designed to carry the 2-year flow 1 foot deep but not to exceed a 6 foot flat bottom ditch. The ditch design is based on a flat bottom ditch at 0.3 percent slope with a manning's roughness coefficient of 0.03. Two small 1 foot diversion berms were proposed to help force the water to meander and not erode the bottom of the basin. The 2-year storm for design of the pipe and ditches were used because the basin is a regional basin and there was a desire to not interfere with the required storage for Beargrass Creek during the 100 year storms.

Project Justification

This basin drains to Beargrass Creek which is on the 303(d) list of impaired streams. MSD is responsible for water quality within Jefferson County and is working towards removing pollutants from local waterways as part of their MS4 permit and larger mission. Incorporating water quality components to the existing basin is a cost-effective method to remove pollutants from stormwater before they enter Beargrass Creek.

Other Considerations

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RICHLAND AVENUE BASIN RETROFIT
BUDGET ID: X_0110

20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD

LEGEND

- Storage Basin
- Catch Basin
- Storm Sewer
- Streams
- MSD Property Line

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1 inch = 167 feet
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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	RICHLAWN EARLY ACTION PROJECT		
Budget ID	X_0105		
Start FY	2017	**Completion FY**	2017
Project Budget (2016 Dollars)	$350,000	**Project Budget** (Escalated Dollars)	$360,500
Service Type	Stormwater	**Program**	Drainage

Project Description

The Richlawn area is generally bordered on the north by the railroad, on the east by Bonner Avenue, on the south by Shelbyville Road, and on the west by Thierman Lane. This area lies within the Middle Fork Beargrass Creek watershed. The current stormwater infrastructure includes isolated dry wells with minimal existing pipe systems. Key flooding and drainage issues within the area include properties between Ledyard Road and Shelbyville Road and between Gibson Road and Bonner Avenue. To improve drainage within the Richlawn Area, new dry wells will be installed and existing ones rehabilitated.

Project Justification

Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations

The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.

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COMPREHENSIVE 20-YEAR FACILITY PLAN PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	SEATONVILLE EARLY ACTION PROJECT		
Budget ID	X_0099		
Start FY	2018	**Completion FY**	2020
Project Budget (2016 Dollars)	$3,400,000	**Project Budget** (Escalated Dollars)	$3,690,264
Service Type	Stormwater	**Program**	Drainage

Project Description

The Seatonville area generally runs parallel with I-265 and is bordered by Bardstown road to the west and Billtown road to the East. This area lies within the Cedar Creek watershed. The current stormwater infrastructure includes a combination of pipe systems, roadside drainage channels, and backyard drainage channels. Underground pipe systems are located near street intersections and convey stormwater from the roadside and backyard channels to downstream conveyance. Pipe sizes range from 12 to 36 inches. All of the area flows to the southeast into Hawkins Rill that is a tributary of Cedar Creek. Key flooding and drainage issues within the area include certain areas, such as a subdivision northeast of Brookridge Village Apartments, where the 10 percent annual chance (10-year) storm causes street-level flooding and potentially structure flooding and damage. There are also areas where downstream systems are smaller than the upstream systems. To address the 10 percent annual chance storm, possible solutions include an increase in system conveyance, increase in storage, and the purchase of a number of homes for placement of infrastructure and/or the removal of flood-prone structures. Specific solution areas include increasing the diameter of the existing system along Willow Branch Drive, Willow Branch Court System, Jefferson Trace, Wooden Branch Lane, and Sycamore Bend Trace and possibly replacing existing open channels with a system of greater capacity along Brighton Springs Lane, Montecito Lane, and Spring Lawn Drive. The systems along the area north of Seatonville Road, Monty Lane, and Sonic Drive need an increase in their capacity as well. Possible new underground detention areas include the area north of Seatonville Road near Monty Lane (0.36 ac-ft) and near the Sonic Drive and Monty Lane area (0.54 ac-ft).

Project Justification

Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations

The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.

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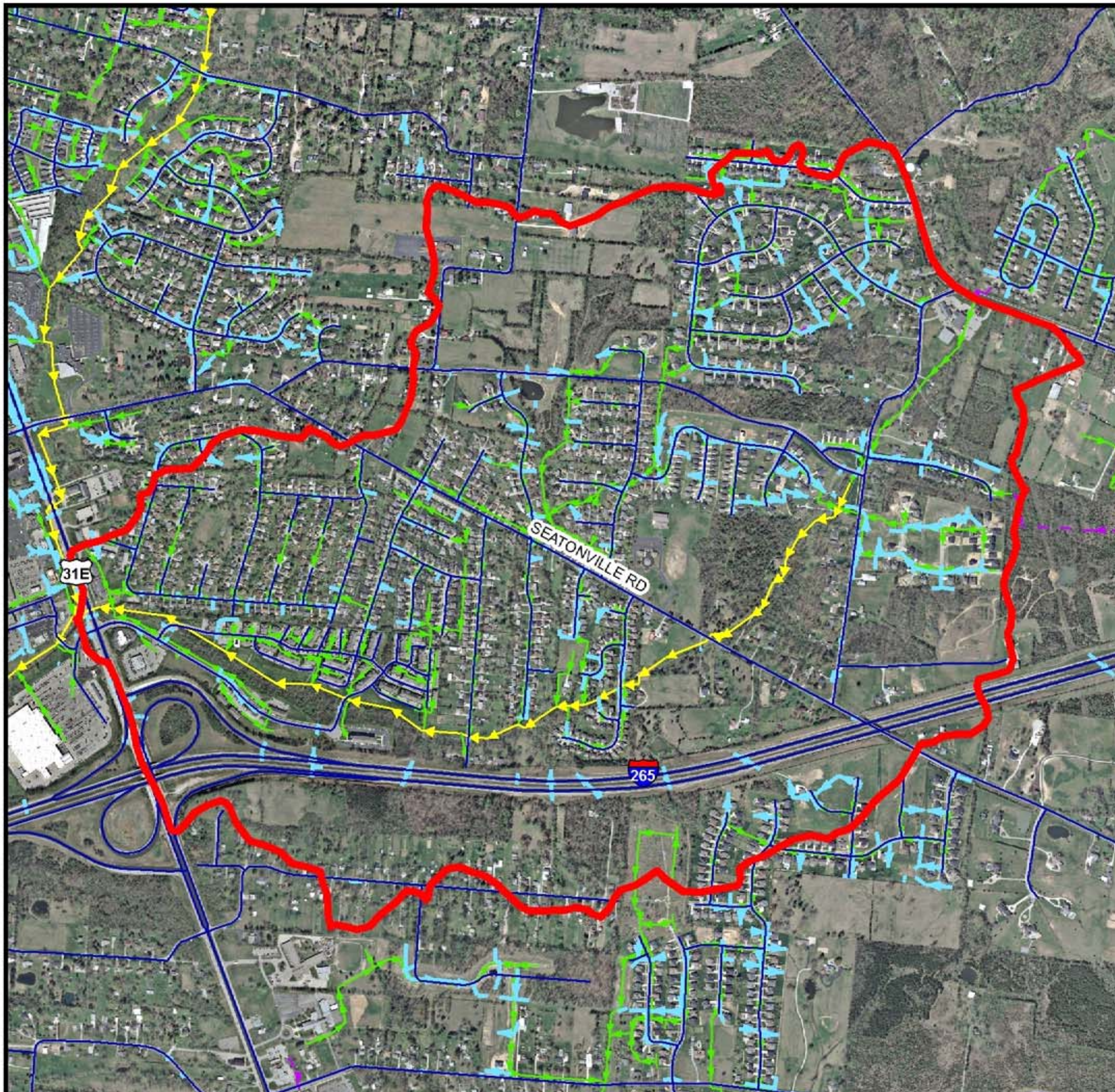
SEATONVILLE EARLY ACTION PROJECT
BUDGET ID: X_0099

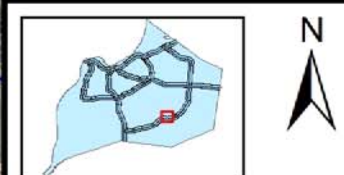
20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD



LEGEND

- Seatonville Project Area
- Street Centerline
- Force Main
- Sanitary Sewer
- Interceptor Sewer
- Storm Sewer

General representation of stormwater solutions are for preliminary planning purposes. Locations may be altered during design.



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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	STORMWATER MASTER PLAN		
Budget ID	X_0027		
Start FY	2017	**Completion FY**	2018
Project Budget (2016 Dollars)	$4,000,000	**Project Budget** (Escalated Dollars)	$4,181,800
Service Type	Stormwater	**Program**	Drainage

Project Description

A new comprehensive stormwater master plan is recommended to define and drive the stormwater capital program for the next 20 years. The recommended goals and objectives of the proposed comprehensive stormwater master plan are as follows:

1. Work towards minimum level of service for everyone in the MSD drainage service area, based on rainfall intensity duration and frequency projections anticipated to occur at the end of the 20-year planning period;
2. Develop and maintain an up-to-date inventory of the stormwater infrastructure, including identified deficiencies;
3. Prepare a process to develop annual ratings of stormwater infrastructure by comparing present conditions against established standards and required levels of service;
4. Establish a methodology to review technical standards and design criteria for stormwater infrastructure in the MSD drainage service area within the MSD drainage service area, at least once every 10 years;
5. Identify projects that conform to adopted design criteria and standards;
6. Update rainfall and discharge data for watersheds and sub-basins to reflect the projected rainfall over the next 20 years; and
7. Look for opportunities to integrate green infrastructure into the planning of MSD projects to meet the objectives of the MS4 Program.

Project Justification

Although MSD has completed several capital projects, including both conveyance and basin projects in the last 15 years and the recently completed Aluma Basin in the Pond Creek Watershed, the stormwater capital program is not currently being driven by any previous comprehensive master planning efforts. The 1997 flood and competing priorities, such as the EPA Consent Decree, diverted MSD's attention and resources away from master plan implementation. This, combined with the increased frequency of extreme events, represents a gap in planning that the recommended master planning effort will help bridge.

Other Considerations

Funding an updated comprehensive stormwater master plan is recommended with a budget of at least $4 million for the initial update. This amount is an estimate of the effort it would take to complete comprehensive master planning at this level. A similar amount was expended for planning efforts and the wastewater countywide model soon after the EPA Consent Decree became reality. Volume 3, Chapter 3, provides more information regarding the need for the proposed comprehensive stormwater master plan.

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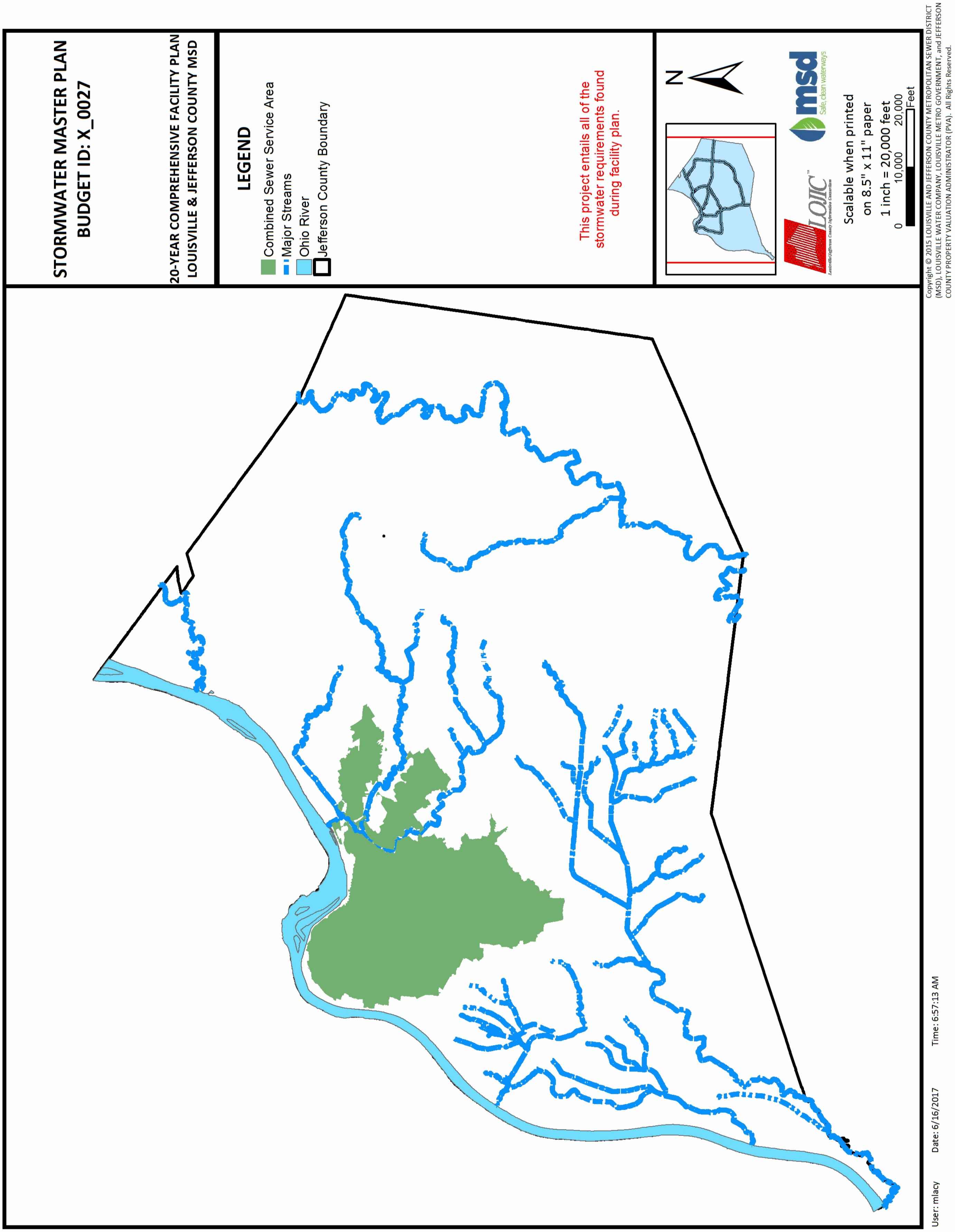

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COMPREHENSIVE 20-YEAR FACILITY PLAN PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	TEN BROECK EARLY ACTION PROJECT		
Budget ID	X_0102		
Start FY	2019	**Completion FY**	2020
Project Budget (2016 Dollars)	$4,000,000	**Project Budget** (Escalated Dollars)	$4,469,200
Service Type	Stormwater	**Program**	Drainage

Project Description

The Ten Broeck area is generally located southeast of the Prospect area and north of the City of Hurstbourne area. This area lies within the Goose Creek watershed. Flooding and drainage issues are prevalent throughout the area, with the main drainage concern being access into and out of the neighborhood during periods of high water that make the main road impassible. Possible solutions include an increase in system conveyance, roadway modifications, and an increase of storage volume with in the watershed. Other solutions outside of MSD's jurisdiction such as providing another access point to the community may be more cost effective than trying to improve drainage. Before implementing this solution all stakeholders should be involved in selecting the best solution. MSD could participate in the costs to extent they are related to MSD's responsibility.

Project Justification

Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations

The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.

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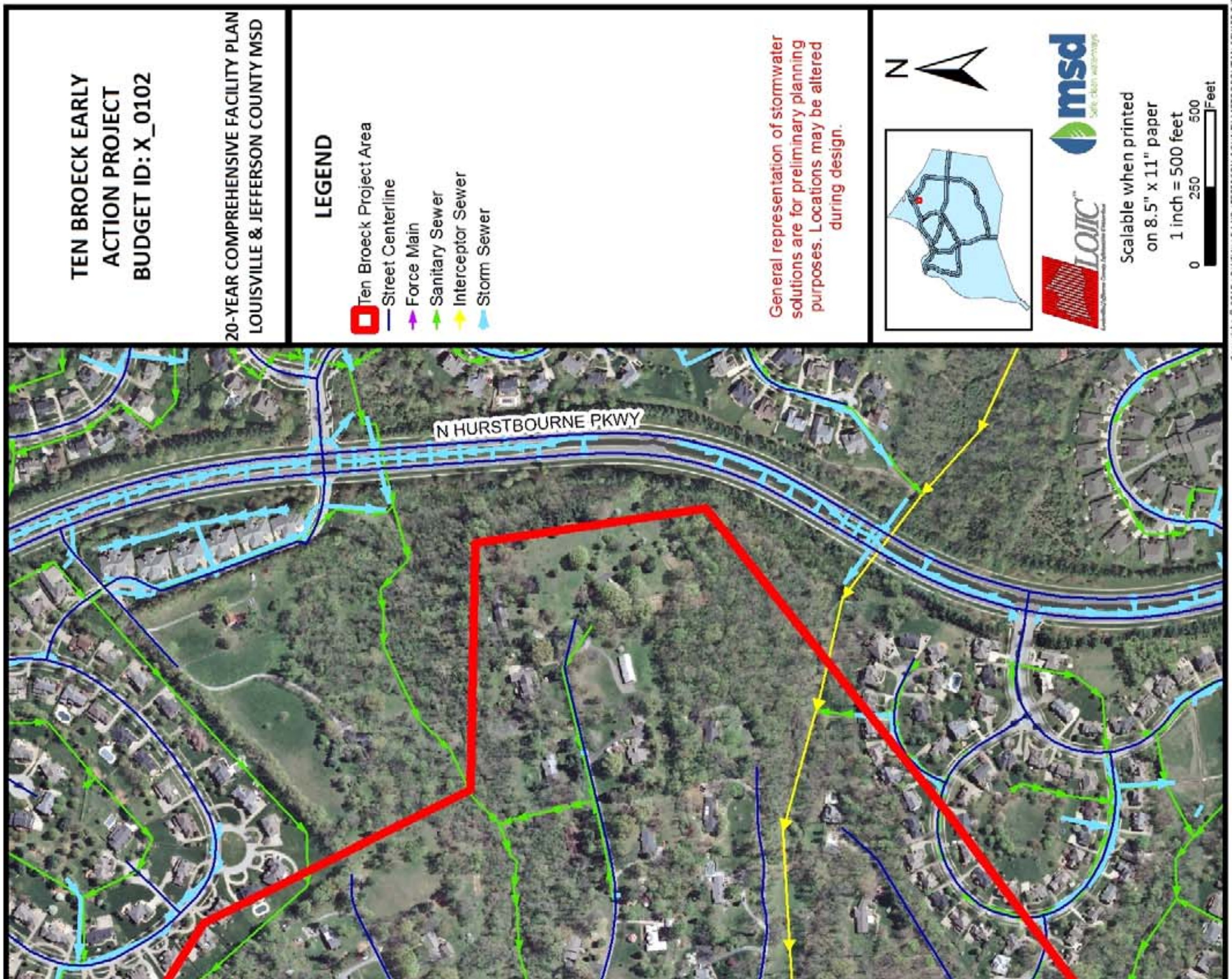

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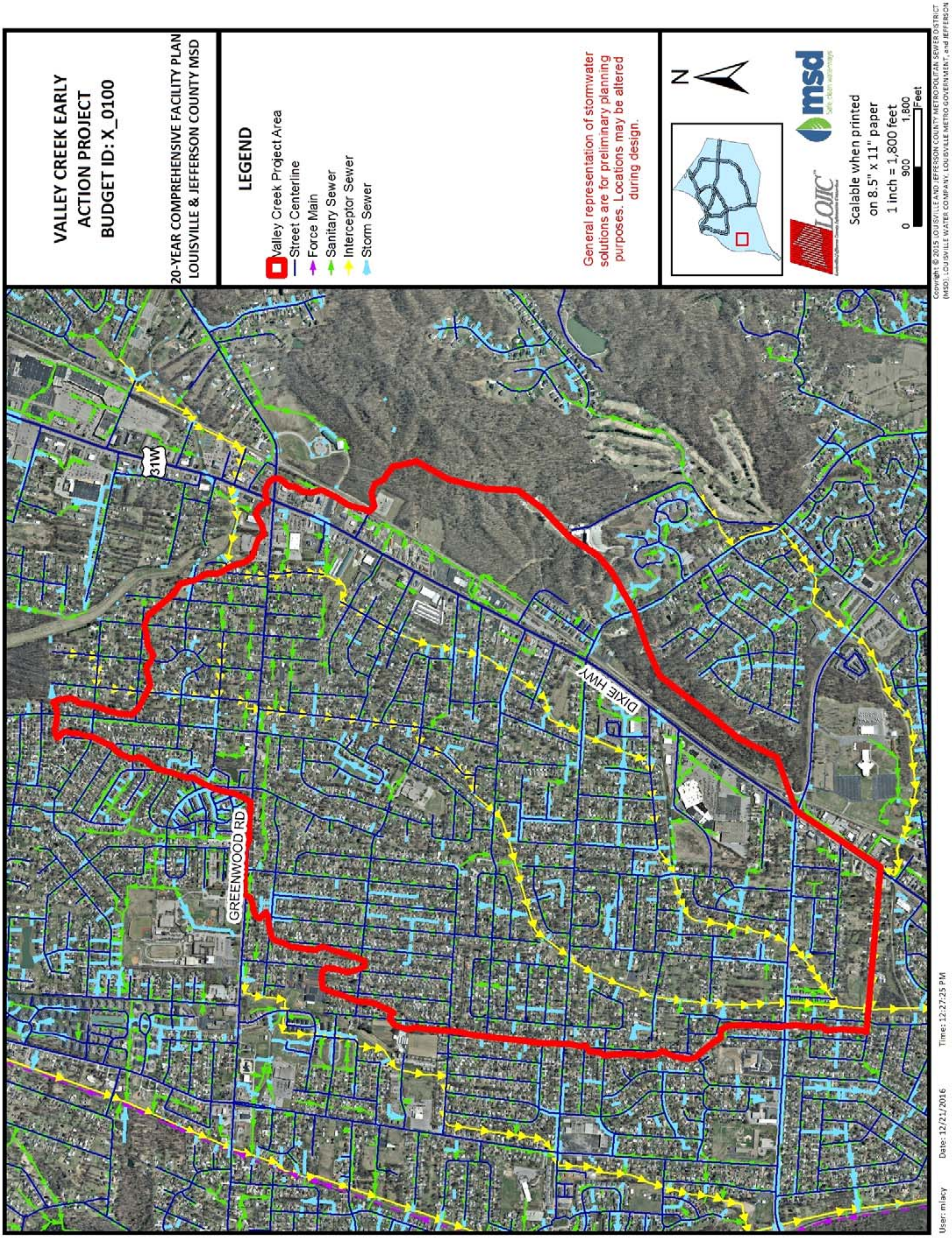
COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VALLEY CREEK EARLY ACTION PROJECT		
Budget ID	X_0100		
Start FY	2020	**Completion FY**	2021
Project Budget (2016 Dollars)	$9,700,000	**Project Budget** (Escalated Dollars)	$11,057,958
Service Type	Stormwater	**Program**	Drainage

Project Description
The Valley Creek area is generally bordered on the north by Greenwood Road and Big Run Diversion, east by Dixie Highway, on the south by Speedway Avenue, and on the west by Devonshire Drive. This area lies within the Mill Creek watershed. The current stormwater infrastructure includes a roadside and backyard open channel systems with pipe and culverts. Key flooding and drainage issues within the area is the 10-year storm event that inundates the majority of the Valley Creek Basin. However, areas of more severe flooding are Clover Avenue, Johnsontown Road, the area above Stephan Drive and West Pages to Marryman Road, Greenwood Road, west of Jessamine Lane, and areas along the three main channels. Possible solutions include an increase in system conveyance, increase in storage, and the purchase of a number of homes for placement of infrastructure and/or the removal of flood-prone structures. More specifically, solutions include increasing the capacity of the existing system along Clover Avenue, south of Johnsontown Road, Vicki Lane/Sally Drive/Chase Road System, Marryman Drive, Jessamine Lane, West Pages Lane, Dixie Highway, and Stephan Drive, along Moonglow Avenue to Mahoney Drive and Chase Road to channel. Additional underground detention is proposed along West Pages Lane (5.4 ac-ft).

Project Justification
Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations
The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.



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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA01 13TH AND MARKET VIADUCT FLOOD RELIEF		
Budget ID	X_0131		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$5,019,000	**Project Budget** (Escalated Dollars)	$8,551,874
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 3 separate parcels of property will need to be acquired, including 2 buildings.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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VIA01 13TH & MARKET
VIADUCT FLOOD RELIEF
BUDGET ID: X_0131

20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD

LEGEND

- MSD Viaduct
- Combined Sewer
- Sanitary Sewer

General representation of viaduct solutions are for preliminary planning purposes. Locations may be altered during design.

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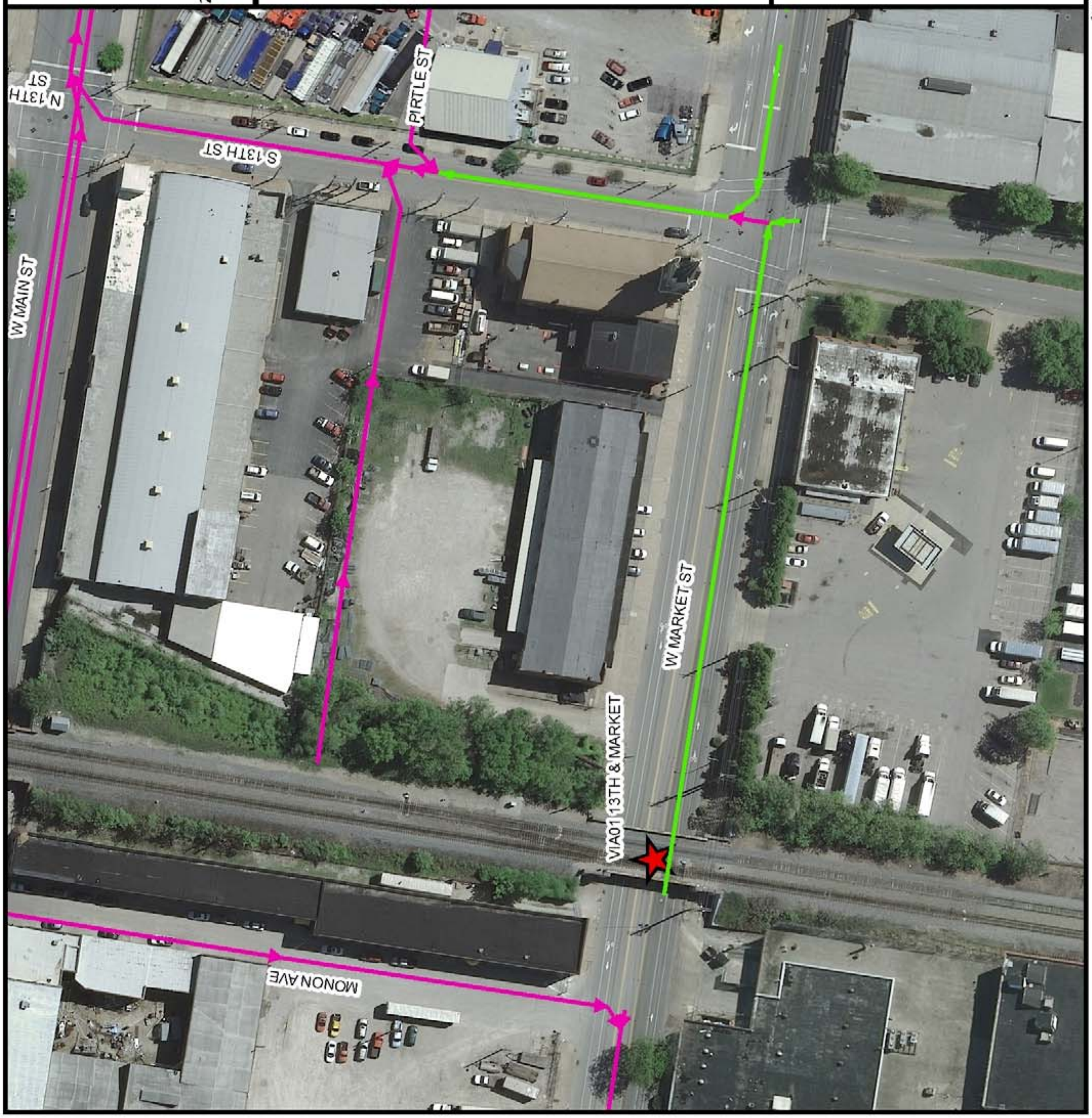
1 inch = 100 feet



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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA02 32ND AND MARKET VIADUCT FLOOD RELIEF		
Budget ID	X_0140		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$6,716,000	**Project Budget** (Escalated Dollars)	$11,443,724
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. Currently, Louisville Metro owns land near the viaduct, so partnering opportunities exist which may help lower property acquisition cost.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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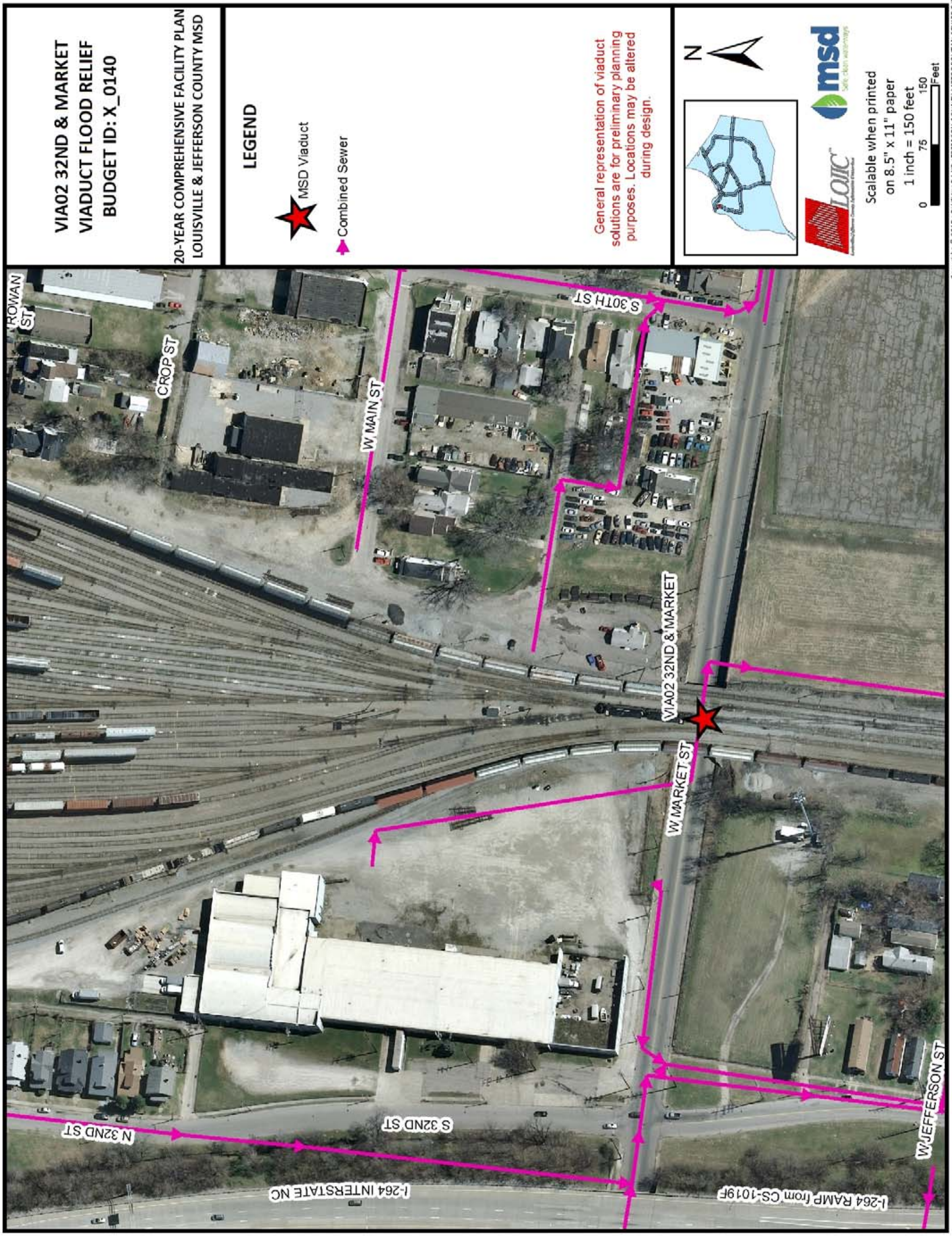

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA03 13TH AND MAIN STREET VIADUCT FLOOD RELIEF
Budget ID	X_0137

Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$5,368,000	**Project Budget** (Escalated Dollars)	$9,146,286
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 parcel of property will need to be acquired.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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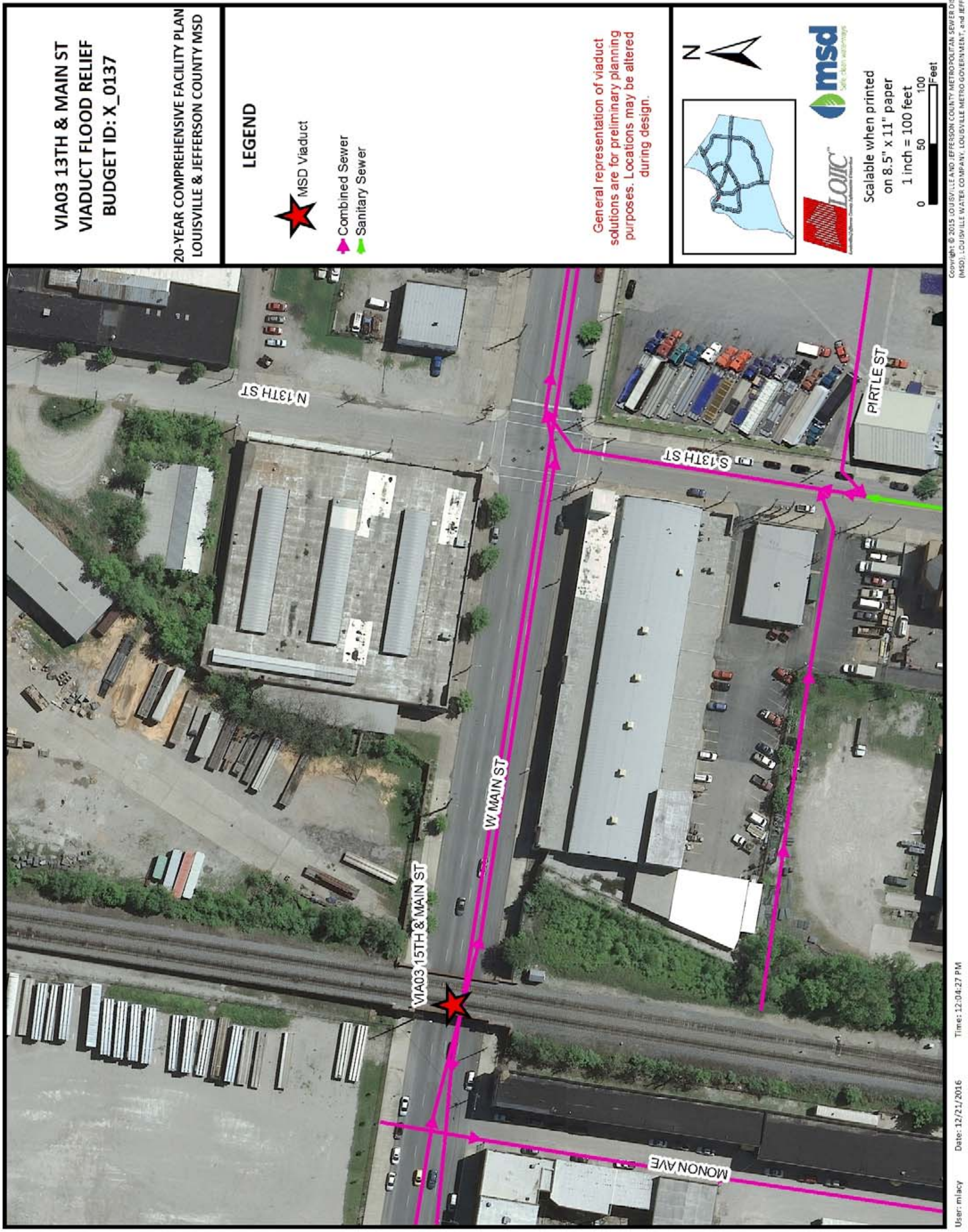

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COMPREHENSIVE 20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA04 13TH AND MUHAMMAD ALI VIADUCT FLOOD RELIEF		
Budget ID	X_0138		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$5,822,000	**Project Budget** (Escalated Dollars)	$9,919,579
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 parcel of property will need to be acquired, including 1 building.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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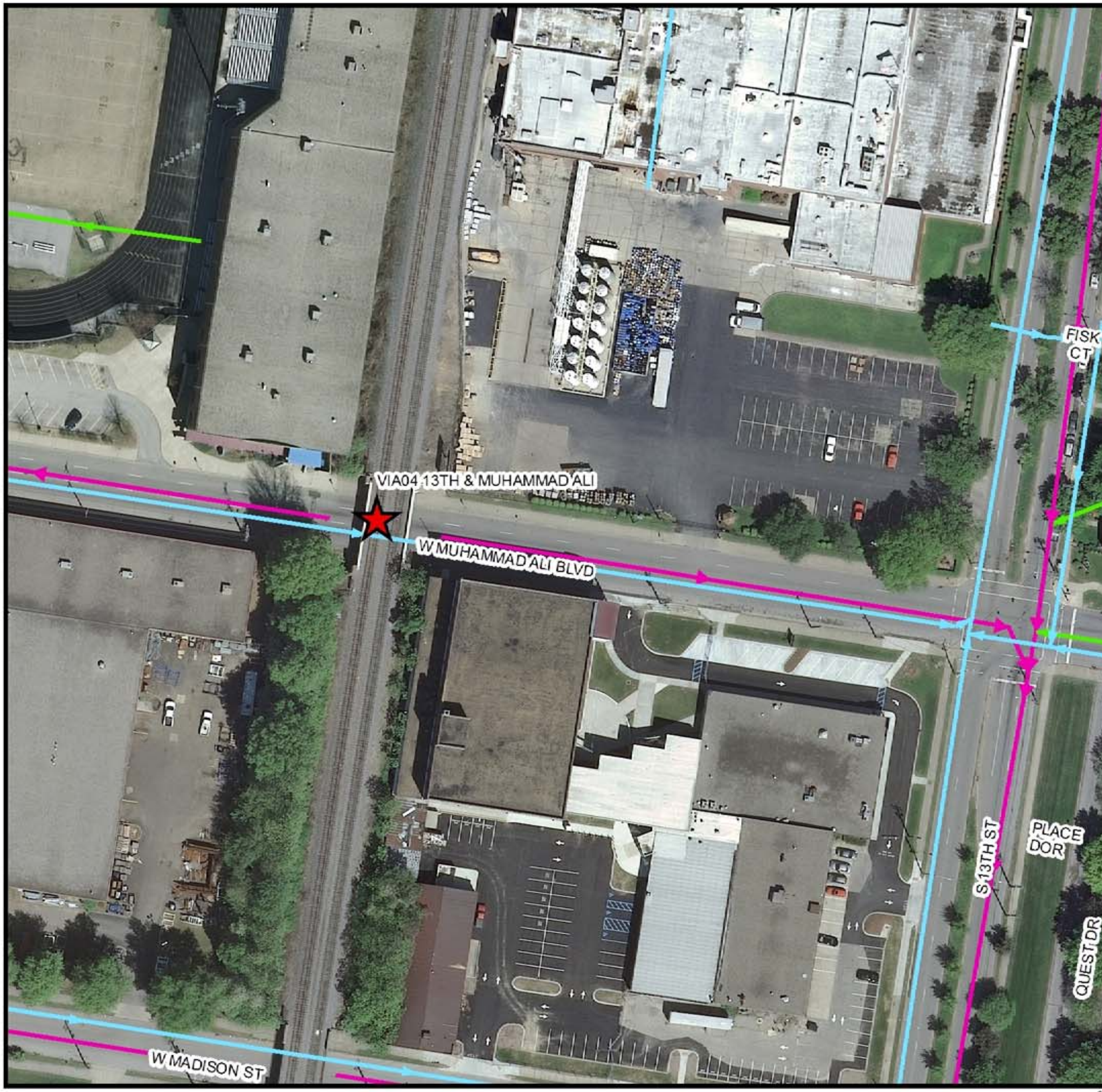

VIA04 13TH & MUHAMMAD VIADUCT FLOOD RELIEF
BUDGET ID: X_0138

20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD

LEGEND

- MSD Viaduct
- Combined Sewer
- Sanitary Sewer
- Storm Sewer

General representation of viaduct solutions are for preliminary planning purposes. Locations may be altered during design.

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1 inch = 100 feet
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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA05 30TH AND PORTLAND VIADUCT FLOOD RELIEF		
Budget ID	X_0128		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$4,354,000	**Project Budget** (Escalated Dollars)	$7,418,781
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 10 separate parcels of property will need to be acquired, including 4 buildings.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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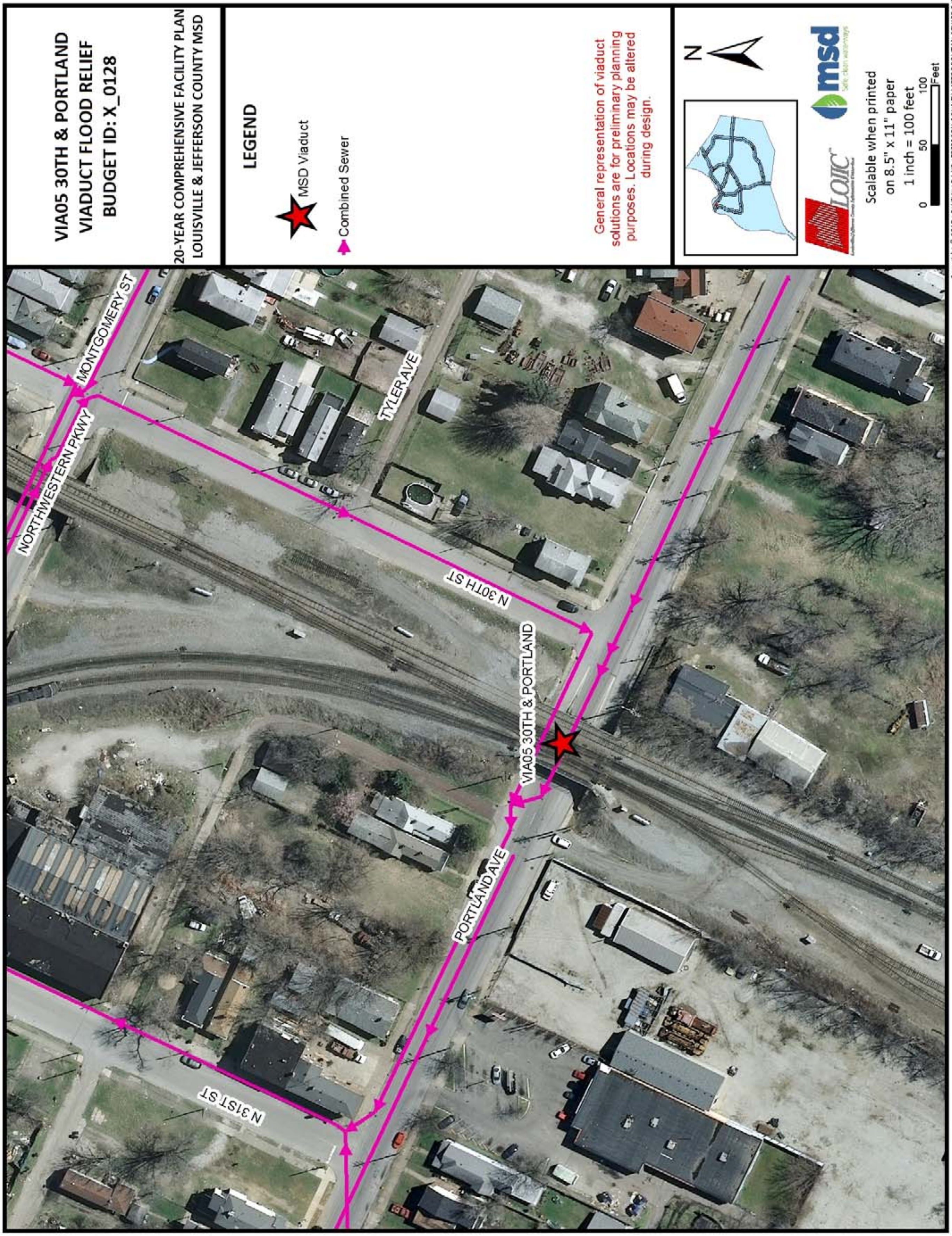

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name VIA06 30TH AND BANK STREET VIADUCT FLOOD RELIEF

Budget ID X_0127

Start FY 2027 **Completion FY** 2031

Project Budget (2016 Dollars) $4,255,000 **Project Budget** (Escalated Dollars) $6,254,084

Service Type Stormwater **Program** Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 2 separate parcels of property will need to be acquired, including 11 buildings.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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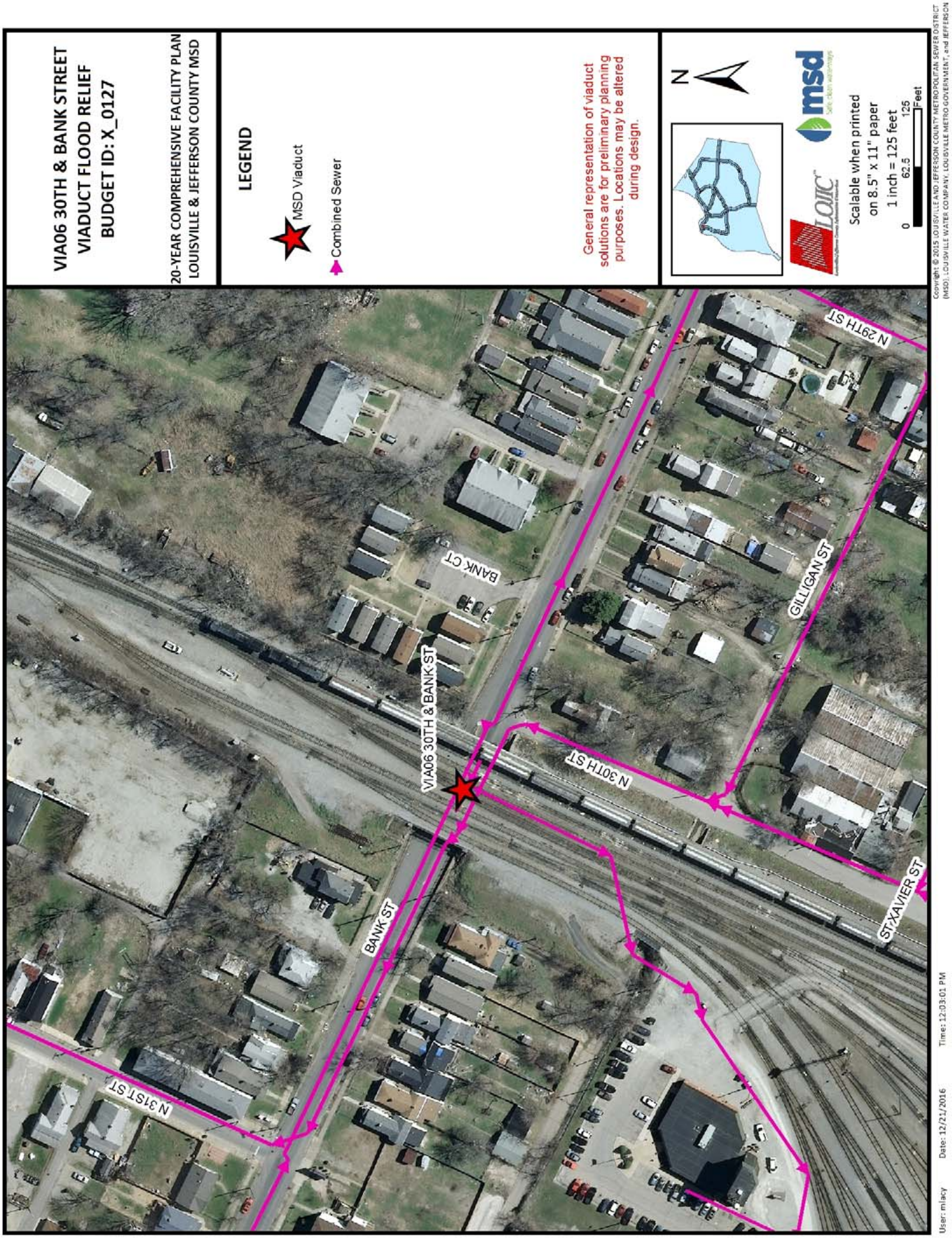

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA07 13TH AND JEFFERSON VIADUCT FLOOD RELIEF		
Budget ID	X_0132		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$5,019,000	**Project Budget** (Escalated Dollars)	$8,551,999
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 3 separate parcels of property will need to be acquired, including 2 buildings.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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VIA07 13TH & JEFFERSON
VIADUCT FLOOD RELIEF
BUDGET ID: X_0132

20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD

LEGEND

- MSD Viaduct
- Combined Sewer
- Sanitary Sewer
- Storm Sewer

General representation of viaduct solutions are for preliminary planning purposes. Locations may be altered during design.

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1 inch = 100 feet
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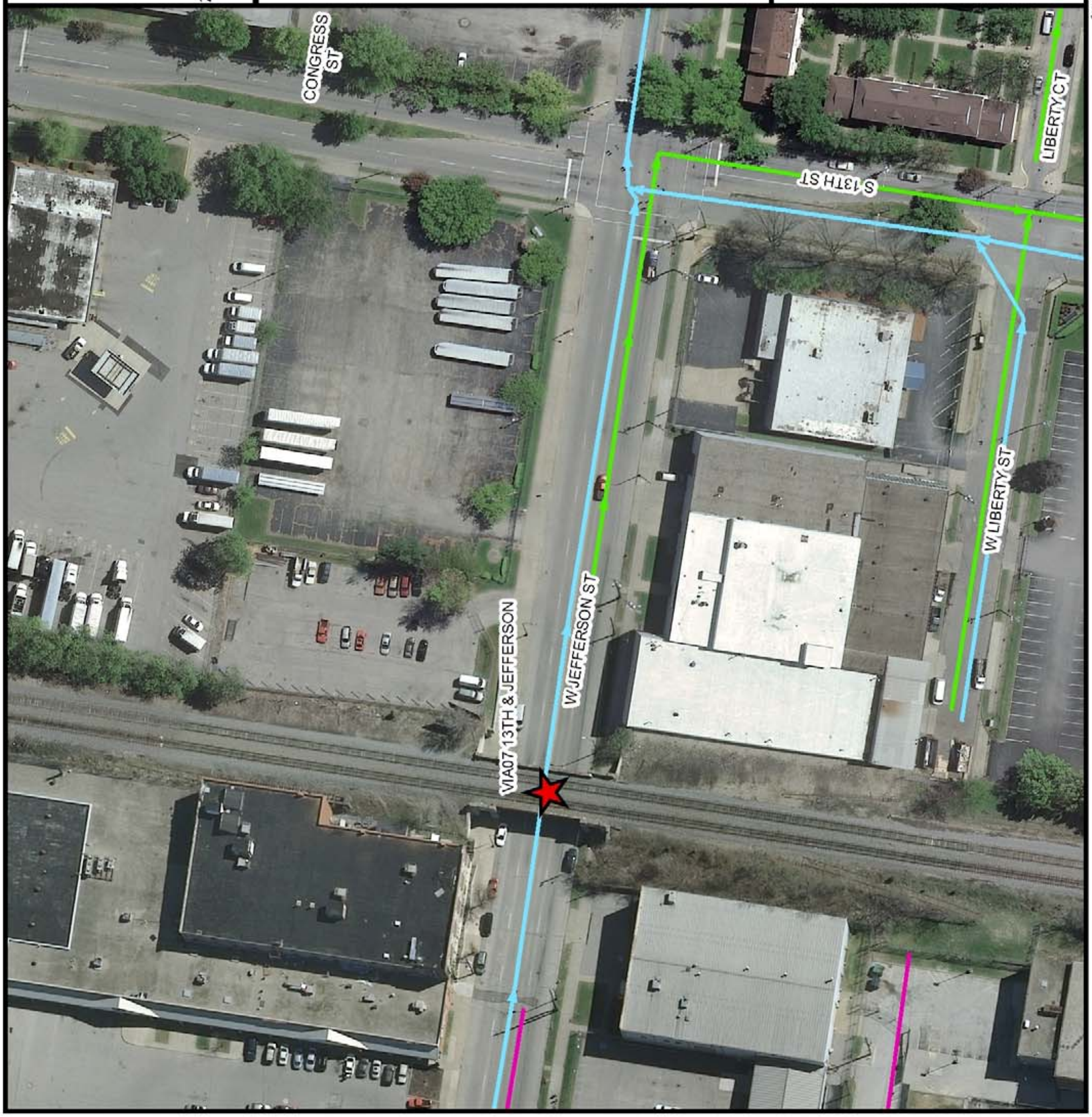

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA08 16TH AND ALGONQUIN VIADUCT FLOOD RELIEF		
Budget ID	X_0142		
Start FY	2034	**Completion FY**	2036
Project Budget (2016 Dollars)	$28,041,536	**Project Budget** (Escalated Dollars)	$40,727,990
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. The existing pumps at this viaduct are drastically undersized and backwater from the Southern Outfall could occur as well (need to verify with additional modeling). The recommended solutions include substantially upgrading the existing pump stations to larger stations, installation of one-way valves to eliminate backwater, and provide an outlet by means of an approximate 2.1 MG underground storage basin (final volume to be determined by watershed modeling). The storage basins size is thought to be similar to the Brandeis Viaduct, where preliminary modeling has occurred. It appears numerous options are available for the location of the storage basin, but it is anticipated that 1 parcel of property will need to be acquired, including one building.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary. Reference the draft “University of Louisville Area Flooding Analysis” (Heritage, Dec. 2015) for more information on this viaduct.

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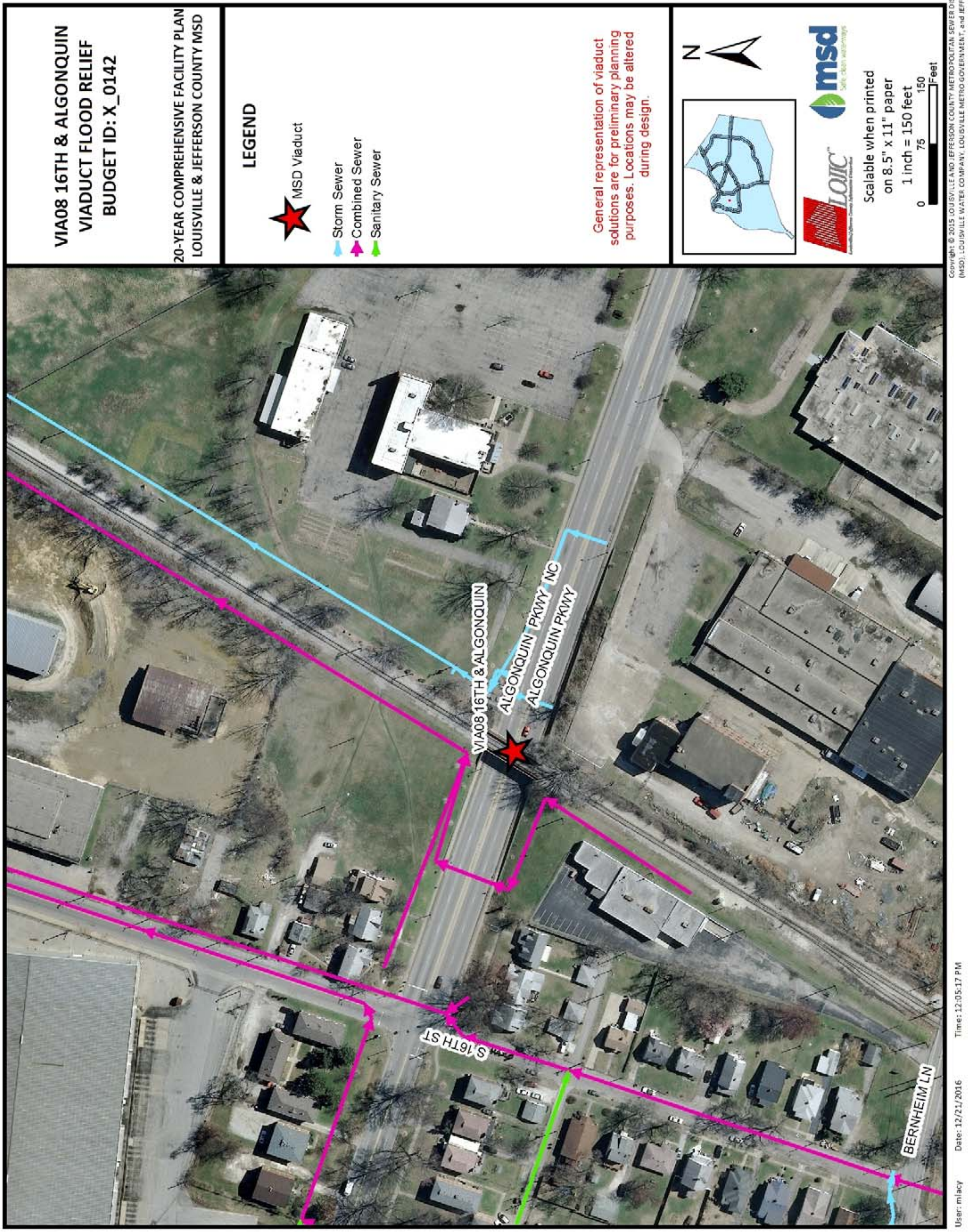

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA09 6TH AND HILL STREET VIADUCT FLOOD RELIEF		
Budget ID	X_0121		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$3,984,000	**Project Budget** (Escalated Dollars)	$5,051,314
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 2 separate parcels of property will need to be acquired, including 1 building.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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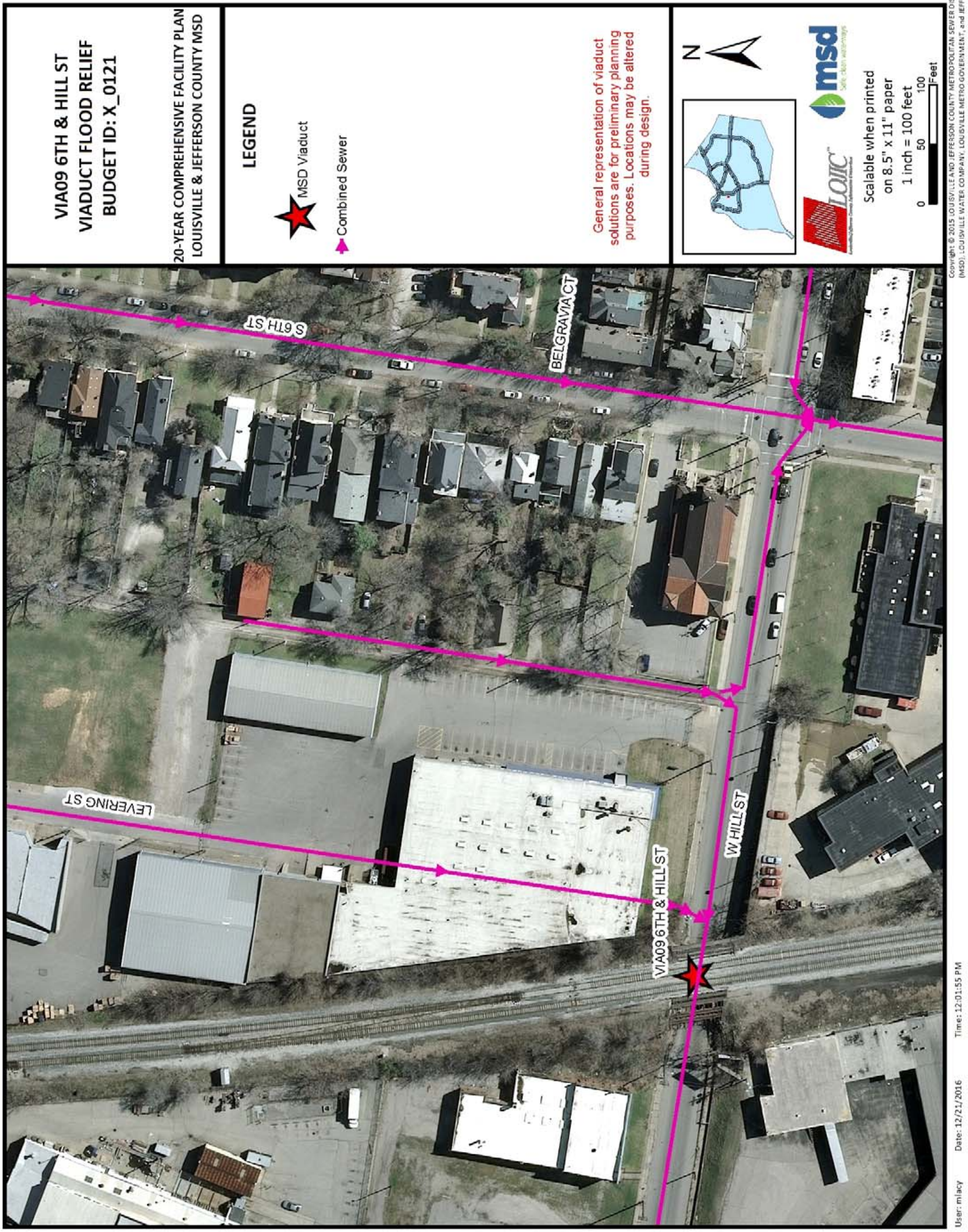

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA10 FLOYD AND HILL STREET VIADUCT FLOOD RELIEF		
Budget ID	X_0143		
Start FY	2021	**Completion FY**	2025
Project Budget (2016 Dollars)	$28,043,000	**Project Budget** (Escalated Dollars)	$34,520,396
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. The existing pumps at this viaduct are drastically undersized and backwater from the Southern Outfall could occur as well (need to verify with additional modeling). The recommended solutions include substantially upgrading the existing pump stations to larger stations, installation of one-way valves to eliminate backwater, and provide an outlet by means of an approximate 2.1 MG underground storage basin (final volume to be determined by watershed modeling). The storage basin size is thought to be similar to the Brandeis Viaduct, where preliminary modeling has occurred. It is anticipated that 1 parcel of property will need to be acquired, including 2 buildings.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary. Reference the draft “University of Louisville Area Flooding Analysis” (Heritage, Dec. 2015) for more information on this viaduct.

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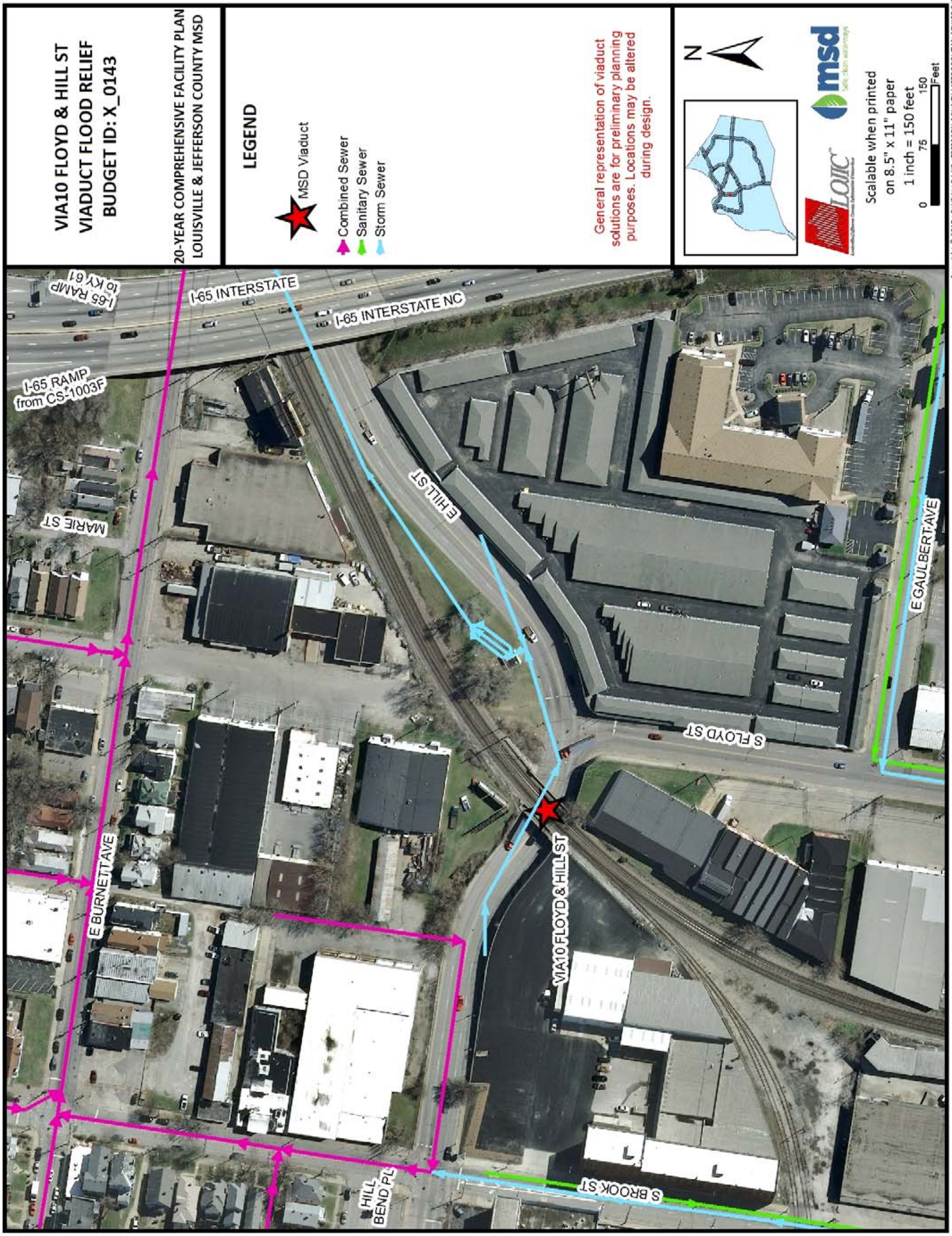

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA11 E BRANDEIS AVENUE AND BROOK VIADUCT FLOOD RELIEF		
Budget ID	X_0144		
Start FY	2018	**Completion FY**	2020
Project Budget (2016 Dollars)	$28,043,000	**Project Budget** (Escalated Dollars)	$30,846,732
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. The existing pumps at this viaduct are drastically undersized and backwater from the Southern Outfall is known to occur here as well. In addition, and MSD manhole (MH 76671) overflows in to the viaduct sump area. To remedy this, the Southern Outfall must be re-routed such that it does not pass under the viaduct. The other recommended solutions include substantially upgrading the existing pump stations to larger stations, installation of one-way valves to eliminate backwater, and provide an outlet by means of an approximate 2.1 MG underground storage basin (final volume to be verified by watershed modeling). The recommended location for the basin is on the campus of Dupont Manual High School.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary. Reference the draft “University of Louisville Area Flooding Analysis” (Heritage, Dec. 2015) for more information on this viaduct.

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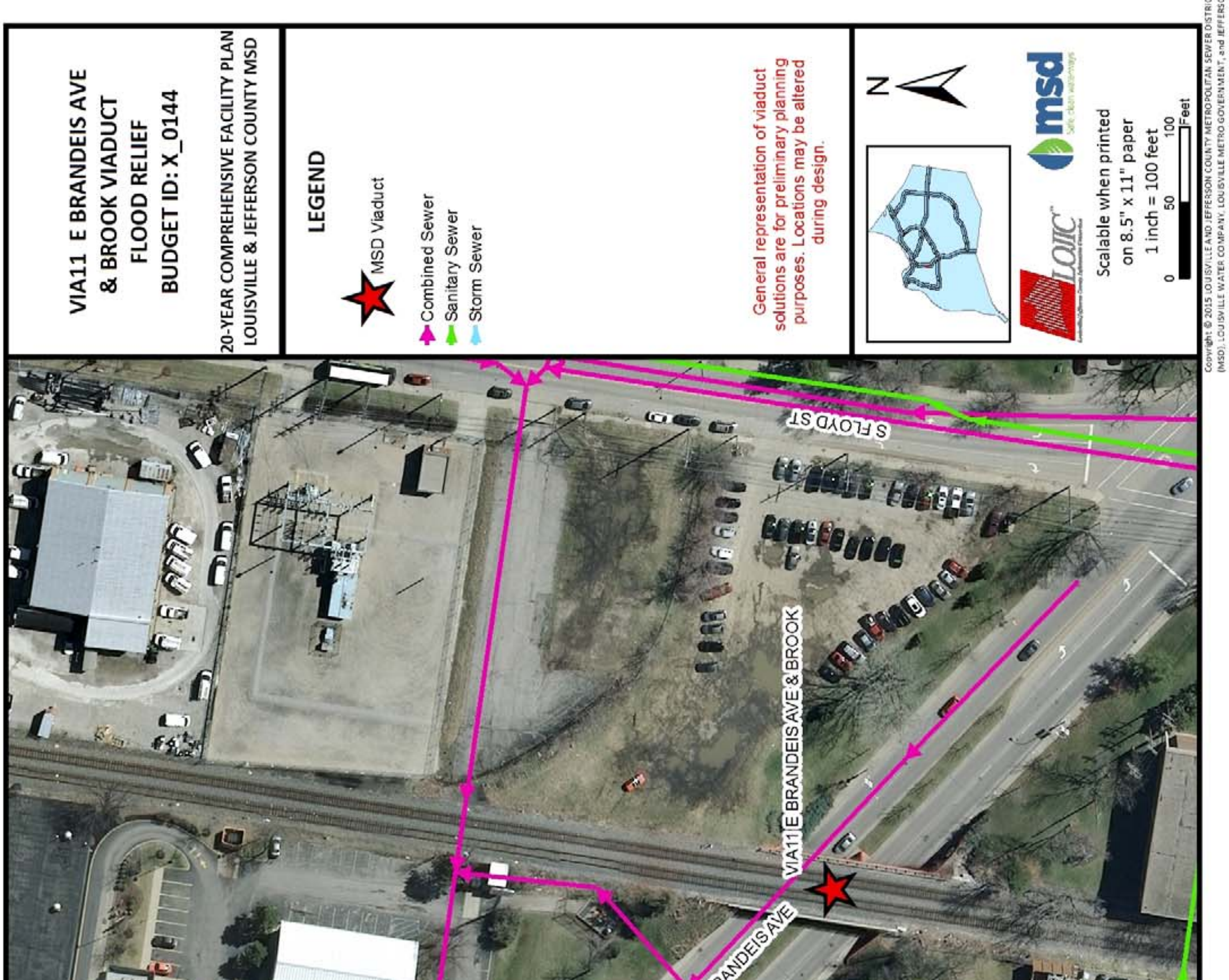

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA12 8TH AND OAK VIADUCT FLOOD RELIEF		
Budget ID	X_0122		
Start FY	2027	**Completion FY**	2031
Project Budget (2016 Dollars)	$3,991,000	**Project Budget** (Escalated Dollars)	$5,866,052
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 8 separate parcels of property will need to be acquired, including 1 buildings.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

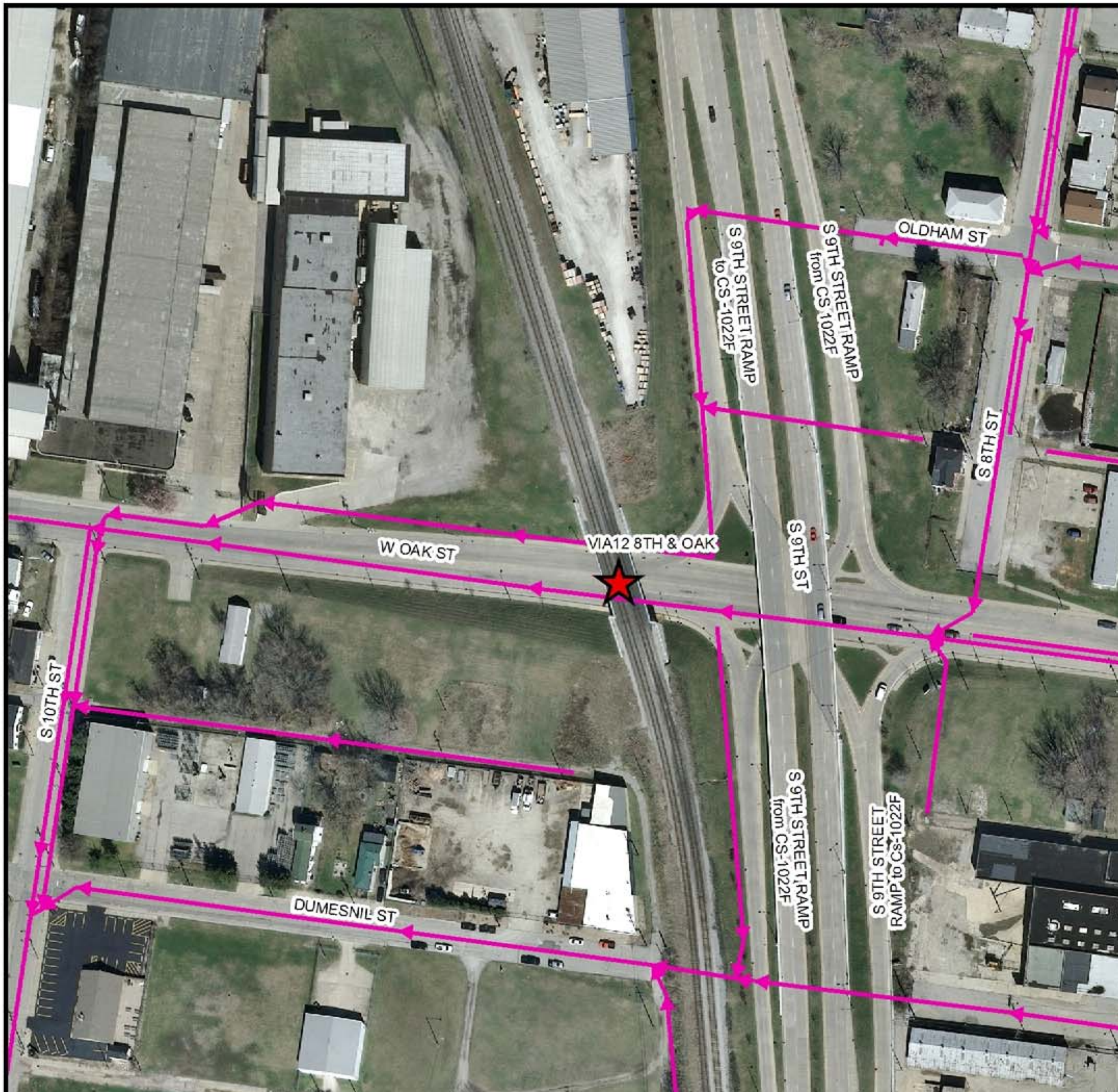
Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

Last Updated: 6/5/2017 **Printed:** 6/9/2017

VIA12 8TH & OAK
VIADUCT FLOOD RELIEF
BUDGET ID: X_0122

20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD



LEGEND

MSD Viaduct

Combined Sewer

General representation of viaduct solutions are for preliminary planning purposes. Locations may be altered during design.

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LOJIC msd Safe clean waterways

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1 inch = 150 feet
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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name VIA13 13TH AND HILL STREET VIADUCT FLOOD RELIEF

Budget ID X_0126

Start FY 2027 **Completion FY** 2031

Project Budget (2016 Dollars) $4,093,000 **Project Budget** (Escalated Dollars) $6,015,435

Service Type Stormwater **Program** Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 separate parcels of property will need to be acquired.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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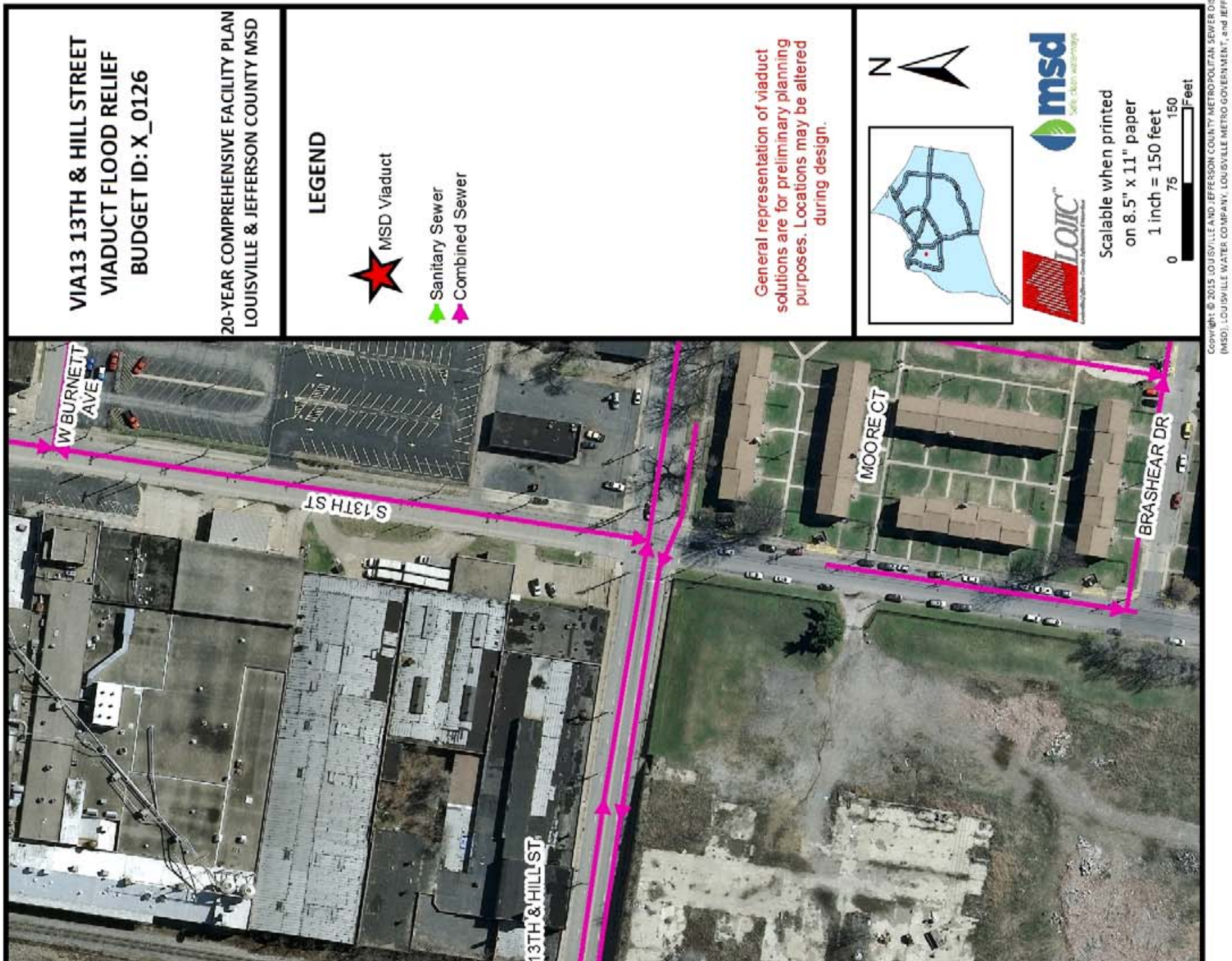

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA14 31ST AND BROADWAY VIADUCT FLOOD RELIEF		
Budget ID	X_0130		
Start FY	2027	**Completion FY**	2031
Project Budget (2016 Dollars)	$4,604,000	**Project Budget** (Escalated Dollars)	$6,766,722
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 3 separate parcels of property will need to be acquired, including 1 building.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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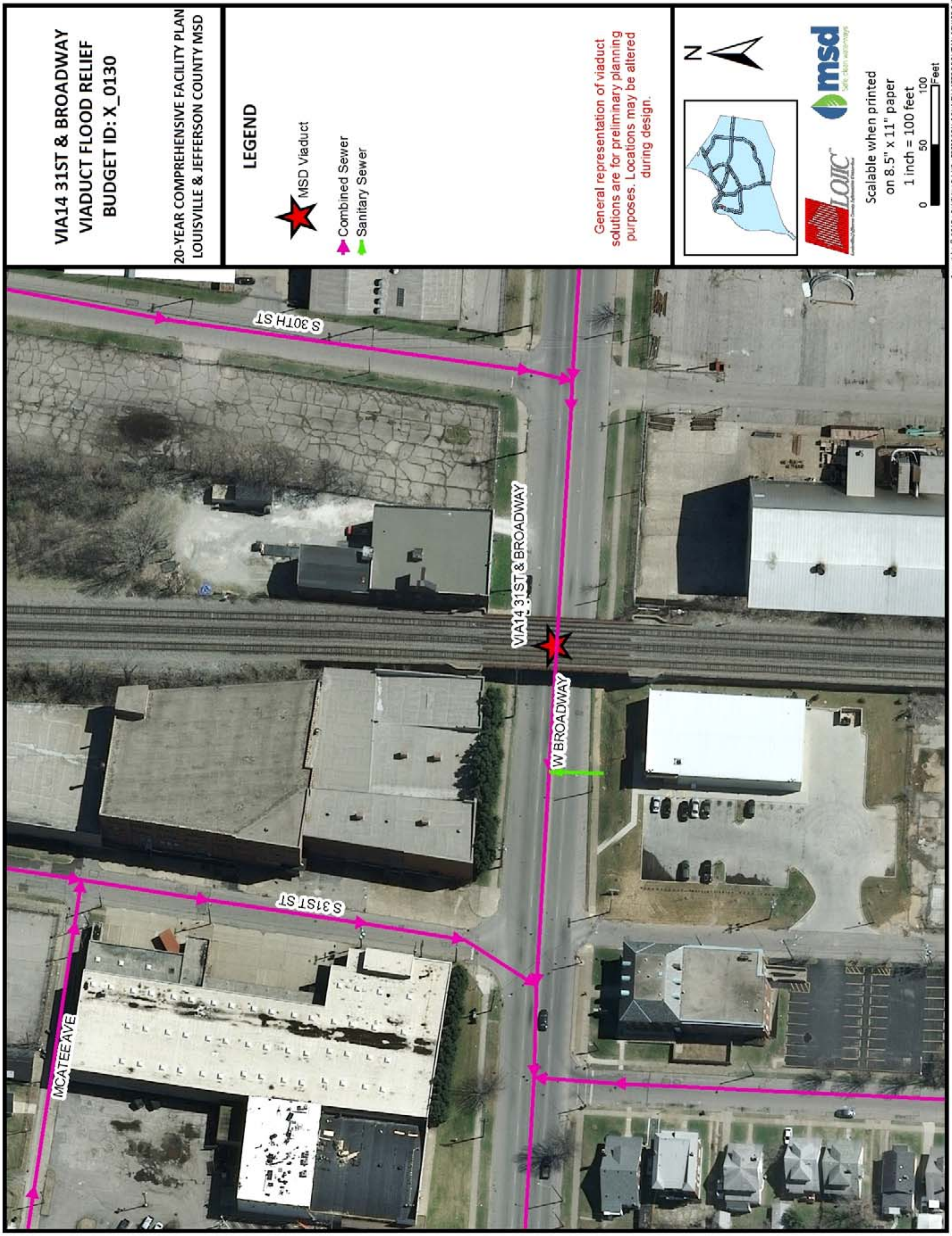

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA15 7TH AND MAGNOLIA VIADUCT FLOOD RELIEF		
Budget ID	X_0125		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$4,054,000	**Project Budget** (Escalated Dollars)	$6,907,611
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 separate parcels of property will need to be acquired. Central Park is in close proximity; this needs to be examined further in preliminary engineering to assess the feasibility of using it.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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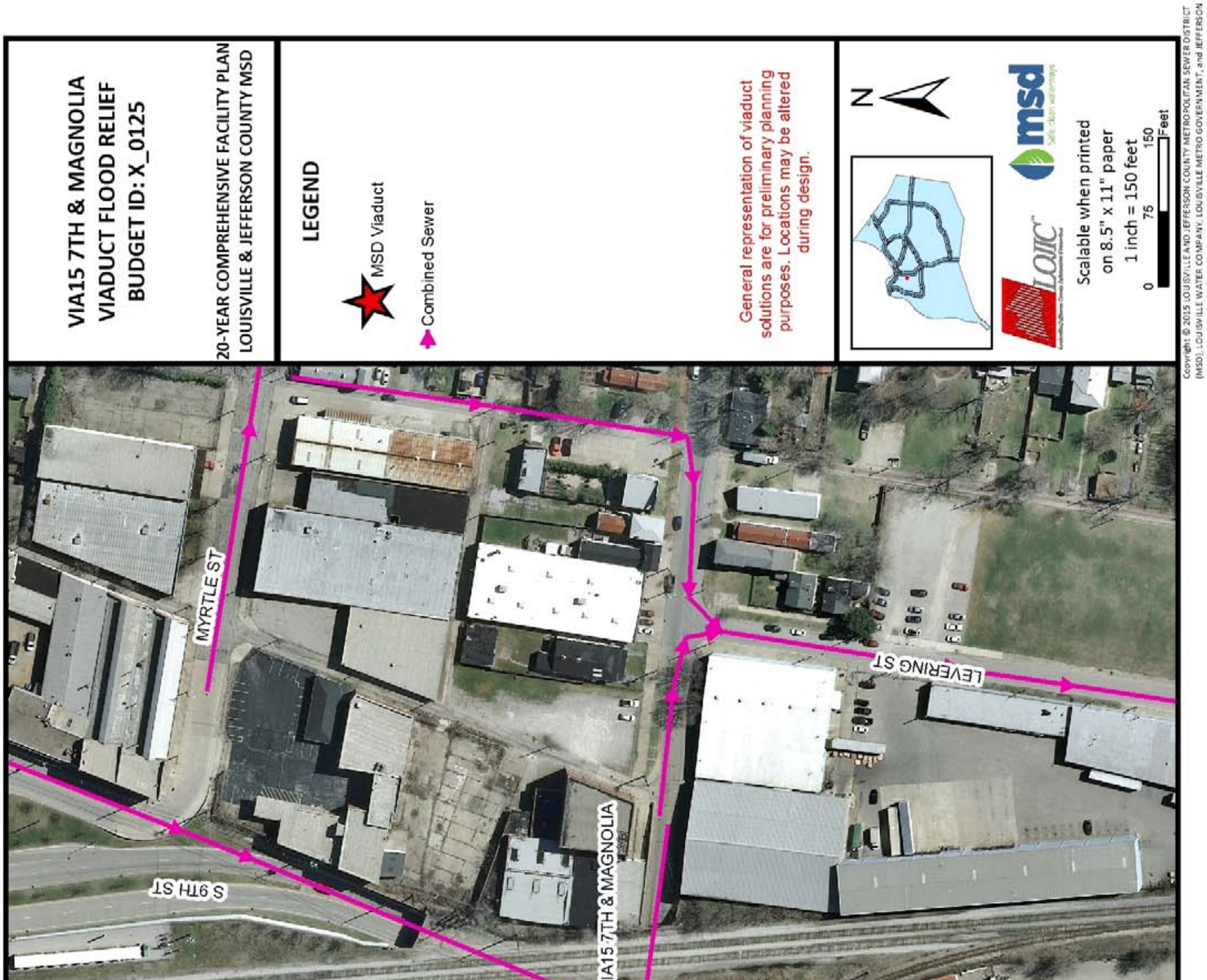
VIA15 7TH & MAGNOLIA
VIADUCT FLOOD RELIEF
BUDGET ID: X_0125
20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD
LEGEND
MSD Viaduct
Combined Sewer
General representation of viaduct solutions are for preliminary planning purposes. Locations may be altered during design.
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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name VIA16 3RD AND EASTERN PARKWAY VIADUCT FLOOD RELIEF

Budget ID X_0145

Start FY 2020 **Completion FY** 2026

Project Budget (2016 Dollars) $29,912,000 **Project Budget** (Escalated Dollars) $36,100,114

Service Type Stormwater **Program** Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. The existing pumps at this viaduct are drastically undersized and backwater from the Southern Outfall is known to occur here as well. In addition, during some events, overflow from certain catch basins create a circular pumping pattern. The recommended solutions include substantially upgrading the existing pump stations to larger stations, installation of one-way valves to eliminate backwater, and provide an outlet by means of an approximate 6.9 MG underground storage basin (final volume to be verified by watershed modeling). The recommended location for the basin is Stansbury Park.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary. Reference the draft “University of Louisville Area Flooding Analysis” (Heritage, Dec. 2015) for more information on this viaduct. One alternative solution that could potentially save significant cost would be to design a gravity in, pumped out storage basin. The feasibility of this should be considered in the preliminary engineering for the project.

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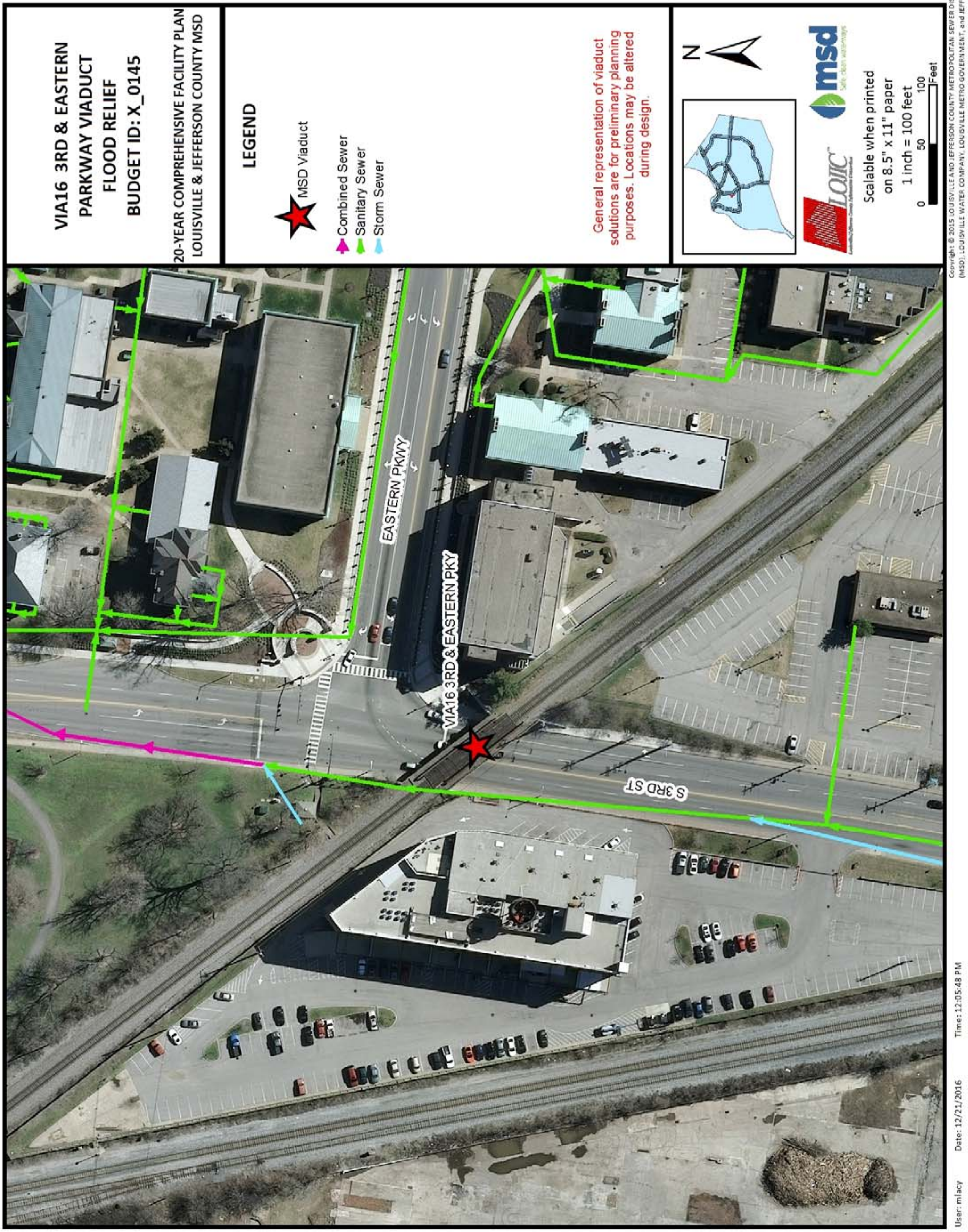

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA17 4TH STREET AND INDUSTRY ROAD VIADUCT FLOOD RELIEF		
Budget ID	X_0146		
Start FY	2021	**Completion FY**	2026
Project Budget (2016 Dollars)	$29,912,000	**Project Budget** (Escalated Dollars)	$37,871,125
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. The existing pumps at this viaduct are drastically undersized and backwater from the Southern Outfall is known to occur here as well. In addition, during some events, overflow from certain catch basins create a circular pumping pattern. The recommended solutions include substantially upgrading the existing pump stations to larger stations, installation of one-way valves to eliminate backwater, and provide an outlet by means of an approximate 6.9MG underground storage basin (final volume to be verified by watershed modeling). The recommended location for the basin is Stansbury Park.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary. Reference the draft "University of Louisville Area Flooding Analysis" (Heritage, Dec. 2015) for more information on this viaduct. One alternative solution that could potentially save significant cost would be to design a gravity in, pumped out storage basin. The feasibility of this should be considered in the preliminary engineering for the project.

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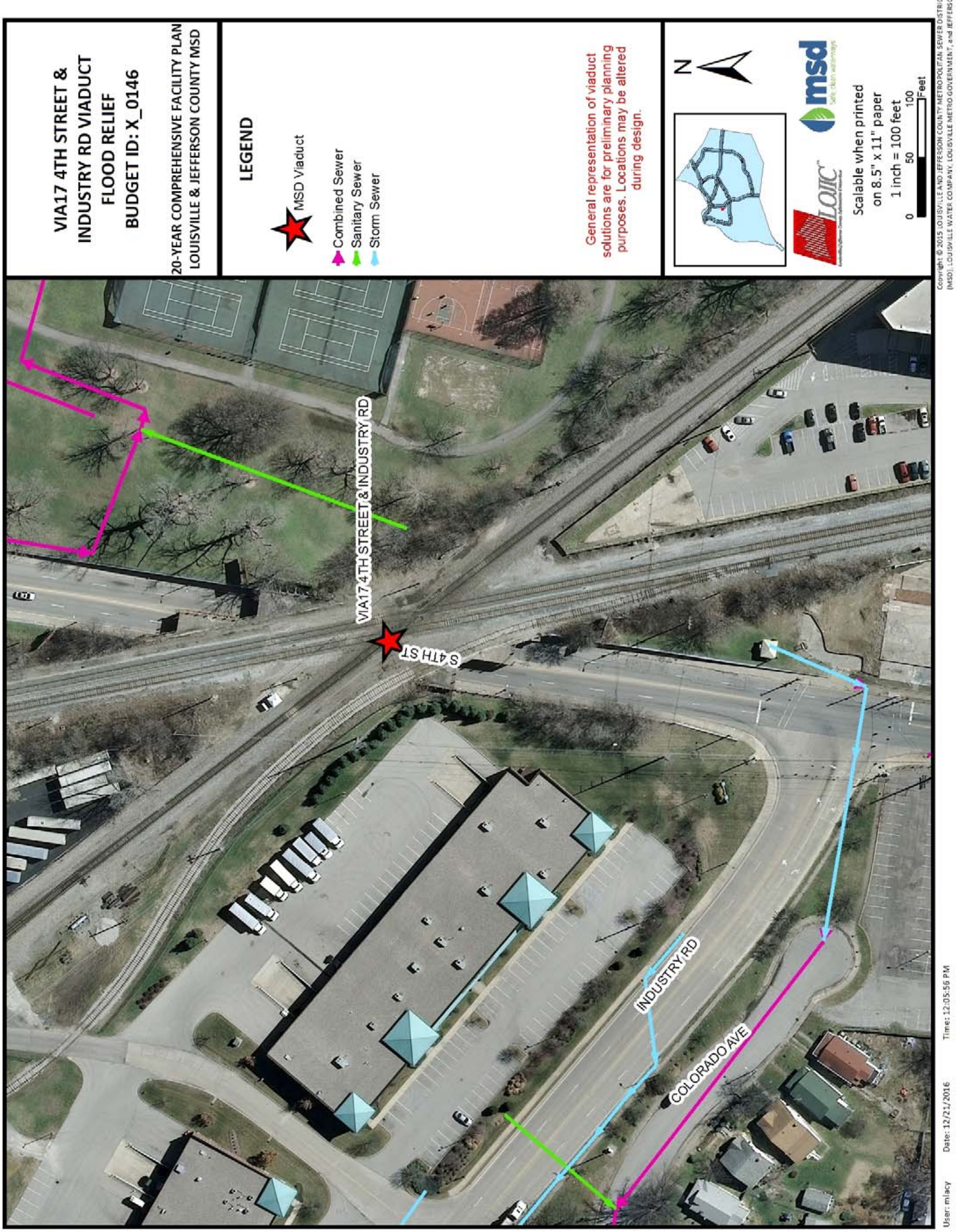

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA18 EASTERN PARKWAY AND HAHN VIADUCT FLOOD RELIEF		
Budget ID	X_0139		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$6,500,000	**Project Budget** (Escalated Dollars)	$11,075,350
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 2 separate parcels of property will need to be acquired, although there are many small parks in the area that should be assessed further in preliminary engineering for the feasibility of using one of them.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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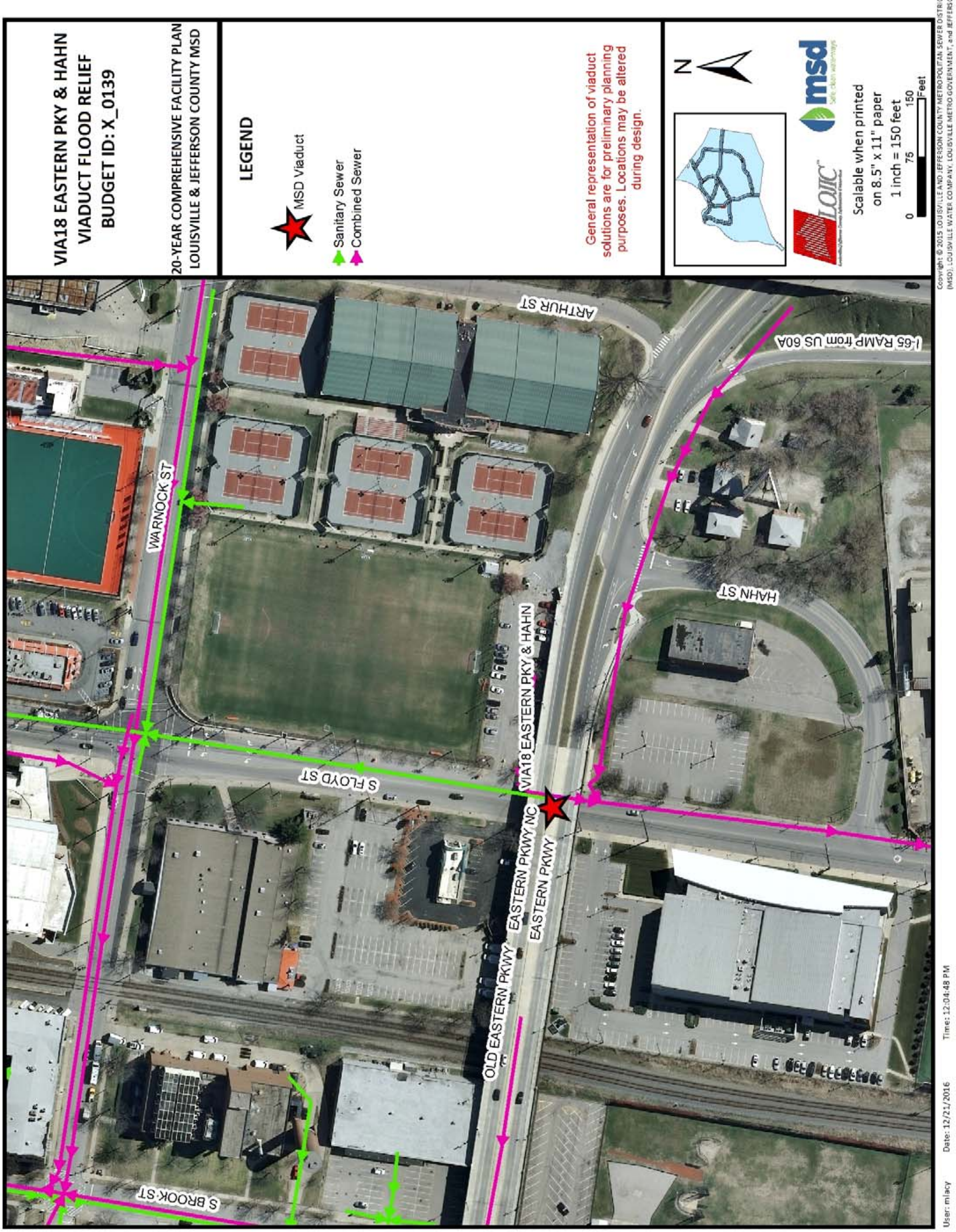

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COMPREHENSIVE 20-YEAR FACILITY PLAN PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA19 32ND AND MUHAMMAD ALI VIADUCT FLOOD RELIEF		
Budget ID	X_0141		
Start FY	2027	**Completion FY**	2031
Project Budget (2016 Dollars)	$6,720,000	**Project Budget** (Escalated Dollars)	$9,877,190
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. Currently, Louisville Metro owns land near the viaduct, so partnering opportunities exist which may help lower property acquisition cost.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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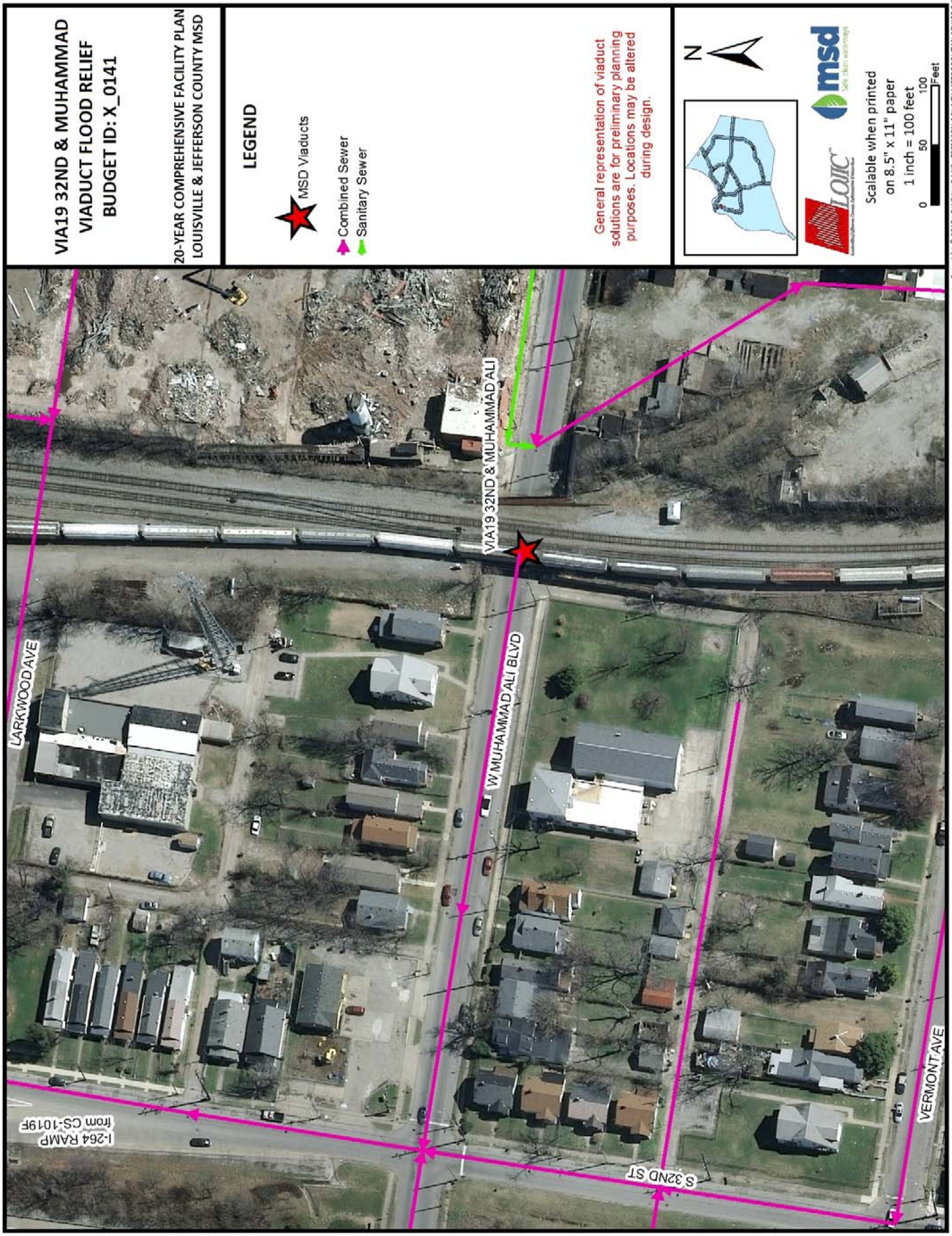

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COMPREHENSIVE 20-YEAR FACILITY PLAN PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA20 31ST AND VERMONT VIADUCT FLOOD RELIEF		
Budget ID	X_0124		
Start FY	2027	**Completion FY**	2031
Project Budget (2016 Dollars)	$4,015,000	**Project Budget** (Escalated Dollars)	$5,901,327
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 3 separate parcels of property will need to be acquired.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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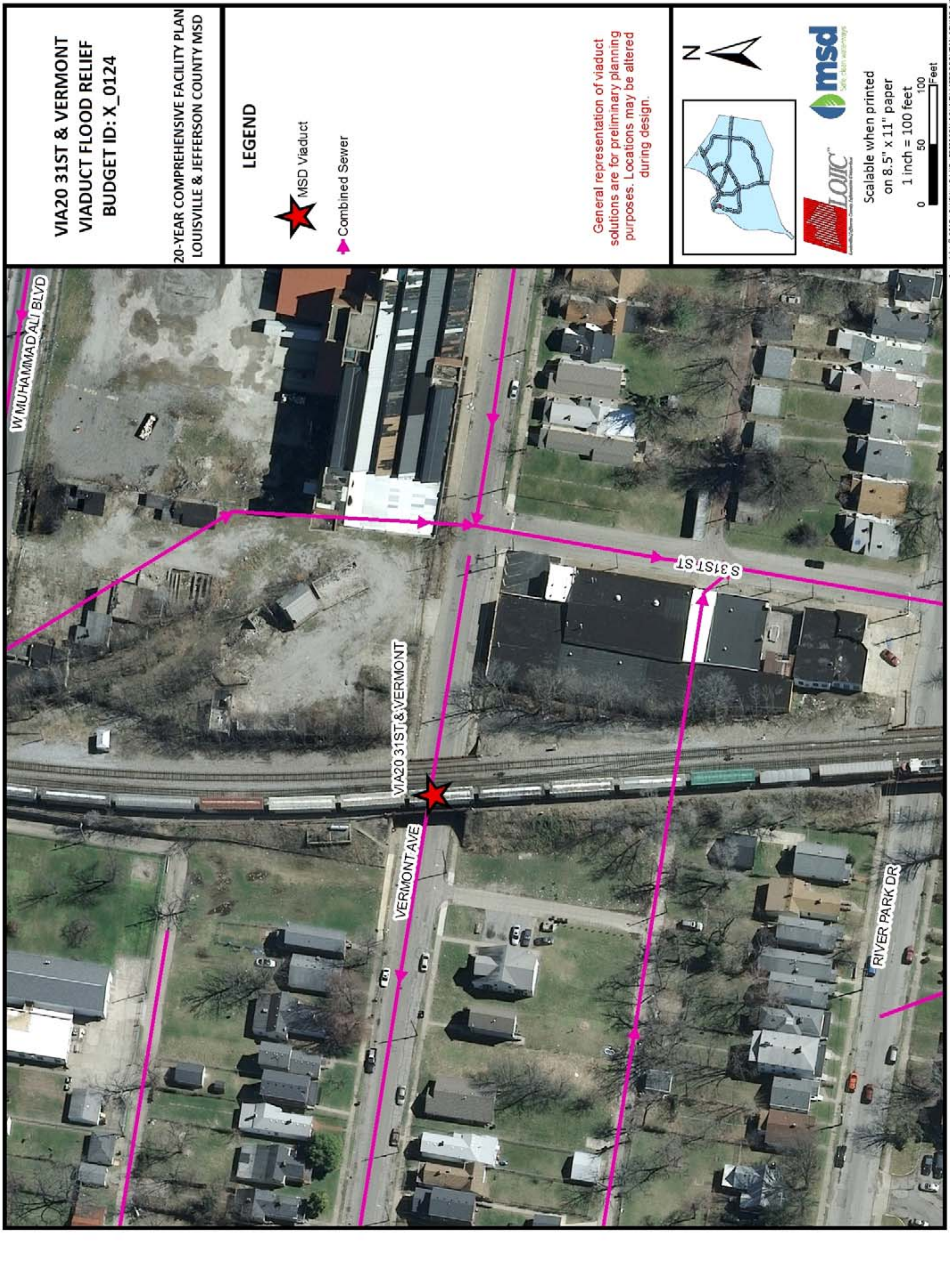

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA21 30TH AND DEL PARK TER VIADUCT FLOOD RELIEF		
Budget ID	X_0123		
Start FY	2027	**Completion FY**	2031
Project Budget (2016 Dollars)	$4,000,000	**Project Budget** (Escalated Dollars)	$5,879,280
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 3 separate parcels of property will need to be acquired.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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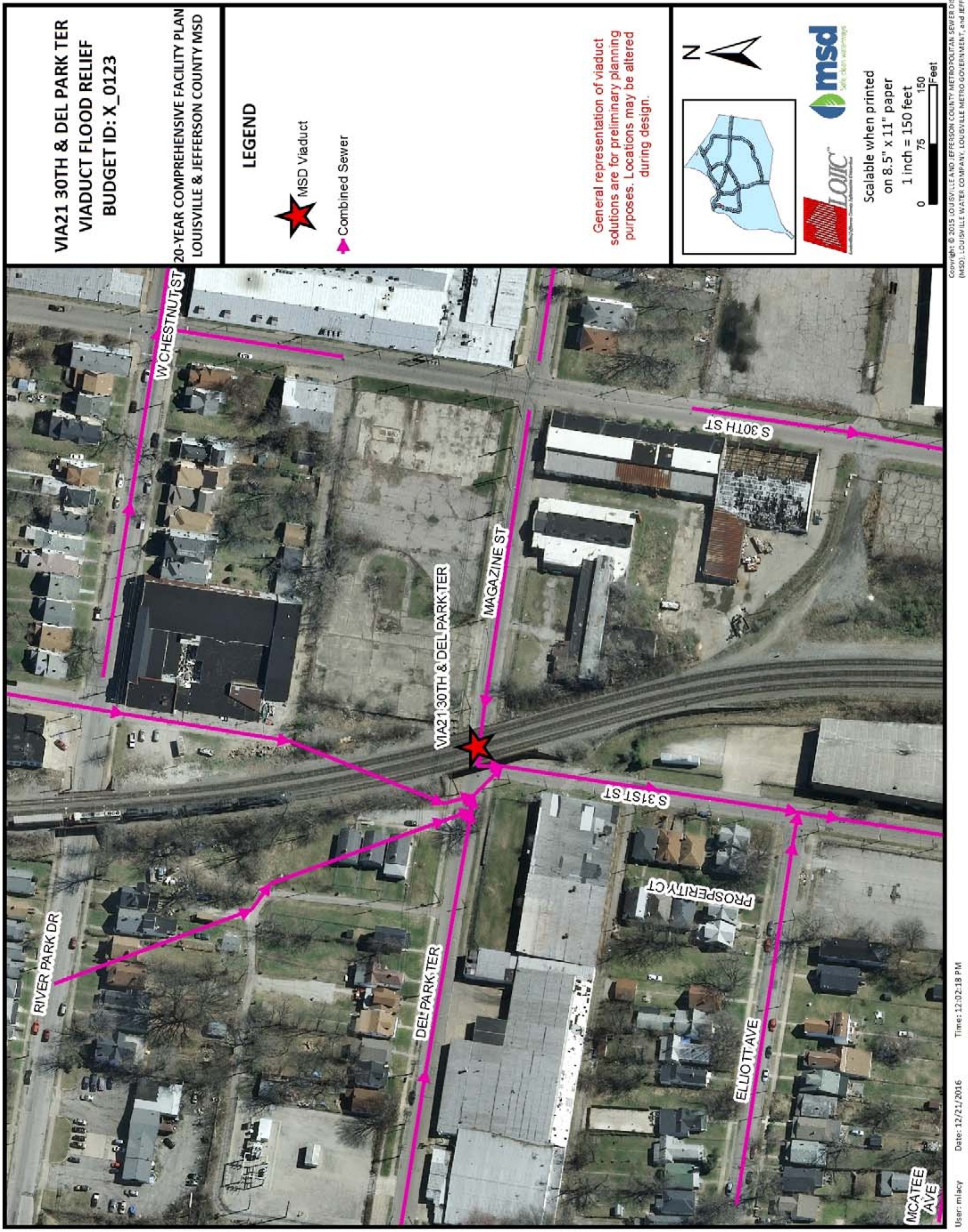

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA22 22ND AND STANDARD AVENUE VIADUCT FLOOD RELIEF		
Budget ID	X_0117		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$3,804,000	**Project Budget** (Escalated Dollars)	$4,823,092
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 parcel of property will need to be acquired, including 2 buildings.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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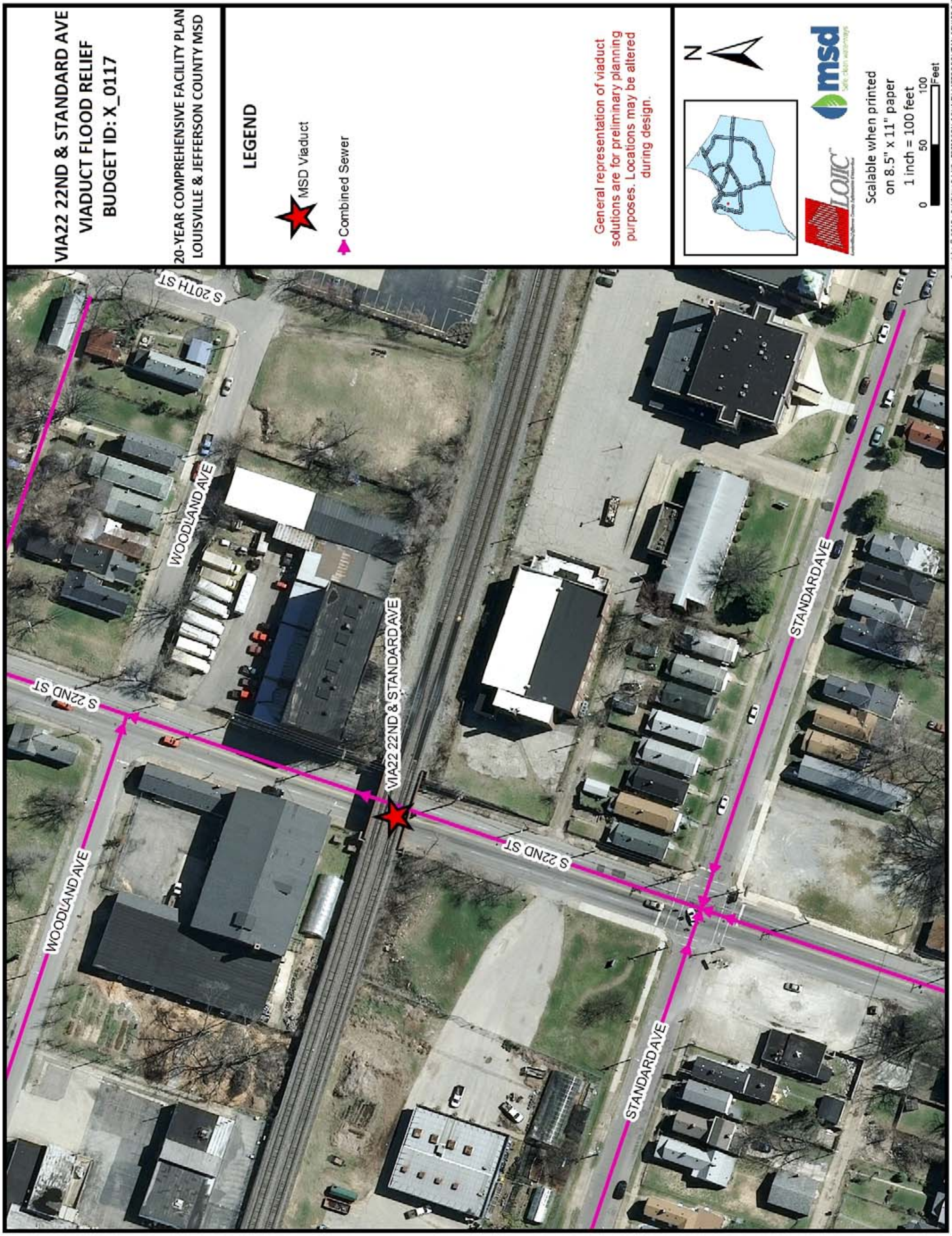

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COMPREHENSIVE 20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA23 DIXIE HIGHWAY AND STANDARD AVENUE VIADUCT FLOOD RELIEF		
Budget ID	X_0136		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$5,347,000	**Project Budget** (Escalated Dollars)	$9,111,004
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 parcel of property will need to be acquired, including 3 buildings.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

Last Updated: 6/5/2017 **Printed:** 6/9/2017

VIA23 DIXIE HWY & STANDARD AVE VIADUCT FLOOD RELIEF BUDGET ID: X_0136

20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD

LEGEND

MSD Viaduct

Combined Sewer

General representation of viaduct solutions are for preliminary planning purposes. Locations may be altered during design.

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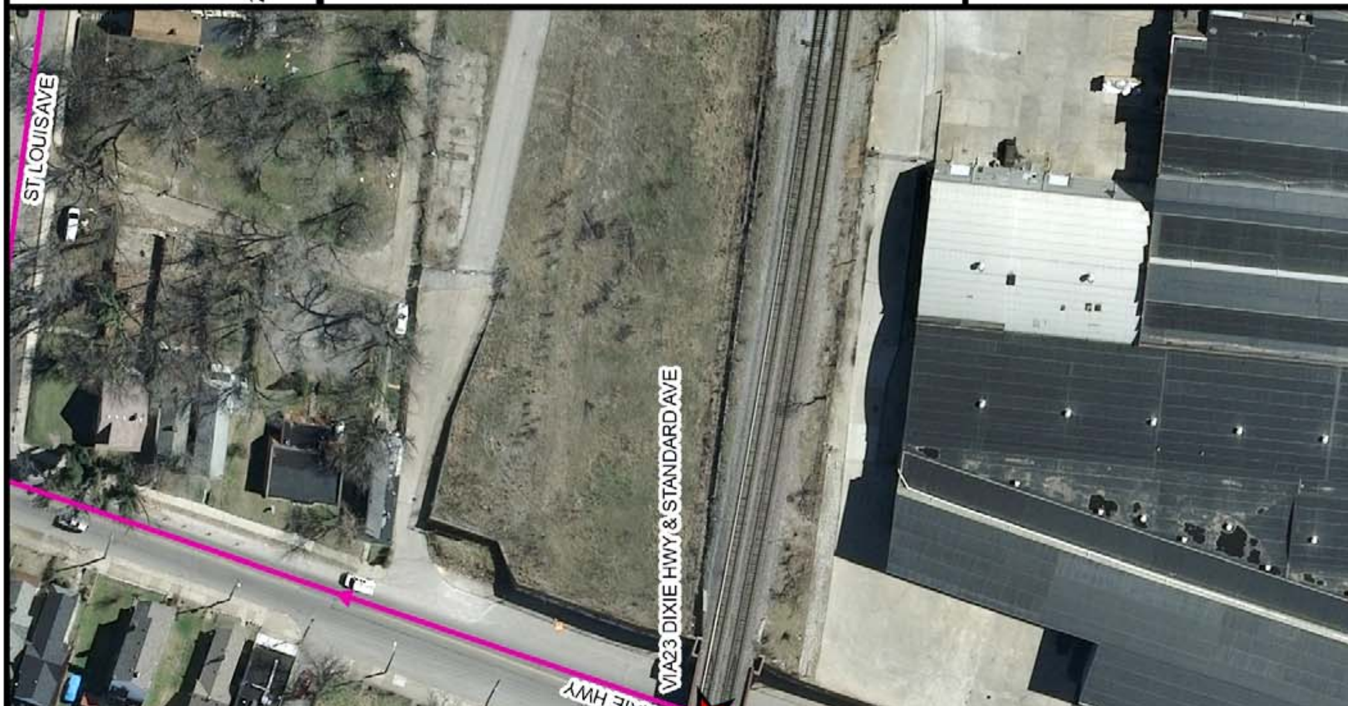
msd safe clean waterways

Scalable when printed on 8.5" x 11" paper
1 inch = 100 feet
0 50 100 Feet



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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA24 15TH AND OAK VIADUCT FLOOD RELIEF		
Budget ID	X_0133		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$5,288,000	**Project Budget** (Escalated Dollars)	$9,010,514
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 2 separate parcels of property, currently owned by the railroad, will need to be acquired.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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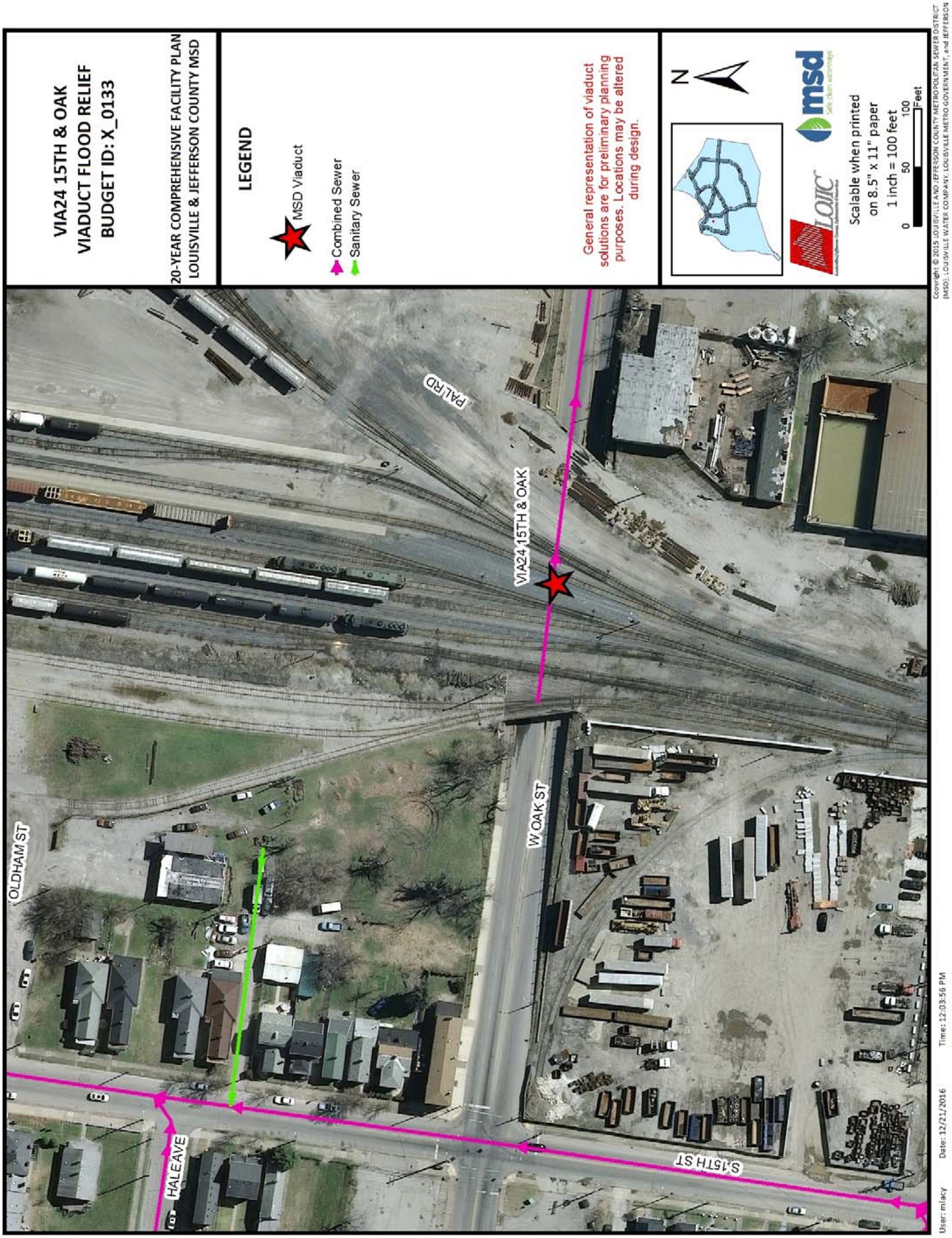

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA25 10TH AND HILL VIADUCT FLOOD RELIEF		
Budget ID	X_0134		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$5,332,000	**Project Budget** (Escalated Dollars)	$9,084,704
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 2 separate parcels of property will need to be acquired. Currently, Louisville Metro owns the parcels needed, so partnering opportunities exist which may help lower property acquisition cost.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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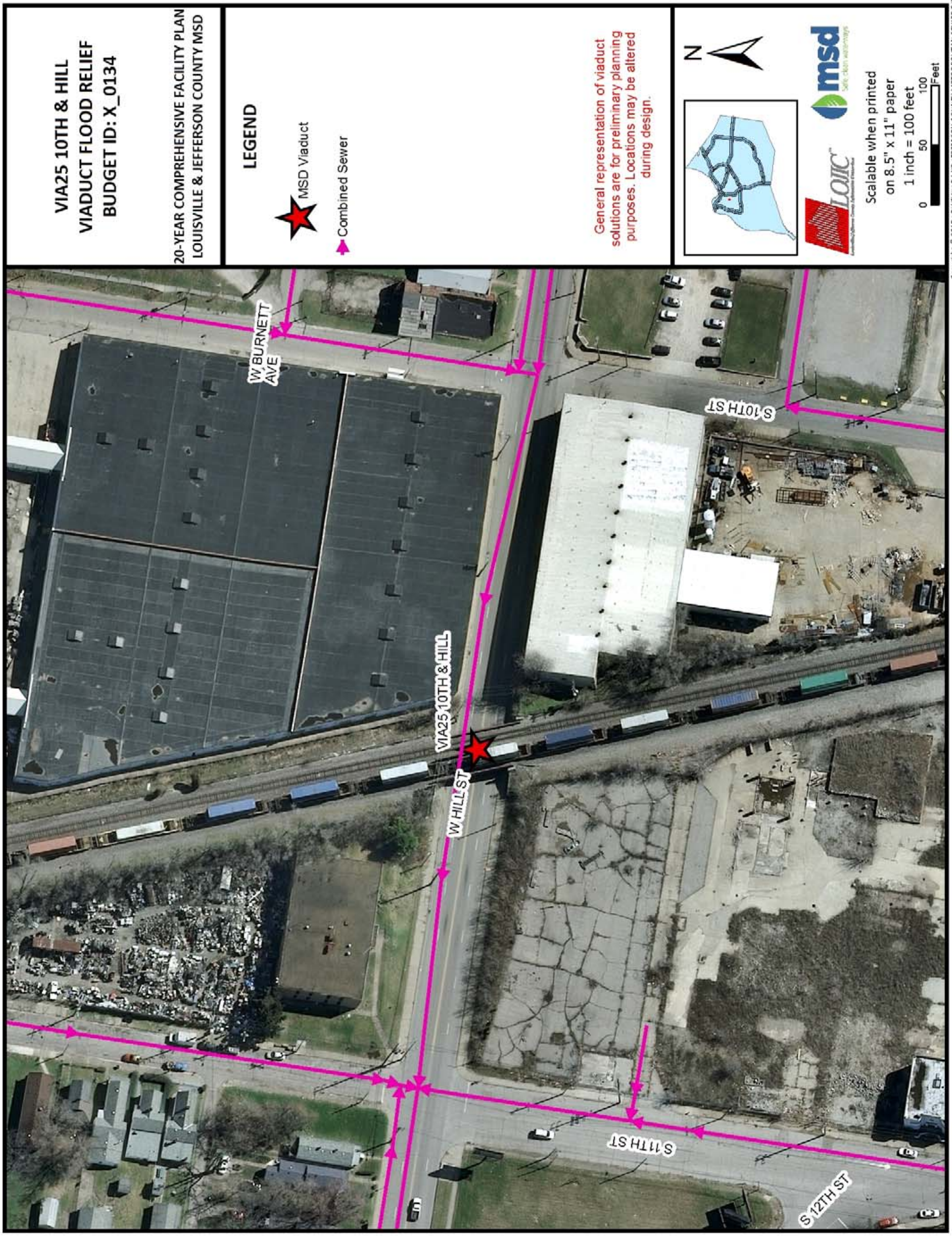

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA26 7TH AND DAVIES VIADUCT FLOOD RELIEF		
Budget ID	X_0135		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$5,332,000	**Project Budget** (Escalated Dollars)	$9,084,704
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 2 separate parcels of property will need to be acquired. Currently, Louisville Metro owns the parcels needed, so partnering opportunities exist which may help lower property acquisition cost.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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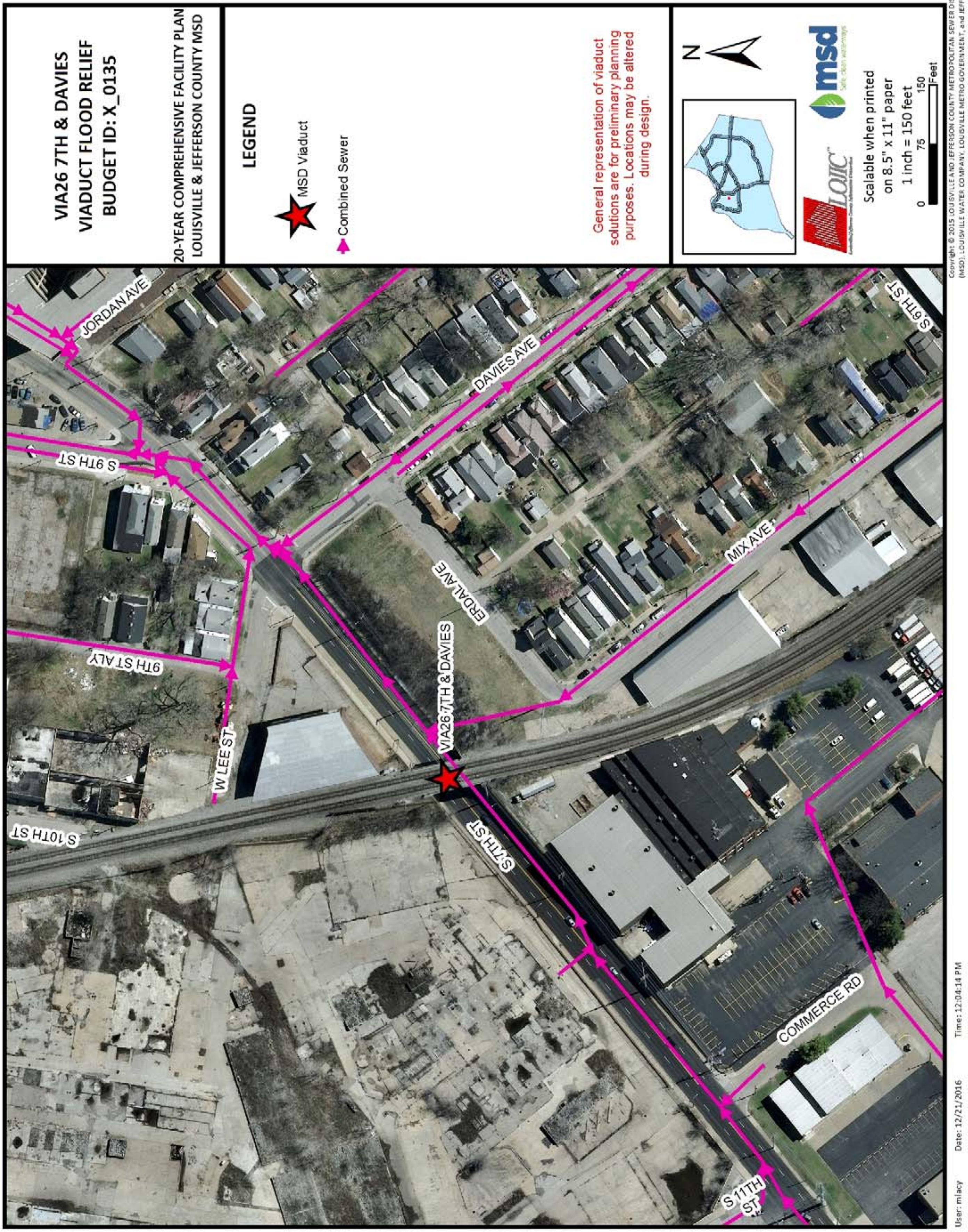

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA27 15TH AND CHESTNUT VIADUCT FLOOD RELIEF		
Budget ID	X_0118		
Start FY	2027	**Completion FY**	2031
Project Budget (2016 Dollars)	$3,855,000	**Project Budget** (Escalated Dollars)	$5,666,156
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 2 separate parcels of property will need to be acquired.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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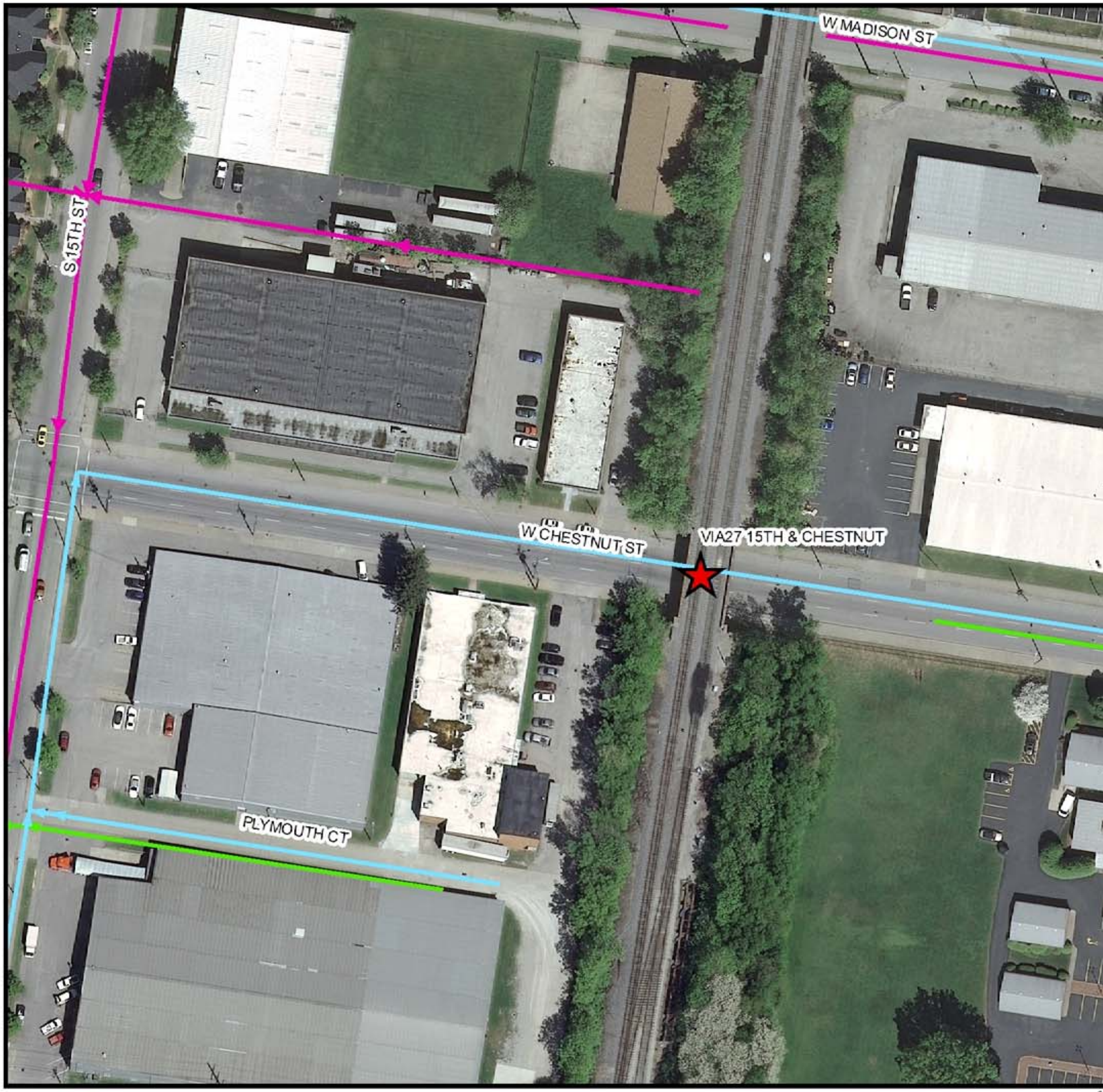

VIA27 15TH & CHESTNUT
VIADUCT FLOOD RELIEF
BUDGET ID: X_0118

20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD

LEGEND

- MSD Viaduct
- Combined Sewer
- Sanitary Sewer
- Storm Sewer

General representation of viaduct solutions are for preliminary planning purposes. Locations may be altered during design.

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LOJIC msd Safe clean waterways

Scalable when printed
on 8.5" x 11" paper
1 inch = 100 feet
0 50 100 Feet

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA28 15TH AND BROADWAY VIADUCT FLOOD RELIEF		
Budget ID	X_0119		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$3,873,000	**Project Budget** (Escalated Dollars)	$4,909,979
Service Type	Stormwater	**Program**	Drainage

Project Description

This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 parcel of property will need to be acquired, including 1 building.

Project Justification

Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations

The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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VIA28 15TH & BROADWAY
VIADUCT FLOOD RELIEF
BUDGET ID: X_0119

20-YEAR COMPREHENSIVE FACILITY PLAN
LOUISVILLE & JEFFERSON COUNTY MSD

LEGEND

- MSD Viaduct
- Storm Sewer
- Combined Sewer
- Sanitary Sewer

General representation of viaduct solutions are for preliminary planning purposes. Locations may be altered during design.

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msd safe clean waterways

Scalable when printed on 8.5" x 11" paper
1 inch = 100 feet
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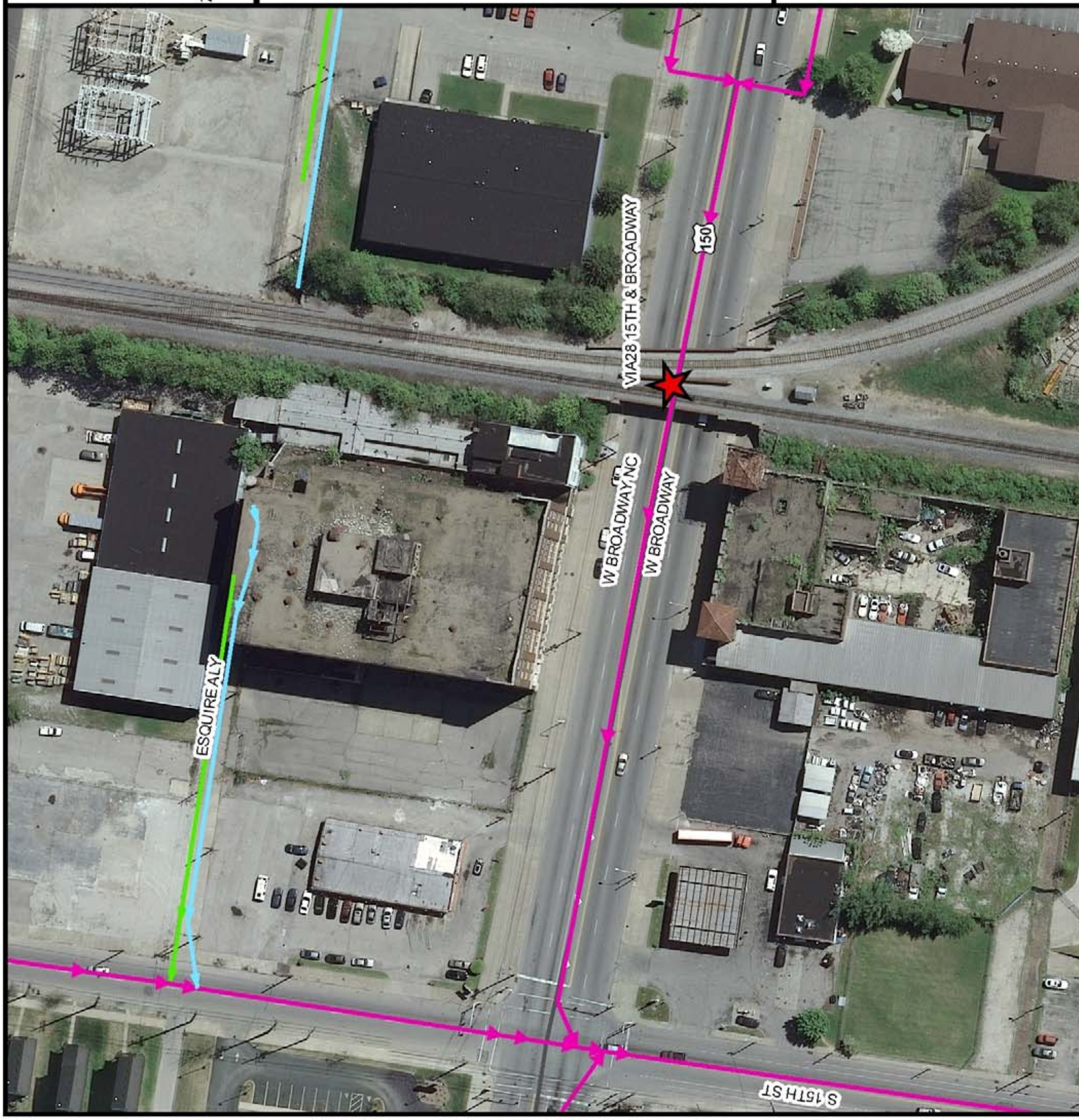

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COMPREHENSIVE 20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA29 13TH AND MAPLE VIADUCT FLOOD RELIEF		
Budget ID	X_0114		
Start FY	2027	**Completion FY**	2031
Project Budget (2016 Dollars)	$3,755,000	**Project Budget** (Escalated Dollars)	$5,519,174
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 parcel of property will need to be acquired.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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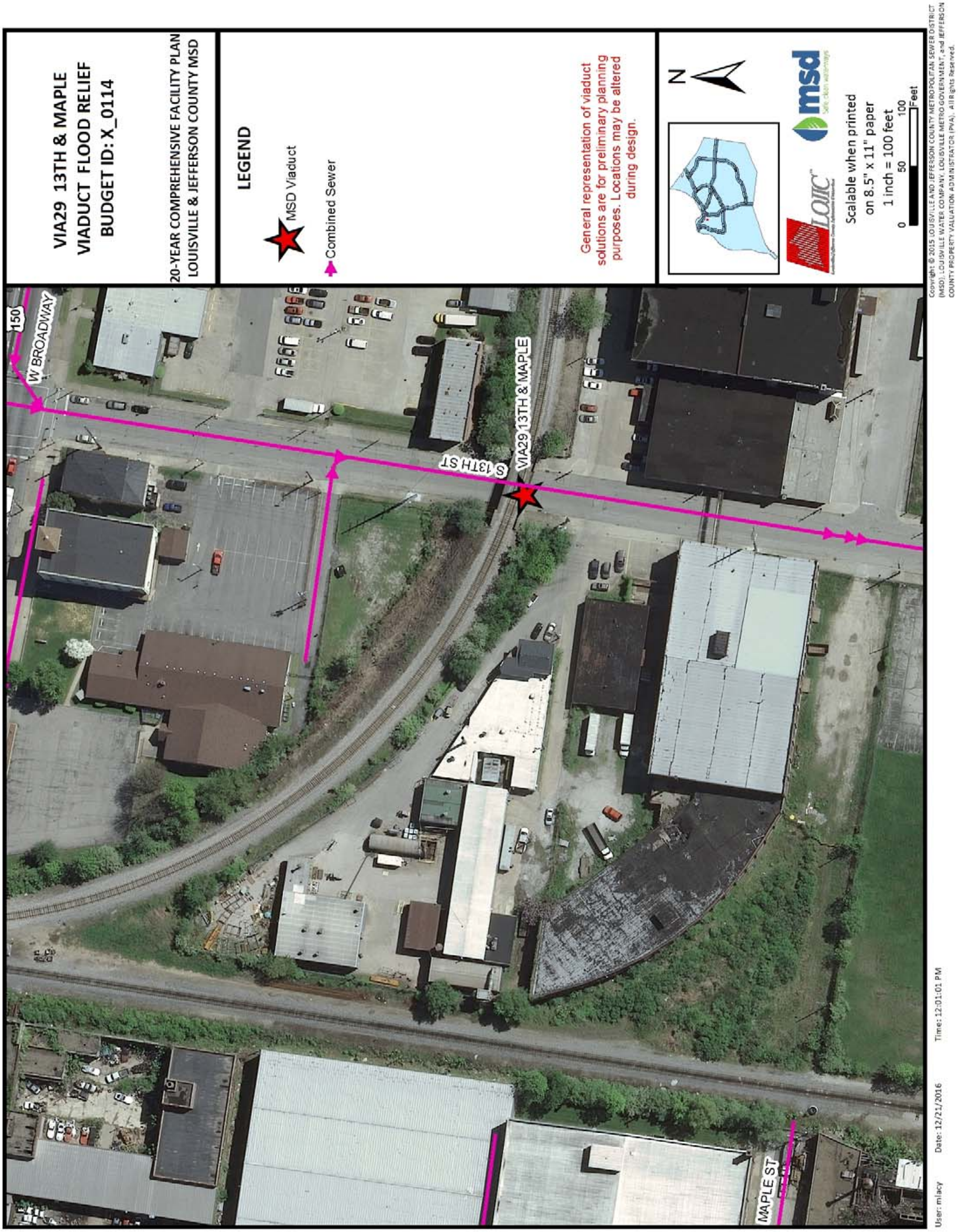

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA30 12TH AND MAPLE VIADUCT FLOOD RELIEF		
Budget ID	X_0115		
Start FY	2027	**Completion FY**	2031
Project Budget (2016 Dollars)	$3,799,000	**Project Budget** (Escalated Dollars)	$5,583,846
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed for this viaduct that the combined sewer system does not significantly surcharge at this location. If further modeling suggests otherwise, a storage of greater volume will be needed. It is also assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 parcel of property will need to be acquired, including 1 building.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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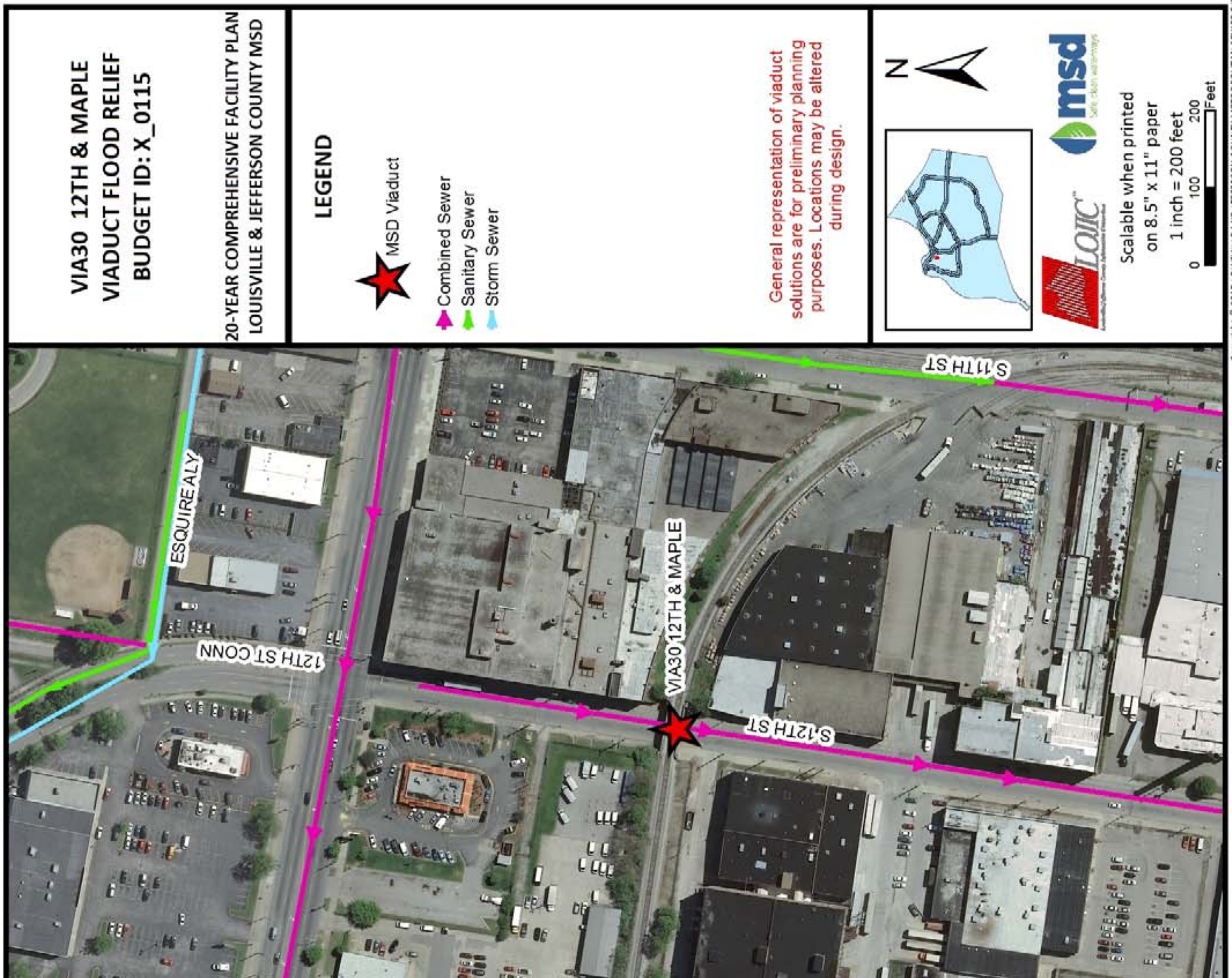

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA32 3RD AND WINKLER VIADUCT FLOOD RELIEF		
Budget ID	X_0147		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$29,912,000	**Project Budget** (Escalated Dollars)	$37,777,825
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. The existing pumps at this viaduct are drastically undersized and backwater from the Southern Outfall is known to occur here as well. In addition, during some events, overflow from certain catch basins create a circular pumping pattern. The recommended solutions include substantially upgrading the existing pump stations to larger stations, installation of one-way valves to eliminate backwater, and provide an outlet by means of an approximate 6.9 MG underground storage basin (final volume to be verified by watershed modeling). The recommended location for the basin is Stansbury Park.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary. Reference the draft “University of Louisville Area Flooding Analysis” (Heritage, Dec. 2015) for more information on this viaduct. One alternative solution that could potentially save significant cost would be to design a gravity in, pumped out storage basin. The feasibility of this should be considered in the preliminary engineering for the project.

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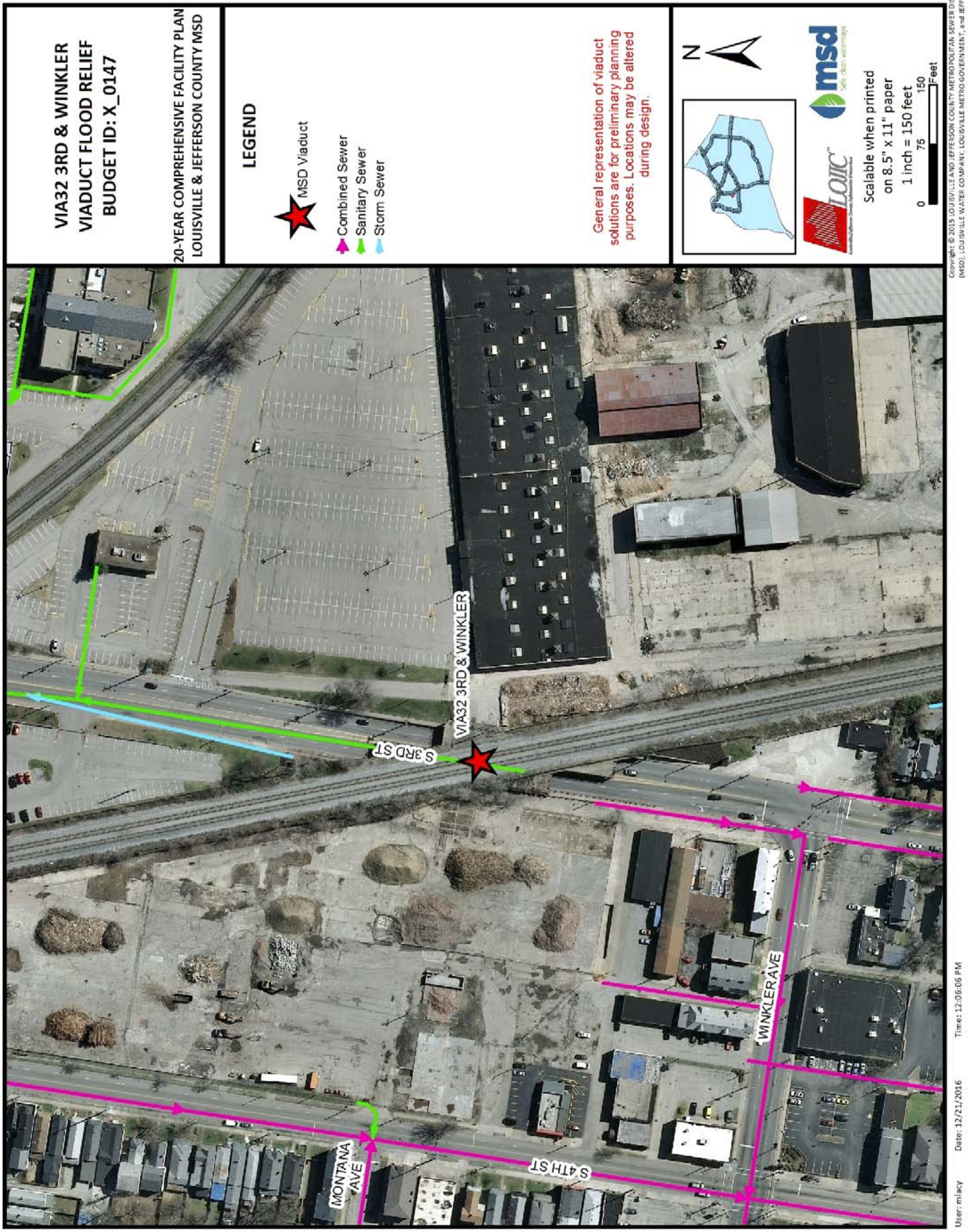

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	VIA33 TAYLORSVILLE ROAD AND MERIONETH VIADUCT FLOOD RELIEF		
Budget ID	X_0129		
Start FY	2032	**Completion FY**	2036
Project Budget (2016 Dollars)	$4,388,000	**Project Budget** (Escalated Dollars)	$7,476,713
Service Type	Stormwater	**Program**	Drainage

Project Description
This viaduct will be upgraded to pass stormwater flows from the 4 percent probability (25-year) storm without significant ponding. This will be accomplished by adding underground storage of approximately 3 MG (final volume to be verified by watershed modeling). It is assumed a gravity solution can be employed to convey the water from the viaduct to the proposed underground storage basin. Pumping cost have been included in the conceptual estimate to empty the storage basin after the event. Final pump sizing will occur during preliminary engineering. It is anticipated that 1 parcel of property will need to be acquired.

Project Justification
Viaducts represent a serious hazard to the travelling public during and immediately after intense rainfall events. Most viaducts are in a sump condition in the roadway, meaning there is no natural overland overflow area. The water will collect and build up, often very rapidly, if the outlet pipes or pumps are not sufficient to convey stormwater out of the viaduct at a higher rate than it can accumulate. Due to the flash flooding that can occur at a viaduct, many motorist are unaware of the danger. In the past 25 years, there has been one documented death of a motorist who tried to drive through a flooded viaduct, and numerous water rescues of many others.

Other Considerations
The solutions for this viaduct are conceptual in nature. Full preliminary engineering, complete with full hydrologic and hydraulic modeling for accurate sizing of facilities are necessary.

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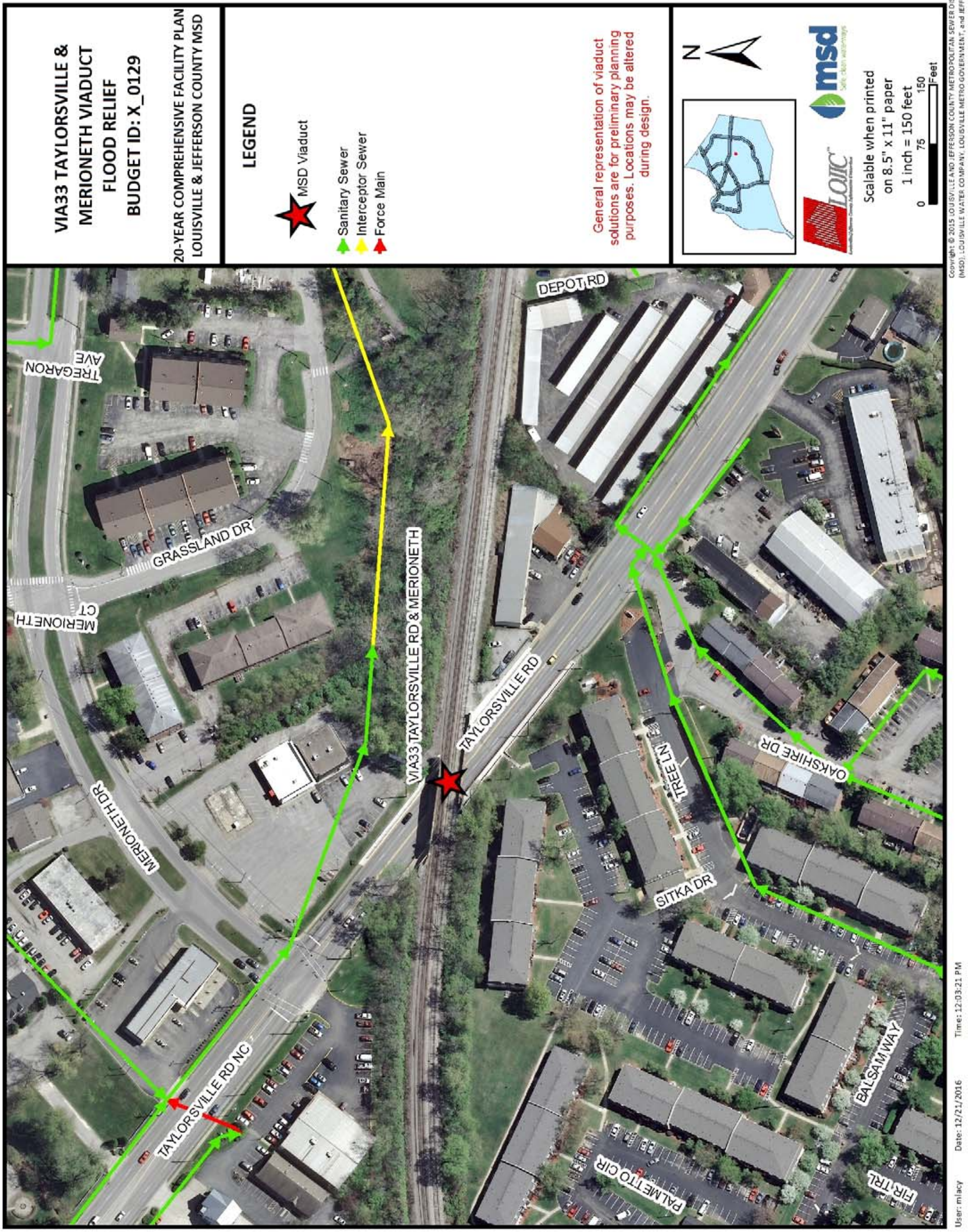

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COMPREHENSIVE
20-YEAR FACILITY PLAN
PROJECT FACT SHEET
LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	WHISPERING HILLS EARLY ACTION PROJECT		
Budget ID	X_0101		
Start FY	2018	**Completion FY**	2021
Project Budget (2016 Dollars)	$3,200,000	**Project Budget** (Escalated Dollars)	$3,518,912
Service Type	Stormwater	**Program**	Drainage

Project Description
The Whispering Hills area is generally bordered on the north by the main channel of Fern Creek, on the east by Fegenbush Road and Downs Branch, on the south by Outer Loop, and on the west by Shepherdsville Road. This area lies within the Pond Creek watershed. Key flooding and drainage issues within the area include property and structure flooding in the Fegenbush Lane and Vaughn Mill Road area. The system in the Wynde Manor Road, Fendwick Drive Woodrow Way, Brightstone and Crispa Court is undersized. To address the 10 percent annual chance storm, possible solutions include an increase in system conveyance and the purchase of select flood-prone structures. Specific solutions include increasing the capacity of the existing system along Fegenbush Lane, Vaughn Mill Road, Wynde Manor Road, Fendwick Drive, Woodrow Way, Brightstone, Crispa Court, Woodrow Way across from Brook Valley Drive, and Doresta Way. These solutions were developed using the results from a preliminary overland 2-D model of the 10 percent annual chance storm event. In many areas, “street-level flooding” as well as some structural flooding, was observed in the models. This is caused when the storm sewer and open-channel systems are overwhelmed, thereby flooding the streets or adjacent properties. Preliminary engineering is needed to further refine the problem areas and solutions. It appears that new detention is not necessary for the 10 percent annual chance storm event solution, however, during preliminary engineering it would be prudent to look for areas of possible detention for the larger storm events.

Project Justification
Ten early action project areas have been identified that can be designed and constructed while the comprehensive stormwater county-wide master planning is being performed. Planning level cost have been calculated to achieve a 10 percent annual chance (10-year) level of service in these ten areas. Four of these areas (Ten Broeck, Prospect, Hurstbourne, and Richlawn) were included due to the 2015 extreme storm events that were studied and determined to contain worthwhile drainage improvement projects. The other 6 areas (Pope Lick, Seatonville, Whispering Hills, Newburg, Auburndale, Valley Creek) are referenced as stormwater pilot areas. They were carefully screened to contain areas of poor drainage. These pilot areas do not represent the worst drainage areas in the county, nor do they represent the best. All areas were also screened to be outside of known mapped floodplains.

Other Considerations
The description of solutions and cost estimates are conceptual in nature and full preliminary and final engineering need to be performed for this project.

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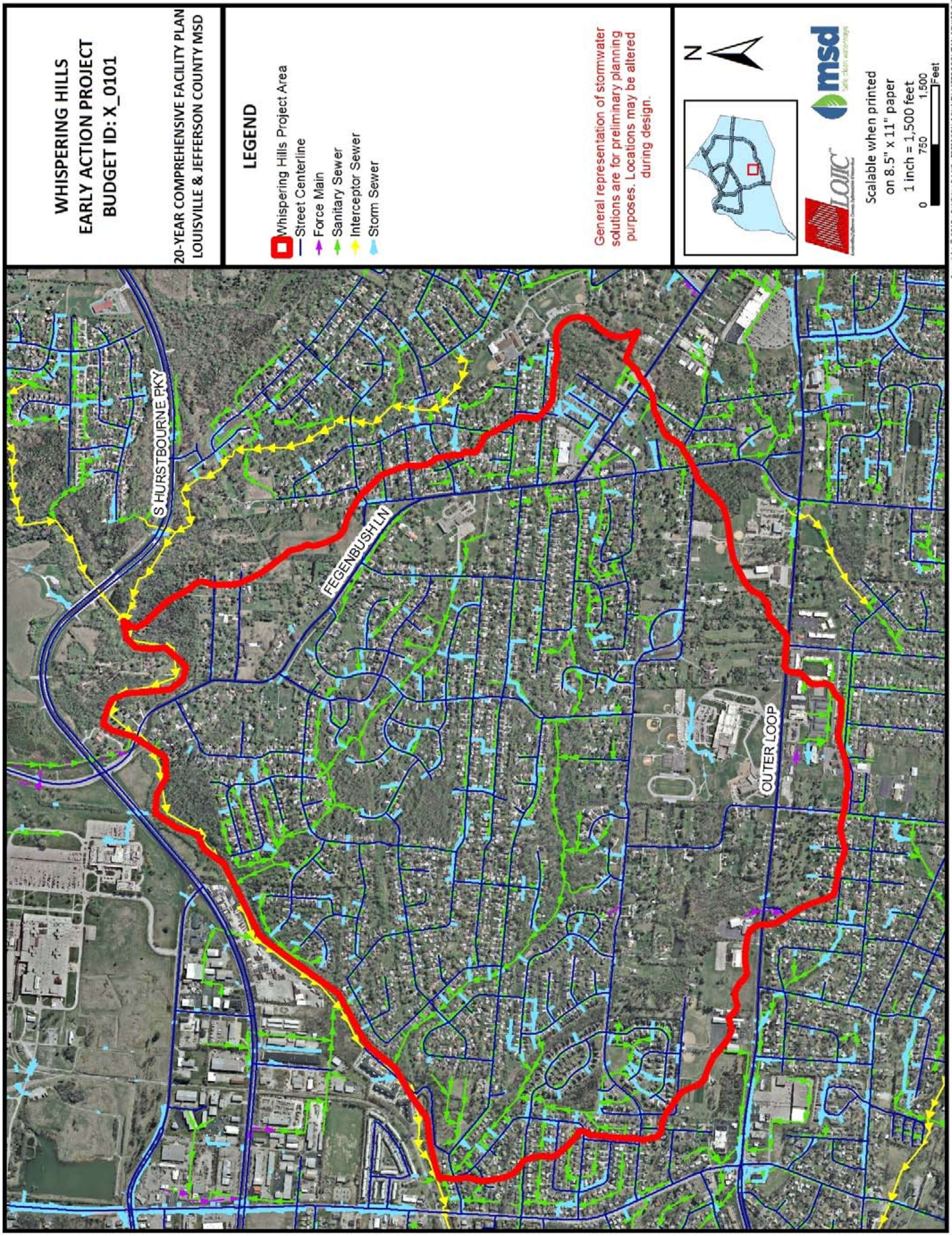

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COMPREHENSIVE 20-YEAR FACILITY PLAN PROJECT FACT SHEET

LOUISVILLE AND JEFFERSON COUNTY MSD

Project Name	WOODLAWN PARK BASIN RETROFIT		
Budget ID	X_0108		
Start FY	2022	**Completion FY**	2026
Project Budget (2016 Dollars)	$145,000	**Project Budget** (Escalated Dollars)	$183,846
Service Type	Stormwater	**Program**	Stormwater Quality (MS4)

Project Description

The existing 30 and 24 inch pipes entering the basin in the northern and eastern most corner are to have a rock berm forebay added in order to allow maintenance crews easy access. From there the drainage will travel along a circuitous path into a Water Quality Storage Area that will have native plants added and the existing turf grass removed. This area will be defined by a berm bisecting the existing basin with an overflow elevation established so as to contain the entire volume from the 1 inch rain event. In larger rain events, the drainage will leave the storage area and travel within a defined channel, ultimately leaving the basin through the existing outlet structure. The central portion of the basin will not have inlet pipes associated with it, and for the most part will remain dry except in large rain events in which the entire basin is inundated. Because of this, the only proposed revisions are to create a defined low-flow channel and to remove all turf grass and replace with upland prairie type seed. The low flow channel of this area will be kept separate from the channel leaving the large upstream storage area. The southernmost area of the basin has existing 21 and 54 inch entering from the surrounding subdivision. The 54 inch pipe inlet drains a large portion of the neighborhood, but also acts as an overflow pipe from another nearby detention basin. An earthen berm, with rip-rap overflow is proposed in order to contain the 1 inch rain event from the 2 inlet pipes and define the Water Quality Storage Area. The lowest portion of this area will have lowland wetland seed mix added, and turf grass removed. Before arriving in the lowland area, the drainage will travel within a defined low flow channel. The overflow from this area will enter into another micropool, with wetland seed mix added. In larger rain events the drainage will leave both the water quality storage area and the micropool and join drainage from the northern and central portions of the basin before leaving the basin in the existing outlet structure.

Project Justification

This basin drains to Beargrass Creek which is on the 303(d) list of impaired streams. MSD is responsible for water quality within Jefferson County and is working towards removing pollutants from local waterways as part of their MS4 permit and larger mission. Incorporating water quality components to the existing basin is a cost-effective method to remove pollutants from stormwater before they enter Beargrass Creek.

Other Considerations

Initial percolation tests taken during a dry period were favorable. Additional percolation tests should be performed prior to final design and construction.

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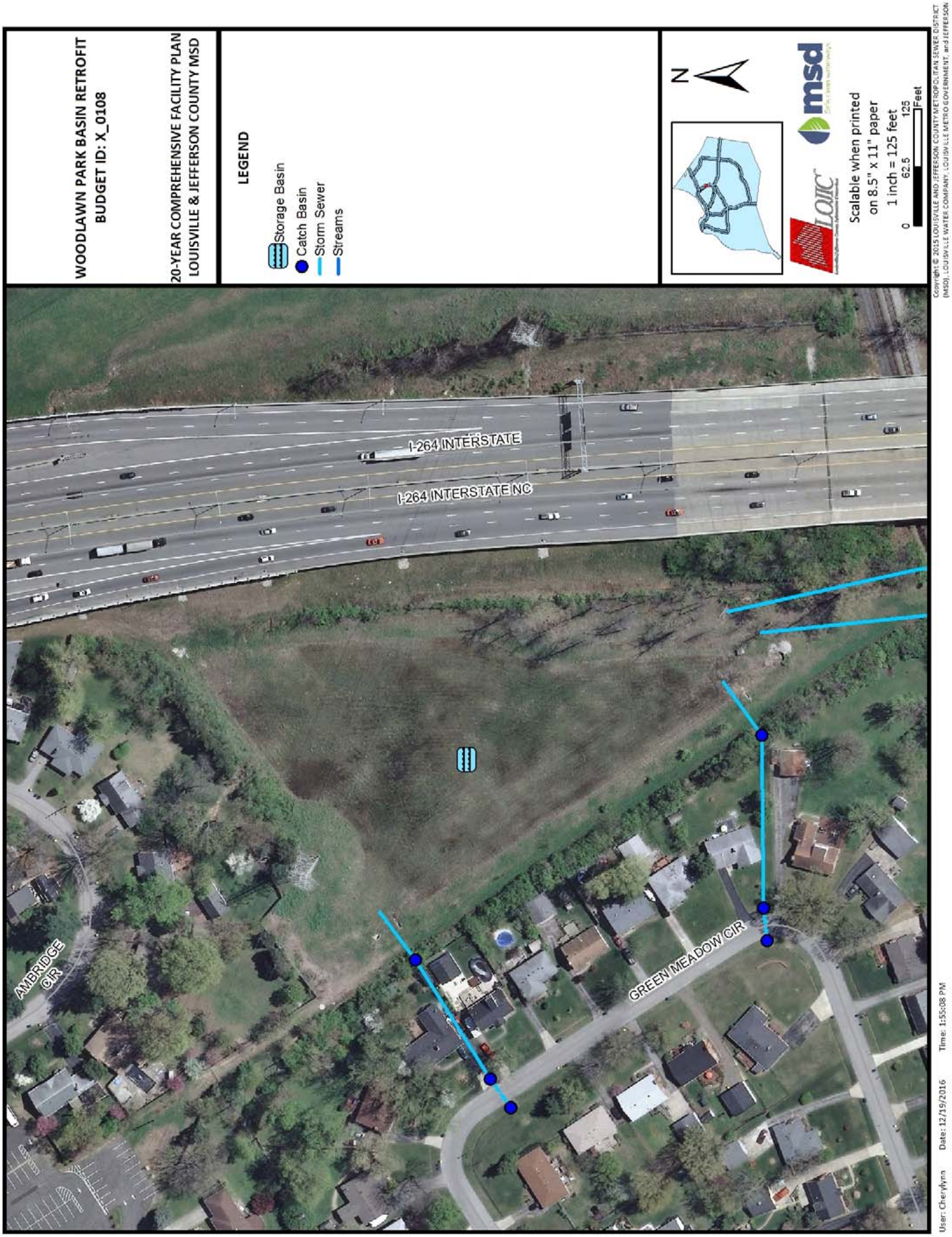

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